INDOT CERTIFIED ASPHALT TECHNICIAN

PROGRAM 2023

INDIANA DEPARTMENT OF TRANSPORTATION

INDOT

APAI

ASPHALT PAVEMENT ASSOCIATION of INDIANA

Table of Contents

ASPHALT PAVEMENT ASSOCIATION of INDIANA

INDOT Certified Asphalt Lab Technician Program

Location: The Center, The Heritage Group

Date: January 23 – February 26, 2023

Moderator: Nathan Awwad

Day 1

8:00 AM – 9:00 AM	Registration	
9:00 AM – 9:20 AM	Opening Comments	Chris Campbell Todd Dobbs Taylor Cornelius Kirsten Fowler
9:20 AM – 10:00 AM	Course Purpose and Overview, Chap. 1 Manual Layout ITM 583 and Program Requirements Rounding and Calculator Intro	Matt Beeson
10:00 AM – 10:15 AM	*** Break ***	
10:15 AM – 11:45 AM	Aggregate Fundamentals, Chap. 2 Highway Construction Materials Properties and Specifications	Melissa Ehrhart
11:45 AM – 12:30 PM	*** Lunch ***	
12:30 PM – 2:30 PM	Aggregate Sampling and Testing, Chap. 2 Segregation Sampling and Splitting Moisture and Decant Gradation Fine & Coarse Aggregate Specific Gravity Fine Aggregate Angularity Flat & Elongated Particles Percentage of Fractured Particles in Coarse Aggregate	Doug Corey Daniel Jones Tom Partipilo Jason Stroud

2:30 PM – 2:45 PM *** Break ***

2:30 PM – 4:30 PM (40 min. rotations) Aggregate Laboratory Demonstrations and Calculation Practice

Group	Topic	Room Location	Instructor
A	Sampling Splitting Moisture Decant Gradation	Laboratory A	Jason Stroud Chris Campbell
B	Fine & Coarse Aggregate Specific Gravity Fine Aggregate Angularity Flat & Elongated Particles Percentage of Fractured Particles in Coarse Aggregate	Laboratory B	Jason Howard Bart Williamson
C	Calculation Practice	Classroom	Melissa Ehrhart Doug Corey Daniel Jones Tom Partipilo

4:30 PM – 5:30 PM Optional Review Session at The Center

7:00 PM – 9:00 PM Optional Review Session at Hotel

Day 2

8:30 AM – 9:30 AM Asphalt Binder, Chap. 3 — Chris Campbell, Gerry Huber
- Manufacturing
- Testing
- Grading
- Specifications

9:30 AM – 10:00 AM Asphalt Volumetrics, Chap. 4 — Gerry Huber, Kate DeCarlo
- Superpave
- Specific Gravity
- Asphalt Content, Air Voids, VMA, & VFA
- Mix Design Basics
- SMA

10:00 AM – 10:15 AM *** Break ***

10:15 AM – 11:45 AM Asphalt Volumetrics (continued from above)

11:45 AM – 12:30 PM *** Lunch ***

12:30 PM – 1:00 PM Aggregate Blending, Chap. 4 Kirsten Fowler

1:00 PM – 2:15 PM QC/QA Program and PWL, Chap. 7 Nathan Awwad, Jason Galetka

- DMF Process
- PWL
- Single Sublot Acceptance
- 402 Acceptance
- SMA Acceptance

2:15 PM – 2:30 PM *** Break ***

2:30 PM – 4:30 PM (40 min. rotations) Asphalt Laboratory Demonstrations and Calculation Practice

Group	Topic	Room Location	Instructor
1	Splitting Maximum Specific Gravity Dryback Gyratory Compactor Bulk Specific Gravity	Laboratory A	Chris Campbell Jason Stroud Harley Phillips
2	Extraction NCAT Oven Bulk Specific Gravity in Corelok	Laboratory B	Jason Howard Cartia Martin
3	Calculation Practice	Classroom	Elizabeth Pastuszka Nathan Awwad

4:30 PM – 5:30 PM Optional Review Session at The Center

7:00 PM – 9:00 PM Optional Review Session at Hotel

Day 3

8:30 AM – 9:15 AM Plants, Chap. 5 Tim Sievers

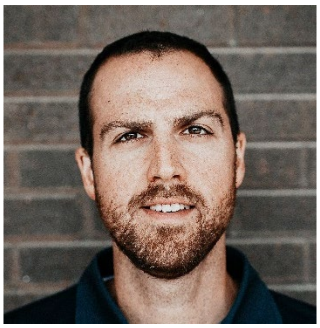
- Plant Types
- Operations
- Inspection and Calibration
- Safety

9:15 AM – 10:00 AM	Field Testing, Chap. 7 Truck Sampling Plate Sampling Coring Smoothness	Cody Fowler Jason Galetka
10:00 AM – 10:15 AM	*** Break ***	
10:15 AM – 11:45 AM	Audits and Equipment Calibration, Chap. 6 Example Audit Calibration Verification	Elizabeth Pastuszka Harley Phillips
11:45 AM – 12:30 PM	*** Lunch ***	
12:30 PM – 12:45 PM	Ethics	CJ Potts
12:45 PM – 1:45 PM	Quality Control Troubleshooting, Chap. 6 Relationships between volumetric properties	Brad Cruea
1:45 PM – 2:00 PM	*** Break ***	
2:00 PM – 2:30 PM	How INDOT Works Next Steps after Certification	Matt Beeson Nathan Awwad
2:30 PM – 3:30 PM	Exam Preparation	Kirsten Fowler Nathan Awwad Matt Beeson Brad Cruea
3:30 PM – 5:30 PM	Optional Review Session at The Center	
7:00 PM – 9:00 PM	Optional Review Session at Hotel	

Day 4

8:30 AM – 12:30 PM	Certification Exam	Kirsten Fowler

ICAT Instructors & Staff



Nathan Awwad, P.E.
Asphalt Engineer
Indiana Department of Transportation
nawwad@indot.in.gov

Brad Cruea
Quality Control Manager – Indianapolis Milestone Contractors, L.P.
Brad.cruea@milestonelp.com

Matt Beeson, P.E.
Director, Division of Materials and Tests
Indiana Department of Transportation
mbeeson@indot.in.gov

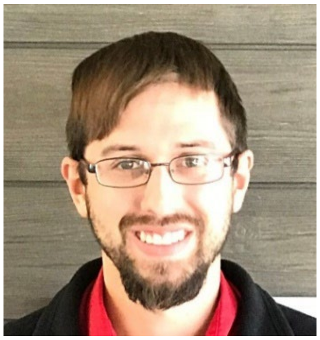
Melissa Ehrhart
Statewide Geologist
Indiana Department of Transportation
mehrhart@indot.in.gov

Chris Campbell
Design Technician
The Heritage Group
chris.campbell@hrglab.com

Cody Fowler, P.E.
Regional QC Manager
Rieth-Riley Construction
cfowler@rieth-riley.com

Doug Corey, P.E.
Greenfield District Testing Engineer
Indiana Department of Transportation
dcorey@indot.in.gov

Kirsten Fowler, P.E.
Executive Director
Asphalt Pavement Association of Indiana (APAI)
kfowler@asphaltindiana.org

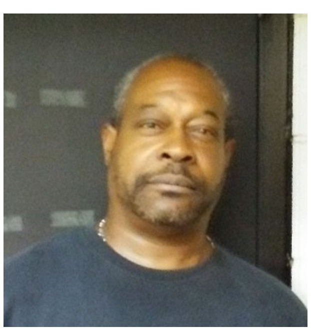


Jason Galetka
Assistant Asphalt Engineer
Indiana Department of Transportation
jgaletka@indot.in.gov

Jason Howard
Design Technician
Heritage Group
jason.howard@hrglab.com

Gerry Huber, P.E.
Associate Director of Research
The Heritage Group
Gerald.huber@hrglab.com

Jaymie Hunckler
Member Services Manager
Asphalt Pavement Association of Indiana (APAI)
jhunckler@asphaltindiana.org



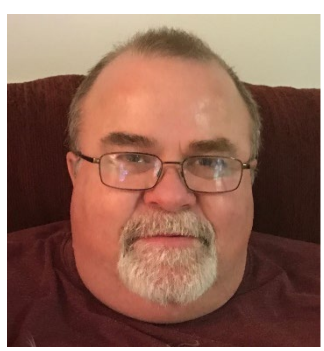
Cartia Martin
Asphalt Lab Supervisor
Indiana Department of Transportation
Cartiamartin@indot.in.gov

Tom Partipilo
HMA Design & QC Coordinator – South
E&B Paving, Inc.
Tom.partipilo@constructionmaterialslab.com

Elizabeth Pastuszka
HMA Design & QC Coordinator – North
E&B Paving, Inc.
Elizabeth.pastuszka@ebpaving.com

Harley Phillips
Quality Assurance Manager
Indiana Department of Transportation
hphillips@indot.in.gov

Tim Sievers
Mix Cost Analyst
Brooks Construction Company, Inc.
tlsievers@brooks1st.com



Bart Williamson
Aggregate Materials Technician
Indiana Department of Transportation
bartwilliamson@indot.in.gov

INDIANA DEPARTMENT OF TRANSPORTATION

CERTIFIED ASPHALT TECHNICIAN PROGRAM

(ICAT)

HMA POLICIES AND PROCEDURES

2023

INDOT CERTIFIED ASPHALT TECHNICIAN PROGRAM

Objectives

The Indiana Department of Transportation (INDOT) Certified Asphalt Technician Program (ICAT) is conducted in cooperation with the Asphalt Pavement Association of Indiana (APAI).

The principal objective of the ICAT Program is to provide the necessary training to plant personnel so that they may administer quality control of Hot Mix Asphalt (HMA). Knowledge of materials, mix design, HMA plants, laboratory test methods, and specifications are provided to enhance the technician's ability to meet the program requirements.

INDOT requires that a Level 1 Asphalt Technician perform or supervise all sampling and testing of HMA materials produced by a Certified HMA Producer. Explanation of how to achieve Level 1 status can be found in the Certification Requirements portion of this document.

Program Committee

The Program Committee acts as the steering committee which establishes the needs for the certification program and provides technical assistance for course materials and examinations. The committee is composed of representatives from INDOT, FHWA, and APAI.

Certification Committee

The Certification Committee is responsible for revocation or suspension of certifications for technicians. The Committee tasks include reviewing the violations of standard policies, rendering judgement of the seriousness of the violation, and hearing any subsequent appeal. The committee is composed of selected members of the Program Committee.

Certification Requirements

A technician is required to pass a written examination to become Certified. The examination will be given at the completion of the training course.

A technician is required to fulfill the requirements of the INDOT Independent Assurance and Qualified Acceptance Personnel Program to become Qualified.

A technician that is both Certified and Qualified becomes a Level 1 Asphalt Technician. INDOT specifications require that a Level 1 Asphalt Technician perform or supervise all sampling and testing of HMA materials produced by a Certified Asphalt Producer.

However, it is possible to be either Qualified or Certified only:

- A Qualified Technician can perform sampling and testing, but the work must be performed under the direct supervision of a Level 1 or Certified Technician.
- A Certified Technician cannot perform sampling and testing, but can directly supervise Qualified Technicians.

Both of these situations fulfill INDOT specification requirements.

A technician must be Qualified in the following test methods to become a Qualified Asphalt Technician:

AASHTO T 166 -- Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
AASHTO T 209 -- Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
AASHTO T 275 -- Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens
AASHTO T 312 -- Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
AASHTO T 331 -- Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Automatic Vacuum Sealing Method (if applicable)
*ITM 571 -- Quantitative Extraction of Asphalt and Gradation of Extracted Aggregate from HMA Mixtures
ITM 572 -- Drying HMA Mixtures
ITM 580 -- Sampling HMA
**ITM 586 -- Asphalt Content by Ignition
ITM 587 -- Reducing HMA Samples to Testing Size

*At least one Test Method required

A technician may become a Qualified Technician in all of the designated sampling, sample reduction and test procedures before or after becoming Certified. Please contact District Testing to become Qualified.

If the technician is not Qualified at the time of becoming Certified, the technician is required to contact INDOT after becoming Qualified to be granted Level 1 status. Please contact:

Mary White
Indiana Department of Transportation
Division of Materials and Tests
120 S. Shortridge Rd.
Indianapolis, IN 46219
317-522-9703
e-mail: mwhite@indot.in.gov

Certification Examination

The examination time is limited to a maximum duration of 4 hours and the examination is open book/open note. There are 2 parts of the examination. Part I consists of multiple choice and fill in the blank questions, and Part II consists of word problems and other numerical calculations. A minimum score of 70 percent is required on each part to pass the examination.

A technician that has failed the certification examination will be allowed one retake of the exam. Only the part(s) failed are required to be retaken. A duration of 2 hours for Part I and 2 hours for Part II are allowed. The retake examination will be open book/open note and consist of a format similar to the original examination. The retake examination will be given at the INDOT Division of Materials and Tests within 45 days of notification of the technician's results of the original examination. A minimum score of 70 percent on each part is required to pass the retake examination. Technicians failing either part of the retake examination will be required to participate in the training course the following year and pass the examination to become certified.

The examinations will be retained by INDOT for a period of 1 year after such time the examinations will be destroyed. Technicians may review their examinations in the presence of an INDOT representative within 1 year of the examination date. Arrangements for review of the examination shall be made with INDOT.

Maintaining Status

Once a Technician passes the Certification Examination, they are Certified. There are no Recertification requirements.

Level 1 Asphalt Technicians will retain that status as long as they stay current as a Qualified Technician.

The certified technician will be notified of the recertification procedures prior to the expiration of the certification. The technician is responsible for applying for certification renewal. A current address is required to be maintained on file with INDOT. Address revisions are required to be sent to:

Mary White
Indiana Department of Transportation
Division of Materials and Tests
120 S. Shortridge Rd.
Indianapolis, IN 46219
317-522-9703
e-mail: mwhite@indot.in.gov

Fees

The fee for attending the certification training course will be established by the Program Committee. The fee will cover a training manual, course materials, and refreshments

The refund policy for the certification course fee is as follows:

1. An administration fee of $100 will be charged for cancellation by the technician within 7 days of the course.

2. Lack of attendance of the course will result in no refund of fees.

3. Unforeseen emergencies that result in absences during the course will result in a refund of the course fee.

The fee for attending the Recertification Course will be established by the Program Committee. The fee will cover a training manual, course materials, refreshments, and lunch. No refunds will be given for the Recertification Course; however, unforeseen emergencies that result in absence of the course will result in a refund of the course fee.

Failure to pay the training course or examination fees will result in suspension of the certification.

Cancellation Policy

If a scheduled certification course or recertification refresher course is cancelled because of insufficient class size, the technicians will be notified 1 week prior to the start of the course. The technicians will be reimbursed the course fee.

Revocation or Suspension of Certification

Certifications awarded may be revoked or suspended at any time by the Certification Committee for just cause. The procedure that will be taken to revoke or suspend a technician's certification is as follows:

1. The technician will be sent written notification of the intent to revoke or suspend the certification by a registered letter. A copy of the written notification will be sent to the technician's employer. The letter will state the grounds for the revocation or suspension, request a written response, and establish a hearing date.

2. The technician will be allowed 60 days from the date of the notification to respond by letter. The response shall include an explanation of why the technician disagrees with the decision to revoke or suspend the certification.

3. After the 60 day time period has elapsed or upon receipt of the response, the case will be reviewed by the Certification Committee on the hearing date. The technician's response letter will be considered and the technician may appear before the Certification Committee.

4. The Certification Committee will issue a decision within 1 week of the hearing.

5. If the technician does not send a response letter, or fails to appear before the Certification Committee, a default judgement will be issued by the Certification Committee based on the evidence available. The revocation or suspension may be affirmed, modified, or vacated following the hearing.

The reasons that a technician's certification may be revoked or suspended include:

1. Cheating on recertification examinations

2. Falsification of quality control test results and/or records

3. Not meeting the requirements of the Qualified Laboratory and Technician Program for the required sampling, sample reduction, and testing procedures

The Certification Committee may decide to revoke or suspend the certification depending upon the seriousness of the violation. Violations deemed as unintentional will result in a penalty of a letter of reprimand to the technician and the technician's employer. Subsequent violations will result in suspension of certification for a designated period as determined by the Certification Committee. The certification will return to good standing after the period of suspension expires.

Intentional violations will result in a 1 year suspension of the certification. Subsequent violations will result in permanent revocation of the certification. If the technician wishes to become recertified after the period of suspension, the technician will be required to complete all steps as if they were a brand new technician.

Appendix A
Level 1 Asphalt Technician
Qualification Credit Form

Name: ____

I verify that the above-noted person has successfully demonstrated the following test methods:

[ ] AASHTO T 166 -- Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens

[ ] AASHTO T 209 -- Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)

[ ] AASHTO T 275 -- Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens

[ ] AASHTO T 312 -- Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

[ ] AASHTO T 331 -- Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Automatic Vacuum Sealing Method (if applicable)

[ ] ITM 571 -- Quantitative Extraction of Asphalt and Gradation of Extracted Aggregate from HMA Mixtures

[ ] ITM 572 -- Drying HMA Mixtures

[ ] ITM 580 -- Sampling HMA

[ ] ITM 586 -- Asphalt Content by Ignition

[ ] ITM 587 -- Reducing HMA Samples to Testing Size

______________________________________ ____________________

Independent Assurance Technician Date

Send To: Asphalt Technical Writer
Indiana Department of Transportation
Division of Materials and Tests
120 S. Shortridge Rd.
Indianapolis, IN 46219
e-mail: mwhite@indot.in.gov

WHY ARE WE HERE? COURSE PURPOSE & OVERVIEW

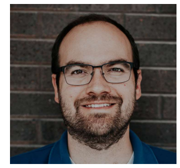
INDOT Certified Asphalt Technician Program

Chapter One

1

2

Meet the Team



MATT BEESON, P.E.

Director, Division of Materials and Tests
Indiana Department of Transportation

2

3

Hot Mix Asphalt

- One of INDOT's biggest expenses
- Vast majority of pavement in Indiana is HMA
- A way to validate the properties of the HMA met specs was needed

3

4

Quality Control

- Contractor testing
- Contractor performs testing to *control* mixture production

Quality Assurance

- INDOT testing
- INDOT performs testing to *assure* the material meets specifications

Balances responsibility for quality between Contractor and INDOT

4

5

Indiana Test Method 583

Certified Hot Mix Asphalt Producer Program

- Documentation
- Laboratory and Equipment Calibration
- Materials Sampling and Testing
- Diary
- Quality Control Plan

5

6

Aggregates

- Aggregates in Indiana
- Aggregate Specifications

6

Aggregates

- Sampling

7

Aggregate Testing

- Splitting

8

Aggregate Testing

- Decant

9

Aggregate Testing

- Gradation

10

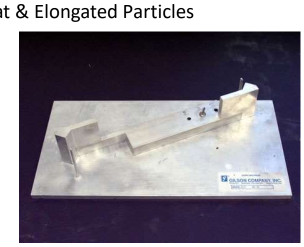
Aggregate Testing

- Specific Gravity

11

Aggregate Testing

- Flat & Elongated Particles

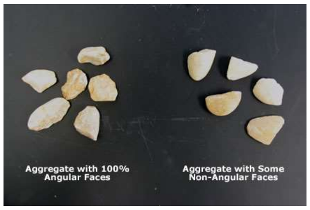


12

13

Aggregate Testing

- Coarse Aggregate Angularity

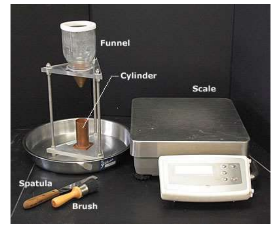


13

14

Aggregate Testing

- Fine Aggregate Angularity

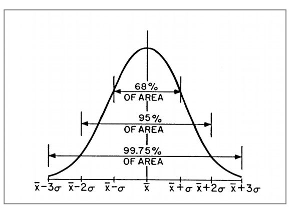


14

15

QC/QA HMA Acceptance Specs

- PWL (Percent Within Limits)



15

16

Asphalt Binder

- Manufactured

16

17

Asphalt Binder

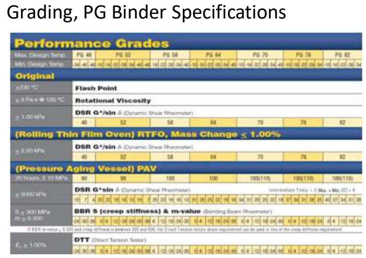
- Testing

17

18

Asphalt Binder

- Grading, PG Binder Specifications

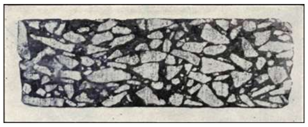


18

19

Mix Design

- Background



19

20

Mix Design

- Volumetric Properties

- G_{mb} Bulk specific gravity of compacted specimens
- G_{mm} Maximum theoretical specific gravity
- Va Air voids
- VMA Voids in mineral aggregate
- VFA Voids filled with asphalt

20

21

Mix Design

- Superpave

21

22

HMA Plants

- Plant Types

22

23

HMA Plants

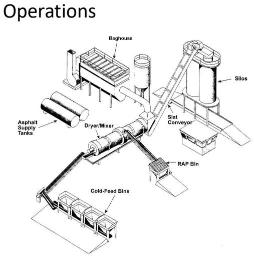
- Plant Types

23

24

HMA Plants

- Plant Operations



24

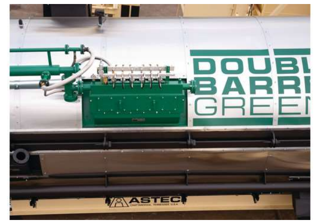
HMA Plants

- Plant Inspection

25

HMA Plants

- Warm Mix (Foaming)



26

HMA Plants

- Plate Sampling

27

HMA Plants

- Coring

28

HMA Laboratory Demo

29

Annual Plant Audits

CERTIFIED
HOT MIX ASPHALT
PRODUCER PROGRAM
AUDIT CHECKLIST

Date ________ Page ___ of ___

Plant No. ________

Producer ________

Plant Location ________

INDOT Audit Team Members

	Name	Position
1.	________	District Testing Engineer
2.	________	Area Supervisor
3.	________	Technician
4.	________	________
5.	________	________
6.	________	________

Producer Members

	Name	Position
1.	________	Management Representative
2.	________	Certified Asphalt Technician
3.	________	________
4.	________	________

-1-

30

31

Equipment Calibration/Verification

31

32

Quality Control Troubleshooting

32

33

Quality Control Troubleshooting

33

34

Quality Control Troubleshooting

34

35

All HMA produced for an INDOT Contract required to come from Certified Plant

Certified Plants are required to have a Certified Technician

That's you!

35

36

QC/QA HMA Certified Technician

Certified Technician

- Complete this course and pass exam
- Can supervise but not perform tests

Qualified Technician

- Have to be Qualified to actually run tests
- Can perform testing under supervision of a Certified Technician

Level 1 Technician

- Both Qualified and Certified

36

37

Steps to Remain Compliant

- Certification good for life
  - We may add Continuing Education in the future
- Level 1 Technician
  - Maintain Qualified Tech status

37

38

Safety

Two main hazards in Asphalt Industry

- Fire
  - explosion hazards
- Health hazards
  - eye contact, skin contact (burns), inhalation of fumes

38

39

Fire

- Asphalt often heated to high temperatures
- Control possible ignition sources in vicinity of asphalt

Health Hazards

- Eye Contact
  - Safety glasses, goggles, face shield
- Fumes
  - Improve ventilation, respirators
- Skin Contact
  - Long sleeve shirts, long gloves, full high-top safety boots, pants over top of boots

39

40

Skin Contact

- What do you do if you get hot asphalt on your skin
  - DON'T try to remove asphalt from skin
  - Apply cold or lukewarm water to remove heat from asphalt as quickly as possible (major burns – lukewarm water)
  - Do not bandage the burned area
  - Go to the hospital/doctor immediately

40

41

41

Rounding and Calculator Intro

INDOT Certified Asphalt Technician Program
Chapter One

1

2

Rounding - "5" up Procedure

- When the first digit discarded is less than 5, the last digit retained should not be changed.
- Examples: 2.4 becomes 2
  - 2.43 becomes 2.4
  - 2.434 becomes 2.43
  - 2.4341 becomes 2.434

2

3

Rounding - "5" up Procedure

- When the first digit discarded is 5 or greater, the last digit retained should be increased by one unit.
- Examples : 2.6 becomes 3
  - 2.56 becomes 2.6
  - 2.416 becomes 2.42
  - 2.4157 becomes 2.416

3

4

ONE DECIMAL PLACE

1. 75.72	**75.7**
2. 16.38	
3. 33.251	
4. 42.650	

4

5

ONE DECIMAL PLACE

1. 75.72	**75.7**
2. 16.38	**16.4**
3. 33.251	
4. 42.650	

5

6

ONE DECIMAL PLACE

1. 75.72	**75.7**
2. 16.38	**16.4**
3. 33.251	**33.3**
4. 42.650	

6

7

ONE DECIMAL PLACE

1. 75.72 75.7
2. 16.38 16.4
3. 33.251 33.3
4. 42.650 42.7

7

8

TWO DECIMAL PLACES

1. 31.331 31.33
2. 16.917
3. 56.4251
4. 70.5150

8

9

TWO DECIMAL PLACES

1. 31.331 31.33
2. 16.917 16.92
3. 56.4251
4. 70.5150

9

10

TWO DECIMAL PLACES

1. 31.331 31.33
2. 16.917 16.92
3. 56.4251 56.43
4. 70.5150

10

11

TWO DECIMAL PLACES

1. 31.331 31.33
2. 16.917 16.92
3. 56.4251 56.43
4. 70.5150 70.52

11

12

MEAN (AVERAGE) - TI – 30X

- Enter the first data point and press the Σ+ key. The display should read n = 1

12

MEAN (AVERAGE) - TI – 30X

Enter other data points. Press Σ+ key after each entry

13

MEAN (AVERAGE) - TI – 30X

To obtain mean (x), press the **2nd** key and then the x^2 key

14

STANDARD DEVIATION - TI – 30X

To find standard deviation (σ_{n-1}), press **2nd** key and then σ_{xn-1} key

15

Manual Walkthrough

- Instructors
- Policies and Procedures

16

Manual Walkthrough

- Chapter 1: Introduction
- Chapter 2: Aggregate Fundamentals, Sampling, and Testing
- Chapter 3: Asphalt Binder
- Chapter 4: Asphalt Volumetrics
- Chapter 5: Asphalt Plants
- Chapter 6: Audits, Equipment Calibration, and Quality Control Troubleshooting

17

Manual Walkthrough

- Chapter 7: Percent Within Limits and Field Testing
- Chapter 8: Appendix A
  - Indiana Test Methods
- Chapter 9: Appendix B
  - Audits
  - Example QCP
- Chapter 10: Appendix C
  - Standard Specifications

18

19

Thank you!

Good Luck!

19

AGGREGATE FUNDAMENTALS: Highway Construction Materials in Indiana

INDOT Certified Asphalt Technician Program

Chapter Two

1

MEET THE TEAM

Melissa Earhart
Indiana Department of Transportation

2

- Asphalt mixture is binder and aggregate
  We are going to start by talking about aggregates (Yay rocks!)
- Aggregate types and their origin and distribution in Indiana
- Materials found in Indiana aggregate which are considered non-durable (deleterious)

3

Aggregate Types

There are 4 types of aggregate.

- Sand
- Gravel
- Crushed stone
- Slag

Each type of aggregate has its own unique origin.

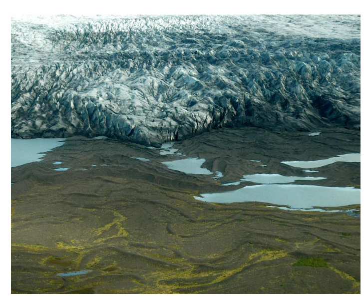
4

Natural sand and gravel

- Used in asphalt pavements
- Transported in Indiana by glaciers and streams
- Abundant in the state

5

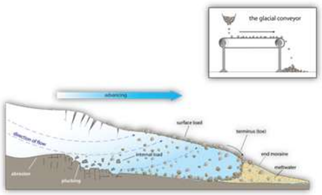
Heavy sheets of ice carved out the northern Indiana landscape and transported and deposited sand and gravel.

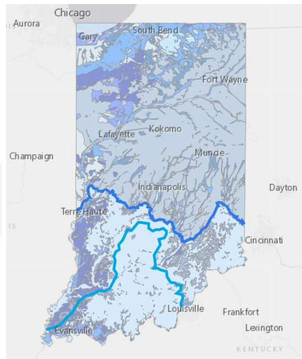


6

7

- Over the past 2.6 million years, Indiana has experienced a series of glacial advances and retreats
- There are many glacial features in Indiana.

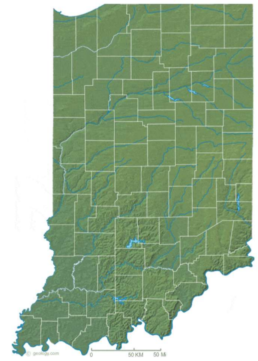




7

8

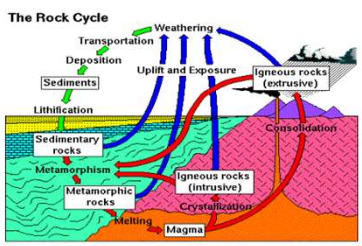
- Streams carry sand and gravel.
- Another word for stream related activity is fluvial.
- Large rivers carry more material- Example: The Ohio, White, and Wabash Rivers



8

9

- Three rock types: Igneous, sedimentary, metamorphic
- Type of road aggregate used in US states is highly dependent on regional geology
- In Indiana, we have sedimentary bedrock, especially limestone



9

10

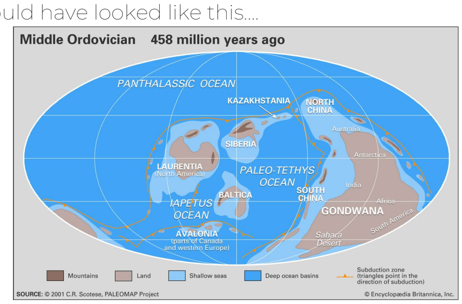
Ocean marine fossils are common in Indiana bedrock.

How is this possible?

10

11

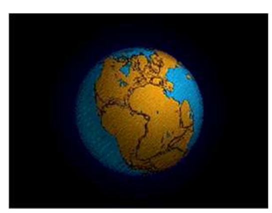
Oldest exposed Indiana bedrock originated when the world map would have looked like this....

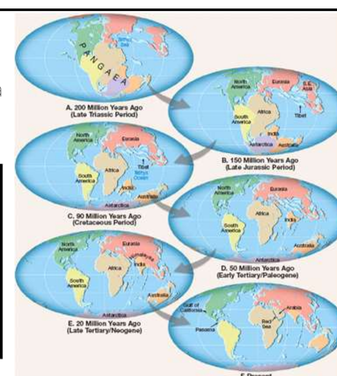


11

12

The continental plates merged to form the supercontinent Pangea and then split apart again.

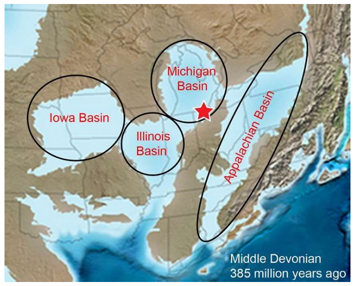




12

13

Eroded Appalachian Mountain and continental sediments collected in the Illinois Basin.



13

14

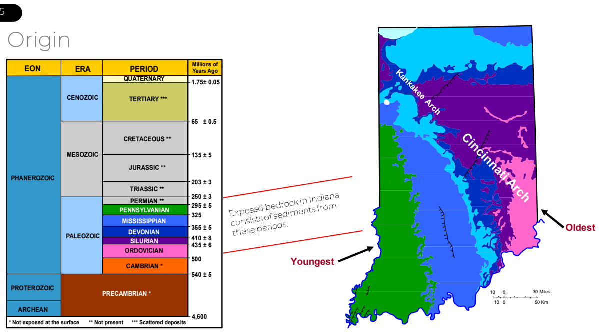
Geologic Structures

- Illinois Basin
- Michigan Basin
- Kankakee/Cincinnati Arch
- Faults

14

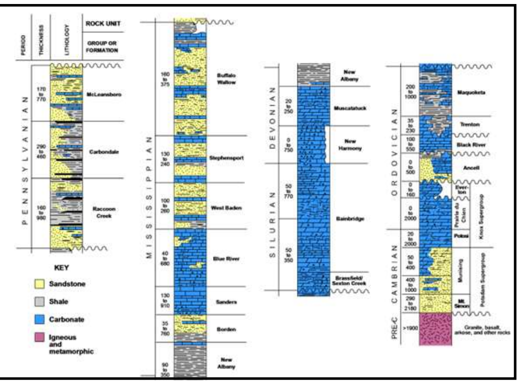
15

Origin



15

16



16

17

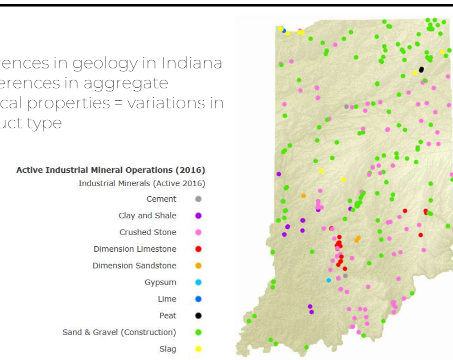
Slag

- Blast Furnace slag- non-metallic material removed in molten state of iron production
- Steel slag- material derived from iron-to-steel refinement
- Slag is sometimes used in the production of asphalt

17

18

Differences in geology in Indiana = differences in aggregate physical properties = variations in product type



18

19

- Crushed stone is mined in quarries
- Bedrock is blasted and trucked to the primary crusher

19

20

Natural sand and gravels are mined from water filled pits, sand bars, and gravel banks

20

21

Dredging operation on the Ohio River

21

22

Primary (Jaw) Crusher

22

23

- Stone is processed by: crushing, screening, and washing to produce proper size and angularity

23

24

- Screening is the best technique for gradation control
- Gradation consistency is vital especially in asphalt

24

25

Materials in Indiana aggregate considered Non-durable ITM-206/VISUAL

- IN Spec. 904.03(a) Note 5 regarding ITM 206
- Conglomerates or Cemented gravels
- Soft Sandstones
- Shale
- Limonite
- Weathered schist
- Ocher
- Shells-unfossilized
- Coal/wood
- Material with loose grains or weathered coatings

25

26

Conglomerate

- Contains coarse rock (gravel) within a matrix of fine grained material (silt, sand).
- Subject to untimely breaking apart into the constituent parts

26

27

Soft Sandstone

- Composed of sand-sized mineral particles or rock fragments.
- Generally contains high amounts of quartz and feldspar grains
- Varies in color depending on constituents
- May look similar to limestone, but will not “fizz” when a weak acid (HCl) is applied

27

28

Shale

- Fine grained rock composed of mud and clay
- Thinly laminated
- Breaks easily into fragile slabs

28

29

Limonite

- Soft rock consisting of hydrated iron oxides
- Color is commonly yellow to reddish-brown
- Easily breaks into layers or powder

29

30

Weathered Schist

- Schist is a substantial rock, but is subject to weathering between layers
- Minerals have tendency to weather out, leaving friable material behind

30

31

Ocher

- Soft iron oxide rock
- Colors generally range from yellow, orange, and reddish-brown
- Easily disintegrates into a fine powder

31

32

Shells

- Unfossilized shells
- Mussel shells from rivers and lakes are common

Mussel shells in the Tippecanoe River, Indiana

32

AGGREGATE PROPERTIES

INDOT Certified Asphalt Technician Program

Chapter Two

1

2

- How aggregates are classified based on state requirements for gradation and their inherent physical properties
- Coarse and Fine Aggregate Test Methods used
- Special conditions to watch for
- Segregation pitfalls

2

3

Aggregate Properties

- ✓ Aggregate Quality Ratings
- ✓ Physical Quality Tests
- ✓ General Usage Requirements
- ✓ Gradation Requirements

3

4

Fine and Coarse - Aggregate Definitions

Fine Aggregate shall be 100% passing the 3/8" (9.5mm) sieve, and a minimum of 80% passing the #4 (4.75mm) sieve.

Coarse Aggregate shall have a minimum of 20% retained on the #4 (4.75mm) sieve.

4

5

Fine Aggregate - Quality Classifications

- Fine aggregates are not divided into quality classes as are coarse aggregate.
- Quality ratings on fine aggregate are no longer included in INDOT reports.

5

6

Requirements Of Fine Aggregates In Accordance With Standard Specifications Section 904.02

TYPE OF CONSTRUCTION	ACCEPTABLE FINE AGGREGATE
Portland cement concrete for pavement or bridge decks	Natural sand
Portland cement concrete for other construction	Natural sand or crushed limestone/dolomite, or air-cooled blast furnace slag
Hot Mix Asphalt (HMA)	Natural sand or manufactured sand. Steel furnace slag when used with steel furnace slag coarse aggregates. Combination of natural and manufactured with some proportionate limitations.
Pneumatic placement	Natural sand with suitable grading requirements.
Mortar	Natural sand with suitable grading requirements.
Mineral filler	Dust produced by crushing stone, portland cement, or other inert mineral matter.
Snow and ice abrasives	SF Slag, ABF Slag, GGBF Slag, NS, CS, Wet bottom boiler slag (cinders).

6

7

Fine Aggregate Requirements

- Bulk specific gravity and absorption
- Soundness
- Special Requirements

7

8

Special Requirements

- Acid Insoluble (ITM 202)
- Fine Aggregate Angularity (FAA) (T 304)
- Organic impurities (T 21)

8

9

Coarse Aggregate - Quality Classifications

- Coarse aggregates are assigned to quality classes
- Based on physical quality properties, graded size, and eventual end use of the material.

9

9

10

Coarse Aggregate Requirements

- Section 904.03 defines the acceptable limits for coarse aggregate classes
- Coarse aggregates are divided into classes based on test result limits

10

11

Aggregate Quality Ratings

Coarse Aggregate

- AP
- AS
- A
- B
- C
- D
- E
- F
- G-Not Approved

11

12

Class Of Coarse Aggregates Required For Various Types Of Construction

TYPE OF CONSTRUCTION	REQUIRED QUALITY CLASS
Aggregate Base	Class A, B, C, or D
Subbase	Class A or B (No. 8) Class A, B, C, or D (No. 53)
Aggregate Pavements or shoulders	Class A, B, C, or D
HMA Base Coarse	Class A, B, C, or D
HMA Intermediate Course	Class A, B, or C
HMA Surface Course	Class A or B
SMA Surface Course	Class AS
Asphalt Seal Coat	Class A or B
Portland Cement concrete pavement	Class AP
Portland Cement concrete structural-exposed	Class A or AP
Portland Cement concrete structural-non-exposed	Class A or B
Cover (choke) aggregates coarse aggregate	Class A or B

12

The minimum quality rating for a specified use of coarse aggregate is as follows:

No. 8 Exposed Concrete	A
No. 11 Exposed Concrete	A
No. 11 Non-exposed concrete	B
HMA/CMA Surface	B, B, or B
No. 8 Seal Coats	B
No. 9 Seal Coats	B
No. 11 Seal Coats	B
No. 12 Seal Coats	B
HMA/CMA Intermediate	C, C, or C
HMA/CMA Base	D
No. 43 Compacted Aggregate Base	B
No. 53 Compacted Aggregate Base	D
No. 73 Compacted Aggregate Base	D
No. 8 Aggregate for Shoulder Drains	E
No. 11 Aggregate for Shoulder Drains	E
No.12 Aggregate for Shoulder Drains	E
Rip Rap	F

13

Aggregate for Hot Mix Asphalt

INDOT uses hot mix asphalt in a number of different ways. In all cases, the aggregates used should meet five requirements

1. Strong, tough and durable
2. The ability to be crushed into bulky particles, without many flaky particles, slivers or pieces that are flat and elongated
3. Low porosity
4. Low permeability
5. Correct particle size and gradation for the type of pavement

14

Properties

- Absorption/specific gravity
- Resistance to abrasion
- Soundness
- Additional requirements

15

Quality Test

1. Bulk Specific Gravity and Absorption (AASHTO T 85)
2. LA Abrasion (Durability Strength) (AASHTO T 96)
3. Soundness
   1. Sodium Sulfate (T 104)
   2. Brine (ITM 209)
   3. Water (T 103)

16

Absorption
Fine Aggregate AASHTO T-84/Coarse Aggregate AASHTO T-85

- Absorption (per AASHTO T-84/T-85) is defined as the increase in the weight of aggregate because of water in the pores of the materials, but not including water adhering to the outside surface of the particles.

17

ABSORPTION –
AASHTO T-84/AASHTO T-85

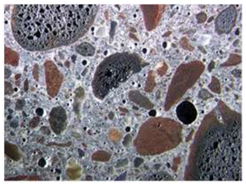
- Aggregates with high absorption are not desirable in most applications.
- Highly absorptive material used in HMA applications will result in an increased asphalt binder demand.
- Some aggregates with elevated absorptions possess other characteristics such as skid resistance that are desirable despite higher asphalt binder demand.

18

19

Internal Pore Properties

- Absorption – Particle's ability to take in a liquid
- Porosity - Ratio of the volume of pores to the total volume of the particle
- Permeability – Particle's ability to allow liquids to pass through



Size, number and continuity of the pores affect other properties

19

20

Density and Specific Gravity

- Density is the weight per unit of volume of a substance
- Specific gravity is the ratio of the density of the substance to the density of water

20

21

Specific gravity
Fine Aggregate AASHTO T-84/Coarse Aggregate AASHTO T-85

- Specific Gravity is the ratio of the weight of a substance (aggregate in this case) to the weight of an equal volume of water.

21

22

Specific Gravity of Common Materials

Substance	Specific Gravity
Wood (Oak)	0.7
Water	1
Coal	1.6
Blast Furnace Slag	2.4
Limestone	2.6
Quartz	2.6
Shale	2.6
Gravel	2.7
Trap Rock	2.9
Steel Slag	3.5
Iron	7.9
Lead	11.4
Gold	19.3

22

23

The Importance of Specific Gravity

- Specific gravity information is very important in the design asphalt mixtures
- Helps in determining the amount of binding material needed
- Mixtures are designed using volumes and specific gravity allows conversion between weight and volume

23

24

GSB List

- INDOT tracks present and historical bulk specific gravity data
- Quality samples are obtained from state approved sources on an annual or biannual basis
- The GSB list is updated to reflect the most current 5 year average
- The list is published on INDOT'S website around the end of January each year
- Contractors construct mix designs using bulk numbers

24

24

Bulk Specific Gravity

25

Steel Furnace Slag - Specification Requirements

- CAP Producer processing steel slag are required to:
  - A) Establish quality control testing for bulk specific gravity at a frequency of 1/2000 Tons
  - B) Establish a Target Bulk Specific Gravity with upper and lower control limits set at +/- 0.050 from the Target Mean.
  - C) Maintain a running 4 point moving average (no, not five point, but four point!!!).
  - D) Material produced outside of these control limits is to be isolated

26

Resistance to Abrasion

An aggregate's ability to resist destruction by mechanical means such as the process of mixing, rolling during the paving process, and under traffic through the service life of the pavement.

Aggregate Breakage Due to a Roller

27

Los Angeles abrasion - AASHTO T-96

- Revolving steel drum
- 6-12 steel balls depending on top size of aggregate
- 500 revolutions @ 32 RPM's
- Calculate the percent of material lost through a # 12 sieve

28

29

Soundness

An aggregate's ability to the resist the effect of harsh conditions, such as periodic freeze and thaw cycles and exposure to salts.

Quality requirements for the soundness of coarse aggregates may be found in 904.03 (a) of the INDOT Standard Specifications.

30

31

Freeze/ thaw in water
AASHTO T-103

Material is immersed in water and subjected to 50 cycles of freeze and thaw.

After completion of the final cycle the material is dried to a constant weight.

The percent of material lost during this process is then calculated for each sieve fraction.

31

32

Sodium sulfate - AASHTO T-104

Material is immersed in sodium sulfate solution for 16 hours and then dried to a constant weight.

This is repeated for a total of five cycles.

After completion of the final cycle the material is rinsed and dried to a constant weight.

The percent of material lost during this process is then calculated for each sieve fraction.

32

33

33

34

34

35

Freeze/thaw in brine - ITM 209

Material is immersed in a 3% brine solution and subjected to 25 cycles of freeze and thaw.

After completion of the final cycle the material is rinsed and dried to a constant weight.

The percent of material lost during this process is then calculated for each sieve fraction.

35

36

- Freeze / Thaw in water AASHTO T-103 is the validating test.
- Sodium sulfate AASHTO T-104 and Brine ITM-209 are additional tests.

36

Class AS Requirements

- Class A for SMA (Stone Matrix Asphalt) pavements.
- The quality requirements for this classification are identical to class A with the exception that the Los Angeles Abrasion require no more than a 30% result (904.03-a) and are designed in accordance with ITM 220 (Class AS aggregate for use in SMA mixture).
- ITM 220 includes Micro-Deval and compacted mixture breakdown requirements.

37

Additional Requirements-Deleterious

Non-durable Particles

- Soft material as determined by ITM 206 (brass rod scratch hardness-gravel only)
- Known structurally weak material
- Conducted on material retained on the ⅜ sieve
- Visual identification of known non-durable particles

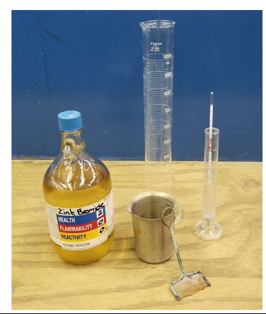
38

Deleterious – scratch hardness tester

39

Chert AASHTO T-113

In accordance with 904.03 a, lightweight chert (Specific Gravity less than 2.450) is limited to 3% in Class A applications.



40

Particle Shape

- Angular vs rounded
- Crushed stone and gravel
- Natural sand and gravel
- Angular particles tend to interlock, creating stability
- Flat and elongated
- INDOT Specifications – Less than 10% of particles may have length to thickness ratio of >5.
- "Dice-like" particles are optimal

41

Special Requirements

Coarse

- Flat and Elongated (ASTM-4791)
  Length as compared with thickness
  5:1 ratio limit
- Coarse aggregate angularity
  ASTM D-5821. (904.03-b)

Determines the number of fractured surfaces

1 faced vs. 2 faced

42

43

Uncompacted Voids Fine Aggregate AASHTO T-304. IN Spec. 904.02(b)

- Measures the angularity of fine aggregate

43

44

Acid insoluble ITM-202

For fine aggregates the acid insoluble fraction will be no less than 40% (904.02)
This Specification applies only to FA used in 4.75mm sand surface mixes

44

45

Surface Texture

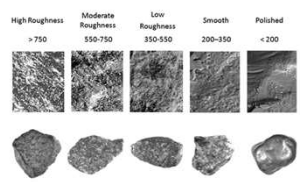
- The pattern and the relative roughness or smoothness of the aggregate particle
- Impacts bond between aggregate and cementing material
- Gives cementing material something to grip

45

46

Surface Texture Polishing

- Aggregates that are exposed to traffic may polish over time
- This is why additional testing is required to verify that the aggregates are not susceptible to polishing



46

47

Approved Polish Resistant Aggregates (PRA)

- Source materials must undergo a series of several specific tests in order to obtain approval for use as a polish resistant aggregate
- ITM 214 describes the process, which includes an initial laboratory test under a polishing wheel, followed by the installation of a test strip
- Test strips are skid tested against a control, two times per year for at least two years
- Results will be analyzed by the The Division of Materials and Tests (M&T) for potential approval
- ITM 221 outlines the process for approval for use as a high friction aggregate

47

47

48

Special Requirements

HMA

- Dolomite (ITM 205)
- Sandstone
- Polish Resistance (ITM 214, 221)
- Slag
- Crushed (ASTM 5821)

48

49

Review

- T-84/85 Specific Gravity/Absorption
- T-96 Los Angeles Abrasion
- T-104 Sodium Sulfate Soundness
- T-103 Freeze/Thaw Soundness
- ITM-209 Brine Freeze/Thaw Soundness
- T-112 Clay Lumps and Friable Particles
- ITM-206 Scratch Hardness
- T-113 Lightweight Particles (Chert)
- ITM-202 Acid Insoluble content
- D-4791 Flat and Elongated Particles
- D-5821 Coarse Aggregate Angularity
- T-304 Fine Aggregate un-compacted Voids
- ITM-214 Acceptance procedure for polish resistant aggregates

49

50

General Usage and Gradation Requirements

Fine Aggregate
- 904.02

Coarse Aggregate
- 904.03

50

51

Additional Gradation Requirements Based on Use

B Borrow/Structure Backfill
- 211.02

RipRap
- 904.04

Aggregate Base
- 301.02

SubBase
- 302.02

Aggregate Pavement or Shoulder
- 303.02

51

52

FA Gradation Requirements IN Spec. 904.02(h)

	SIZES (PERCENT PASSING)					
Sieve Size	23	24	15	16	PP	S&I
3/8 in. (9.5 mm)	100	100				100
No. 4 (4.75 mm)	95-100	95-100			100	
No. 6 (3.35 mm)			100			
No. 8 (2.36 mm)	80-100	70-100	90-100		85-95	
No. 16 (1.18 mm)	50-85	40-80				
No. 30 (600 um)	25-60	20-60	50-75	100	50-65	
No. 50 (300 um)	5-30	7-40	15-40		15-25	0-30
No. 80 (180 um)				95-100		
No. 100 (150 um)	0-10	1-20	0-10		0-10	
No. 200 (75 um)	0-3	0-6	0-3	65-100		0-7

52

53

CA Gradation Requirements IN Spec. 904.03(e)

Sieve	2	5	8	9	11, SC 11[(5)]	12, SC 12[(5)]	SC 16[(5)]	43[1]	91	93PG[(6)]	53[1]	73[1]
2.5 in. (63 mm)	100											
2.0 in. (50 mm)	80-100											
1.5 in. (37.5 mm)		100						100			100	
1.0 in. (25.0 mm)	0-25	85-98	100					70-90	100		80-100	100
¾ in. (19.0 mm)	0-10	60-85	75-95	100				50-70			70-90	90-100
½ in. (12.5 mm)	0-7	30-60	40-70	60-85	100	100	100	35-50		98-100	55-80	60-90
3/8 in. (9.5mm)		15-45	20-50	30-60	75-95	95-100	94-100			75-100		
N0. 4 (4.75 mm)		0-15	0-15	0-15	10-30	50-80	15-45	20-40		10-60	35-60	35-60
N0. 8 (2.36 mm)		0-10	0-10		0-10	0-35		15-35		0-15	25-50	
No. 16 (1.18 mm)							0-4					
N0. 30 (600 mm)						0-4		5-20		0-5	12-30	12-30
No. 200 (75 um)[2]								0-6.0			5.0-10.0[4]	5.0-12.0
Decant (PCC)[3]		0-1.5	0-1.5	0-1.5	0-1.5	0-1.5			0-1.5			
Decant (non PCC)	0-2.5	0-2.5	0-3.0	0-2.5	0-2.5	0-2.5			0-2.5	0-20		
Decant (SC)					0-1.5	0-1.5	0-1.5					

1. The liquid limit shall not exceed 25 (35 if slag) and the plasticity index shall not exceed 5. The liquid limit shall be determined in accordance with AASHTO T89 and the plasticity index in accordance with AASHTO T90.
2. Includes the total amount passing the No. 200 (75um) sieve as determined by AASHTO T 11 and AASHTO T27.
3. Decant may be 0-2.5 for stone or slag
4. When slag is used for separation layers as defined on 302.01, the total amount passing the No.200 (75um) sieve shall be 10.0-12.0.
5. Seal coat (SC) aggregates shall be 85% one face and 80% two face crushed. The Flakiness Index in accordance with ITM 224 shall be a maximum of 25%.
6. Pea gravel shall be generally uncrushed gravel, with a maximum of 20% crushed particles, and shall meet the gradation requirements of 93PG. Determination of crushed particles shall be made from the weight (mass) of material retained on the No. 4 (4.75 mm) sieve in accordance with ASTM D5821

53

54

When does segregation/degradation occur?

Every time you handle the aggregate

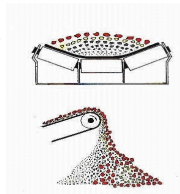



54

55

Conveyor Belt Segregation

- Segregation begins on the belt where fines vibrate to the bottom and coarse remains on top
- At the end of the belt if left un-deflected the coarse particles are thrown out and away. Fine particles drop down or adhere to the belt. Higher speeds increase this affect.



55

56

High Conveyor Drop

- Segregation
- Degradation
- Loss of fines

56

57

Stockpile Segregation

- Segregation is the separation of a well graded aggregate into individual sizes due to gravity
- Segregation is probably the greatest nemesis of stockpiling and handling, but other situations such as degradation and contamination will affect quality as well

57

58

Roll Down Segregation

58

59

Techniques to reduce segregation

- Construct truck-built stockpiles one dump high to reduce roll-down segregation.
- This requires a large area. To reduce required area, restock some dumps on top of other dumps with a front-end loader.

59

60

60

AGGREGATE SAMPLING AND TESTING

INDOT Certified Asphalt Lab Technician Program
Chapter Two

1

2

Aggregate

- Introduction - Aggregate Testing
- Sampling
- Sample Reduction
- Testing
  - Moisture
  - Decant
  - Gradation
  - Practice Problems

2

3

Aggregate (continued)

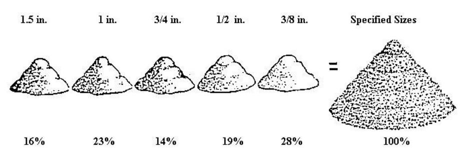
- Specific Gravity
- Flat & Elongated
- Coarse Aggregate Angularity
- Fine Aggregate Angularity

3

4

Gradation

Range and Relative Distribution of
Particle Sizes in the Aggregate Mixture



4

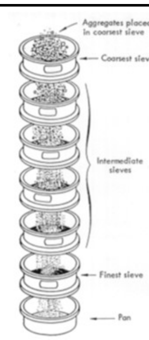
5

5

6

Sieve Openings

- 1" nominal opening
- No. 4
  - 4 openings per linear inch
- No. 200
  - 200 openings per linear inch



6

7

Standard Specifications 904.03

Sieve Sizes	COARSE AGGREGATE SIZES (PERCENT PASSING)										
	COARSE GRADED									DENSE GRADED	
	2	5	8	9	11, SC 11(5)	12, SC 12(5)	SC 16(5)	43(1)	91	53(1)	73(1)
4 in. (100 mm)											
3 1/2 in. (90 mm)											
2 1/2 in. (63 mm)	100										
2 in. (50 mm)	80-100										
1 1/2 in. (37.5 mm)		100						100		100	
1 in. (25 mm)	0-25	85-98	100					70-90	100	80-100	100
3/4 in. (19 mm)	0-10	60-85	75-95	100				50-70		70-90	90-100
1/2 in. (12.5 mm)	0-7	30-60	40-70	60-85	100	100	100	35-50		55-80	60-90
3/8 in. (9.5 mm)		15-45	20-50	30-60	75-95	95-100	94-100				
No. 4 (4.75 mm)		0-15	0-15	0-15	10-30	50-80	15-45	20-40		35-60	35-60
No. 8 (2.36 mm)		0-10	0-10	0-10	0-10	0-35		15-35		25-50	
No. 16 (1.18 mm)							0-4				
No. 30 (600 µm)						0-4		5-20		12-30	12-30
No. 200 (75 µm)(2)								0-6.0		5.0-10.0(4)	5.0-12.0
Decant (PCC)(3)		0-1.5	0-1.5	0-1.5	0-1.5	0-1.5			0-1.5		
Decant (Non-PCC)	0-2.5	0-2.5	0-3.0	0-2.5	0-2.5	0-2.0			0-2.5		
Decant (SC)					0-1.5	0-1.5	0-1.5				

Notes: (1) The liquid limit shall not exceed 25 (35 if slag) and the plasticity index shall not exceed 5. The liquid limit shall be determined in accordance with AASHTO T 89 and the plasticity index in accordance with AASHTO T 90.

(2) Includes the total amount passing the No. 200 (75 µm) sieve as determined by AASHTO T 11 and AASHTO T 27.

(3) Decant may be 0-2.5 for stone and slag.

(4) When slag is used for separation layers as defined in 302.01, the total amount passing the No. 200 (75 µm) sieve shall be 10.0 to 12.0.

(5) Seal coat (SC) aggregates shall be 85% one face and 80% two face crushed. The Flakiness Index in accordance with ITM 224 shall be a maximum of 25%.

7

8

Standard Specifications 904.02

Sieve Sizes	SIZES (PERCENT PASSING)					
	23	24	15	16	PP	S&I
3/8 in. (9.5 mm)	100	100				100
No. 4 (4.75 mm)	95-100	95-100			100	
No. 6 (3.35 mm)			100			
No. 8 (2.36 mm)	80-100	70-100	90-100		85-95	
No. 16 (1.18 mm)	50-85	40-80				
No. 30 (600 µm)	25-60	20-60	50-75	100	50-65	
No. 50 (300 µm)	5-30	7-40	15-40		15-25	0-30
No. 80 (180 µm)				95-100		
No. 100 (150 µm)	0-10	1-20	0-10		0-10	
No. 200 (75 µm)	0-3	0-6	0-3	65-100		0-7

8

9

Aggregate Definitions

- **Coarse Aggregate** – Material that has a minimum of 20% retained on the No.4 sieve
- **Fine Aggregate** – Material that has 100% passing the 3/8 inch sieve and a minimum of 80% passing the No.4 sieve.
- **Mineral Filler** – Fraction of fine aggregate passing the No. 200 sieve
- **Maximum Particle Size** – The largest sieve size through which all material must pass
- **Nominal Maximum Particle Size** – The smallest sieve opening through which the entire amount of the aggregate is permitted to pass

9

12

Standard Specifications 904.03

Sieve Sizes	COARSE AGGREGATE SIZES (PERCENT PASSING)										
	COARSE GRADED									DENSE GRADED	
	2	5	8	9	11, SC 11(5)	12, SC 12(5)	SC 16(5)	43(1)	91	53(1)	73(1)
4 in. (100 mm)											
3 1/2 in. (90 mm)											
2 1/2 in. (63 mm)	100										
2 in. (50 mm)	80-100										
1 1/2 in. (37.5 mm)		100						100		100	
1 in. (25 mm)	0-25	85-98	100					70-90	100	80-100	100
3/4 in. (19 mm)	0-10	60-85	75-95	100				50-70		70-90	90-100
1/2 in. (12.5 mm)	0-7	30-60	40-70	60-85	100	100	100	35-50		55-80	60-90
3/8 in. (9.5 mm)		15-45	20-50	30-60	75-95	95-100	94-100				
No. 4 (4.75 mm)		0-15	0-15	0-15	10-30	50-80	15-45	20-40		35-60	35-60
No. 8 (2.36 mm)		0-10	0-10	0-10	0-10	0-35		15-35		25-50	
No. 16 (1.18 mm)							0-4				
No. 30 (600 µm)						0-4		5-20		12-30	12-30
No. 200 (75 µm)(2)								0-6.0		5.0-10.0(4)	5.0-12.0
Decant (PCC)(3)		0-1.5	0-1.5	0-1.5	0-1.5	0-1.5			0-1.5		
Decant (Non-PCC)	0-2.5	0-2.5	0-3.0	0-2.5	0-2.5	0-2.0			0-2.5		
Decant (SC)					0-1.5	0-1.5	0-1.5				

Notes: (1) The liquid limit shall not exceed 25 (35 if slag) and the plasticity index shall not exceed 5. The liquid limit shall be determined in accordance with AASHTO T 89 and the plasticity index in accordance with AASHTO T 90.

(2) Includes the total amount passing the No. 200 (75 µm) sieve as determined by AASHTO T 11 and AASHTO T 27.

(3) Decant may be 0-2.5 for stone and slag.

(4) When slag is used for separation layers as defined in 302.01, the total amount passing the No. 200 (75 µm) sieve shall be 10.0 to 12.0.

(5) Seal coat (SC) aggregates shall be 85% one face and 80% two face crushed. The Flakiness Index in accordance with ITM 224 shall be a maximum of 25%.

12

13

Aggregate

- Introduction - Aggregate Testing
- **Sampling**
- Sample Reduction
- Testing
  - Moisture
  - Decant
  - Gradation
  - Practice Problems

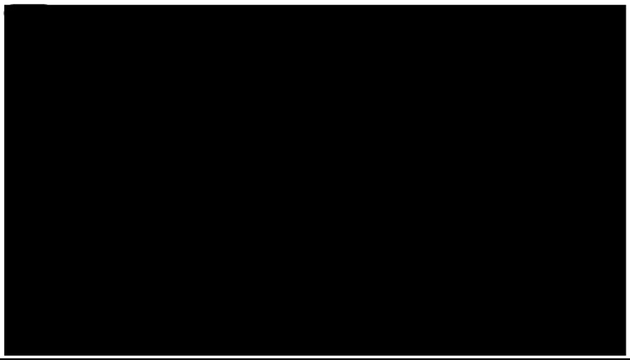
13

14

ITM 207

Sampling Stockpiled Aggregate Video

14



15

16

End of
Aggregate Sampling



16

17

Aggregate

- Introduction - Aggregate Testing

- Sampling
- **Sample Reduction**
- Testing
  - Moisture
  - Decant
  - Gradation
  - Practice Problems

17

18

AASHTO R76

Reducing Samples of
Aggregate to Testing Size


18

19

AASHTO R76 Video


19

20

Aggregate

- Introduction - Aggregate Testing

- Sampling
- Sample Reduction
- **Testing**
  - **Moisture**
  - Decant
  - Gradation
  - Practice Problems

20

21

Moisture Content

Drying The Sample

21

22

Moisture Content Video

APAI

2021
ICAT
VIRTUAL PROGRAM

22

23

Moisture Content

Drying The Sample

23

24

Aggregate

- Introduction - Aggregate Testing

- Sampling
- Sample Reduction
- **Testing**
  - Moisture
  - **Decant**
  - Gradation
  - Practice Problems

24

25

AASHTO T11

MATERIALS FINER THAN
No. 200 SIEVE IN MINERAL
AGGREGATES BY WASHING
(Decant)

25

26

Decant Video

26

27

Aggregate

- Introduction - Aggregate Testing
- Sampling
- Sample Reduction
- **Testing**
  - Moisture
  - Decant
  - **Gradation**
  - Practice Problems

27

28

AASHTO T27

Sieve Analysis of
Fine And Course
Aggregates
(Gradation)

28

29

Uses

Particle Size Distribution

29

30

AASHTO T27 Video

30

31

Aggregate

- Introduction - Aggregate Testing
- Sampling
- Sample Reduction
- **Testing**
  - Moisture
  - Decant
  - Gradation
  - **Practice Problems**

31

32

HMA QC/QA Certified Technician Training

Aggregate Testing Classroom Problems

32

33

No. 8 Gravel for Non-PCC

Compute Percent Moisture

1. Determine applicable Specification and enter in the “Percent Required” column
2. Compute Decant
3. Compute Weight Passing
4. Compute Percent Passing
5. Compare results with Specifications
   Pass or Fail?
6. Compute % Error – Valid Test?

33

34

No. 8 CS for Non-PCC
Calculate Percent Moisture:

%Moisture: (Wet-Dry) x 100
Dry

ORIGINAL (Wet) = 6731.5 g
TOTAL (Dry) = 6678.1 g

TOTAL WEIGHT:	6678.1 g			
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	g	%	100 %
¾ in.	720.9 g	g	%	%
½ in.	3169.1 g	g	%	%
⅜ in.	1280.2 g	g	%	%
No. 4	1094.5 g	g	%	%
No. 8	223.8 g	g	%	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	g	%	%

34

35

No. 8 CS for Non-PCC
Calculate Percent Moisture:

%Moisture: (Wet-Dry) x 100
Dry

ORIGINAL (Wet) = 6731.5 g
TOTAL (Dry) = 6678.1 g

(53.4 / 6678.1) x 100 = 0.8%

TOTAL WEIGHT:	6678.1 g			
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	g	%	100 %
¾ in.	720.9 g	g	%	%
½ in.	3169.1 g	g	%	%
⅜ in.	1280.2 g	g	%	%
No. 4	1094.5 g	g	%	%
No. 8	223.8 g	g	%	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	g	%	%

35

36

No. 8 Gravel for Non-PCC

TOTAL WEIGHT:	6678.1 g			
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	g	%	%
¾ in.	720.9 g	g	%	%
½ in.	3169.1 g	g	%	%
⅜ in.	1280.2 g	g	%	%
No. 4	1094.5 g	g	%	%
No. 8	223.8 g	g	%	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	g	%	%

36

37

No. 8 Gravel for Non-PCC

1. Determine applicable Specification and enter in the “Percent Required” column

37

38

Standard Specifications 904.03

Sieve Sizes	COARSE AGGREGATE SIZES (PERCENT PASSING)										
	COARSE GRADED									DENSE GRADED	
	2	5	8	9	11, SC 11(5)	12, SC 12(5)	SC 16(5)	43(1)	91	53(1)	73(1)
4 in. (100 mm)											
3 1/2 in. (90 mm)											
2 1/2 in. (63 mm)	100										
2 in. (50 mm)	80-100										
1 1/2 in. (37.5 mm)		100						100		100	
1 in. (25 mm)	0-25	85-98	100					70-90	100	80-100	100
3/4 in. (19 mm)	0-10	60-85	75-95	100				50-70		70-90	90-100
1/2 in. (12.5 mm)	0-7	30-60	40-70	60-85	100	100	100	35-50		55-80	60-90
3/8 in. (9.5 mm)		15-45	20-50	30-60	75-95	95-100	94-100				
No. 4 (4.75 mm)		0-15	0-15	0-15	10-30	50-80	15-45	20-40		35-60	35-60
No. 8 (2.36 mm)		0-10	0-10	0-10	0-10	0-35		15-35		25-50	
No. 16 (1.18 mm)							0-4				
No. 30 (600 µm)						0-4		5-20		12-30	12-30
No. 200 (75 µm)(2)								0-6.0		5.0-10.0(4)	5.0-12.0
Decant (PCC)(3)		0-1.5	0-1.5	0-1.5	0-1.5	0-1.5			0-1.5		
Decant (Non-PCC)	0-2.5	0-2.5	0-3.0	0-2.5	0-2.5	0-2.0			0-2.5		
Decant (SC)					0-1.5	0-1.5	0-1.5				

Notes: (1) The liquid limit shall not exceed 25 (35 if slag) and the plasticity index shall not exceed 5. The liquid limit shall be determined in accordance with AASHTO T 89 and the plasticity index in accordance with AASHTO T 90.

(2) Includes the total amount passing the No. 200 (75 µm) sieve as determined by AASHTO T 11 and AASHTO T 27.

(3) Decant may be 0-2.5 for stone and slag.

(4) When slag is used for separation layers as defined in 302.01, the total amount passing the No. 200 (75 µm) sieve shall be 10.0 to 12.0.

(5) Seal coat (SC) aggregates shall be 85% one face and 80% two face crushed. The Flakiness Index in accordance with ITM 224 shall be a maximum of 25%.

38

No. 8 Gravel for Non-PCC

TOTAL WEIGHT:	6678.1 g			
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	g	%	100 %
¾ in.	720.9 g	g	%	%
½ in.	3169.1 g	g	%	%
⅜ in.	1280.2 g	g	%	%
No. 4	1094.5 g	g	%	%
No. 8	223.8 g	g	%	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	g	%	%

39

No. 8 Gravel for Non-PCC

TOTAL WEIGHT:	6678.1 g			
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	g	%	100 %
¾ in.	720.9 g	g	%	75-95 %
½ in.	3169.1 g	g	%	%
⅜ in.	1280.2 g	g	%	%
No. 4	1094.5 g	g	%	%
No. 8	223.8 g	g	%	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	g	%	%

40

No. 8 Gravel for Non-PCC

TOTAL WEIGHT:	6678.1 g			
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	g	%	100 %
¾ in.	720.9 g	g	%	75-95 %
½ in.	3169.1 g	g	%	40-70 %
⅜ in.	1280.2 g	g	%	20-50 %
No. 4	1094.5 g	g	%	0-15 %
No. 8	223.8 g	g	%	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	g	%	0-3.0 %

41

No. 8 Gravel for Non-PCC

1. Determine applicable Specification and enter in the Percent Required Column
2. Compute Decant

$$\% \text{ Decant} = \frac{\text{Original Dry Wt.} - \text{Dry Wt. after Decant}}{\text{Original Dry Wt.}} \times 100$$

42

No. 8 Gravel for Non-PCC

TOTAL WEIGHT:	6678.1 g			
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	g	%	100 %
¾ in.	720.9 g	g	%	75-95 %
½ in.	3169.1 g	g	%	40-70 %
⅜ in.	1280.2 g	g	%	20-50 %
No. 4	1094.5 g	g	%	0-15 %
No. 8	223.8 g	g	%	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	113.8 g	%	0-3.0 %

43

No. 8 Gravel for Non-PCC

TOTAL WEIGHT:	6678.1 g			
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	g	%	100 %
¾ in.	720.9 g	g	%	75-95 %
½ in.	3169.1 g	g	%	40-70 %
⅜ in.	1280.2 g	g	%	20-50 %
No. 4	1094.5 g	g	%	0-15 %
No. 8	223.8 g	g	%	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	113.8 g	1.7 %	

$$(6678.1 - 6564.3) / 6678.1 \times 100 = 1.7\%$$

44

45

No. 8 Gravel for Non-PCC

1. Determine applicable Specification and enter in the Percent Required Column
2. Compute Decant

$$\% \text{ Decant} = \frac{\text{Original Dry Wt.} - \text{Dry Wt. after Decant}}{\text{Original Dry Wt.}} \times 100$$

$$= \frac{6678.1 - 6564.3}{6678.1} \times 100 \quad = 1.7\%$$

45

46

No. 8 Gravel for Non-PCC

1. Determine applicable Specification and enter in the Percent Required Column
2. Compute Decant
3. Compute Weight Passing

46

47

No. 8 Gravel for Non-PCC

TOTAL WEIGHT: 6678.1 g				
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	6678.1 g	%	100 %
¾ in.	720.9 g	g	%	75-95 %
½ in.	3169.1 g	g	%	40-70 %
⅜ in.	1280.2 g	g	%	20-50 %
No. 4	1094.5 g	g	%	0-15 %
No. 8	223.8 g	g	%	0-10 %
No. 16	g	g	%	%
No. 30		g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
[illegible]	[illegible]564.3 g	[illegible]	[illegible]	[illegible]

6678.1 - 0.0 = 6678.1

47

48

No. 8 Gravel for Non-PCC

TOTAL WEIGHT: 6678.1 g				
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	6678.1 g	%	100 %
¾ in.	720.9 g	5957.2 g	%	75-95 %
½ in.	3169.1 g	g	%	40-70 %
⅜ in.	1280.2 g	g	%	20-50 %
No. 4	1094.5 g	g	%	0-15 %
No. 8	223.8 g	g	%	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	113.8 g	1.7 %	0-3.0 %

48

49

No. 8 Gravel for Non-PCC

TOTAL WEIGHT: 6678.1 g				
SIEVE SIZE	WEIGHT RETAINED	WEIGHT PASSING	PERCENT PASSING	PERCENT REQUIRED
1½ in.	g	g	%	%
1 in.	0.0 g	6678.1 g	%	100 %
¾ in.	720.9 g	5957.2 g	%	75-95 %
½ in.	3169.1 g	2788.1 g	%	40-70 %
⅜ in.	1280.2 g	1507.9 g	%	20-50 %
No. 4	1094.5 g	413.4 g	%	0-15 %
No. 8	223.8 g	189.6 g	%	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g		%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	113.8 g	1.7 %	0-3.0 %

49

50

No. 8 Gravel for Non-PCC

1. Determine applicable Specification and enter in the Percent Required Column
2. Compute Decant
3. Compute Weight Passing
4. Compute Percent Passing

$$\% \text{ Passing} = \frac{\text{Weight Passing Each Sieve}}{\text{Original Dry Sample Weight}} \times 100$$

50

51

No. 8 Gravel for Non-PCC

TOTAL WEIGHT: 6678.1 g				
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	g	g	%	%
1 in.	0.0 g	6678.1 g	100.0 %	
¾ in.	720.9 g	5957.2 g	%	75-95 %
½ in.	3169.1 g	2788.1 g	%	40-70 %
⅜ in.	1280.2 g	1507.9 g	%	20-50 %
No. 4	1094.5 g	413.4 g	%	0-15 %
No. 8	223.8 g	189.6 g	%	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g	g	%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	13.8 g	1.7 %	0-3.0 %

6678.1 / 6678.1 x 100 = 100%

52

No. 8 Gravel for Non-PCC

TOTAL WEIGHT: 6678.1 g				
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	g	g	%	%
1 in.	0.0 g	6678.1 g	100.0 %	100 %
¾ in.	720.9 g	5957.2 g	89.2 %	75-95 %
½ in.	3169.1 g	2788.1 g	%	40-70 %
⅜ in.	1280.2 g	1507.9 g	%	20-50 %
No. 4	1094.5 g	413.4 g	%	0-15 %
No. 8	223.8 g	189.6 g	%	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g		%	%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	113.8 g	1.7 %	0-3.0 %

53

No. 8 Gravel for Non-PCC

TOTAL WEIGHT: 6678.1 g				
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	g	g	%	%
1 in.	0.0 g	6678.1 g	100.0 %	100 %
¾ in.	720.9 g	5957.2 g	89.2 %	75-95 %
½ in.	3169.1 g	2788.1 g	41.7 %	40-70 %
⅜ in.	1280.2 g	1507.9 g	22.6 %	20-50 %
No. 4	1094.5 g	413.4 g	6.2 %	0-15 %
No. 8	223.8 g	189.6 g	2.8 %	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g			%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	113.8 g	1.7 %	0-3.0 %

54

No. 8 Gravel for Non-PCC

1. Determine applicable Specification and enter in the Percent Required Column
2. Compute Decant
3. Compute Weight Passing
4. Compute Percent Passing
5. Compare results with Specifications
   Pass or Fail?

55

No. 8 Gravel for Non-PCC

TOTAL WEIGHT: 6678.1 g				
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	g	g	%	%
1 in.	0.0 g	6678.1 g	100.0 %	100 %
¾ in.	720.9 g	5957.2 g	89.2 %	75-95 %
½ in.	3169.1 g	2788.1 g	41.7 %	40-70 %
⅜ in.	1280.2 g	1507.9 g	22.6 %	20-50 %
No. 4	1094.5 g	413.4 g	6.2 %	0-15 %
No. 8	223.8 g	189.6 g	2.8 %	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g			%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	113.8 g	1.7 %	0-3.0 %

56

No. 8 Gravel for Non-PCC

TOTAL WEIGHT: 6678.1 g				
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	g	g	%	%
1 in.	0.0 g	6678.1 g	10.00 %	100 %
¾ in.	720.9 g	5957.2 g	89.2 %	75-95 %
½ in.	3169.1 g	2788.1 g	41.7 %	40-70 %
⅜ in.	1280.2 g	1507.9 g	22.6 %	20-50 %
No. 4	1094.5 g	413.4 g	6.2 %	0-15 %
No. 8	223.8 g	189.6 g	2.8 %	0-10 %
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	64.7 g			%
DECANT ORIGINAL	FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
6678.1 g	6564.3 g	113.8 g	1.7 %	0-3.0 %

PASS

57

No. 8 Gravel for Non-PCC

1. Determine applicable Specification and enter in the Percent Required Column
2. Compute Decant
3. Compute Weight Passing
4. Compute Percent Passing
5. Compare results with Specifications
   Pass or Fail?
6. Compute % Error – Valid Test?

57

58

No. 8 Gravel for Non-PCC

DECANT	ORIGINAL	Σ = 6553.2 FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
	6678.1 g	6564.3 g	113.8 g	1.7 %	0-3.0 %

% ERROR = $\frac{\text{Original Dry Weight – Summation of Weights Measured}}{\text{Original Dry Weight}}$ x 100

58

59

No. 8 Gravel for Non-PCC

DECANT	ORIGINAL	Σ = 6553.2 FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
	6678.1 g	6564.3 g	113.8 g	1.7 %	0-3.0 %

% ERROR = $\frac{\text{Original Dry Weight – Summation of Weights Measured}}{\text{Original Dry Weight}}$ x 100

Summation of Weights Measured =
6553.2 + 113.8 = 6667.0

59

60

No. 8 Gravel for Non-PCC

DECANT	ORIGINAL	Σ = 6553.2 FINAL	GRAMS LOSS	PERCENT LOSS	PERCENT REQUIRED
	6678.1 g	6564.3 g	113.8 g	1.7 %	0-1.5 %

% ERROR = $\frac{\text{Original Dry Weight – Summation of Weights Measured}}{\text{Original Dry Weight}}$ x 100

Summation of Weights Measured =
6553.2 + 113.8 = 6667.0

$\frac{6678.1 - 6667.0}{6678.1}$ x 100 = 0.2% Valid Test
($\leq$0.3)

60

61

UNIFORM
&
CONSISTENT

61

62

Aggregate

- Introduction - Aggregate Testing
- Sampling
- Sample Reduction
- Testing
  - Moisture
  - Decant
  - Gradation
  - Practice Problems

62

63

Aggregate (continued)

- Specific Gravity

- Flat & Elongated
- Coarse Aggregate Angularity
- Fine Aggregate Angularity

63

Chapter Two Continued

AASHTO T84
INDOT Certified Asphalt Lab Technician
Program
Chapter Two

1

Aggregate

- Specific Gravity
- Flat & Elongated
- Coarse Aggregate Angularity
- Fine Aggregate Angularity

2

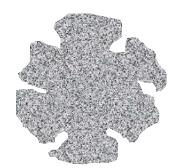
Specific Gravity and Absorption of Fine Aggregates

AASHTO T84
INDOT Certified Asphalt Lab Technician
Program
Chapter Two

3

Glossary

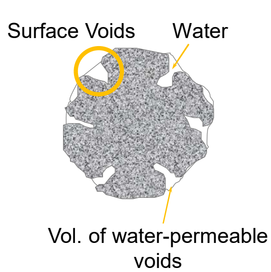
- Apparent Specific Gravity: ratio of a volume of the impermeable portion of the aggregate to the weight of an equal volume of water.



4

Glossary

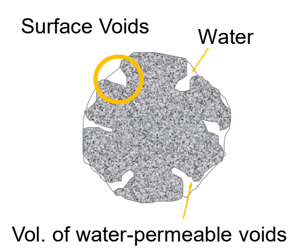
- SSD – Saturated, Surface Dry. The condition in which the aggregate has been soaked in water and has absorbed water into its pore spaces. The excess, free surface moisture has been removed so that the particles are still saturated, but the surface of the particle is essentially dry.



5

Glossary

- Bulk Specific Gravity: ratio of the weight of a volume of aggregate to the weight of an equal volume of water.

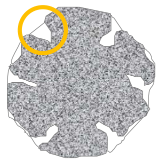


6

7

Glossary

- Absorption: the increase in mass due to water in the pores of material.



7

8

Apparatus

8

9

Preparation

- Obtain approximately 1000 grams of Fine Aggregate in accordance with AASHTO T 248.
- Dry test samples to constant weight in an oven regulated at 230 +- 9 F.
- Cool the sample at room temperature for 1-3 hours.

9

10

Preparation

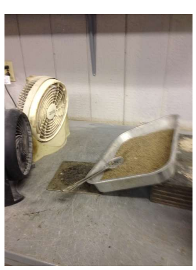
- Immerse the sample in water at room temperature for a period of 15-19 hours.

10

11

Preparation

- Gently pour off water from sample. Be careful not to lose any fines.
- Spread sample on a flat surface exposed to a gently moving current of warm air to assist drying.



11

12

Preparation

- Determine the SSD condition of the sand using the Cone Test.

12

13

Procedure

Too Wet

14

Procedure

Too Dry

15

Procedure

Just Right

16

Procedure

- After achieving SSD immediately weigh out 500 ± 10 grams and record this weight.

17

Procedure

- Calibrate a specific gravity flask pycnometer by filling with water at 73.4 +- 3 F to the calibration line.
- Record this weight as the weight of the pycnometer filled with water to the nearest .1 g.

18

Procedure

- Partially fill the pycnometer with water and then add the SSD sand and fill with additional water to 90 % of pycnometer capacity.

Procedure

- Manually roll, invert, and agitate the pycnometer to eliminate air bubbles.

19

Procedure

- Use the tip of a paper towel to remove any foam and fill to calibration line and record weight.

20

Procedure

- Remove sample from pycnometer and dry to constant mass and record the weight.

21

Calculations

Bulk Specific Gravity (Gsb) $$Gsb = \frac{A}{(B - C)}$$

Bulk SSD Specific Gravity (Gsb SSD) $$Gsb\ SSD = \frac{B}{(B - C)}$$

Apparent Specific Gravity (Gsa) $$Gsa = \frac{A}{(A - C)}$$

Absorption (% Abs) $$\%\ Abs = \frac{B - A}{A} \times 100$$

- A = Oven Dry Weight in air, g
- B = Saturated Surface-Dry (SSD) Weight in air , g
- C = Weight in Water, g

22

Specific Gravity and Absorption of Coarse Aggregate

AASHTO T85
INDOT Certified Asphalt Lab Technician Program
Chapter Two

23

Purpose

- This method covers the determination of specific gravity and absorption of coarse aggregate.

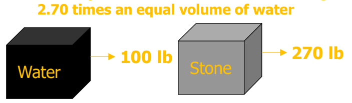
24

25

Glossary & Terminology

- Absorption: the increase in mass due to water in the pores of material.
- Bulk Specific Gravity: Ratio of aggregate weight to the weight of an equal volume of water

Specific Gravity = 2.70 means that the rock weighs 2.70 times an equal volume of water



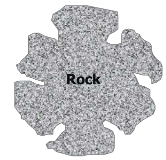
25

26

Apparent Specific Gravity

<u>Considerations:</u>

1) Mass of Oven Dry Rock
2) Volume of Solid Rock Only



$$G_{sa} = \frac{\text{Mass of Oven Dry Aggregate}}{(\text{Volume of Oven Dry Aggregate}) \text{ x } (\text{Unit Weight of Water})}$$

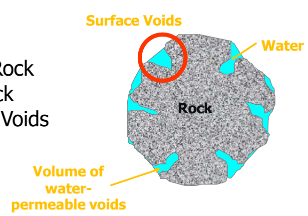
26

27

Dry Bulk Specific Gravity

<u>Considerations:</u>

1) Mass of Oven Dry Rock
2) Volume of Solid Rock
3) Volume of External Voids



$$G_{sb} = \frac{\text{Mass of Oven Dry Aggregate}}{(\text{Volume of Aggregate} + \text{Volume of Voids}) \text{ x } (\text{Unit Weight of Water})}$$

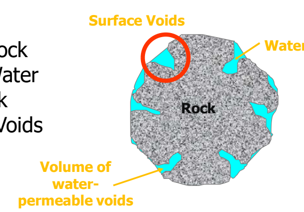
27

28

SSD Specific Gravity

<u>Considerations:</u>

1) Mass of Oven Dry Rock
2) Mass of Absorbed Water
3) Volume of Solid Rock
4) Volume of External Voids



$$G_{SSD} = \frac{\text{Mass of Oven Dry Aggregate} + \text{Mass of Absorbed Water}}{(\text{Volume of Aggregate} + \text{Volume of Voids}) \text{ x } (\text{Unit Weight of Water})}$$

28

29

Apparatus

Balance

29

30

Apparatus

Sample Container

30

31

Apparatus

Water Tank

31

32

Apparatus

Suspended Apparatus

32

33

Apparatus

Oven

33

34

Procedure

- Obtain the sample in accordance with T2 and reduce to testing size according to the table in section 7.3

34

35

Sample Size

- Testing performed on material retained on the 4.75 mm (No. 4) sieve and up.
- If substantial material passes the 4.75 mm (No. 4) you may need to use the 2.36 mm (No. 8) sieve instead.

Nominal Maximum Size	Minimum Mass of Test Sample
≤ 12.5mm (1/2 in.)	2,000 g (4.4 lb)
19.0 mm (3/4 in.)	3,000 g (6.6 lb)
25.0 mm (1 in.)	4,000 g (8.8 lb)

35

36

Procedure

- Dry test sample to constant weight.
- Cool for 1-3 hours.

36

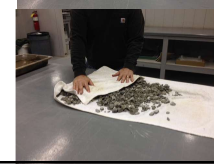
Procedure

- Immerse the aggregate in water at room temperature for 15-19 hours.

37

Procedure

- Remove the sample from water and roll it in an absorbent cloth to remove all free surface water.
- Place sample as quickly as possible into calibrated container and determine the mass. This is the SSD weight.



38

Procedure

- Place sample and container in water bath and determine its mass in water.

39

Procedure

- Dry sample to constant mass at 110 +- 5 C
- Cool at room temperature for 1-3 hours
- Determine the mass.
- Record all masses to nearest 1.0g or .1 percent of mass.

40

Calculations

Bulk Specific Gravity (Gsb) $$Gsb = \frac{A}{(B - C)}$$

Bulk SSD Specific Gravity (Gsb SSD) $$Gsb\ SSD = \frac{B}{(B - C)}$$

Apparent Specific Gravity (Gsa) $$Gsa = \frac{A}{(A - C)}$$

Absorption (% Abs) $$\%\ Abs = \frac{B - A}{A} \times 100$$

- A = Oven Dry Weight in air, g
- B = Saturated Surface-Dry (SSD) Weight in air , g
- C = Weight in Water, g

41

Specification and Reporting

- Report Bulk Specific Gravity to nearest 0.001
- Report Absorption to nearest 0.1 percent
- Absorption for use in HMA < 5.0%

- Note: $G_{sb} > G_{se} > G_{sa}$

42

Uncompacted Void Content of Fine Aggregate

AASHTO T-304
INDOT Certified Asphalt Lab Technician Program
Chapter Two

43

44

Purpose

- To describe the determination of the loose un-compacted void content of a sample of fine aggregate.

44

45

Apparatus

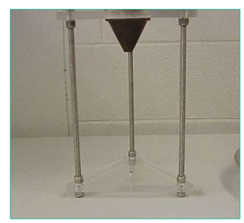
Funnel

45

46

Apparatus

Funnel Stand



46

47

Apparatus

Calibrated Cylinder

47

48

Apparatus

Pan

48

49

Apparatus

Metal Spatula

49

50

Apparatus

Scale or Balance

50

51

Procedure

- Method A - Standard Graded Sample.
- Weigh out and combine the following quantities after drying and sieving according to AASHTO T27

Individual Size Fraction	Mass, g
2.36 mm (No. 8) to 1.18 mm (No. 16)	44
1.18 mm (No. 16) to 600 µm (No. 30)	57
600 µm (No. 30) to 300 µm (No. 50)	72
300 µm (No. 50) to 150 µm (No. 100)	17
	190

51

52

Procedure

- Combine individual size fractions and mix with the spatula until sample appears homogeneous

52

53

Procedure

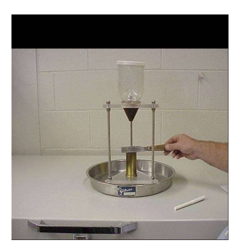
- Put finger under funnel
- Pour combined sample into the funnel
- Level top of sample in the funnel with the spatula

53

54

Procedure

- Allow the sample to fall freely through the funnel into the cylindrical measure
- Rapidly strike off excess aggregate with spatula



54

55

Procedure

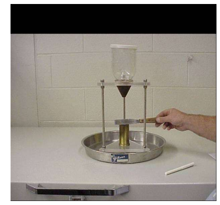
- Lightly tap the sides of the cylindrical measure to compact for easy transfer to balance
- Determine the mass of the cylindrical measure and contents

55

56

Procedure

- Recombine the sample from the pan and cylindrical measure and repeat procedure



56

57

Procedure

- For each run, record the mass of the measure and fine aggregate

57

58

Procedure

- Record the mass of empty measure

58

59

Calculations

$$U = \frac{V - (F/G)}{V} \times 100$$

- U = % Uncompacted Voids in the material
- V = Volume of cylindrical measure, mL
- F = net mass (g) of fine aggregate in measure (gross mass – mass of empty measure)
- G = bulk dry specific gravity of fine aggregate

59

Flat Particles, Elongated Particles in Coarse Aggregate

ASTM D-4791

INDOT Certified Asphalt Lab Technician Program

Chapter Two

60

61

Purpose

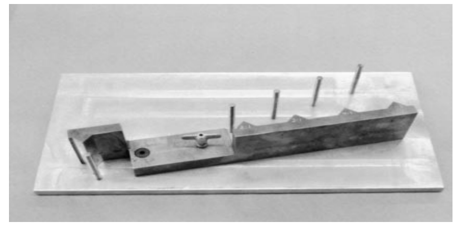
- This test method covers the determination of the percentages of flat and elongated particles

61

62

Apparatus

Proportional Caliper Device

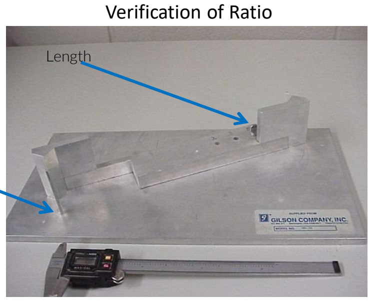


62

63

Apparatus

Verification of Ratio



63

64

Apparatus

Balance

64

65

Sample

Nominal Maximum Size	Minimum Weight
3/8 in. (9.5 mm)	2 lb (1,000 g)
1/2 in. (12.5 mm)	4 lb (2,000 g)
3/4 in (19.0 mm)	11 lb (5,000 g)
1 in. (25.0 mm)	22 lb (10,000 g)

- Reduce each size fraction larger than the 3/8 in. (9.5 mm) sieve that is present in the amount of 10% or more of the original sample until 100 particles are obtained
- Size fractions < 10% of the original total sample mass are not tested

65

66

Procedure

- Oven dry sample and determine mass

66

67

Procedure

- Sieve the sample in accordance with AASHTO T27

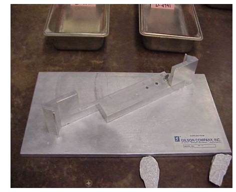
67

68

Procedure

Flat and Elongated Particle Test

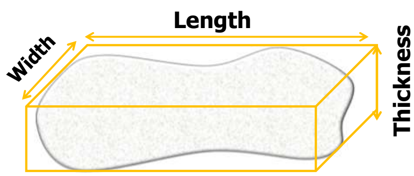
- Test each particle in each size fraction
- Place into two groups



68

69

Procedure



- Length = the maximum dimension
- Thickness = the maximum dimension perpendicular to the length and width
- Width = the maximum dimension in the plane perpendicular to the length

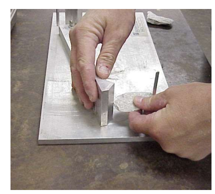
69

70

Procedure

Flat and Elongated Particle Test

- Set the larger opening equal to the particle length



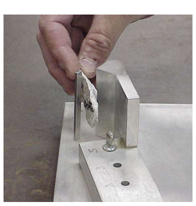
70

71

Procedure

Flat and Elongated Particle Test

- Particle is flat and elongated if the maximum thickness can be placed through the smaller opening



71

72

Procedure

Flat and Elongated Particle Test

- Test each of the particles in each size fraction and place into two groups

72

73

Procedure

- Determine the portion of the sample in each group

73

74

Calculation

- Calculate the percentage of flat and elongated particles to the nearest 1% for each sieve size greater than 3/8 in (9.5 mm)

74

75

Example

¾ in. (19.0 mm) Stone

Sieve Size	1 in. (25.0 mm)	3/4 in. (19.0 mm)	1/2 in. (12.5 mm)	3/8 in. (9.5 mm)
% Passing	100	99.4	75.7	46.4
% Retained	0	0.6	23.7	29.3

- No test performed on the ¾ in. (19.0 mm) size aggregate because it is < 10% of the total sample
- Assume that the ¾ in. (19.0 mm) particles have the same % Flat & Elongated as the ½ in. (12.5 mm)

75

76

Example

¾ in. (19.0 mm) Stone

Sieve Size	1 in. (25.0 mm)	3/4 in. (19.0 mm)	1/2 in. (12.5 mm)	3/8 in. (9.5 mm)
% Passing	100	99.4	75.7	46.4
% Retained	0	0.6	23.7	29.3

- The ½ in. (12.5 mm) size material = 715.3 g after reducing to about 100 particles
- 6.9 g classified as flat and elongated. The % flat and elongated on the ½ in. (12.5 mm) is:

$$\frac{6.9}{715.3} \text{ X } 100 = 1.0\% \approx 1\%$$

76

77

Example

¾ in. (19.0 mm) Stone

Sieve Size	1 in. (25.0 mm)	3/4 in. (19.0 mm)	1/2 in. (12.5 mm)	3/8 in. (9.5 mm)
% Passing	100	99.4	75.7	46.4
% Retained	0	0.6	23.7	29.3

- The 3/8 in (9.5 mm) material = 239.7 g after reduction
- 12.2 g classified as flat and elongated. The % flat and elongated on the 3/8 in. (9.5 mm) is:

$$\frac{12.2}{239.7} \text{ X } 100 = 5.1\% \approx 5\%$$

77

78

Specifications

- Specifications require HMA to have

  < 10% flat and elongated particles using a 5:1 ratio

78

Determining the Percentage of Fractured Particles in Coarse Aggregate

ASTM D-5821
INDOT Certified Asphalt Lab Technician Program
Chapter Two

79

Purpose

- This test method covers the determination of the percentage of fractured particles of a coarse aggregate, gravel sample

80

Apparatus

Splitter

81

Apparatus

Sieves

82

Apparatus

Balance

83

Procedure

- Decant the sample and oven dry to a constant mass

84

85

Procedure

- Separate sample in to separate size fractions according to AASHTO T27

85

Sample Size

Nominal Maximum Sieve Sizes	Minimum Sample Size lb (g)
3/8 in (9.5 mm)	0.5 lb (200 g)
1/2 in. (12.5 mm)	1 lb (500 g)
3/4 in. (19.0 mm)	3 lb (1500 g)
1 in. (25.0 mm)	6 lb (3000 g)

86

87

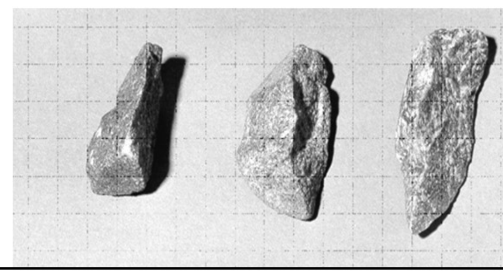
Sample Size

- For aggregates with a nominal maximum size of 19.0 mm or larger, the test sample may be separated on the 9.5mm. The portion passing the 9.5mm may be further reduced to a minimum of 200g.

87

88

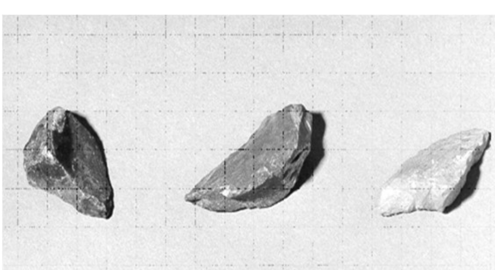
Fractured particle (sharp edges, rough surfaces)



88

89

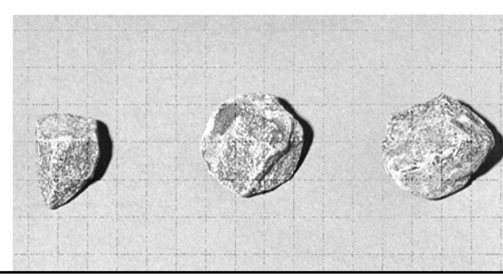
Fractured particle (sharp edges, smooth surfaces)



89

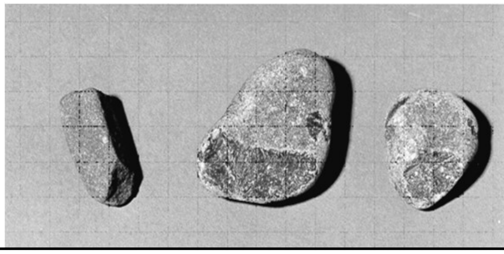
90

Fractured particle (round edges, rough surfaces)



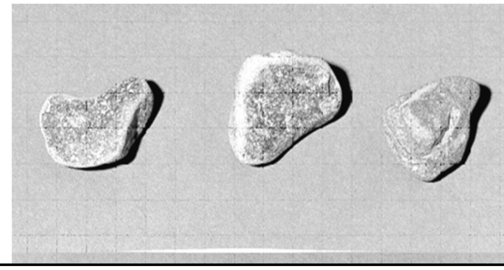
90

Fractured particle (center) flanked by two non-fractured particles (chipped only)



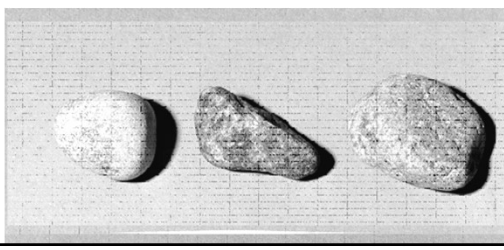
91

Non Fractured particle (round edges, smooth surfaces)



92

Non Fractured particle (rounded particles, smooth surfaces).



93

Procedure

- Particles are separated into two categories:
  - Fractured
  - Non-Fractured

94

Procedure

- Determine the mass of each category
- When two-faced particles are required, the procedure is repeated on the same sample.

95

Calculation

- Calculate the percentage of crushed particles with specified number of fractured faces as follows:

$$P = \frac{F}{F + N} \times 100$$

- P = percentage of particles with the specified number of faces
- F = mass of fractured particles with at least specified number of faces
- N = mass of non-fractured particles

96

97

Specification Requirement

Section 904.03 (b)

Coarse Aggregate Angularity		
Traffic, ESAL	Depth from Surface	
	≤ 4 in.	> 4 in.
< 3,000,000	75	50
3,000,000 to < 10,000,000	85/80*	60
≥ 10,000,000	95/90*	95/90*
* Denotes two faced crush requirements.		

97

Asphalt Binders for
Quality Assurance Certified
Technician Program

INDOT CERTIFIED ASPHALT LAB TECHNICIAN PROGRAM
CHAPTER THREE

1

2

MEET THE TEAM

CHRIS CAMPBELL

Design Technician
The Heritage Group

CHRIS CAMPBELL

Associate Director of Research
The Heritage Group

2

3

Asphalt Binders
Overview

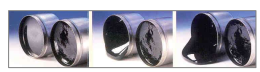
- What are Asphalt Binders ?
- How are they Manufactured ?
- The Grading System
- How are they Tested and Certified ?
- Safety
- Storage Handling and Sampling
- Specific Gravity of Asphalt Binder
- Temperature Volume

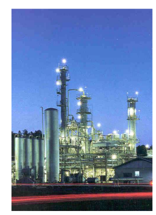
3

4

Asphalt

- Asphalt is a black cementing material varying from solid to semi-solid at room temperature. Virtually all asphalts used in roads are produced in petroleum refineries



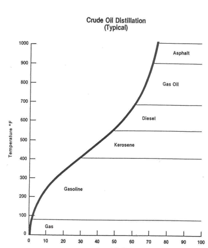


4

5

Asphalt Binders

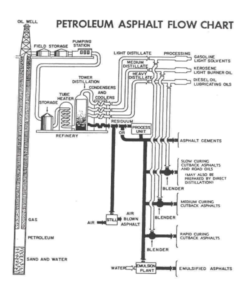
- Asphalt Binders used in paving asphalts are produced from the distillation of petroleum crude oil. Asphalt is the non-distillable portion of the crude oil.



5

6

Asphalt Binders



6

Performance Graded Asphalt Binders

1987 - SHRP (Strategic Highway Research Program) Began

- outcome was Superpave (Superior Performing Pavements)

Superpave developed a new system for specifying asphalt binders

7

Superpave Performance Graded Asphalt Binders

- Based on Fundamental Properties measured at actual service temperatures

8

PG 64-22

Performance Grade

Maximum pavement design temperature (°C)

Minimum pavement design temperature (°C)

9

Testing

- Aging
- Dynamic Shear Rheometer
- Bending Beam
- Viscosity
- Flash Point

10

Aging

Short Term
Rolling Thin Film Oven

Simulates Hot Mix Plant

11

Aging

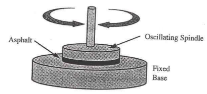
Long Term
Pressure Aging Vessel

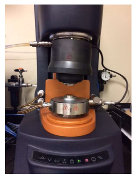
Simulates 8-10 years in Pavement

12

13

Dynamic Shear Rheometer



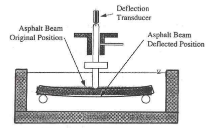


Evaluates High Temperature Stiffness and Intermediate Stiffness

13

14

Bending Beam

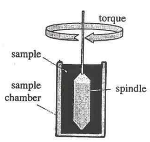


Determines Stiffness and Ability of Asphalt to Relax at Low Temperature Pavement Condition

14

15

Rotational Viscosity



Test for High Temperature Storage and Handling

15

16

Flash Point

- Flash Point is a Safety Test
- Asphalt Binders should be stored below Flash Point temperature

16

17

Asphalt Safety Issues

- Storage & Handling Hazards
  - Burns
  - H_2S
  - Fumes
- Traffic

17

18

Storage & Handling Solutions

- Be Aware of Burn Hazard Locations
- Use Designated Walk Areas
- Look Out for Construction Traffic
- Avoid Tank Vent Openings for H_2S Build-up
- Stay Upwind of Asphalt Fumes if possible
- When Sampling, wear long sleeve shirt & pants
- Follow Established Safety Procedures

18

19

Burns

- Apply Cold Water
- Do Not Remove Asphalt
- Have Physician Examine
- Asphalt Institute has developed a new video for 1st Responders
  - Pocket Safety cards
  - Posters

19

20

H_2S Hydrogen Sulfide

- Builds up in Vapor Space of Asphalt Binder Tank (Rotten Egg Smell)
- Some Modified Asphalt Binders have higher levels

20

21

H_2S

- Keep Face out of Man-Ways (1/2 meter)
- Stay Upwind of Hatch
- Avoid Breathing Fumes

21

22

H_2S

- If overexposure occurs, move to fresh air
- Administer Oxygen if breathing difficult
- Start Artificial Respiration if breathing stops
- Have exposed person see physician immediately

22

23

Storage

- Asphalt Binders are sampled for compliance by INDOT at Hot Mix Facility
- Storage Issues
  - Contamination from Other Binders
  - Contamination from Fuel Oil
  - Overheating or Extended Heating
- Follow Storage & Handling Guidelines from producer

23

24

Sampling

INDOT collects Asphalt Binder for Quality Control at HMA Facility

24

Sampling

Proper Sampling important for representative sample

25

Sampling Issues

- Avoid sampling from top of tank if possible
- Use only clean containers
- Allow 1 Gallon of asphalt binder to drain before sampling
- Seal container immediately

26

Sampling Issues

- Clean container outside if spilled asphalt binder present
- Label all containers clearly
- Do not label lid
- Follow Safety Procedures

27

Specific Gravity of Asphalt Binder Pycnometer Method

Performed by Material Supplier

Usually listed at 60ºF

28

Specific Gravity of Asphalt Binders

- Specific Gravity of Asphalt is the ratio of the weight of a volume of material to the weight of an equal volume of water, both at a specified temperature
- Asphalt Binders Expand & Contract with Temperature
- Specific Gravity at a specified temperature provides a Yardstick for Temperature Volume Calculation

29

Temperature – Volume Relationship

- Conversion between Mass and Volume is necessary
- Asphalt Binders typically sold by Mass, not Volume
- In HMA, Volume is more important for volumetrics of design

30

Temperature - Volume

- Needed for Metering Asphalt by Volume
- Determining Inventory

31

Temperature – Volume Example

- Storage Tank contains 15,000 gallons of PG 64-22 @ 295ºF
- Specific Gravity of Asphalt Binder is 1.012 @60ºF
- Calculate Tons of PG 64-22 to nearest first decimal place (0.0)

32

Temperature – Volume Example

Step 1 Convert volume from 295ºF to 60ºF

Determine Volume Correction Factor

Specific Gravity of Asphalt >0.966 use Group 0

Column M Multiplier Factor = ?

33

Temperature – Volume Example

Step 1 Convert volume from 295ºF to 60ºF

Determine Volume Correction Factor

Specific Gravity of Asphalt >0.966 use Group 0

Column M Multiplier Factor = 0.9204

34

Temperature – Volume Example

Step 2
Volume @ 60ºF = Vol @ (actual Temp) x Conversion Factor

15,000 Gallons x 0.9204 = ?

35

Temperature – Volume Example

Step 2
Volume @ 60ºF = Vol @ (actual Temp) x Conversion Factor

15,000 Gallons x 0.9204 = 13,806 Gallons

36

37

Temperature – Volume Example

Step 3 Convert Volume @ 60°F to Mass

$$\text{Mass (Tons)} = \frac{\text{Vol @ 60°F (Gal)} \times \text{Sp Gr @ 60°F} \times 8.33\ \text{lb/gal}}{2000\ \text{lb/ton}}$$

$$\text{Mass (Tons)} = \frac{13{,}806\ \text{gallons} \times 1.012 \times 8.33\ \text{lb/gal}}{2000\ \text{lb/ton}}$$

Mass (Tons) = ?

37

38

Temperature – Volume Example

Step 3 Convert Volume @ 60°F to Mass

$$\text{Mass (Tons)} = \frac{\text{Vol @ 60°F (Gal)} \times \text{Sp Gr @ 60°F} \times 8.33\ \text{lb/gal}}{2000\ \text{lb/ton}}$$

$$\text{Mass (Tons)} = \frac{13{,}806\ \text{gallons} \times 1.012 \times 8.33\ \text{lb/gal}}{2000\ \text{lb/ton}}$$

Mass (Tons) = 58.2

38

39

ASC Program

- A Voluntary Asphalt Supplier Certification Program
  - Permits supplier to manufacture and ship to HMA facilities
  - Requires instruction of proper storage and handling

39

40

Goal: To Have Long-Lasting Asphalt Pavements

40

41

Conclusions

- QC/QA Program is a critical part of Indiana's success in Highways
- Certified Technicians are often the difference between long term performance and early failures
- Do not underestimate the role you play!

41

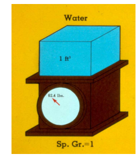
Asphalt Mixture
Maximum Specific Gravity

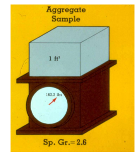
INDOT Certified Asphalt Lab Technician Program
Chapter Four

1

Specific Gravity

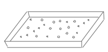
- Definition
  - ratio of object density to water density (water unit wt. = 62.416 lb./ft^3.)
- Used as Bridge Between Mass and Volume of Objects





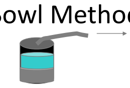
2

Maximum Specific Gravity of Mix (Bowl Method)

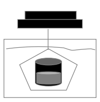


1. Separate fine aggregate to less than 1/4 in.

2. Place in bowl and weigh cool
A = mass of dry sample in air, g.

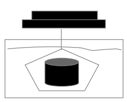


3. Vacuum sample under water @ 25-30 mm. Hg. 15 min. agitation



4. Weigh bowl and sample under water.

C=mass of bowl and mix in water (g)



5. Weigh bowl under water

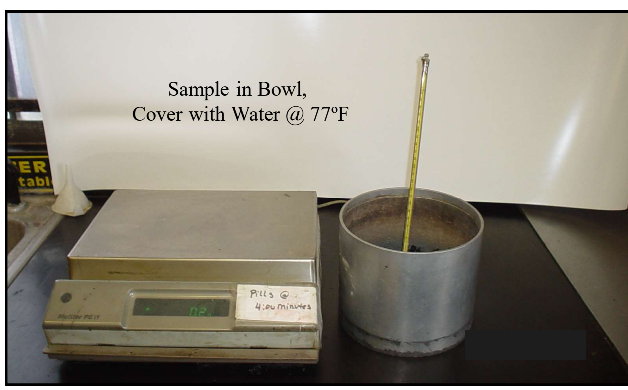
B=mass of bowl in water (g)

Max. Specific Gravity of Mix
G_{mm} = A/ (A-(C-B))

3

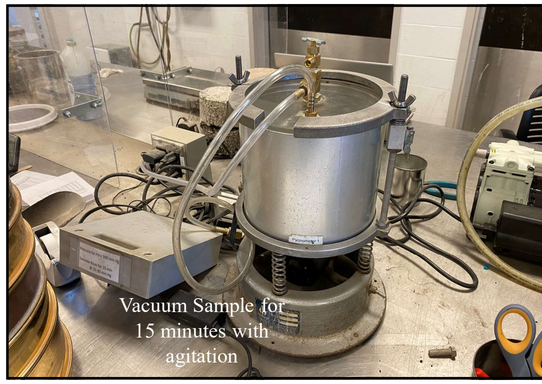
4

5



6

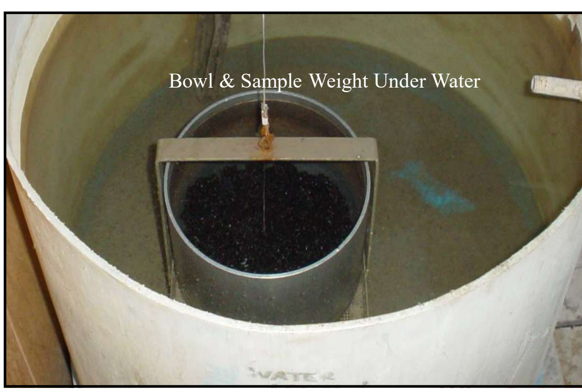
7



8

9

10



11

Maximum Sp. Gravity (Bowl Method)

Asphalt Content, %	= 4.9
Weight of Bowl in Water, g (B)	= 1229.2
Weight of Sample, g (A)	= 2215.9
Weight of Bowl + Mix in Water, g (C)	= 2557.0

Maximum Sp. Gr. of Mix = A/(A-(C-B))

= 2215.9 / 2215.9 - (2557.0-1229.2)

= 2.495

12

Maximum Specific Gravity of Mix

Air Voids, %	4.2
Weight of Sample, g	2526.3
Weight of Bowl, g	2399.5
Weight of Bowl in Water, g	1228.2
Weight of Bowl + Mix in Water, g	2753.6

Maximum Sp. Gr. of Mix =

13

Maximum Specific Gravity of Mix

Air Voids, %	4.2
Weight of Sample, g	2526.3
Weight of Bowl, g	2399.5
Weight of Bowl in Water, g	1228.2
Weight of Bowl + Mix in Water, g	2753.6

$$\text{Maximum Sp. Gr. of Mix} = \frac{2526.3}{2526.3 - (2753.6 - 1228.2)} =$$

14

Maximum Specific Gravity of Mix

Air Voids, %	4.2
Weight of Sample, g	2526.3
Weight of Bowl, g	2399.5
Weight of Bowl in Water, g	1228.2
Weight of Bowl + Mix in Water, g	2753.6

$$\text{Maximum Sp. Gr. of Mix} = \frac{2526.3}{2526.3 - (2753.6 - 1228.2)} = 2.524$$

15

Asphalt Mixture
Bulk Specific Gravity

INDOT Certified Asphalt Lab Technician Program
Chapter Four

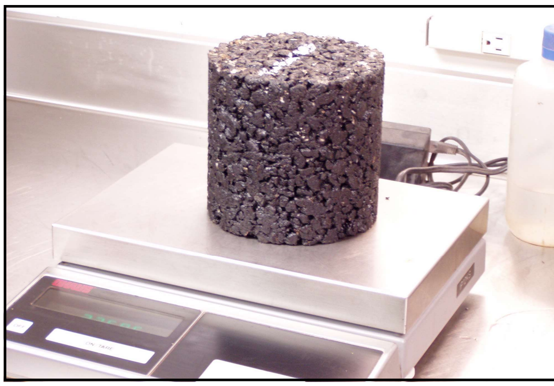
1

2

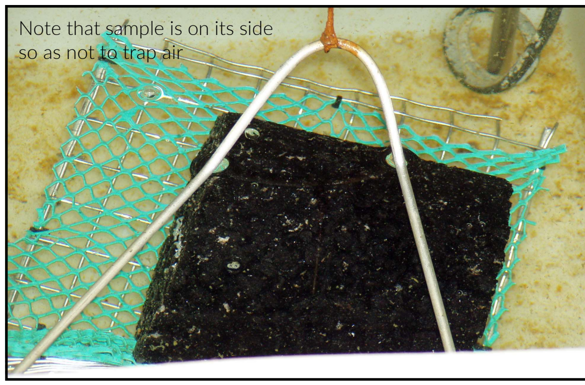
Bulk Specific Gravity of Mixture

- Weigh in air
- Weigh in water
- Weigh in air with surface water

2



3



Note that sample is on its side so as not to trap air

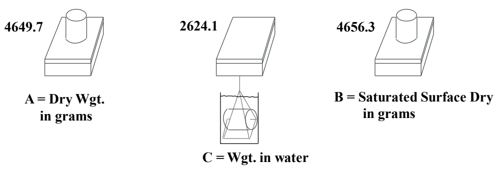
4

Pat with a damp cloth to reach saturated surface dry condition.

5

6

Bulk Specific Gravity of Mixture



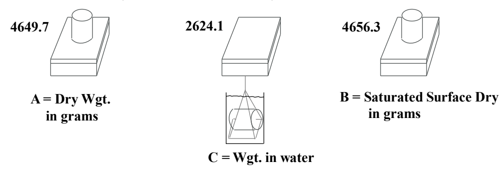
Bulk Specific Gravity of Mixture = $\dfrac{A}{B - C}$

$= \dfrac{4649.7}{4656.3 - 2624.1}$

=

7

Bulk Specific Gravity of Mixture



Bulk Specific Gravity of Mixture = $\dfrac{A}{B - C}$

$= \dfrac{4649.7}{4656.3 - 2624.1}$

= 2.288

8

Bulk Specific Gravity of Mix

Design Number of Gyrations = 50
Weight in Water, g = 2776.0
Gsb = 2.609
Dry Weight, g = 4718.2
Saturated Surface Dry (SSD)Weight, g = 4724.9

Bulk Specific Gravity of Mix = $\dfrac{A}{(B\text{-}C)}$

A = 4718.2
B = 4724.9
C = 2776.0

Bulk Specific Gravity of Mix = $\dfrac{4718.2}{(4724.9 - 2776.0)}$

Bulk Specific Gravity of Mix =

9

Bulk Specific Gravity of Mix

Design Number of Gyrations = 50
Weight in Water, g = 2776.0
Gsb = 2.609
Dry Weight, g = 4718.2
Saturated Surface Dry (SSD)Weight, g = 4724.9

Bulk Specific Gravity of Mix $\dfrac{A}{(B\text{-}C)}$ =

A = 4718.2
B = 4724.9
C = 2776.0

Bulk Specific Gravity of Mix = $\dfrac{4718.2}{(4724.9 - 2776.0)}$

Bulk Specific Gravity of Mix = 2.421

10

Bulk Specific Gravity of Mix

Specimen Thickness, mm = 413.7
Dry Weight, g = 4527.4
Weight in Water, g = 2594.9
Saturated Surface Dry Weight, g = 4533.8
Air Voids, % = 6.2

Bulk Specific Gravity of Mix = ―――――

=

11

Bulk Specific Gravity of Mix

Specimen Thickness, mm = 413.7
Dry Weight, g = 4527.4
Weight in Water, g = 2594.9
Saturated Surface Dry Weight, g = 4533.8
Air Voids, % = 6.2

Bulk Specific Gravity of Mix = $\dfrac{4527.4}{(4533.8 - 2594.9)}$

=

12

Bulk Specific Gravity of Mix

Specimen Thickness, mm	= 413.7
Dry Weight, g	= 4527.4
Weight in Water, g	= 2594.9
Saturated Surface Dry Weight, g	= 4533.8
Air Voids, %	= 6.2

$$\text{Bulk Specific Gravity of Mix} = \frac{4527.4}{(4533.8 - 2594.9)} = 2.335$$

13

Bulk Specific Gravity of Mixture Using The Automatic Sealing Device (Corelok)

AASHTO T331

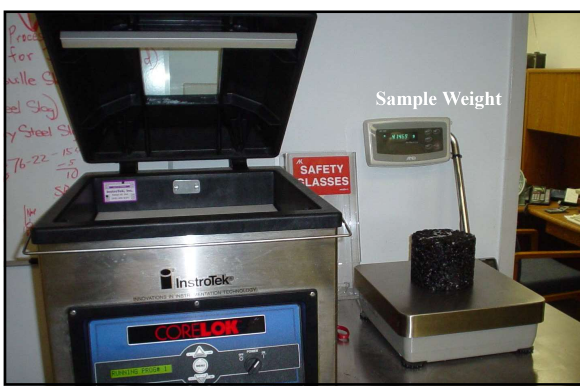
Used for “C” Open Graded Mixtures where mixture is too porous for an accurate SSD measurement

Used for measuring core density when water absorption exceeds 2.0%

14

15

16



17

Place Bag

and Sample

in Vacuum Chamber

18

19

20

21

Bulk Specific Gravity of Mix Using the Corelok Device

G_{mb}=A/ {(B-E)-[(B-A)/F_T]}

Where,

A = Dry Sample Weight (g)

B = Sealed Sample Weight (g)

E = Sealed Sample Weight in Water (g)

F_T = Apparent Specific Gravity of Bag

22

Sample Dry Weight = 4146.6 g

Sealed Sample in Bag Weight = 4199.5 g

Sealed Sample in Water Weight = 2228.8 g

Apparent Specific Gravity of Bag = 0.7257

G_{mb} = 4146.6 / {(4199.5-2228.8) - [(4199.5-4146.6) / 0.7275]}

G_{mb} = 4146.6 /(1970.7 - 72.7)

= 2.185

23

Sample Dry Weight = 4146.6 g

Sealed Sample in Bag Weight = 4199.5 g

Sealed Sample in Water Weight = 2228.8 g

Apparent Specific Gravity of Bag = 0.7257

G_{mb} = 4146.6 / {(4199.5-2228.8) - [(4199.5-4146.6) / 0.7275]}

G_{mb} = 4146.6 /(1970.7 - 72.7)

=

24

Asphalt Mixture Volumetric Properties Calculations

INDOT Certified Asphalt Lab Technician Program
Chapter Four

1

Air Void Calculation

Air Voids $= 100 \times \dfrac{G_{mm} - G_{mb}}{G_{mm}}$

G_{mb} = Bulk Specific Gravity of Mix = 2.290

G_{mm} = Theoretical Max. Sp. Gr. of Mix = 2.428

Air Voids $= 100 \times \dfrac{2.428 - 2.290}{2.428}$

= 5.7%

2

Air Voids

Unit Weight = 144.5 lbs./cu. ft.
Bulk Sp. Gr. of Mix = 2.316
VMA = 14.3%
Aggregate, % = 94.3
Max. Sp. Gr. of Mix = 2.426

Air Voids $= 100 \times \dfrac{G_{mm} - G_{mb}}{G_{mm}}$

$G_{mb} = 2.316$
$G_{mm} = 2.426$

Air Voids $= 100 \times \dfrac{2.426 - 2.316}{2.426}$

Air Voids = 4.5%

3

Air Voids

Max. Sp. Gr. of Mix = 2.443
Asphalt Content, % = 5.9
Bulk Sp. Gr. of Mix = 2.284

Air Voids =

4

Air Voids

Max. Sp. Gr. of Mix = 2.443
Asphalt Content, % = 5.9
Bulk Sp. Gr. of Mix = 2.284

Air Voids $= 100 \times \dfrac{2.443 - 2.284}{2.443}$

Air Voids = 6.5

5

VMA Calculation

VMA $= 100 - \left(\dfrac{Gmb \times Ps}{Gsb}\right)$

G_{mb} = Bulk Specific Gravity of Mix
P_s = Aggregate % of Total Mix
G_{sb} = Bulk Specific Gravity of Aggregate (from Job Mix Formula)

Example:
G_{mb} = 2.290
P_s = 94.5%
G_{sb} = 2.514

VMA $= 100 - \left(\dfrac{2.290 \times 94.5}{2.514}\right)$

= 13.9 %

6

7

VMA

Asphalt Content, %	= 4.5
Bulk Sp. Gr. of Agg.	= 2.609
Air Voids, %	= 6.1
Bulk Sp. Gr. of Mix	= 2.342
% Passing #200	= 3.5

100 - AC% = Agg. % = 95.5

$$VMA = 100 - \left(\frac{G_{mb} \times P_s}{G_{sb}}\right)$$

G_{mb} = 2.342
P_s = 95.5
G_{sb} = 2.609

$$VMA = 100 - \left(\frac{2.342 \times 95.5}{2.609}\right)$$

VMA = 100 - 85.7
VMA = 14.3%

7

8

VMA

Bulk Sp. Gr. of Aggregate 2.599

Asphalt Index
210.5

Bulk Sp. Gr. of Mix
2.335

Asphalt Content, %
6.1

VMA =
Air Voids, %
5.5

8

9

VMA

Bulk Sp. Gr. of Aggregate 2.599

Asphalt Index
210.5

Bulk Sp. Gr. of Mix
2.335

Asphalt Content, %
6.1

Air Voids, %
5.5

$$VMA = 100 - \left(\frac{2.335 \times 93.9}{2.599}\right) = 15.6\%$$

9

10

Voids Filled with Asphalt

Bulk Sp. Gr. of Aggregate	2.599
VMA	15.6
Bulk Sp. Gr. of Mix	2.335
Asphalt Content, %	6.1
Air Voids, %	5.5

$$VFA = \frac{VMA - Air\ Voids}{VMA} \times 100$$

$$VFA = \frac{15.6 - 5.5}{15.6} \times 100 = 65\%$$

10

11

Voids Filled with Asphalt

Bulk Sp. Gr. of Aggregate	2.599
VMA	13.6
Bulk Sp. Gr. of Mix	2.335
Asphalt Content, %	6.1
Air Voids, %	4.0

VFA =

11

12

Voids Filled with Asphalt

Bulk Sp. Gr. of Aggregate	2.599
VMA	13.6
Bulk Sp. Gr. of Mix	2.335
Asphalt Content, %	6.1
Air Voids, %	4.0

$$VFA = \frac{VMA - Air\ Voids}{VMA} \times 100$$

$$VFA = \frac{13.6 - 4.0}{13.6} \times 100 = 71\%$$

12

13

Binder Replacement

$$\frac{(A \text{ x } B)+(C \text{ x } D)}{E} \text{ x } 100\%$$

where:

A = RAP, % Binder Content
B = RAP, % in Mixture
C = RAS, % Binder Content
D = RAS, % in Mixture
E = Total, % Binder Content in Mixture

13

14

Binder Replacement

Example:

RAP, % Binder Content	= 4.0
RAP, % in Mixture	= 15.0
RAS, % Binder Content	= 20.0
RAS, % in Mixture	= 3.0
Total, % Binder Content in Mixture	= 4.8

$$\frac{(0.04 \text{ x } 0.15)+(0.20 \text{ x } 0.03)}{0.048} \text{ x } 100 = 25.0\,\%$$

14

How To Do An Asphalt Mix Design

INDOT Certified Asphalt Lab Technician Program
Chapter Four

1

2

HMA Mix Design Process

- Contract specifications
- Selection of materials
- Selection of aggregate structure (trial blends)
- Trial blend batching & compaction
- Trial blend evaluation
- Selection of final aggregate structure
- Selection of final binder content

2

3

Mix Design Requirements

- Design Mix Formula (DMF) done by an INDOT-approved lab and submitted to INDOT
- AASHTO R 35

3

4

Contract Specifications

- Sec. 401- QC/QA HMA
- Sec. 402- HMA
- Sec.410- SMA
- Sec. 902- PG binders
- Sec.904- Aggregates

INDIANA
DEPARTMENT
OF
TRANSPORTATION

STANDARD
SPECIFICATIONS

2020

4

5

Mixture Types- QC/QA HMA Pavement

- Item Description
  - QC/QA HMA, ___, ___, ___, ___mm

ESAL Category (2-4)
Binder Grade (PG high temp.)
Course
Mix Size (NMAS)

- QC/QA HMA, 2,64,intermediate,19.0 mm

ESAL Category 2
PG64-22
Intermediate Course
19.0 mm NMAS

5

6

ESAL Category (Equivalent Single Axle Load)

ESAL Category	ESAL
2	< 3,000,000
3	3,000,000 to < 10,000,000
4	≥10,000,000

6

Mix Design Criteria

- Sec. 401.05
  - Dense Graded Gradation
  - Open Graded (OG) Gradation
  - Gyratory Compaction Effort
  - Voids in the Mineral Aggregate
  - Voids filled with Asphalt
- Sec. 904-Aggregates
  - FAA, CAA, Surface Aggregates

7

Material Selection

- ESAL (category number)
  - Compaction effort, FAA, CAA
- Course (base, intermediate, surface)
  - Friction aggregate requirements
- Nominal Maximum Size
  - Lift thickness
- PG Binder Grade

8

Selection of Aggregate Structure

- Establish trial blends (on paper)
- Trial batching and compaction
- Evaluate Trial Blends

9

Dense Graded Mixtures

Dense Graded, Mixture Designation – Control Point (Percent Passing)					
	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm**
Sieve Size					
50.0 mm					
37.5 mm	100.0				
25.0 mm	90.0 - 100.0	100.0			
19.0 mm	< 90.0	90.0 - 100.0	100.0		
12.5 mm		< 90.0	90.0 - 100.0	100.0	100.0
9.5 mm			< 90.0	90.0 - 100.0	95.0 - 100.0
4.75 mm				< 90.0	90.0 - 100.0
2.36 mm	19.0 - 45.0	23.0 - 49.0	28.0 - 58.0	32.0 - 67.0*	
1.18 mm					30.0 - 55.0
600 µm					
300 µm					
75 µm	1.0 - 7.0	2.0 - 8.0	2.0 - 10.0	2.0 - 10.0	3.0 - 8.0

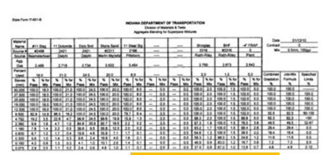
10

Open Graded Mixtures

Open Graded, Mixture Designation – Control Point (Percent Passing)			
	OG9.5mm	OG19.0 mm	OG25.0 mm
Sieve Size			
37.5 mm			100.0
25.0 mm		100.0	70.0 – 98.0
19.0 mm		70.0 – 98.0	50.0 – 85.0
12.5 mm	100.0	40.0 – 68.0	28.0 – 62.0
9.5 mm	75.0 – 100.0	20.0 – 52.0	15.0 – 50.0
4.75 mm	10.0 – 35.0	10.0 – 30.0	6.0 – 30.0
2.36 mm	0.0 – 15.0	7.0 – 23.0	7.0 – 23.0
1.18 mm		2.0 – 18.0	2.0 – 18.0
600 µm		1.0 – 13.0	1.0 – 13.0
300 µm		0.0 – 10.0	0.0 – 10.0
150 µm		0.0 – 9.0	0.0 – 9.0
75 µm	0 – 6.0	0.0 – 8.0	0.0 – 8.0
% of Binder	> 3.0	> 3.0	> 3.0

11

Selection of Aggregate Structure



Trial paper blends to meet specification gradation

12

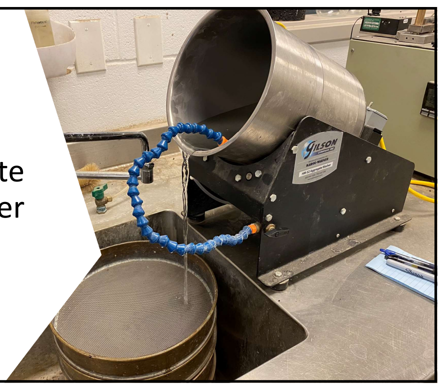
19

13

Washed Gradation

14

Aggregate Washer



15

How Aggregates Behave

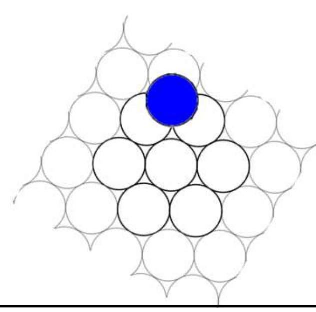
16

What Controls Packing of Aggregates?

- Gradation
- Shape
- Texture
- Angularity
- Compaction:
  - Type, Amount
- Hardness

17

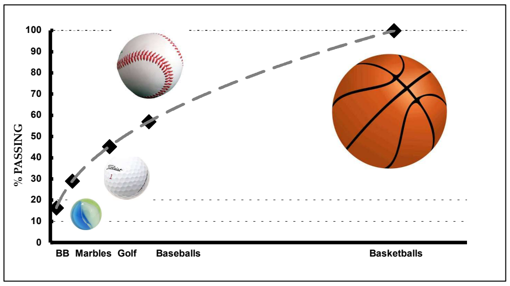
Packing of Balls



18

19

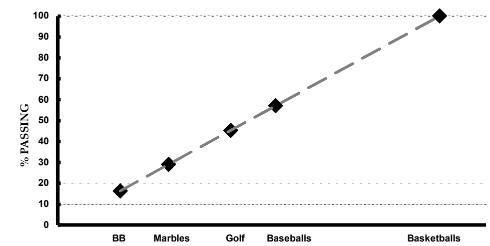
Percent by Diameter



19

20

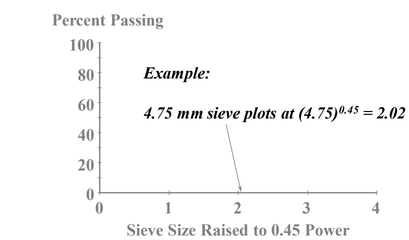
Percent by Square Root Diameter



20

21

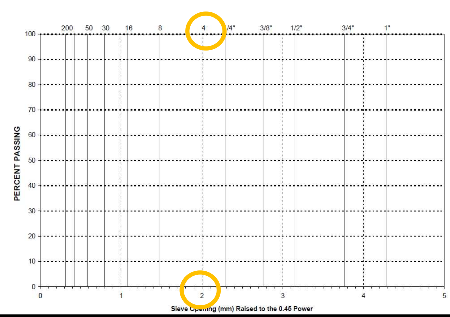
0.45 Power Grading Chart



21

22

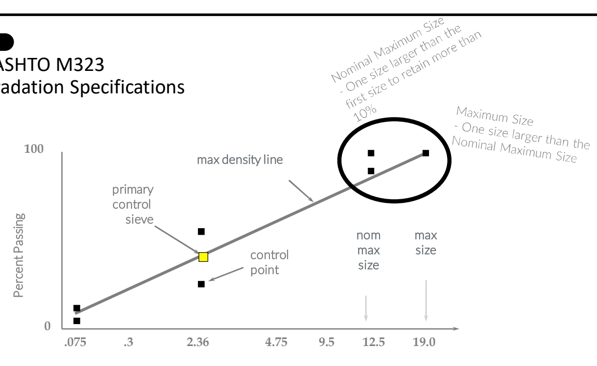
0.45 Power Gradation Chart



22

23

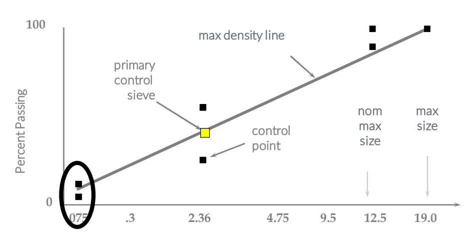
AASHTO M323
Gradation Specifications



23

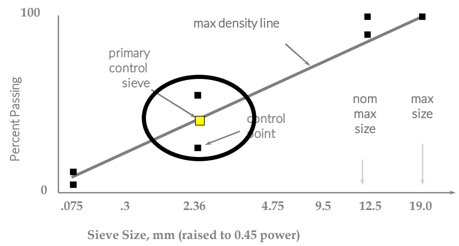
24

AASHTO M323
Gradation Specifications



24

AASHTO M323
Gradation Specifications



25

19.0-mm NMS Mixture

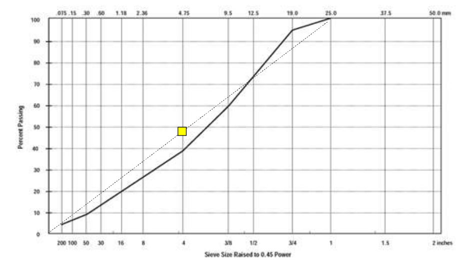
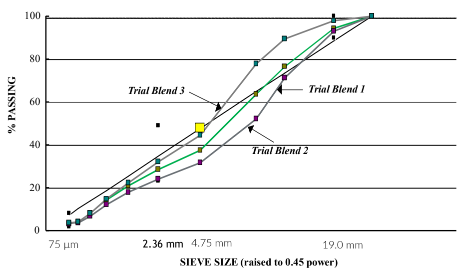


Figure 3.7 0.45 Power Chart

26

Typical Coarse Superpave Gradations



27

Aggregate and RAP Preparation

28

Trial Blend Aggregate Batching Computations

- Determination of batch weights
- 115.0 +/-5.0 mm

LAB SPECIMEN BLEND - (+8 / 8-30 / Passing 30)

Project	QC 9.5mm, 4,76
Blend #	TSR 100 gyr 96th

Total Sample Wt gr.	3953.0
Agg Portion gr.	3726.1

Material	#11 Slag	11 Dolomite	Dolo Snd	Stone Sand	11 Steel Slg			Shingles	BHF	-4" FRAP	TOTAL
Source	Beemsterboer	Delphi	Delphi	Martin Marietta	Pittsboro			Rieth-Riley	Rieth-Riley	Plant	
Percent	18.0	21.0	24.5	20.0	8.0	0.0	0.0	2.0	1.5	5.0	100.0
SG Agg	2.489	2.718	2.734	2.622	3.454			2.760	2.673	2.642	
	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams	Grams
1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3/4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1/2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3/8	114.7	105.6	0.0	0.0	60.5	0.0	0.0	0.0	0.0	0.0	280.8
#4	427.2	500.0	1.8	3.0	190.2	0.0	0.0	1.3	0.0	0.4	1123.9
#8	62.4	140.1	136.9	51.4	40.8	0.0	0.0	0.7	0.0	43.4	475.8
#30	21.5	23.5	595.2	425.5	1.5	0.0	0.0	24.4	0.0	68.9	1160.5
P#30	44.9	13.3	178.9	265.3	5.1	0.0	0.0	48.1	55.9	73.6	685.2
TOTAL	670.7	782.5	912.9	745.2	298.1	0.0	0.0	74.5	55.9	186.3	3726.1

	Mixture AC Total	Mixture Virgin AC	RAP AC	Mixture RAP AC
Asp. %	6.00 %	5.74 %	5.20 %	0.26 %
GRAMS	----------------	226.9	----------------	----------------

29

Preparation for Mixing

Heat Aggregates, RAP and Asphalt Binder

Heat Mixing Container

30

31 Batching

31

32 Mixing and Preparation for 4-hour Oven Aging

32

33 Specimen Oven Aging and Compaction Preparation

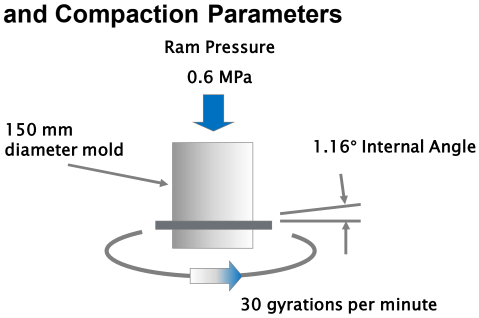
33

34 Compaction

ESAL Category	Gyrations (N_{design})
2	30
3	50
4	50

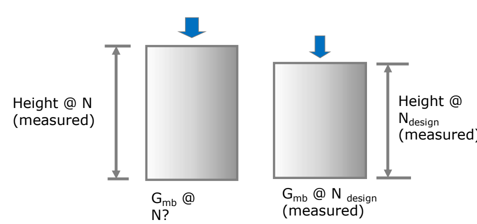
34

Gyratory Mold Configuration and Compaction Parameters



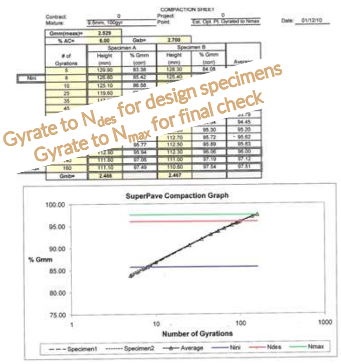
35

Bulk Specific Gravity of Gyratory Compacted Specimens



36

37



Densification Table

-Measure G_{mm}

-Measure G_{mb}

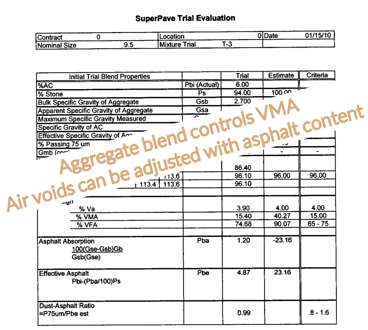
38

Evaluate Trial Blends

- Determine %Air Voids, %VMA
- Estimate asphalt binder content to achieve 5%Air Voids
- Estimate mixture properties at new asphalt binder content
- Estimate $\%G_{mm}$ @ $N_{initial}$, N_{design}
- Estimate dust-asphalt ratio
- Compare all estimates to mixture criteria

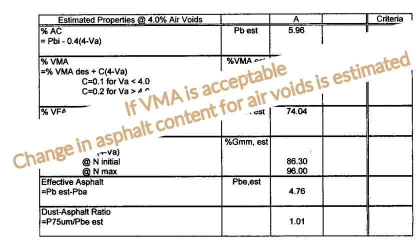
39

Evaluate Trial Blend(s)



40

Estimate Properties @ 5.0% Air Voids



41

Compare Trial Blends to Specification

Criteria	Trial 1	Trial 2	Trial 3	Specs
% Air Voids	6.4	4.9	4.9	5.0
%VMA	17.3	15.4	16.4	16.0 min
%VFA	[illegible]	68	70	60-70
%Gmm @ Nini	[illegible]	[illegible]	87.4	91.5 max.
[illegible]	[illegible]	[illegible]	1.01	0.6-1.4
[illegible]	[illegible]	[illegible]	16.4	

VMA ok
Aggregate blend OK

VMA too high
Change aggregate blend

VMA too low
Change aggregate blend

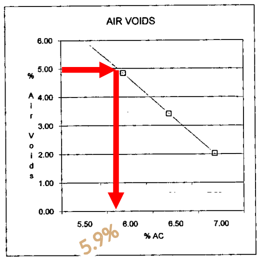
42

Determine Optimum Asphalt Binder Content

- Prepare specimens using the selected aggregate structure
  - 2 points above estimated optimum (+0.5 % & +1.0%)
  - 1 point below estimated optimum
  - (-0.5%)
- Graph Mixture Properties verses Binder %
- Select Design Binder %

43

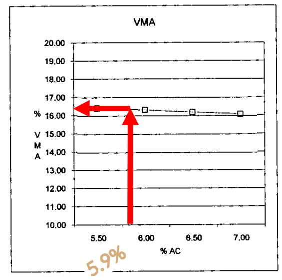
Air Voids versus Percent Binder



43

44

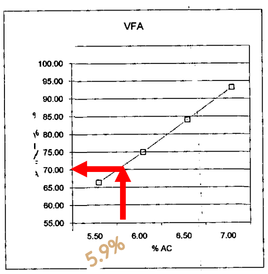
VMA versus Percent Binder



44

45

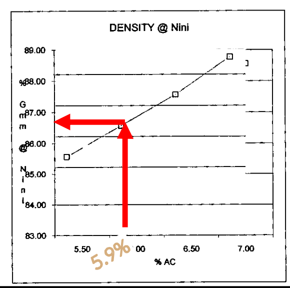
VFA versus Percent Binder



45

46

$\%G_{mm}$ @ N_{ini} versus Percent Binder



46

47

Final Verification Testing

- Evaluate N_{max} @ Optimum Binder % (2 specimens)
- Prepare and analyze specimens for Moisture Sensitivity (TSR)
  - 7% air voids

47

48

Final Report

DMF/JMF number (401 only)				RAP in mixture, %	5.0
DMF/JMF number (402 only)				RAP binder, extracted, %	5.2
Material Code				Ignition oven test temp., °C (°F)	538 c
All applic. 401 ESAL Categories	4			Ignition oven calibration factor	0.57
All applicable 402 Types	A,B,C,D			Ignition oven number	3316
PG-High Temp. Grade (equivalent)				Binder, ignition (actual), %	5.9
Mixture course	Surface			Binder, extracted, %	5.8
Mixture designation	9.5mm			*Extraction required? *Yes or No	NO
Maximum particle size	9.5			Binder, calculated effective, %	4.9
	Spec	Mass	Volume	Gyrations Nini/Ndes/Nmax	6 50 75
%Pass 37.5mm	100.0	100.0	100.0	Mass gyratory pill @ Ndes, g	4820.6
%Pass 25.0mm	100.0	100.0	100.0	Gmm	2.529
%Pass 19.0mm	100.0	100.0	100.0	Gmm w/ dry back? Yes or No	YES
%Pass 12.5mm	100.0	100.0	100.0	Gmm % @ Nini and Nmax	85.7 97.5
%Pass 9.5mm	90-100	92.5	92.6	Gmb @ Ndes	2.428
%Pass 4.75mm	<90	62.3	62.6	Air Voids @ Ndes, %	5.0
%Pass 2.36mm	32-67	49.5	50.0	VMA @ Ndes, %	16.5
%Pass 1.18mm		29.4	29.8	VFA @ Ndes, %	70.0
%Pass 600µm		18.4	18.6	Coarse agg. ang. 1 & 2 face, %	65.0
%Pass 300µm		11.6	11.8	Fine aggregate angularity	47.4
%Pass 150µm		7.2	7.3	Sand equivalency	90.1
%Pass 75µm	2-10	4.8	4.9	Dust/calculated effective binder	1.0
Aggregate blend Gsb	2.700			Tensile strength ratio, %	108.0
Mix temp. Min. °C (°F)	127c			Draindown, % (SMA or OG only)	NA
Mix temp. Max. °C (°F)	160c			Date ignition.oven samples submitted	upon request
Mix compaction temp. lab °C (°F)	150c			MAF calculated by Designer	1.026
* Note - Written request required, submit w / DMF				**MAF by DMTE for PE/PS**	**1.026**

48

Relationship of Mix Design Properties to Performance

INDOT Certified Asphalt Lab Technician Program
Chapter Four

1

2

Pavement Properties

Rut Resistance

2

3

3

4

Low Rut Resistance

Causes	Effects
Excess asphalt content	Rutting, flushing or bleeding
Excess natural sand	Tenderness during and after rolling Difficult to compact
Rounded aggregate, few or no crushed faces	Rutting

4

5

6

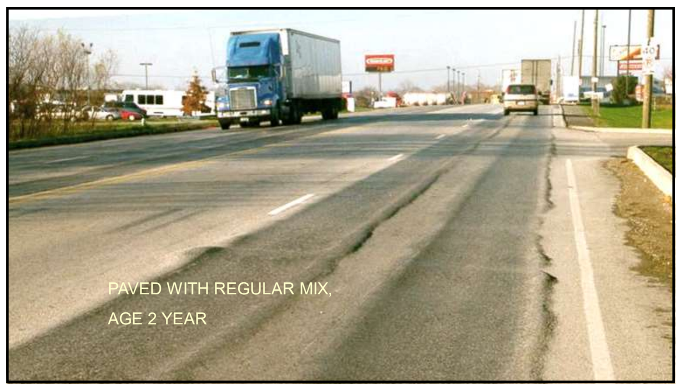
7

Low Rut Resistance

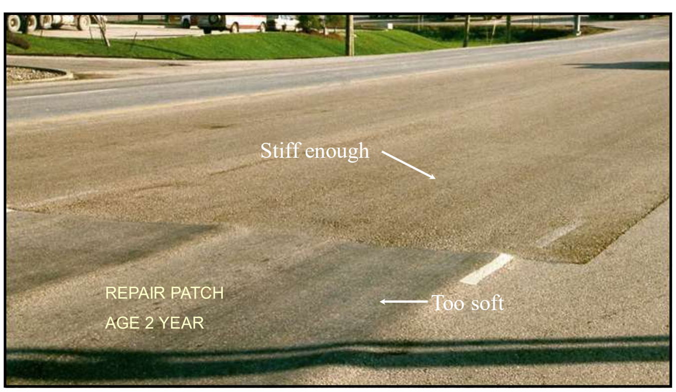
Causes	Effects
Excess asphalt content	Rutting, flushing or bleeding
Excess natural sand	Tenderness during and after rolling Difficult to compact
Rounded aggregate, few or no crushed faces	Rutting

8

9

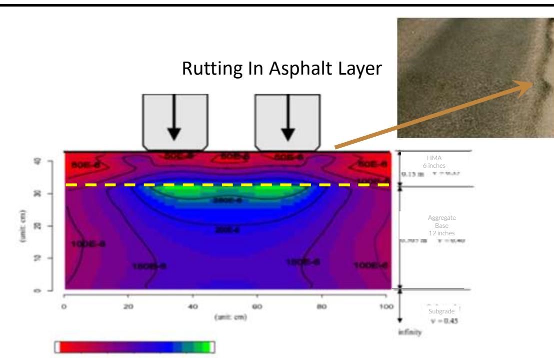


10



11

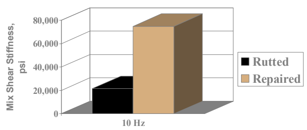
Rutting In Asphalt Layer



12

13

Mixture Stiffness



13

14

15

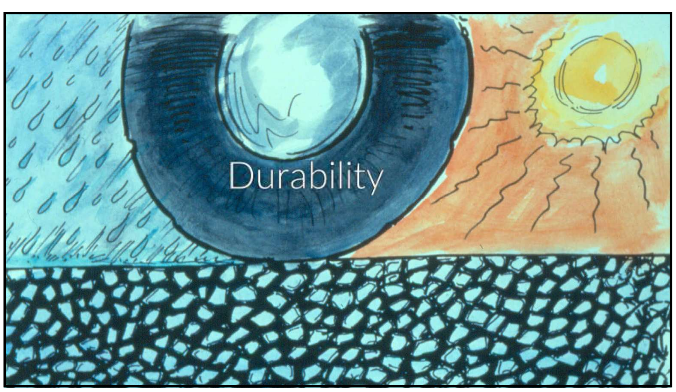
16

Pavement Properties

Rut Resistance

Durability

16



17

18

Poor Mix Durability

Causes	Effects
Low asphalt content	Dryness, raveling
High voids content	Early hardening of asphalt followed by cracking or disintegration
Water susceptible aggregate	Asphalt strips from aggregate causing raveled, low stiffness pavement

18

19

Poor Mix Durability

Causes	Effects
Low asphalt content	Dryness, raveling
High voids content	Early hardening of asphalt followed by cracking or disintegration
Water susceptible aggregate	Asphalt strips from aggregate causing raveled, low stiffness pavement

20

21

22

Poor Mix Durability

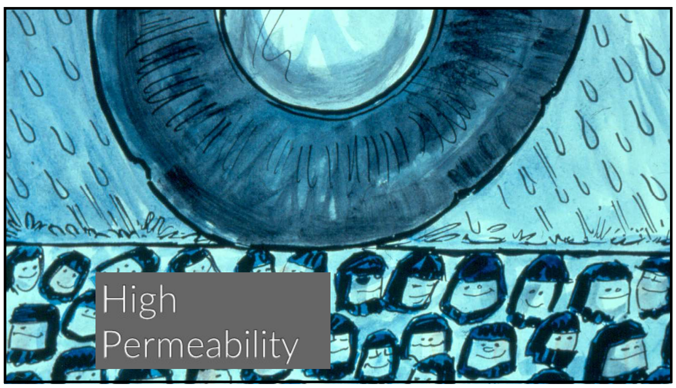
Causes	Effects
Low asphalt content	Dryness, raveling
High voids content	Early hardening of asphalt followed by cracking or disintegration
Water susceptible aggregate	Asphalt strips from aggregate causing raveled, low stiffness pavement

23

24

25

26



27

28

29

30

31

32

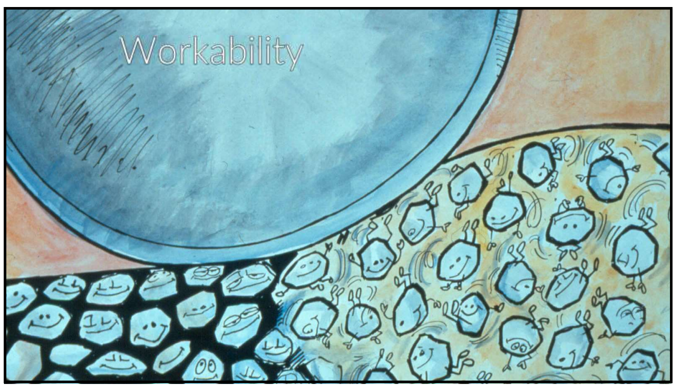
Pavement Properties

Rut Resistance

Durability

Workability

32



33

34

Poor Mix Workability

Causes	Effects
Large maximum size particles	Difficult to place
Excess coarse aggregate	Difficult to compact
Excess natural sand	Tenderness
Low P_{200} (dust)	Tenderness
High P_{200} (dust)	Dryness, gumminess

34

35

36

37

38

39

40

Poor Mix Workability

Causes	Effects
Large maximum size particles	Difficult to place
Excess coarse aggregate	Difficult to compact
Excess natural sand	Tenderness
Low P_{200} (dust)	Tenderness
High P_{200} (dust)	Dryness, gumminess

40

41

42

43

44

Poor Mix Workability

Causes	Effects
Large maximum size particles	Difficult to place
Excess coarse aggregate	Difficult to compact
Excess natural sand	Tenderness
Low P_{200} (dust)	Tenderness
High P_{200} (dust)	Dryness, gumminess

44

45

46

47

48

Poor Mix Workability

Causes	Effects
Large maximum size particles	Difficult to place
Excess coarse aggregate	Difficult to compact
Excess natural sand	Tenderness
Low P_{200} (dust)	Tenderness
High P_{200} (dust)	Dryness, gumminess

49

Pavement Properties

Rut Resistance

Durability

Fatigue Resistance

Workability

50

51

Poor Fatigue Resistance

Causes	Effects
Low asphalt content	Cracking
High voids in-place content	Early aging of asphalt binder followed by cracking
Inadequate pavement thickness	Excessive bending followed by cracking

52

53

54

55

Pavement Properties

Rut Resistance

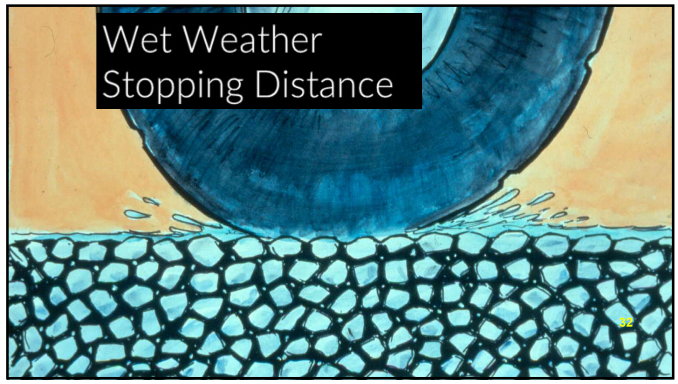
Friction

Workability

Durability

Fatigue Resistance

55



56

57

Poor Friction

- Increases Stopping Distance

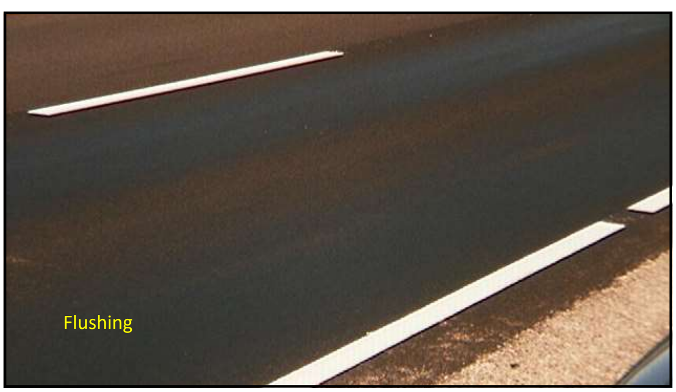
57

58

Poor Friction

Causes	Effects
Excess asphalt content	Bleeding, low wet weather friction
Poorly textured (smooth) aggregate	Low wet weather friction
Polishing aggregate	Low wet weather friction

58



59

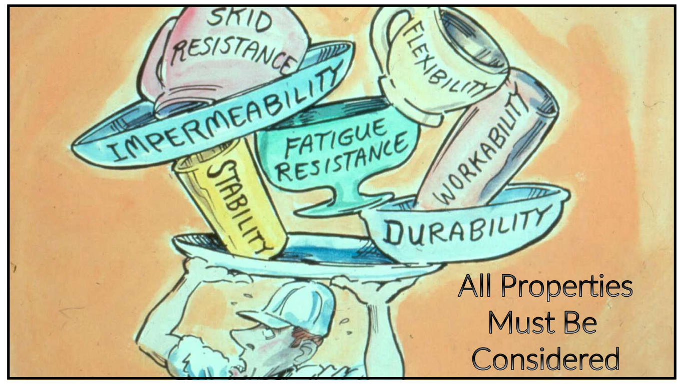
60

Poor Friction

Causes	Effects
Excess asphalt content	Bleeding, low wet weather friction
Poorly textured (smooth) aggregate	Low wet weather friction
Polishing aggregate	Low wet weather friction

60

61



62

63

Relationship of Mixture Properties to Performance

- Rutting
- Fatigue Cracking
- Low Temperature Cracking
- Aging

- PG High Temperature
- PG Low Temperature
- Coarse Aggregate Angularity (CAA)
- Fine Aggregate Angularity (FAA)
- Gradation

- Air Voids in-place (Va_{ip})
- Effective Asphalt Content (Vbe)
- Voids in Mineral Aggregate in-place (VMA_{ip})
- Voids Filled with Asphalt in-place (VFA_{ip})

63

64

Relationship of Mixture Properties to Performance

- Rutting
- Fatigue Cracking
- Low Temperature Cracking
- Aging

- PG High Temperature
- PG Low Temperature
- Coarse Aggregate Angularity (CAA)
- Fine Aggregate Angularity (FAA)
- Gradation

- Air Voids in-place (Va_{ip})
- Effective Asphalt Content (Vbe)
- Voids in Mineral Aggregate in-place (VMA_{ip})
- Voids Filled with Asphalt in-place (VFA_{ip})

64

65

Relationship of Mixture Properties to Performance

- Rutting
- Fatigue Cracking
- Low Temperature Cracking
- Aging

- PG High Temperature
- PG Low Temperature
- Coarse Aggregate Angularity (CAA)
- Fine Aggregate Angularity (FAA)
- Gradation

- Air Voids in-place (Va_{ip})
- Effective Asphalt Content (Vbe)
- Voids in Mineral Aggregate in-place (VMA_{ip})
- Voids Filled with Asphalt in-place (VFA_{ip})

65

66

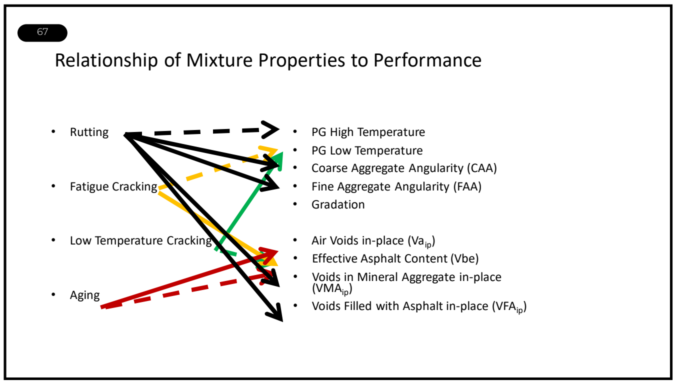
Relationship of Mixture Properties to Performance

- Rutting
- Fatigue Cracking
- Low Temperature Cracking
- Aging

- PG High Temperature
- PG Low Temperature
- Coarse Aggregate Angularity (CAA)
- Fine Aggregate Angularity (FAA)
- Gradation

- Air Voids in-place (Va_{ip})
- Effective Asphalt Content (Vbe)
- Voids in Mineral Aggregate in-place (VMA_{ip})
- Voids Filled with Asphalt in-place (VFA_{ip})

66


67
Relationship of Mixture Properties to Performance
• Rutting
• Fatigue Cracking
• Low Temperature Cracking
• Aging
• PG High Temperature
• PG Low Temperature
• Coarse Aggregate Angularity (CAA)
• Fine Aggregate Angularity (FAA)
• Gradation
• Air Voids in-place (Va_{ip})
• Effective Asphalt Content (Vbe)
• Voids in Mineral Aggregate in-place (VMA_{ip})
• Voids Filled with Asphalt in-place (VFA_{ip})

67

AGGREGATE BLENDING

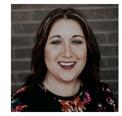
INDOT Certified Asphalt Lab Technician Program

Chapter Four

1

2

Meet the Team



KIRSTEN FOWLER, P.E.

Executive Director
Asphalt Pavement Association of Indiana

2

3

Aggregate Blending

- Plant stockpile blending
  - Cold feeder settings
- Mix Design blending
  - Trial and error
  - Evaluation of blend

3

4

Aggregate Blending Calculations

1. Perform Gradation and Enter Sieve Data
2. Calculate Weight Passing
3. Calculate Percent Passing
4. Calculate Percent Passing for Mix
5. Calculate Combined Gradation

4

5

Example Problem #1

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN									
1 IN									
3/4 IN									
1/2 IN	0								
3/8 IN	93.5				0				
NO. 4	2157.1				40.9				
NO. 8	189.5				385.2				
NO. 16					296.4				
NO. 30					194.8				
NO. 50					153.0				
NO. 100					94.8				
NO. 200					49.2				
PAN					60.7				

5

6

Example Problem #1

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN									
1 IN									
3/4 IN									
1/2 IN	0	2440.3							
3/8 IN	93.5	2346.8			0				
NO. 4	2157.1	189.7			40.9				
NO. 8	189.5				385.2				
NO. 16					296.4				
NO. 30					194.8				
NO. 50					153.0				
NO. 100					94.8				
NO. 200					49.2				
PAN					60.7				

6

7

Example Problem #1

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN									
1 IN									
3/4 IN									
1/2 IN	0	2440.3							
3/8 IN	93.5	2346.8			0	1275.4			
NO. 4	2157.1	189.7			40.9	1234.5			
NO. 8	189.5	0.2			385.2	849.3			
NO. 16					296.4	552.9			
NO. 30					194.8	358.1			
NO. 50					153.0	205.1			
NO. 100					94.8	110.3			
NO. 200					49.2	61.1			
PAN					60.7	0.4			

7

8

Example Problem #1

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN									
1 IN									
3/4 IN									
1/2 IN	0	2440.3							
3/8 IN	93.5	2346.8	96.2%		0	1275.4			
NO. 4	2157.1	189.7			40.9	1234.5			
NO. 8	189.5	0.2			385.2	849.3			
NO. 16					296.4	552.9			
NO. 30					194.8	358.1			
NO. 50					153.0	205.1			
NO. 100					94.8	110.3			
NO. 200					49.2	61.1			
PAN					60.7	0.4			

8

9

Example Problem #1

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN									
1 IN									
3/4 IN									
1/2 IN	0	2440.3	100.0%						
3/8 IN	93.5	2346.8	96.2%		0	1275.4	100.0%		
NO. 4	2157.1	189.7	7.8%		40.9	1234.5	96.8%		
NO. 8	189.5	0.2	0.0%		385.2	849.3	66.6%		
NO. 16					296.4	552.9	43.4%		
NO. 30					194.8	358.1	28.1%		
NO. 50					153.0	205.1	16.1%		
NO. 100					94.8	110.3	8.6%		
NO. 200					49.2	61.1	4.8%		
PAN					60.7	0.4	0.0%		

9

10

Example Problem #1

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN									
1 IN									
3/4 IN									
1/2 IN	0	2440.3	100.0%						
3/8 IN	93.5	2346.8	96.2%	52.9%	0	1275.4	100.0%		
NO. 4	2157.1	189.7	7.8%		40.9	1234.5	96.8%		
NO. 8	189.5	0.2	0.0%		385.2	849.3	66.6%		
NO. 16					296.4	552.9	43.4%		
NO. 30					194.8	358.1	28.1%		
NO. 50					153.0	205.1	16.1%		
NO. 100					94.8	110.3	8.6%		
NO. 200					49.2	61.1	4.8%		
PAN					60.7	0.4	0.0%		

10

11

Example Problem #1

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN				55.0%				45.0%	
1 IN				55.0%				45.0%	
3/4 IN				55.0%				45.0%	
1/2 IN	0	2440.3	100.0%	55.0%				45.0%	
3/8 IN	93.5	2346.8	96.2%	52.9%	0	1275.4	100.0%	45.0%	
NO. 4	2157.1	189.7	7.8%	4.3%	40.9	1234.5	96.8%	43.6%	
NO. 8	189.5	0.2	0.0%	0.0%	385.2	849.3	66.6%	30.0%	
NO. 16					296.4	552.9	43.4%	19.5%	
NO. 30					194.8	358.1	28.1%	12.6%	
NO. 50					153.0	205.1	16.1%	7.2%	
NO. 100					94.8	110.3	8.6%	3.9%	
NO. 200					49.2	61.1	4.8%	2.2%	
PAN					60.7	0.4	0.0%	0.0%	

11

12

Example Problem #1

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN				55.0%				45.0%	
1 IN				55.0%				45.0%	
3/4 IN				55.0%				45.0%	
1/2 IN	0	2440.3	100.0%	55.0%				45.0%	
3/8 IN	93.5	2346.8	96.2%	52.9%	0	1275.4	100.0%	45.0%	
NO. 4	2157.1	189.7	7.8%	4.3%	40.9	1234.5	96.8%	43.6%	47.9%
NO. 8	189.5	0.2	0.0%	0.0%	385.2	849.3	66.6%	30.0%	
NO. 16					296.4	552.9	43.4%	19.5%	
NO. 30					194.8	358.1	28.1%	12.6%	
NO. 50					153.0	205.1	16.1%	7.2%	
NO. 100					94.8	110.3	8.6%	3.9%	
NO. 200					49.2	61.1	4.8%	2.2%	
PAN					60.7	0.4	0.0%	0.0%	

12

Example Problem #1

13

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN				55.0%				45.0%	100.0%
1 IN				55.0%				45.0%	100.0%
3/4 IN				55.0%				45.0%	100.0%
1/2 IN	0	2440.3	100.0%	55.0%				45.0%	100.0%
3/8 IN	93.5	2346.8	96.2%	52.9%	0	1275.4	100.0%	45.0%	97.9%
NO. 4	2157.1	189.7	7.8%	4.3%	40.9	1234.5	96.8%	43.6%	47.9%
NO. 8	189.5	0.2	0.0%	0.0%	385.2	849.3	66.6%	30.0%	30.0%
NO. 16					296.4	552.9	43.4%	19.5%	19.5%
NO. 30					194.8	358.1	28.1%	12.6%	12.6%
NO. 50					153.0	205.1	16.1%	7.2%	7.2%
NO. 100					94.8	110.3	8.6%	3.9%	3.9%
NO. 200					49.2	61.1	4.8%	2.2%	2.2%
PAN					60.7	0.4	0.0%	0.0%	0.0%

13

Example Problem #1

14

Material	#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				45.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	2440.3				1275.4				
1 1/2 IN				55.0%				45.0%	100.0%
1 IN				55.0%				45.0%	100.0%
3/4 IN				55.0%				45.0%	100.0%
1/2 IN	0	2440.3	100.0%	55.0%				45.0%	100.0%
3/8 IN	93.5	2346.8	96.2%	52.9%	0	1275.4	100.0%	45.0%	97.9%
NO. 4	2157.1	189.7	7.8%	4.3%	40.9	1234.5	96.8%	43.6%	47.8%
NO. 8	189.5	0.2	0.0%	0.0%	385.2	849.3	66.6%	30.0%	30.0%
NO. 16					296.4	552.9	43.4%	19.5%	19.5%
NO. 30					194.8	358.1	28.1%	12.6%	12.6%
NO. 50					153.0	205.1	16.1%	7.2%	7.2%
NO. 100					94.8	110.3	8.6%	3.9%	3.9%
NO. 200					49.2	61.1	4.8%	2.2%	2.2%
PAN					60.7	0.4	0.0%	0.0%	0.0%

14

Example Problem #2

15

Material	#8 Stone				#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				25.0%				20.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	4720.0				2150.0				570.0				
1 1/2 IN													
1 IN	0												
3/4 IN	883.4												
1/2 IN	1571.6				0								
3/8 IN	982.9				322.3				0				
NO. 4	1043.2				1288.1				16.4				
NO. 8	184.0				488.0				112.5				
NO. 16									69.3				
NO. 30									184.2				
NO. 50									81.9				
NO. 100									64.0				
NO. 200									28.9				

15

Example Problem #2

16

Material	#8 Stone				#11 Stone				Sand				Combined Gradation %
Percent Used	55.0%				25.0%				20.0%				
Sieves	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	Fraction Wt. Ret.	Tot. Wt. Passing	% Passing	% For Mix	
TOTALS	4720.0				2150.0				570.0				
1 1/2 IN				55.0%				25.0%				20.0%	100.0%
1 IN	0	4720.0	100.0%	55.0%				25.0%				20.0%	100.0%
3/4 IN	883.4	3836.6	81.3%	44.7%				25.0%				20.0%	89.7%
1/2 IN	1571.6	2265.0	48.0%	26.4%	0	2150.0	100.0%	25.0%				20.0%	51.4%
3/8 IN	982.9	1282.1	27.2%	15.0%	322.3	1827.7	85.0%	21.3%	0	570.0	100.0%	20.0%	56.3%
NO. 4	1043.2	238.9	5.1%	2.8%	1288.1	539.6	25.1%	6.3%	16.4	553.6	97.1%	19.4%	28.5%
NO. 8	184.0	54.9	1.2%	0.7%	488.0	51.6	2.4%	0.6%	112.5	441.1	77.4%	15.5%	16.8%
NO. 16				0.7%				0.6%	69.3	371.8	65.2%	13.0%	14.3%
NO. 30				0.7%				0.6%	184.2	187.6	32.9%	6.6%	7.9%
NO. 50				0.7%				0.6%	81.9	105.7	18.5%	3.7%	5.0%
NO. 100				0.7%				0.6%	64.0	41.7	7.3%	1.5%	2.8%
NO. 200				0.7%				0.6%	28.9	12.8	2.2%	0.4%	1.7%

16

QC/QA Program and Asphalt Acceptance

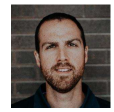
INDOT Certified Asphalt Lab Technician Program

Chapter Seven

1

2

Meet the Team



NATHAN AWWAD, PE

Asphalt Engineer

Indiana Department of Transportation

2

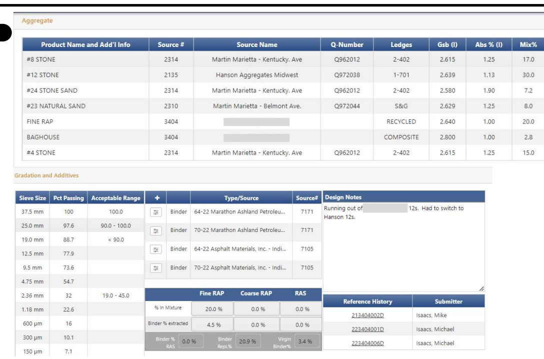
3

Design Mix Formulas (DMFs)

- Shall be in accordance with 401.05, 402.05 or 410.05
- DMFs must come from an INDOT Approved Mix Design Laboratory
- All mix must be produced at an INDOT Certified HMA Plant
- Online system "DMF ENTRY"

3

4



Aggregate

Product Name and Add'l Info	Source #	Source Name	Q-Number	Ledges	Gsb (I)	Abs % (I)	Mix%
#8 STONE	2314	Martin Marietta - Kentucky. Ave	Q962012	2-402	2.615	1.25	17.0
#12 STONE	2135	Hanson Aggregates Midwest	Q972038	1-701	2.639	1.13	30.0
#24 STONE SAND	2314	Martin Marietta - Kentucky. Ave	Q962012	2-402	2.580	1.90	7.2
#23 NATURAL SAND	2310	Martin Marietta - Belmont Ave.	Q972044	S&G	2.629	1.25	8.0
FINE RAP	3404			RECYCLED	2.640	1.00	20.0
BAGHOUSE	3404			COMPOSITE	2.800	1.00	2.8
#4 STONE	2314	Martin Marietta - Kentucky. Ave	Q962012	2-402	2.615	1.25	15.0

Gradation and Additives

Sieve Size	Pct Passing	Acceptable Range
37.5 mm	100	100.0
25.0 mm	97.6	90.0 - 100.0
19.0 mm	88.7	< 90.0
12.5 mm	77.9	
9.5 mm	73.6	
4.75 mm	54.7	
2.36 mm	32	19.0 - 45.0
1.18 mm	22.6	
600 μm	16	
300 μm	10.1	
150 μm	7.1	

+		Type/Source	Source#
	Binder	64-22 Marathon Ashland Petroleu...	7171
	Binder	70-22 Marathon Ashland Petroleu...	7171
	Binder	64-22 Asphalt Materials, Inc. - Indi...	7105
	Binder	70-22 Asphalt Materials, Inc. - Indi...	7105

	Fine RAP	Coarse RAP	RAS
% In Mixture	20.0 %	0.0 %	0.0 %
Binder % extracted	4.5 %	0.0 %	0.0 %

Binder % RAS 0.0 % Binder Repl.% 20.9 % Virgin Binder% 3.4 %

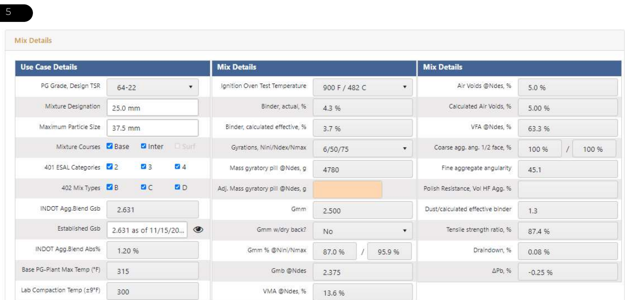
Design Notes

Running out of 12s. Had to switch to Hanson 12s.

Reference History	Submitter
213404002D	Isaacs, Mike
223404001D	Isaacs, Michael
223404006D	Isaacs, Michael

4

5



Mix Details

Use Case Details	
PG Grade, Design TSR	64-22
Mixture Designation	25.0 mm
Maximum Particle Size	37.5 mm
Mixture Courses	☑ Base ☑ Inter ☐ Surf
401 ESAL Categories	☑ 2 ☑ 3 ☑ 4
402 Mix Types	☑ B ☑ C ☑ D
INDOT Agg.Blend Gsb	2.631
Established Gsb	2.631 as of 11/15/20...
INDOT Agg.Blend Abs%	1.20 %
Base PG-Plant Max Temp (°F)	315
Lab Compaction Temp (±9°F)	300

Mix Details	
Ignition Oven Test Temperature	900 F / 482 C
Binder, actual, %	4.3 %
Binder, calculated effective, %	3.7 %
Gyrations, Nini/Ndex/Nmax	6/50/75
Mass gyratory pill @Ndes, g	4780
Adj. Mass gyratory pill @Ndes, g	
Gmm	2.500
Gmm w/dry back?	No
Gmm % @Nini/Nmax	87.0 % / 95.9 %
Gmb @Ndes	2.375
VMA @Ndes, %	13.6 %

Mix Details	
Air Voids @Ndes, %	5.0 %
Calculated Air Voids, %	5.00 %
VFA @Ndes, %	63.3 %
Coarse agg. ang. 1/2 face, %	100 % / 100 %
Fine aggregate angularity	45.1
Polish Resistance, Vol HF Agg. %	
Dust/calculated effective binder	1.3
Tensile strength ratio, %	87.4 %
Draindown, %	0.08 %
ΔPb, %	-0.25 %

5

6

3 Main HMA Specifications

401 -- QC/QA HMA

Dense Graded

Open Graded

402 – HMA

410 – QC/QA HMA , **S**tone **M**atrix **A**sphalt

6

Lots and Sublots – Dense Graded

401.07

Base/Intermediate:

- Lot = 5,000 tons
- Sublot = 1,000 tons

Surface:

- Lot = 3,000 tons
- Sublot = 600 tons

7

Lots and Sublots – SMA

410.07

Intermediate:

- Lot = 4,000 tons
- Sublot = 1,000 tons

Surface:

- Lot = 2,400 tons
- Sublot = 600 tons

8

Different Mixes are Accepted in Different Ways

- 401 mix less than a Lot – Single sublot
- 401 mix by Lot – **P**ercent **W**ithin **L**imits
- 410 SMA – Adjustment Points
- Open Graded – Single Sublot
- 402 mix – Certification

9

Volumetric Formulas

$$\text{Air Voids, \%} = 100 \times \frac{(Gmm - Gmb_{pill})}{Gmm}$$

$$\text{Vbe, \%} = VMA - Air\ Voids$$

$$\text{VMA, \%} = 100 - \frac{(Gmb_{pill} \times Ps)}{Gsb}$$

$$\text{Density, \%} = 100 \times \frac{(Gmb_{core})}{Gmm}$$

10

Testing

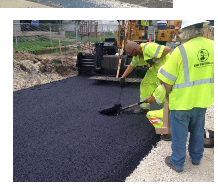
An acceptance sample will consist of plate samples and cores obtained in accordance with ITM 802 and ITM 580.

The Engineer will randomly select the location within each sublot lot for sampling in accordance with ITM 802.

INDOT will take immediate possession of the sample

11

Sampling



12

401 Mix – Single Sublot

Air Voids	
Dense Graded Deviation from Spec (±%)	Pay Factor
≤ 0.5	1.05
> 0.5 and ≤ 1.7	1.00
1.8	0.96
1.9	0.90
2.0	0.84
> 2.0	Submitted to the Office of Materials Management*

* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.

Volume of Effective Binder, Vbe	
Dense Graded Deviation from Spec Minimum	Pay Factors
> +3.0	Submitted to the Office of Materials Management*
≥ +2.5 and ≤ +3.0	1.00 - 0.05 for each 0.1% above +2.5%
≥ +2.0 and < +2.5	1.05 - 0.01 for each 0.1% above +2.0%
> +0.5 and < +2.0	1.05
≥ 0.0 and ≤ +0.5	1.05 - 0.01 for each 0.1% below +0.5%
≥ -0.5 and < 0.0	1.00 - 0.02 for each 0.1% below 0.0%
≥ -2.0 and < -0.5	0.90 - 0.06 for each 0.1% below - 0.5%
< -2.0	Submitted to the Office of Materials Management*

* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.

Density	
Percentages are based on %MSG Dense Graded	Pay Factors, %
≥ 98.0	Submitted to the Office of Materials Management*
97.0 - 97.9	1.00
96.6 - 96.9	1.05 - 0.01 for each 0.1% above 96.5
95.0 - 96.5	1.05
94.1 - 94.9	1.00 + 0.005 for each 0.1% above 94.0
93.0 - 94.0	1.00
92.0 - 92.9	1.00 - 0.005 for each 0.1% below 93.0
91.0 - 91.9	0.95 - 0.010 for each 0.1% below 92.0
90.0 - 90.9	0.85 - 0.030 for each 0.1% below 91.0
≤ 89.9	Submitted to the Office of Materials Management*

* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.

13

401 Mix – Single Sublot

Air Voids					
AV	PF	AV	PF	AV	PF
2.9	Fail	4.3	1.00	5.7	1.00
3.0	0.84	4.4	1.00	5.8	1.00
3.1	0.90	4.5	1.05	5.9	1.00
3.2	0.96	4.6	1.05	6.0	1.00
3.3	1.00	4.7	1.05	6.1	1.00
3.4	1.00	4.8	1.05	6.2	1.00
3.5	1.00	4.9	1.05	6.3	1.00
3.6	1.00	5.0	1.05	6.4	1.00
3.7	1.00	5.1	1.05	6.5	1.00
3.8	1.00	5.2	1.05	6.6	1.00
3.9	1.00	5.3	1.05	6.7	1.00
4.0	1.00	5.4	1.05	6.8	0.96
4.1	1.00	5.5	1.05	6.9	0.90
4.2	1.00	5.6	1.00	7.0	0.84
				7.1	Fail

14

401 Mix – Single Sublot

Vbe					
Deviation*	PF	**Deviation***	PF	**Deviation***	PF
-2.1	fail	**-0.3**	0.94	**1.5**	1.05
-2.0	0.00	**-0.2**	0.96	**1.6**	1.05
-1.9	0.06	**-0.1**	0.98	**1.7**	1.05
-1.8	0.12	**0.0**	1.00	**1.8**	1.05
-1.7	0.18	**0.1**	1.01	**1.9**	1.05
-1.6	0.24	**0.2**	1.02	**2.0**	1.05
-1.5	0.30	**0.3**	1.03	**2.1**	1.04
-1.4	0.36	**0.4**	1.04	**2.2**	1.03
-1.3	0.42	**0.5**	1.05	**2.3**	1.02
-1.2	0.48	**0.6**	1.05	**2.4**	1.01
-1.1	0.54	**0.7**	1.05	**2.5**	1.00
-1.0	0.60	**0.8**	1.05	**2.6**	0.95
-0.9	0.66	**0.9**	1.05	**2.7**	0.90
-0.8	0.72	**1.0**	1.05	**2.8**	0.85
-0.7	0.78	**1.1**	1.05	**2.9**	0.80
-0.6	0.84	**1.2**	1.05	**3.0**	0.75
-0.5	0.90	**1.3**	1.05	**3.1**	fail
-0.4	0.92	**1.4**	1.05		

*Spec minimum

9.5mm @13.2 Vbe?

Vbe, CRITERIA @ N_{des}	
Mixture Designation	Minimum Vbe, %
4.75 mm	12.0
9.5 mm	11.0
12.5 mm	10.0
19.0 mm	9.0
25.0 mm	8.0
OG	n/a

15

401 Mix – Single Sublot

Density							
Density	PF	**Density**	PF	**Density**	PF	**Density**	PF
89.9	Fail	**91.9**	0.940	**93.9**	1.000	**96.0**	1.050
90.0	0.550	**92.0**	0.950	**94.0**	1.000	**96.1**	1.050
90.1	0.580	**92.1**	0.955	**94.1**	1.005	**96.2**	1.050
90.2	0.610	**92.2**	0.960	**94.2**	1.010	**96.3**	1.050
90.3	0.640	**92.3**	0.965	**94.3**	1.015	**96.4**	1.050
90.4	0.670	**92.4**	0.970	**94.4**	1.020	**96.5**	1.050
90.5	0.700	**92.5**	0.975	**94.5**	1.025	**96.6**	1.040
90.6	0.730	**92.6**	0.980	**94.6**	1.030	**96.7**	1.030
90.7	0.760	**92.7**	0.985	**94.7**	1.035	**96.8**	1.020
90.8	0.790	**92.8**	0.990	**94.8**	1.040	**96.9**	1.010
90.9	0.820	**92.9**	0.995	**94.9**	1.045	**97.0**	1.000
91.0	0.850	**93.0**	1.000	**95.0**	1.050	**97.1**	1.000
91.1	0.860	**93.1**	1.000	**95.1**	1.050	**97.2**	1.000
91.2	0.870	**93.2**	1.000	**95.2**	1.050	**97.3**	1.000
91.3	0.880	**93.3**	1.000	**95.3**	1.050	**97.4**	1.000
91.4	0.890	**93.4**	1.000	**95.4**	1.050	**97.5**	1.000
91.5	0.900	**93.5**	1.000	**95.5**	1.050	**97.6**	1.000
91.6	0.910	**93.6**	1.000	**95.6**	1.050	**97.7**	1.000
91.7	0.920	**93.7**	1.000	**95.7**	1.050	**97.8**	1.000
91.8	0.930	**93.8**	1.000	**95.8**	1.050	**97.9**	1.000
				95.9	1.050	**98.0**	Fail

16

401 Mix – Single Sublot

Sublot Composite Pay Factor

$$SCPF = 0.30\,(PF_{VOIDS}) + 0.35\,(PF_{VBE}) + 0.35\,(PF_{DENSITY})$$

17

401 Mix – Single Sublot

9.5 mm Surface	DMF Target	Sublot 1 600 tons	Sublot 2 600 tons	**Sublot 3** **600 tons**	Sublot 4 600 tons
Air Voids	5.00	4.46	4.07	**4.99**	5.25
Vbe Gsb = 2.710	11.2	12.69	12.98	**12.97**	12.56
Density (% Gmm)		94.1	93.8	**93.0**	93.9

18

401 Mix – Single Sublot

Sublot Composite Pay Factor

SCPF = 0.30 (PF_{VOIDS}) + 0.35 (PF_{VBE}) + 0.35 ($PF_{DENSITY}$)

9.5 mm Surface	Sublot 3 600 tons
AV	4.99
Vbe	12.97
Density %	93.0

SCPF = 0.30 (1.05) + 0.35 (1.05) + 0.35 (1.00)

SCPF = 1.033   SCPF = 1.03

19

401 Mix – Single Sublot

QA Adjustment (\$) = L x U x (SCPF – 1.00) / MAF

L = Sublot Quantity

U = Unit Price

SCPF = Sublot Composite Pay Factor

MAF = Mixture Adjustment Factor ?

20

401 Mix – Single Sublot

MAF_i = DMF Gmm ÷
2.465 for 9.5 mm
2.500 for all else

DMF Gmm = 2.544

MAF_i = (2.544 / 2.465) = 1.032

MAF_i > 1.020 → MAF = MAF_i – 0.020

0.980 ≤ MAF_i ≤ 1.020 → MAF = 1.000

MAF_i < 0.980 → MAF = MAF_i + 0.020

MAF = (1.032) - 0.020 = 1.012

21

401 Mix – Single Sublot

QA Adjustment (\$) = L x U x (SCPF – 1.00) / MAF

L = Sublot Quantity

U = Unit Price

SCPF = Sublot Composite Pay Factor

MAF = Mixture Adjustment Factor

QA (\$) = 600.00ton x \$74.00/ton x (1.03 – 1.00) / 1.012

QA (\$) = + \$1,316.21

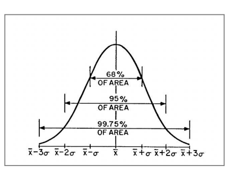
QA (\$) = + \$1,332.00
(No MAF)

22

401 Mix – Percent-Within-Limits (By Lots)

Quality Measure

- Estimates the percentage of material within specification limits
- Assumes normal distribution



Benefits

- A more discerning quality measure:
- Captures the mean *and* standard deviation
- Encourages Uniformity

23

401 Mix – PWL (By Lots)

$$\text{Air Voids, \%} = 100 \times \frac{(Gmm - Gmb_{pill})}{Gmm}$$

$$\text{Vbe, \%} = VMA - Air\ Voids$$

$$\text{VMA, \%} = 100 - \frac{(Gmb_{pill} \times Ps)}{Gsb}$$

$$\text{Density, \%} = 100 \times \frac{(Gmb_{core})}{Gmm}$$

Average, $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$

Standard Deviation, $s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$

24

401 Mix – PWL (By Lots)

Example Problem

9.5.5 mm Surface
$74.00 / ton

3000 tons
5 - 600 ton sublots

MAF = 1.012

25

401 Mix – PWL (By Lots)

401.19 Specification Limits

	Lower Spec Limit LSL	Upper Spec Limit USL
Air Voids @ Ndes, %	3.60	6.40
Vbe @ Ndes, %	Spec	Spec + 2.50
	11.00	11.00+ 2.50
		13.5
Core Density, % Gmm	93.00	Not Applicable

26

401 Mix – PWL (By Lots)

9.5 mm Surface	DMF Target	Sublot 1 600 tons	Sublot 2 600 tons	Sublot 3 600 tons	Sublot 4 600 tons	Sublot 5 600 tons	$\bar{x}$	s
Air Voids	5.00	4.46	4.07	4.99	5.25	7.36	5.23	1.28
Vbe Gsb = 2.710	11.20	12.69	12.98	12.97	12.56	11.59	12.56	0.57
Density (% Gmm)		92.48	93.02	92.66	93.36	89.32	93.38	1.80
		95.78	94.53	93.18	94.35	95.13		

27

401 Mix – PWL (By Lots)

9.5 mm Surface	$\bar{x}$	s	Q_U USL	$Q_U = \frac{USL-\bar{x}}{s}$	PWL_U	Q_L LSL	$Q_L = \frac{\bar{x}-LSL}{s}$	PWL_L	Total PWL
Air Voids n = 5	5.23	1.28	6.40			3.60			
Vbe n = 5	12.56	0.57	13.5			11.0			
Density (% Gmm) n = 10	93.38	1.80				93.0			

28

401 Mix – PWL (By Lots)

9.5 mm Surface	$\bar{x}$	s	Q_U USL	$Q_U = \frac{USL-\bar{x}}{s}$	PWL_U	Q_L LSL	$Q_L = \frac{\bar{x}-LSL}{s}$	PWL_L	Total PWL
Air Voids n = 5	5.23	1.28	6.40	0.91	81	3.60	1.27	91	72
Vbe n = 5	12.56	0.57	13.5	1.65	99	11.0	2.74	100	99
Density (% Gmm) n = 10	93.38	1.80				93.0	0.21	58	58

29

401 Mix – PWL (By Lots)

Air Voids		Vbe		Density		LCPF	QA Adjustment
PF	0.30 x PF	PF	0.35 x PF	PF	0.35 x PF		

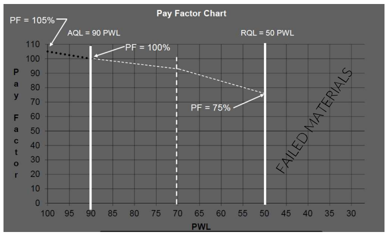
30

401 Mix – PWL (By Lots)

Estimated PWL > 90:
PF = ((0.50 x PWL) + 55.00)/100

Estimated PWL > 70 and ≤ 90:
PF = ((0.40 x PWL) + 64.00)/100

Estimated PWL ≥ 50 and ≤ 70 :
PF = ((0.85 x PWL) + 32.5)/100



31

401 Mix – PWL (By Lots)

Pay Factors										
PWL	9	8	7	6	5	4	3	2	1	0
100	1.05									
90	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.01	1.01	1
80	1.00	0.99	0.99	0.98	0.98	0.98	0.97	0.97	0.96	0.96
70	0.96	0.95	0.95	0.94	0.94	0.94	0.93	0.93	0.92	0.92
60	0.91	0.90	0.89	0.89	0.88	0.87	0.86	0.85	0.84	0.84
50	0.83	0.82	0.81	0.80	0.79	0.78	0.78	0.77	0.76	0.75

32

401 Mix – PWL (By Lots)

Lot Composite Pay Factor

LCPF = 0.30 (PF_{VOIDS}) + 0.35 (PF_{VBE}) + 0.35 ($PF_{DENSITY}$)

Air Voids		Vbe		Density		LCPF	QA Adjustment
PWL = 72		PWL = 99		PWL = 58			
PF	0.30 x PF	PF	0.35 x PF	PF	0.35 x PF	0.93	
0.93	0.279	1.05	0.368	0.82	0.287		

33

401 Mix – PWL (By Lots)

QA Adjustment ($) = L x U x (LCPF – 1.00) / MAF
L = Lot Quantity
U = Unit Price
LCPF = Lot Composite Pay Factor

QA ($) = 3000.00ton x $74.00/ton x (0.93 – 1.00) / 1.012

QA ($) = - $15,355.73

34

401 Mix – PWL (By Lots)

Excel Workbook

STATE - MIX PROPERTIES ACCEPTANCE

Property	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5	Sublot 6	Sublot 7	Sublot 8	Sublot 9
% Binder	6.53	6.49	6.62	6.49	6.18				
% Air Voids	4.46	4.07	4.99	5.25	7.36				
% VMA	17.15	17.05	17.96	17.81	18.95				
% Density, Core 1	92.48	93.02	92.66	93.36	89.32				
% Density, Core 2	95.78	94.53	93.18	94.35	95.13				
% Vbe	12.69	12.98	12.97	12.56	11.59				
% Pbe	5.44	5.56	5.61	5.43	5.10				
%Vbe above min.	1.69	1.98	1.97	1.56	0.59				

Adjst. and is not included in the QA Adjst.

Appeal Adjustment	

LOT QA ADJUSTMENT

Factor	Value
QA Adjustment= Credit $	-$15,355.73
L = Lot Quantity	3000.00
Mix Adjust Factor (MAF)	1.012
U = Unit Price $/Unit	$74.00
LCPF	0.93

STATE - MIX PROPERTIES ACCEPTANCE RESULTS

Property	Average	Sigma	N	Q_U USL	Q_U	PWL_U	Q_L LSL	Q_L	PWL_L	Total PWL
% Air Voids	5.23	1.28	5	6.40	0.91	81	3.60	1.27	91	72
% Vbe	12.56	0.57	5	13.50	1.65	99	11.00	2.74	100	99
% Density, Core 1 / % Density, Core 2	93.38	1.80	10				93.00	0.21	58	58

Signature Technician:

STATE - ACCEPTANCE PWL AND PF RESULTS

Property	PWL		PF
% Air Voids	72		0.93
% Vbe	99		1.05
% Density	58		0.82
LCPF			0.93

NOTES:
Appeal results posted 6/24/19. >TC
LCPF revised per 7/26/19 adjudication letter from John Leckie.

35

401 Mix – PWL (By Lots)

HMA Pay Wizard

Contract: RS-39465 **CLN:** 0023 **DMF:** 193302003 **Lot:** 1 **Acceptance:** PWL

QA/Appeal Unified	Sample Date	Related Sample Id	Rep. Qty (Tons)	Mix % Binder	Mix Gmm	Pill 1 Gmb	Pill 2 Gmb	Pill Avg. Gmb	Core A Gmb	Core B Gmb
Sublot 1	08/22/2019	A194515524100	600.00	6.49	2.399	2.341	2.333	2.337	2.264	2.280
Sublot 2	04/08/2019	R194515524101	600.00	6.60	2.426	2.355	2.350	2.353	2.299	2.311
Sublot 3	04/09/2019	R194515524102	600.00	6.49	2.428	2.337	2.330	2.334	2.260	2.305
Sublot 4	04/09/2019	R194515524103	600.00	6.54	2.428	2.336	2.332	2.334	2.235	2.230
Sublot 5	04/09/2019	R194515524104	600.00	6.58	2.427	2.348	2.349	2.349	2.267	2.212

QA Adjustment **+$4,590.00**
Appeal Adjustment **$500.00**
Total Lot Quantity **3000 Tons**

INDOT T30 Detail

Mix Properties for Acceptance

Acceptance Results and Pay Factors, Final

	Average	Sigma	N	Qu USL	Qu	PWLu	Ql LSL	Ql	PWLl	Total PWL	Pay Factor	LCPF
% Air Voids	3.31	0.65	5	5.40	3.22	100	2.6	1.09	86	86	0.98	1.02
% Vbe	12.21	0.55	5	13.50	2.35	100	11	2.2	100	100	1.05	
% Density	93.52	1.53	10	-	-	-	91	1.65	96	96	1.03	

36

410 Mix – Stone Matrix Asphalt (Adjustment Points

SMA is accepted by 3 main properties

- Aggregate Gradation
- Binder Content
- Density

37

410 Mix – SMA (Adjustment Points)

410.19 of the specifications

ADJUSTMENT POINTS FOR GRADATION								
Adjustment Points	Sieve Size							
	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	600 µm	75 µm
For each 0.1% up to 1.0% out of tolerance	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3
For each 0.1% > 1.0% out of tolerance	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.6

ADJUSTMENT POINTS FOR RANGE	
Sieve Size and Binder Content	Adjustment Points (For each 0.1% out of range)
2.36 mm	0.1
600 µm	0.1
75 µm	0.1
% Binder	1.0

DENSITY	
Percentages are based on % MSG	Pay Adjustments – Percent
> 97.0	Submitted to the Office of Materials Management*
93.0 – 97.0	0.00
92.0 – 92.9	0.20 points for each 0.10% below 93.0
91.0 – 91.9	2.00 + 0.40 points for each 0.10% below 92.0
89.0 – 90.9	6.00 + 1.00 points for each 0.10% below 91.0
≤ 89.0	Submitted to the Office of Materials Management*

* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.

38

410 Mix – SMA (Adjustment Points)

QA Adjustment ($) = (L x U x P/100) / MAF

L = Lot Quantity
U = Unit Price
P = total adjustment points

Example:
Lot Quantity = four 600 ton sublots = 2,400 tons
Unit Price = $69.00 / ton
MAF = 1.124
total adjustment points = 4.0

39

410 Mix – SMA (Adjustment Points)

Lot Quantity = four 600 ton sublots = 2,400 tons
Unit Price = $69.00 / ton
MAF = 1.124
total adjustment points = 4.0

QA ($) = 2,400.00 tons x $69.00 per ton x (4.0/100) / 1.124

*QA ($) = $5,893.24

*There are no bonuses with SMA, so any adjustment points means a credit to the contract ($ to INDOT)

40

410 Mix – SMA (Adjustment Points)

Excel Workbook

Lab Test #									
Sublot No.	1	2	3	4					
Ton Sampled	600	600	600	600					
Sieve Size % CAA & % Binder	Test 1 % Passing	Test 2 % Passing	Test 3 % Passing	Test 4 % Passing	Average Value	Required By DMF/JMF Mass	Accept Tolerance Low	Accept Tolerance High	Adjust Points
25.0 mm	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
19.0 mm	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
12.5 mm	100.0	100.0	100.0	100.0	100.0	100.0	98.0	100.0	
9.5 mm	88.8	89.3	90.2	90.0	89.6	89.1	70.0	95.0	
4.75 mm	40.3	41.1	41.4	39.3	40.5	40.0	30.0	50.0	
2.36 mm	24.2	25.1	24.5	23.9	24.4	25.5	21.5	29.5	
600 µm	16.2	16.6	15.8	16.2	16.2	16.5	14.5	18.5	
75 µm	10.1	10.3	9.9	10.1	10.1	10.0	8.5	11.5	
% CAA							95	100	
% Binder	5.1	5.7	5.8	5.3	5.5	5.9	5.6	6.2	4.0
							Adjustment Points		4.0

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
MSG	2.823	2.801	2.795	2.813
$BSG_{Core\ 1}$	2.636	2.595	2.664	2.639
$BSG_{Core\ 2}$	2.567	2.642	2.545	2.704
BSG_{avg}	2.602	2.619	2.605	2.672
$Density_{\%Gmm}$	92.2	93.5	93.2	95.0

Sieve Size & % Binder	Actual Range Max	Actual Range Min.	Actual Range Difference	Allowable Range	Adjust. Points
2.36 mm	25.1	23.9	1.2	12.0	
600 µm	16.6	15.8	0.8	6.0	
75 µm	10.3	9.9	0.4	2.0	
% Binder	5.8	5.1	0.7	1.0	
			Adjustment Points		0.0

Notes

Density					
Sublot 1	Sublot 2	Sublot 3	Sublot 4	Average Density	Adjust. Points
92.2	93.5	93.2	95.0	93.5	
					0.0

Total Adjustment Points	4.0
Total Pay Factor	0.960
Credit	-5893.24

41

Open Graded Mix – single sublot

Sublot Composite Pay Factor

$$SCPF = 0.20\ (PF_{BINDER}) + 0.35\ (PF_{VOIDS}) + 0.45$$

$$SCPF = 0.20\ (1.04) + 0.35\ (1.00) + 0.45$$

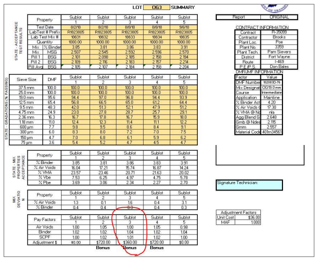
$$SCPF = 1.008$$

<u>SCPF = 1.01</u>

42

Open Graded Mix – single sublot

Excel Workbook



QA Adjustment ($) = L x U x (SCPF – 1.00) / MAF

QA ($) = 1000.00 tons x $36.00 x (1.01 – 1.00) / 1.000

QA ($) = $360.00

43

402 Mix – Less than 300 ton (Certification)

401.09 of the Standard Specifications:

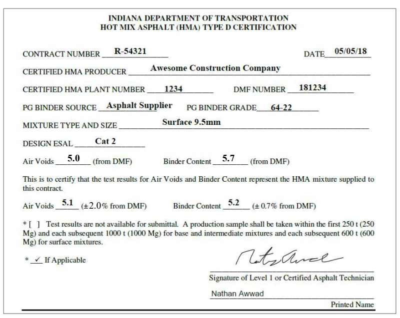
"Acceptance of mixtures for binder content and air voids at N_{des} will be based on a type D certification in accordance with **402.09** for dense graded mixtures with **original contract pay item quantities less than 300 t."**

402.09 of the Standard Specifications:

"Acceptance of mixtures will be in accordance with the Frequency Manual on the basis of a type D certification in accordance with 916. The test results shown on the certification shall be the quality control tests representing the material supplied and include air voids and binder content. **Air voids tolerance shall be ± 2.0%** and **binder content tolerance shall be ± 0.7% from DMF**."

44

402 Mix – Less than 300 ton (Certification)



INDIANA DEPARTMENT OF TRANSPORTATION
HOT MIX ASPHALT (HMA) TYPE D CERTIFICATION

CONTRACT NUMBER R-54321 DATE 05/05/18

CERTIFIED HMA PRODUCER Awesome Construction Company

CERTIFIED HMA PLANT NUMBER 1234 DMF NUMBER 181234

PG BINDER SOURCE Asphalt Supplier PG BINDER GRADE 64-22

MIXTURE TYPE AND SIZE Surface 9.5mm

DESIGN ESAL Cat 2

Air Voids 5.0 (from DMF) Binder Content 5.7 (from DMF)

This is to certify that the test results for Air Voids and Binder Content represent the HMA mixture supplied to this contract.

Air Voids 5.1 (±2.0% from DMF) Binder Content 5.2 (± 0.7% from DMF)

* [ ] Test results are not available for submittal. A production sample shall be taken within the first 250 t (250 Mg) and each subsequent 1000 t (1000 Mg) for base and intermediate mixtures and each subsequent 600 t (600 Mg) for surface mixtures.

* ✓ If Applicable

Signature of Level 1 or Certified Asphalt Technician

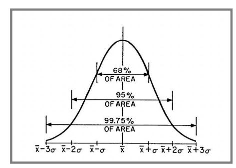
Nathan Awwad

Printed Name

45

QC/QA Program and Asphalt Acceptance

Thank you!



INDOT Certified Asphalt Lab Technician Program

46

PLANTS: Annual Inspection And Calibration

INDOT Certified Asphalt Lab Technician Program
Chapter Five

1

2

Meet the Team

TIM SIEVERS
Mix Cost Analyst
Brooks Construction Company, Inc.

2

3

4

5

6

7

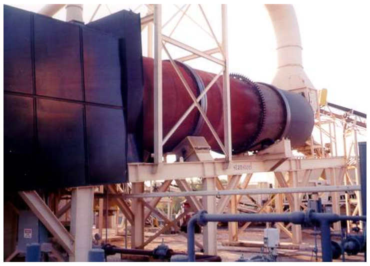
8

9

10

11

12



13

14

15

16

17

18

19

20

21

22

DRUM PLANT

CALIBRATION

22

23

Annual Inspection and Calibration Drum Plant

- For a drum plant, HMA proportioning is accomplished by a moving weight system. The computer monitors must be checked for accuracy.
- The load cell on each aggregate belt must be checked by running material across the load cell into a tared truck. The computer inventory must match the actual weight by 0.5%, in *three consecutive attempts*. A truck load of material should be used each time.

23

24

Annual Inspection and Calibration Drum Plant

- The binder check uses a tared distributor that must check against the pump reading on the flow meter and the computer monitor.
- These units must match the weight in the distributor by 0.5%, *three consecutive times*, within the working range of the plant.
- The fines return system must also be checked to 0.5% accuracy as is done with a batch plant.

24

25

Annual Inspection and Calibration

- Scales and meters shall be checked to the maximum capacity they will be used.
- The allowable difference between the scale reading and the actual weight applied shall be 0.5% or less.
- Meter variation shall also be 0.5% or less.

25

26

Annual Inspection and Calibration

Example 1

26

26

27

Drum Plant
Cold Aggregate Feed System
(Belt Scale Check)

Gross Weight	Tare Weight	**Net Weight**	Gross Comp.	Tare Comp.	Net Comp.	% Error
79,140	36,700		42,720	0		
81,040	36,700		87,210	42,720		
80,290	36,700		130,670	87,210		
78,620	36,700		172,660	130,670		

27

28

Drum Plant
Cold Aggregate Feed System
Belt Scale Check)

Step 1: Determine Net Weight

Net Weight = Gross Weight – Tare Weight
= 79,140 – 36,700
= **42,440**

28

29

Drum Plant
Cold Aggregate Feed System
(Belt Scale Check)

Gross Weight	Tare Weight	**Net Weight**	Gross Comp.	Tare Comp.	Net Comp.	% Error
79,140	36,700	**42,440**	42,720	0		
81,040	36,700		87,210	42,720		
80,290	36,700		130,670	87,210		
78,620	36,700		172,660	130,670		

29

30

Drum Plant
Cold Aggregate Feed System
(Belt Scale Check)

Gross Weight	Tare Weight	Net Weight	Gross Comp.	Tare Comp.	**Net Comp.**	% Error
79,140	36,700	42,440	42,720	0		
81,040	36,700		87,210	42,720		
80,290	36,700		130,670	87,210		
78,620	36,700		172,660	130,670		

30

31

Drum Plant
Cold Aggregate Feed System
Belt Scale Check)

Step 2: Determine Net Computer

Net Weight = Gross Comp. – Tare Comp.
= 42,720 – 0
= **42,720**

31

32

Drum Plant
Cold Aggregate Feed System
(Belt Scale Check)

Gross Weight	Tare Weight	Net Weight	Gross Comp.	Tare Comp.	**Net Comp.**	% Error
79,140	36,700	42,440	42,720	0	**42,720**	
81,040	36,700		87,210	42,720		
80,290	36,700		130,670	87,210		
78,620	36,700		172,660	130,670		

32

33

Drum Plant
Cold Aggregate Feed System
(Belt Scale Check)

Gross Weight	Tare Weight	Net Weight	Gross Comp.	Tare Comp.	Net Comp.	**% Error**
79,140	36,700	42,440	42,720	0	42,720	
81,040	36,700		87,210	42,720		
80,290	36,700		130,670	87,210		
78,620	36,700		172,660	130,670		

33

34

Drum Plant
Cold Aggregate Feed System
(Belt Scale Check)

Step 3: Determine % Error

$$\% \text{ Error} = \frac{\text{Weight}_{known} - \text{Weight}_{varies}}{\text{Weight}_{known}} \times 100$$

$$= \frac{42{,}440 - 42{,}720}{42{,}440} \times 100$$

= 280/42,440 x 100
= 0.0066 x 100
= **0.66**

34

35

Drum Plant
Cold Aggregate Feed System
(Belt Scale Check)

Gross Weight	Tare Weight	Net Weight	Gross Comp.	Tare Comp.	Net Comp.	**% Error**
79,140	36,700	42,440	42,720	0	42,720	**0.66**
81,040	36,700		87,210	42,720		
80,290	36,700		130,670	87,210		
78,620	36,700		172,660	130,670		

35

36

Drum Plant
Cold Aggregate Feed System
(Belt Scale Check)

Gross Weight	Tare Weight	**Net Weight**	Gross Comp.	Tare Comp.	**Net Comp.**	**% Error**
79,140	36,700	42,440	42,720	0	42,720	0.66
81,040	36,700	**44,340**	87,210	42,720	**44,490**	**0.34**
80,290	36,700	**43,590**	130,670	87,210	**43,460**	**0.30**
78,620	36,700	**41,920**	172,660	130,670	**41,990**	**0.17**

36

37

Drum Plant
Asphalt Meter Check

Gross Weight	Tare Weight	**Net Weight**	Computer Weight	% Error
28,030	23,150		4,890	
26,900	22,050		4,870	
25,840	21,050		4,780	

37

38

Drum Plant
Asphalt Meter Check

Step 1: Determine Net Weight

Net Weight = Gross Wt. – Tare Wt.

= 28,030 – 23,150
= **4,880**

38

39

Drum Plant
Asphalt Meter Check

Gross Weight	Tare Weight	**Net Weight**	Computer Weight	% Error
28,030	23,150	**4,880**	4,890	
26,900	22,050		4,870	
25,840	21,050		4,780	

39

40

Drum Plant
Asphalt Meter Check

Gross Weight	Tare Weight	Net Weight	Computer Weight	**% Error**
28,030	23,150	4,880	4,890	
26,900	22,050		4,870	
25,840	21,050		4,780	

40

41

Drum Plant
Asphalt Meter Check

Step 2: Determine % Error

$$\% \text{ Error} = \frac{(\text{Weight}_{known} - \text{Weight}_{varies})}{\text{Weight}_{known}} \times 100$$

$$= \frac{4{,}880 - 4{,}890}{4{,}880} \times 100$$

= 10/4,880 x 100
= 0.0020 x 100
= **0.20**

41

42

Drum Plant
Asphalt Meter Check

Gross Weight	Tare Weight	Net Weight	Computer Weight	**% Error**
28,030	23,150	4,880	4,890	**0.20**
26,900	22,050		4,870	
25,840	21,050		4,780	

42

43

Drum Plant
Asphalt Meter Check

Gross Weight	Tare Weight	**Net Weight**	Computer Weight	**% Error**
28,030	23,150	4,880	4,890	0.20
26,900	22,050	**4,850**	4,870	**0.41**
25,840	21,050	**4,790**	4,780	**0.21**

43

Field Testing

INDOT Certified Asphalt Lab Technician Program

Chapter Seven

1

Meet the Team

CODY FOWLER, P.E.

Regional QC Manager
Rieth-Riley Construction

JASON GALETKA

Assistant Asphalt Engineer
Indiana Department of Transportation

2

Sampling HMA

- All samples to be taken by the contractor/producer.
- INDOT Project Engineer/ Project Supervisor or their designated representative are required to witness the taking of the sample.
- Road samples taken from random locations IAW ITM 802.

3

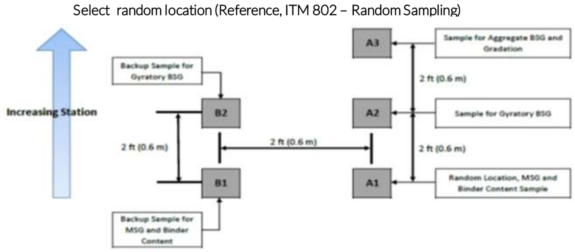
Sampling Techniques

- Plate Samples without a Mold
- Plate Samples with a Mold
- Cores
- Truck Samples
  - 4.75 mm Mixtures
  - Open Graded Mixtures
  - Dense Graded Mixtures

4

Plate Sampling

Select random location (Reference, ITM 802 – Random Sampling)



Transverse Layout

5

Plate Sampling

A2, B2 Boxes

Minimum Sample Sizes
Effective 2017

Size of Sample				
Mixture Designation	Minimum Weight of Sample, g			
	Moisture	MSG and Binder Content	Gyratory Specimens	Aggregate Bulk Specific Gravity
4.75 mm	1,000	3,000	11,000	N/A
9.5 mm	1,500	11,000	11,000	11,000
12.5 mm	2,000	11,000	11,000	11,000
19.0 mm	3,000	11,000	11,000	11,000
25.0 mm	4,000	11,000	11,000	11,000
OG 19.0 mm	3,000	5,500	11,000	N/A
OG 25.0 mm	4,000	7,000	11,000	N/A

A1, B1 Boxes

6

Plate Sampling without a Mold

7

7

Plate Sampling without a Mold

- Apparatus
  - Sampling Plate – 8” square minimum with 3/8” hole
  - No. 18 Mechanics Wire
  - Masonry Nail
  - Pitchfork or Square Bit Shovel
  - Box for Sample with Non-Absorbent Lining
  - Oven bag (for moisture samples)

8

Plate Sampling without a Mold

- Place plate with wire on pavement.
  - (Use nail if movement is a problem.)
- Wire extended beyond pavement width.

9

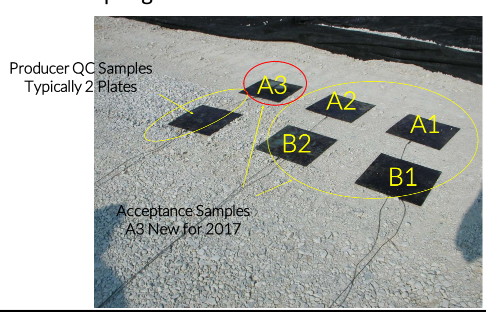
Plate Sampling without a Mold

10

Plate Sampling without a Mold

11

Plate Sampling without a Mold



12

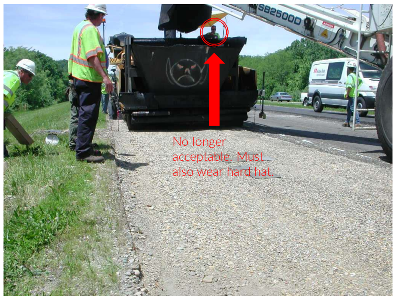
14

Plate Sampling without a Mold

SAFETY NOTE!

QC Technician (on far left) out of the way of the paving crew.

ALL EMPLOYEES on the project wear PPE (Hi-vis shirt/vest, safety-toe boots, hard hat, eye protection)



14

15

Plate Sampling without a Mold

15

16

Plate Sampling without a Mold

16

17

Plate Sampling without a Mold

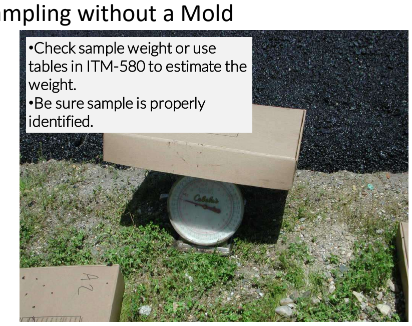
HOT STUFF! = WEAR GLOVES

Place entire sample in box.

17

18

Plate Sampling without a Mold



18

19

Plate Sampling without a Mold

Refill sample hole with HMA.

19

20

Sampling Procedures

- Plate Samples without a Mold
  - Plate Samples with a Mold
- Cores
- Truck Samples
  - 4.75 mm Mixtures
  - Open Graded Mixtures
  - Dense Graded Mixtures

20

21

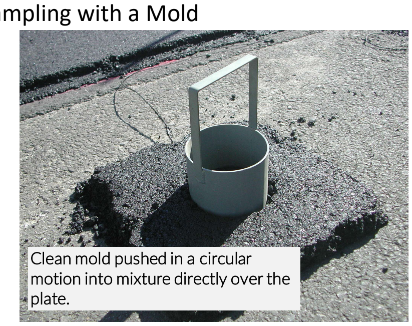
Plate Sampling with a Mold

- Apparatus --
  - Same as sampling without mold plus ...
  - Mold, round with height greater than mixture thickness and diameter less than plate width

21

22

Plate Sampling with a Mold



22

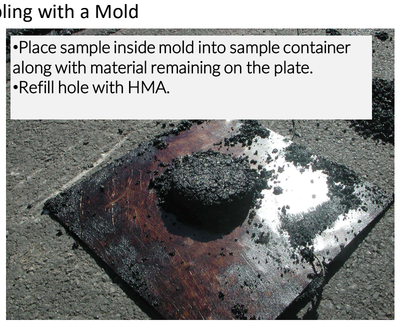
23

Plate Sampling with a Mold

23

24

Plate Sampling with a Mold



24

25

Sampling Procedures

- Plate Samples without a Mold
  - Plate Samples with a Mold
- Cores
- Truck Samples
  - 4.75 mm Mixtures
  - Open Graded Mixtures
  - Dense Graded Mixtures

25

26

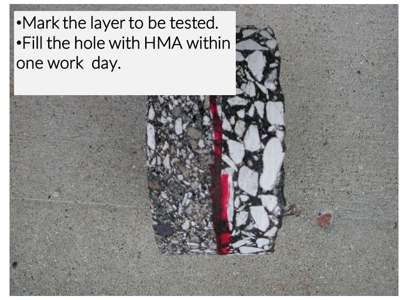
Cores

Cut a uniform 6” diameter pavement sample, being careful not to damage the core.


26

27

Cores



•Mark the layer to be tested.
•Fill the hole with HMA within one work day.

27

28

Sampling Procedures

- Plate Samples without a Mold
  - Plate Samples with a Mold
- Cores
- Truck Samples
  - 4.75 mm Mixtures
  - Open Graded Mixtures
  - Dense Graded Mixtures

28

29

Truck Samples – 4.75 mm Mix

Shovel inserted into several areas that appear uniform in texture.



29

31

Sampling Procedures

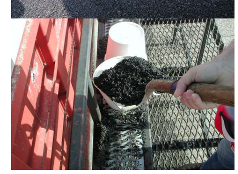
- Plate Samples without a Mold
  - Plate Samples with a Mold
- Cores
- Truck Samples
  - 4.75 mm Mixtures
  - Open Graded Mixtures
  - Dense Graded Mixtures

31

32

Truck Samples – Open Graded Mix

•Shovel inserted into mixture between the center of cone and *front* of truck
•Place sample into container.

32

Truck Samples – Open Graded Mix

- Shovel inserted into mix between the center of the cone and *back* of truck.
- Sample added to first sample.

33

Sampling Procedures

- Plate Samples without a Mold
  - Plate Samples with a Mold
- Cores
- Truck Samples
  - 4.75 mm Mixtures
  - Open Graded Mixtures
  - Dense Graded Mixtures

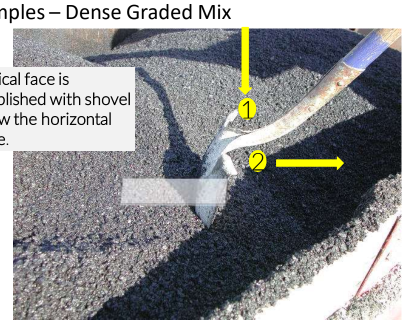
34

Truck Samples – Dense Graded Mix

- Sample location is mid-section of the truck.
- Shovel inserted and lifted to establish horizontal plane.

35

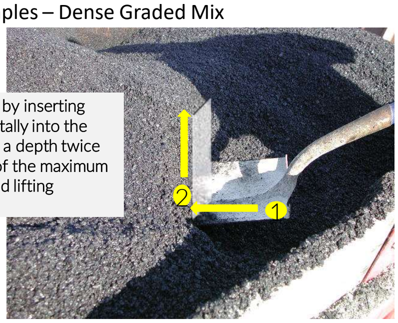
Truck Samples – Dense Graded Mix



Vertical face is established with shovel below the horizontal plane.

37

Truck Samples – Dense Graded Mix



Obtain sample by inserting shovel horizontally into the vertical face at a depth twice the thickness of the maximum particle size and lifting vertically.

38

Truck Samples – Dense Graded Mix

Place sample in container.

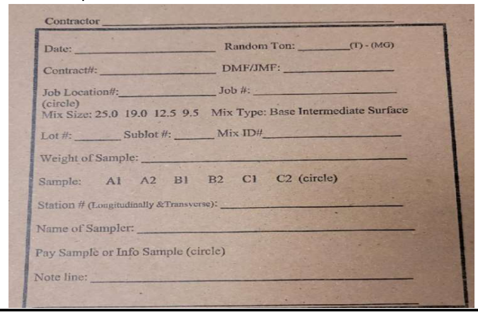
39

Sample Labeling

40

40

Top of Plate Sample Box


Contractor ____________

Date: ____________ Random Ton: ________(T) - (MG)

Contract#: ____________ DMF/JMF: ____________

Job Location#: ____________ Job #: ____________

(circle)
Mix Size: 25.0 19.0 12.5 9.5 Mix Type: Base Intermediate Surface

Lot #: ______ Sublot #: ______ Mix ID#____________

Weight of Sample: ____________

Sample: A1 A2 B1 B2 C1 C2 (circle)

Station # (Longitudinally &Transverse): ____________

Name of Sampler: ____________

Pay Sample or Info Sample (circle)

Note line: ____________

41

41

Plate Sample: Box Labeling

The following information shall be on all box ends for plate samples:

1. A/B sample (A1, A2, A3, B1, B2)
2. Contract Number
3. DMF/JMF Number
4. Item (CLN) Number
5. Lot/Sublot
6. Material Description: Size, Course, ESAL Category, PG Grade
7. Sample Date
8. SiteManager ID Number

42

Plate Sample: Box Label Example

Date:___________________	Random Ton:_____________
Contract #:_____________	DMF:___________________
Job Location:___________	Job #:__________________
Lot: ________ Sublot #:_______	Mix Id:__________________
Sample: A1 A2 B1 B2 C1 C2	

43

Directive 304

- Insufficient Plate Sample Size
  - Original sample
  - Appeal sample

44

44

Pavement Smoothness (SS401.18)

- Smoothness of pavement affects
  - Public safety – vehicles are more controllable
  - Ride quality
  - Pavement longevity? Yes! A smooth road does not suffer point-load impacts.
- How do we monitor smoothness?
  - 16 foot or 10 foot straight edge
  - Profilograph
  - Inertial Profiler

45

46

Straight Edge

46

47

Profilograph – ITM912

47

48

Inertial Profiler – ITM 917

48

49

Sampling HMA

QUESTIONS ?

49

AUDITS AND EQUIPMENT CALIBRATION

INDOT Certified Asphalt Lab Technician Program

Chapter Six

1

2

Meet the Team

ELIZABETH PASTUSZKA
HMA Design &
QC Coordinator – North
E&B Paving, Inc.

HARLEY PHILLIPS
Quality Assurance
Manager
Indiana Department of
Transportation

2

3

Overview

- Types of Audits
- Go through the INDOT audit process
  - INDOT responsibilities
  - Producer Asphalt Technician responsibilities
  - Necessary documentation
  - Equipment Calibration and Verifications

3

4

Types of Audits

- Full Audit Checklist
  - All certified HMA plants that produce mix for INDOT contract(s) each calendar year
- Partial Audit Checklist
  - Certified HMA plants that have already or will have a full audit that calendar year
- No Production Audit Checklist
  - Certified HMA plants where no INDOT mixture was produced that year or after the audit in the previous year

4

5

Audit Process

- Make sure the current audit packet is being used
  - Available online
- General Information and persons present at the audit sign the first page

5

6

1. General Instructions

- The plant number and page number is at the top of each page
- Each Section must have INDOT audit member name
- INDOT Team information
  - Review the QCP prior to audit
  - Review previous year's audit
  - Obtain technician certifications/qualifications and any IA proficiency testing
  - List of INDOT documentation needed during the audit
- Terminology Section

6

7

1. General Instructions (cont'd)

How to fill out the audit packet

- ✓ Satisfactory Item
- X Unsatisfactory Item
- NA Not Applicable
- * Only applicable in some cases

7

8

2. Producer General Information

- QCP general information is correct
- INDOT and Producer QCPs are up to date and the same
- Documentation for Level 1 Asphalt Technician, Certified Technician, or Qualified Technician
- Note if plant is equipped with a water injection foaming device or modified asphalt in-line blending capabilities

8

9

3. Documents

- Current INDOT Specification book
- ICAT Manual
- ITM, AASHTO, ASTM Test Methods referenced in the QCP are **current** and on file
- Number of assigned DMFs in ITAP and SMA DMFs for current calendar year
- Additional documents as needed
  - Fines correction
  - In-line blending information
  - Fibers information

9

10

4. Control Limits-QC/QA HMA and SMA

- Verify test results are within DMF targets or control limits identified by the Producer.
- Review all state properties for one QC/QA HMA (PWL if applicable) or SMA mixture from one current or recently completed contract.
- Select one PWL contract (if applicable) or one of the larger contracts available. Otherwise, select one SMA mixture from one current or recently completed contract.

10

11

4. Control Limits-QC/QA HMA and SMA

Review all test results and properties of that mixture

- Air Voids
- Binder Content
- VMA
  - Dust/Calculated Effective Binder Ratio
  - Volume of Effective Binder
- Aggregate Stockpiles
  - Gradation
- Blended Aggregate
  - Gradation
- Recycled Material Tests
  - Gradation, depending on size of recycled material
  - Binder Content

11

12

5. Diary

- Review of one Production month within current calendar year or past three calendar years.
- General requirements of ITM 583
  - On file for 3 years
  - Open book format
  - One or more pages for each day of production
  - Type of mixture produced and DMF number
  - Contract or Purchase Order number
  - Time sample was obtained and tests completed
  - Significant events or problems
  - Signature of Level 1, Certified Technician or Management Representative

12

5. Diary

- Non-conforming tests documented
  - Air voids
  - Binder Content
  - Vbe
  - VMA
  - Aggregate gradation
  - No. 8 (2.36 mm) sieve % passing
  - Aggregate degradation value for SMA
  - Dust/Pbe Ratio
  - Moisture content of surface mixtures
- Corrective Action was taken or documented

13

6. Sampling and Testing

- Determine the necessary frequency of sampling and testing has been completed.
- One QC/QA HMA or SMA mixture for a selected contract within the current year or past three calendar years.
- Determine the quantity of mixture placed on that contract.
- Calculate the number of test necessary per the QCP.
- Verify the testing was performed at the proper frequency.

14

6. Sampling and Testing (cont'd)

- Recycled Materials
  - Calculation for determining quantity in audit packet
    - Binder Content
    - Moisture
    - Gradation
    - CAA
    - Bulk Specific Gravity of agg
- Aggregate Stockpile and Blended Aggregates
- PG Binder Sampling

15

6. Sampling and Testing (cont'd)

Mixture Sampling

- Plant /Truck Samples
  - Binder Content
  - Gradation
  - Moisture
  - Temperature
  - Draindown (OG and SMA mixes only)
  - Agg. Degradation (SMA, 1 per lot)

16

6. Sampling and Testing (cont'd)

Mixture Sampling

- Pavement/Plate Samples
  - Air Voids
  - VMA
  - Binder Content
  - Gradation
  - Dust/Pbe ratio
  - Vbe
  - Moisture (surface only)

17

6. Sampling and Testing (cont'd)

- HMA Sampling (INDOT 402 Mixtures)
  - One HMA mixture for a DMF within the current calendar year or past three calendar years.
  - Per the QCP or at least first 250 ton and each 600 ton of Surface mix or 1000 ton of Base/Intermediate mixtures.
    - Binder Content (± 0.7% from DMF)
    - CAA
    - Gradation
    - Air Voids (± 2.0% from DMF)

18

19

6. Sampling and Testing (cont'd)

- HMA Sampling (INDOT 402 Mixtures)
  - Type D Certification verification
    - Correct number sent to the jobsite and are on file
      - *"Certification-Type D. For Base and Intermediate one sample for 1st 250 ton and each 1000 ton thereafter per day. For Surface one sample for 1st 250 ton and each 600 ton thereafter per day."*
    - Test results on the certification(s) match test reports

19

20

6. Sampling and Testing (cont'd)

- Verify the calculations performed on a test report are correct.
- Select one test report for a QC/QA HMA or SMA mixture. If only HMA is produced, verify a test report of that mixture.
  - Blended Aggregate
    - Gradation and moisture content
  - Recycled materials
    - Binder content, fines correction (if applicable), gradation, moisture content, CAA, Gsb of recycled aggregate
  - Hot Mix Asphalt
    - Air Voids, VMA, binder content, fines correction (if applicable), gradation, D/Pbe ratio, moisture content, Gsb, Aggregate Degradation (SMA only), Gmm, Vbe, calibration factor calculation for ignition oven (if applicable)

20

21

7. HMA Plant

Plant Documentation on file

- Bill of ladings from ASC Supplier of current material
- Storage and Handling Instructions from PGABS Supplier for current material
- Plant calibrations/blend sheets for each DMF
- Annual plant scales calibration and meter verification IDEM letter for post-consumer shingles (if applicable)
- Weigh ticket sent to an INDOT contract
- Type A certification for all PG Binders

21

22

7. HMA Plant (cont'd)

Inspection of the site and plant is done to verify the overall process is in accordance with the QCP and layout map is up to date.

- Verify the plant site layout diagram is correct
- Aggregate/Material stockpile Binder tanks are labeled
- Baghouse fine addition (if applicable)
- Fiber addition (if applicable)
- Anti-Adhesive Agent (soap)
- Storage Silos
- Truck Loading (if plant is running)
- Other Process Control Techniques

22

23

8. Laboratory

- Overall lab inspection to verify all lab equipment is listed in the QCP and in good working order.
- Check of calibrations and verifications to meet ITM 583 requirements. Documentation must include:
  - Model or Serial Number
  - Name of person doing calibration or verification
  - ID of calibration equipment
  - Date of calibration or verification and next due date
  - Reference of procedure used
  - Calibration or verification results

23

24

8. Laboratory (cont'd)

Equipment	Requirement	Minimum Frequency	Procedure	Date Calibrated/ Verified
Balances	Standardize	12 mo.	ITM 910	
Gyratory Compactor	Verify Ram Pressure, Angle of Gyration, Frequency of Gyration, LVDT	1 mo.	ITM 908	
Gyratory Compactor Internal Angle	Verification	12 mo.	AASHTO T344	
Gyratory Mold and Plate Dimensions	Verification	12 mo.	AASHTO T312	
Ignition Oven	Conduct Lift Test	Weekly	Operators Manual	
Ignition Oven Balance	Standardize	12 mo.	ITM 910	
Mechanical Shakers	Verify Sieving Thoroughness	12 mo.	ITM 906	
Ovens	Verify Temperature Settings	12 mo.	ITM 903	
Sieves	Verify Physical Condition	12 mo.	ITM 902	
Thermometers	Verification	12 mo.	ITM 909	
Vacuum Chamber	Verification	3 mo.	ITM 905	
Calipers	Verification	12 mo.	ITM 916	

24

24

25

8. Laboratory (cont'd)

Calibration Equipment	Testing Equipment	Minimum Frequency	Date Calibrated/Verified
Master ring used with the Bore Gauge	Gyratory Compactor Molds–AASHTO T312	36 mo.	
Dynamometer Load Cell with Height Billet (Troxler Only)	Gyratory Compactor – AASHTO T312	24 mo.	
Proving Ring with Height Gage Blocks	Gyratory Compactor – AASHTO T312	24 mo.	
Vacuum Gage	Vacuum Systems – ITM 905	12 mo.	
Weights, Min. Class 3	Balances – ITM 910	12 mo.	

25

AUDITS AND EQUIPMENT CALIBRATION: Balances

INDOT Certified Asphalt Lab Technician Program

Chapter Six

26

27

EQUIPMENT CALIBRATION

Equipment	Requirements	Minimum Frequency	Procedure
Sieves	Check Physical Condition	12 months	ITM 902
Ovens	Verify Settings	12 months	ITM 903
Vacuum Systems	Verify Readings	12 months	ITM 905
Mechanical Shakers	Check Sieving Thoroughness	12 months	ITM 906
Thermometers	Verify Reading	12 months	ITM 909
Balances	Verification	12 months	ITM 910
Calipers	Verification	12 months	ITM 916

27

28

Verifying Balances ITM No. 910

28

29

TERMINOLOGY

- Accuracy -- The degree of conformity of a measurement with the true value of the quantity measured
- Off-center errors -- The differences in indicated weight when a sample weight is shifted to various positions on the weighing area

29

30

APPARATUS

Balance

Weights

30

31

NIST TRACEABLE WEIGHTS

- The weights shall be a minimum Class 3 for use on G2 and G5 balances.
- The G20 balance requires Class F weights.
- (The weights shall be calibrated at a minimum frequency of once each 12 months.)

31

32

PURPOSE

- Verify the accuracy and off-center error of balances.

32

33

PROCEDURE

- Clean the balance and standard weights with a lint free dry cloth.
- Place the standard weights near the instrument

33

34

PROCEDURE

- Allow the balance and the weights to stabilize to the ambient working temperature

34

35

PROCEDURE

- Place the thermometer on the bench near the balance and record the temperature.

35

36

PROCEDURE

- Place the standard weights in the center of the balance in increasing increments of about 10 % of the capacity

36

37

37

ACCURACY			
WEIGHT APPLIED	INDICATION ON BALANCE	WEIGHT DIFFERENCE	PERCENT OF ERROR
1500	1500.0	0	0
3000	2999.9	0.1	0
4500	4500.1	0.1	0
6000	6000.0	0	0
7500	7500.2	0.2	0
9000	9000.1	0.1	0
10500	10499.8	0.2	0
12000	11999.9	0.1	0
13500	13500.3	0.3	0
15000	15000.6	0.6	0

38

39

PROCEDURE
Off-Center Error

- Place standard weight(s) equal to half-capacity of balance on center of balance

39

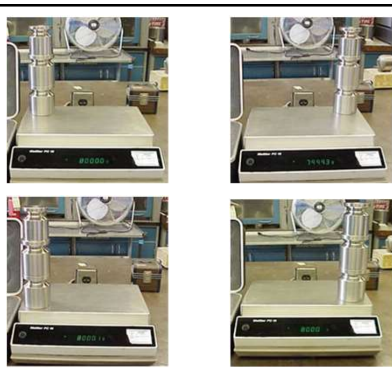
40

PROCEDURE
Off-Center Error

- Place same standard weight(s) on each corner of balance

40

41



41

OFF-CENTER ERROR			
WEIGHT APPLIED	LOCATION	INDICATION ON BALANCE	WEIGHT DIFFERENCE
8000	Center	8000.0	0
8000	Corner	8000.4	0.4
8000	Corner	8000.1	0.1
8000	Corner	7999.7	0.3
8000	Corner	8000.0	0

42

43

TOLERANCES - G2 Balance

- Accuracy -- Any 10 % interval shall be equal to 0.2 g or 0.1 % of test load, whichever is greater
- Off – center error -- Maximum shall be equal to or less than 0.2 g or 0.1 % of test load, whichever is greater

43

44

TOLERANCES - G5 Balance

- Accuracy -- Any 10 % interval shall be equal to 2 g or 0.1% of test load, whichever is greater
- Off – center error -- Maximum shall be equal to or less than 2 g or 0.1% of test load, whichever is greater

44

45

TOLERANCES - G20 Balance

- Accuracy -- Any 10% interval shall be equal to 5 g or 0.1% of test load, whichever is greater
- Off – center error -- Maximum shall be equal to or less than 5 g or 0.1% of test load, whichever is greater

45

AUDITS AND EQUIPMENT CALIBRATION: CALIPERS

INDOT Certified Asphalt Lab Technician Program

Chapter Six

46

47

EQUIPMENT CALIBRATION

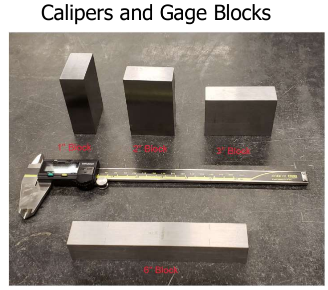
Equipment	Requirements	Minimum Frequency	Procedure
Sieves	Check Physical Condition	12 months	ITM 902
Ovens	Verify Settings	12 months	ITM 903
Vacuum Systems	Verify Readings	12 months	ITM 905
Mechanical Shakers	Check Sieving Thoroughness	12 months	ITM 906
Thermometers	Verify Reading	12 months	ITM 909
Balances	Verification	12 months	ITM 910
Calipers	Verification	12 months	ITM 916

47

48

APPARATUS

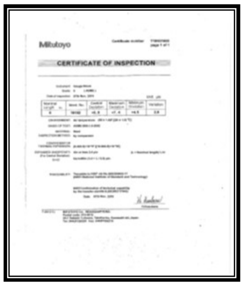
Calipers and Gage Blocks



48

49

NIST TRACEABLE DOCUMENTATION



49

50

VERIFICATION FORM

ITM 916-20
Appendix A

Revised 02/26/2020

CALIPER VERIFICATION FORM ITM 916									
Description:			Tolerance: ± 0.002"				Comm #:		
Location:			Calibration Interval: 12 months		Calibration Procedure: ITM 916		Serial #:		
Lab:									
Ambient Temperature (°F):									
Calibration Date:	Calibrated By:	Visual Inspection	Outside Jaw		Inside Jaw		Depth		In Specs.
			Standard Value	Measured Value	Standard Value	Measured Value	Standard Value	Measured Value	
			1.000 in.		1.000 in.		1.000 in.		Yes □ No □
			3.000 in.		3.000 in.		3.000 in.		Yes □ No □
			6.000 in.		6.000 in.		6.000 in.		Yes □ No □
		Pass □	*12.000 in.		*12.000 in.		*12.000 in.		Yes □ No □
		Fail □							Yes □ No □
									Yes □ No □
									Yes □ No □
Comments:					Previous Calibration Date:		Next Calibration Date:		

*If applicable

A1 of 1

50

51

1" OUTSIDE DIMENSION

51

52

3 " OUTSIDE DIMENSION

52

53

6" OUTSIDE DIMENSION

53

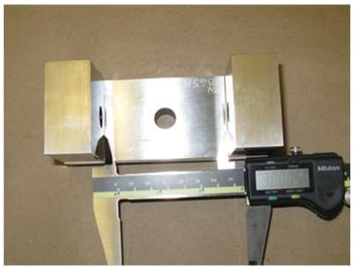
54

1" INSIDE DIMENSION

54

55

3" INSIDE DIMENSION



55

56

6" INSIDE DIMENSION

56

57

VERIFICATION FORM

ITM 916-20
Appendix A

Revised 02/26/2020

CALIPER VERIFICATION FORM
ITM 916

Description: Mitutoyo Calipers			Tolerance: ± 0.002"				Comm #: 83468		
Location: HMA Lab			Calibration Interval: 12 months		Calibration Procedure: ITM 916		Serial #: Gage Block Set Serial Number 8364		
Lab: Bituminous									
Ambient Temperature (°F): 73 deg									
Calibration Date:	Calibrated By:	Visual Inspection	Outside Jaw		Inside Jaw		Depth		In Specs.
			Standard Value	Measured Value	Standard Value	Measured Value	Standard Value	Measured Value	
7/29/2021	S. Summers		1.000 in.	1.000	1.000 in.	1.000	1.000 in.	1.000	Yes ☒ No ☐
			3.000 in.	3.000	3.000 in.	3.000	3.000 in.	3.000	Yes ☒ No ☐
			6.000 in.	6.000	6.000 in.	6.000	6.000 in.	6.000	Yes ☒ No ☐
		Pass ☒	*12.000 in.		*12.000 in.		*12.000 in.		Yes ☐ No ☐
		Fail ☐							Yes ☐ No ☐
									Yes ☐ No ☐
									Yes ☐ No ☐
Comments:					Previous Calibration Date:		Next Calibration Date: 7/29/2022		

*If applicable

A1 of 1

57

AUDITS AND EQUIPMENT CALIBRATION:
Sieves

INDOT Certified Asphalt Lab Technician Program

Chapter Six

58

59

EQUIPMENT CALIBRATION

Equipment	Requirements	Minimum Frequency	Procedure
Sieves	Check Physical Condition	12 months	ITM 902
Ovens	Verify Settings	12 months	ITM 903
Vacuum Systems	Verify Readings	12 months	ITM 905
Mechanical Shakers	Check Sieving Thoroughness	12 months	ITM 906
Thermometers	Verify Reading	12 months	ITM 909
Balances	Verification	12 months	ITM 910
Calipers	Verification	12 months	ITM 916

59

60

PURPOSE

Verify the physical condition of testing sieves

60

61

APPARATUS

Caliper

61

62

PROCEDURE
No. 4 and Coarser

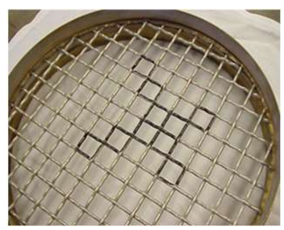
62

General Physical Condition				
Sieves No. 4 or Coarser			Sieves Finer than No. 4	
The frame is not cracked			The frame is not cracked	
The welds are not broken			The welds are not broken	
The wires are tight			No weaving defects, creases or wrinkles	
No irregular openings apparent			The screen is tight	
			No irregular openings apparent	

63

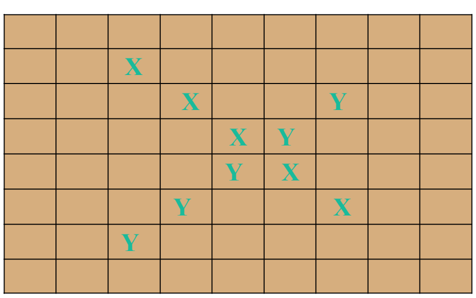
64

PROCEDURE
No. 4 and Coarser



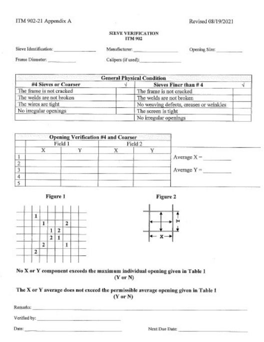
64

Measurement Locations



65

66



ITM 902-21 Appendix A — Revised 08/19/2021

SIEVE VERIFICATION
ITM 902

Sieve Identification: ____________ Manufacturer: ____________ Opening Size: ________

Frame Diameter: ________ Calipers (if used): ____________

General Physical Condition			
#4 Sieves or Coarser	√	Sieves Finer than # 4	√
The frame is not cracked		The frame is not cracked	
The welds are not broken		The welds are not broken	
The wires are tight		No weaving defects, creases or wrinkles	
No irregular openings		The screen is tight	
		No irregular openings	

Opening Verification #4 and Coarser				
	Field 1		Field 2	
	X	Y	X	Y
1				
2				
3				
4				
5				

Average X = ________

Average Y = ________

Figure 1 Figure 2

No X or Y component exceeds the maximum individual opening given in Table 1
(Y or N)

The X or Y average does not exceed the permissible average opening given in Table 1
(Y or N)

Remarks: ____________

Verified by: ____________

Date: ____________ Next Due Date: ____________

A1 of 1

66

Opening Verification for sieves No. 4 and Coarser				
	Field 1		Field 2	
	X	X	Y	Y
1	24.75	25.14	24.66	24.91
2	25.04	24.48	24.62	24.76
3	24.82	24.92	24.99	24.44
4	24.47	24.77	24.72	25.07
5	25.11	25.04	25.17	24.79
Average of all ten X 24.85		Average of all ten Y 24.81		

67

68

TOLERANCE – No. 4 and COARSER

Sieve Designation	PERMISSIBLE AVERAGE OPENING	MAXIMUM INDIVIDUAL OPENING
4 in.	±3.00 mm	104.8 mm
3 1/2 in.	±2.70 mm	94.4 mm
3 in.	±2.20 mm	78.7 mm
2 1/2 in.	±1.90 mm	66.2 mm
2 in.	±1.50 mm	52.6 mm
1 1/2 in.	±1.10 mm	39.5 mm
1 in.	±0.800 mm	26.4 mm
3/4 in.	±0.600 mm	20.1 mm
1/2 in.	±0.390 mm	13.31 mm
3/8 in.	±0.300 mm	10.16 mm
No. 4	±0.150 mm	5.14 mm

68

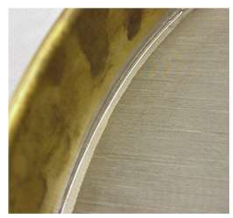
69

PROCEDURE
Sieves Finer Than No. 4

- Hold the sieve against a uniformly illuminated background
- Check general condition of sieve for:
  - cracks in frame
  - broken solder joints
  - weaving defects
  - creases
  - wrinkles
  - wire tightness
  - irregular openings

69

Solder Joint



Crack in frame

70

71

AUDITS AND EQUIPMENT CALIBRATION: Mechanical Shakers

INDOT Certified Asphalt Lab Technician Program

Chapter Six

72

73

EQUIPMENT CALIBRATION

Equipment	Requirements	Minimum Frequency	Procedure
Sieves	Check Physical Condition	12 months	ITM 902
Ovens	Verify Settings	12 months	ITM 903
Vacuum Systems	Verify Reading	12 months	ITM 905
Mechanical Shakers	Check Sieving Thoroughness	12 months	ITM 906
Thermometers	Verify Reading	12 months	ITM 909
Balances	Verification	12 months	ITM 910
Calipers	Verification	12 months	ITM 916

73

74

PURPOSE: Verify sieving sufficiency and accuracy of timers.


74

75

APPARATUS


75

76

APPARATUS


76

77

PROCEDURE

- Operate shaker
- Measure the time

77

78

PROCEDURE

- Repeat with the timer set at 10 min and 15 min


78

TIMER VERIFICATION

Setting on Shaker Timer	Timing Device Reading	Corrective Adjustment Made
5 min	5 min - .78 sec	----
10 min	10 min- .07 sec	----
15 min	15 min- .13 sec	----

79

80

TOLERANCE

- Timer shall be within ± 5 sec at 5 min, ± 10 sec at 10 min, and ± 15 sec at 15 min of stopwatch reading

80

81

Shakers using 8 in and 12 in Sieves

- Determine and record initial sample weight

81

82

PROCEDURE

- Insert sieves 1 ½ in to No. 8 for coarse aggregates
- Insert sieves No. 4 through No. 200 for fines

82

83

PROCEDURE

Shake blended aggregates for 10 min and Sands for 15 min

83

84

PROCEDURE

- Place first sieve retaining material on a pan and cover the sieve with the lid

84

PROCEDURE

- Hand shake sieve for 1 min by holding sieve in a slightly inclined position

85

PROCEDURE

- Strike sieve sharply with heel of hand at 150 times per minute
- Turn sieve about 1/6 revolution at intervals of 25 strokes

86

PROCEDURE

- Weigh material passing the sieve and retained in the pan

87

PROCEDURE

- Weigh the material retained on the sieve

88

PROCEDURE

- Add weight retained on sieve and weight passing the sieve to verify sieve was not overloaded

Screen Size	12" Diameter	8" Diameter
3 in.	12.6 kg	--------
2 in.	8.4 kg	3.6 kg
1 ½ in.	6.3 kg	2.7 kg
1 in.	4.2 kg	1.8 kg
¾ in.	3.2 kg	1.4 kg
½ in.	2.1 kg	890 g
3/8 in.	1.6 kg	670 g
No. 4	800 g	330 g

89

PROCEDURE

- If sieve was overloaded, verification is void and new sample shall be obtained

90

SIEVING SUFFICIENCY VERIFICATION

Sieve Size	Weight Retained by Mechanical Sieving	Weight Passing After Hand Sieving	% Passing After Hand Sieving
1 in.	0	0	
¾ in.	402.4	0	
½ in.	2618.7	21.6	0.33
3/8 in.	1270.6	10.4	0.16
No. 4	2269.0	12.7	0.19
No. 8	8.6	0	
No. 16			
No. 30			
No. 50			
No. 100			
No. 200			

91

92

TOLERANCE

- No more than 0.5 percent by weight of the total sample shall pass any sieve after 1 min of hand sieving

92

93

PROCEDURE

- Repeat procedure for the remaining sieves.
- If a sieve does not meet the allowable tolerance , the shaking time shall be increased to determine an adequate time.

93

AUDITS AND EQUIPMENT CALIBRATION: Thermometers

INDOT Certified Asphalt Lab Technician Program

Chapter Six

94

95

EQUIPMENT CALIBRATION

Equipment	Requirements	Minimum Frequency	Procedure
Sieves	Check Physical Condition	12 months	ITM 902
Ovens	Verify Settings	12 months	ITM 903
Vacuum Systems	Verify Reading	12 months	ITM 905
Mechanical Shakers	Check Sieving Thoroughness	12 months	ITM 906
Thermometers	Verify Reading	12 months	ITM 909
Balances	Verification	12 months	ITM 910
Calipers	Verification	12 months	ITM 916

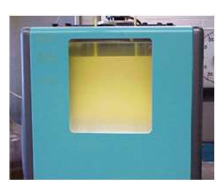
95

96

APPARATUS

Certified Thermometer

Oil Bath



Water Bath

96

97

PURPOSE

- Verify the thermometer scale accuracy for:
  - Liquid-in-glass total immersion
  - Liquid-in-glass partial immersion
  - Dial type
  - Handheld digital

97

98

PROCEDURE

Record the manufacturer, serial number, type, model number, graduation, and date of calibration for the certified thermometer

98

99

PROCEDURE

- Liquid-In-Glass Total and Partial Immersion Thermometers

99

100

PROCEDURE

- Record the manufacturer, serial number, type, model number, and graduation of thermometer being verified.

100

101

PROCEDURE

- Visually inspect the shaft of the thermometer for:
  - Air bubbles
  - Separation of the liquid
  - Foreign matter
  - Glass faults
  - Other apparent defects

101

102

PROCEDURE

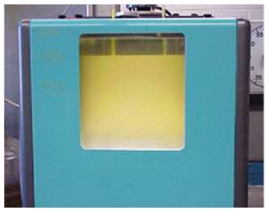
- Immerse the thermometer being verified into a water/oil bath
  - Partial immersion thermometers
    - to immersion line
  - Total immersion thermometers
    - to point being verified

102

103

PROCEDURE

- Use water bath for < 200 °F
- Use oil bath for ≥ 200 °F



103

104

PROCEDURE

- Immerse the certified thermometer into water/oil bath
- Allow the readings on both thermometers to stabilize
- Record the temperature of each thermometer

104

105

TOLERANCE

- Within scale error max from Table 1 of ITM 909
- Thermometer may be used if difference is visibly noted and offset is applied during use

105

106

PROCEDURE

Dial Type

106

107

PROCEDURE

- Record the manufacturer, serial number, type, model number, and graduation of thermometer being verified.

107

108

PROCEDURE

- Immerse thermometer and certified thermometer into a container of boiling water to ≈ ½ depth of container

108

PROCEDURE

- Allow the readings on both thermometers to stabilize, and record the temperature of each thermometer

109

TOLERANCE

- Within ±5.0 °F
- If within ±5.0 °F, thermometer may be used if difference is visibly noted and offset is applied during use

110

PROCEDURE

Handheld digital thermometer

111

PROCEDURE

- Record the manufacturer, serial number, type, model number, and graduation of the thermometer being verified

112

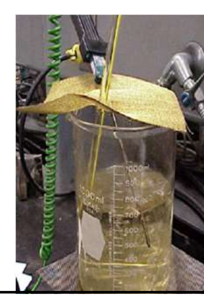
PROCEDURE

- Immerse the thermocouple assembly and certified thermometer into a container of boiling water to ≈ ½ depth of container

113

PROCEDURE

- Allow the readings on both thermometers to stabilize and record the temperature of each thermometer



114

115

TOLERANCE

- Within ±2 °F
- If within ±2 °F, thermometer may be used if difference is visibly noted and offset is applied during use

115

116

Liquid Calibration Bath

116

AUDITS AND EQUIPMENT CALIBRATION: Ovens

INDOT Certified Asphalt Lab Technician Program

Chapter Six

117

118

EQUIPMENT CALIBRATION

Equipment	Requirements	Minimum Frequency	Procedure
Sieves	Check Physical Condition	12 months	ITM 902
Ovens	Verify Settings	12 months	ITM 903
Vacuum Systems	Verify Reading	12 months	ITM 905
Mechanical Shakers	Check Sieving Thoroughness	12 months	ITM 906
Thermometers	Verify Reading	12 months	ITM 909
Balances	Verification	12 months	ITM 910
Calipers	Verification	12 months	ITM 916

118

119

PURPOSE

Verify temperature settings

119

120

APPARATUS

Aluminum/Brass Well

Verified Thermometer

120

OVEN TEMPERATURE VERIFICATION
ITM 903

Oven Identification: Comm. No. 093060

Manufacturer: Blue M Electric

Model No.: 246 Batch Oven

Thermometer used: ASTM No. 9297J90

Ser. No. 322

Drying Temperature: ____________

Initial Reading: 1 h ____________
1-1/2 h ____________
2h ____________
2-1/2 h ____________
3 h ____________

Verified by: ____________

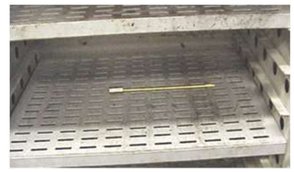
Date: ____________ Next Due Date: ____________

121

122

PROCEDURE

- Place thermometer inside brass well and position in the center of the oven



122

123

PROCEDURE

- Set oven temperature

123

OVEN TEMPERATURE VERIFICATION
ITM 903

Oven Identification: Comm. No. 093060

Manufacturer: Blue M Electric

Model No.: 246 Batch Oven

Thermometer used: ASTM No. 9297J90

Ser. No. 322

Drying Temperature: 110 ± 5º C

Initial Reading: 1 h ____________
1-1/2 h ____________
2h ____________
2-1/2 h ____________
3 h ____________

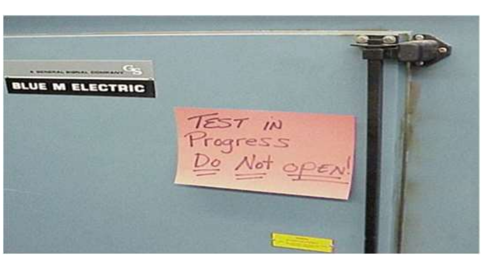
Verified by: ____________

Date: ____________ Next Due Date: ____________

124

125

PROCEDURE



125

OVEN TEMPERATURE VERIFICATION
ITM 903

Oven Identification: Comm. No. 093060

Manufacturer: Blue M Electric

Model No.: 246 Batch Oven

Thermometer used: ASTM No. 9297J90

Ser. No. 322

Drying Temperature: 110 ± 5 ºC

Initial Reading: 1 h 102 ºC
1-1/2 h ____________
2h ____________
2-1/2 h ____________
3 h ____________

Verified by: ____________

Date: ____________ Next Due Date: ____________

126

127

PROCEDURE

127

OVEN TEMPERATURE VERIFICATION
ITM 903

Oven Identification: _Comm. No. 093060______

Manufacturer: ___Blue M Electric__________

Model No.: ___246 Batch Oven____________

Thermometer used: ASTM No. __9297J90______

Ser. No. __322______

Drying Temperature: __110 ± 5 °C________

Initial Reading: 1 h ___102 °C__
1-1/2 h ___112 °C__
2h ___110 °C__
2-1/2 h ___110 °C__
3 h __________

Verified by:______________________________

Date: __________ Next Due Date: ________

128

129

PROCEDURE

129

AUDITS AND EQUIPMENT CALIBRATION:
Vacuum Systems

INDOT Certified Asphalt Lab Technician Program
Chapter Six

130

131

EQUIPMENT CALIBRATION

Equipment	Requirements	Minimum Frequency	Procedure
Sieves	Check Physical Conditions	12 months	ITM 902
Ovens	Verify Settings	12 months	ITM 903
Vacuum Systems	Verify Reading	12 months	ITM 905
Mechanical Shakers	Check Sieving Thoroughness	12 months	ITM 906
Thermometers	Verify Reading	12 months	ITM 909
Balances	Verification	12 months	ITM 910
Calipers	Verification	12 months	ITM 916

131

132

PURPOSE

Vacuum Systems

132

133

VERIFYING DIGITAL GAGE FROM A MERCURY MANOMETER

133

134

AutoRice

134

134

135

TOLERANCE

- A maximum of ± 2mm Hg offset for the digital vacuum gage may be applied and is required to be clearly indicated on the gage

135

136

VERIFYING CORELOK WITH TORR GAGE (EVERY 3 MONTHS)

136

137

137

138

TOLERANCES

- The reading of the vacuum gage used for AASHTO T331 shall be 10 mm Hg (10 torr) or less
- The reading of the vacuum gage used for ITM 572 shall be 6 mm Hg (6 torr) or less
- The reading of the vacuum gage used for T209 shall be 27.5 ± 2.5 mm Hg. A maximum of ± 2 mm Hg offset for the digital vacuum gage may be applied and is required to be clearly indicated on the gage

138

9. Comparison Testing

- Verify the technician complies with sampling and testing procedures.
- IA comparison testing every 2 years is adequate
- Obtain sample of mixture, blended aggregate, and RAP
  - Sampling
  - Sample reduction
  - Gradation
  - Binder content of RAP
  - Binder content of mixture

139

Corrective Actions

- *Any item deemed as unsatisfactory or deficient requires a Corrective Action Sheet with the problem and solution to resolve the corrective action stated.*
  - *An item that occurred in the past and cannot be corrected is documented as an Observation*
  - *An item that is has been corrected during the audit is documented as resolved*
  - *An item that requires specific action from the Producer is documented and will need follow up from and INDOT audit team member*
- *Deadline date is two weeks maximum to resolve a Corrective Action from the date of the audit. Anything requiring longer than two weeks must be addressed by the DTE*

140

Appendix: Testing Results Outside of Control Limits

- Record the date and test value outside of the control limits
  - Air Voids
  - Mixture Binder Content
  - VMA
  - Dust/Effective Binder Ratio
  - Vbe

141

141

10. Audit Close-Out

- Meeting with the Producer and INDOT immediately after the audit is performed.
- The Producer shall submit any Addenda or Annex to the QCP.
- Make copies of each Corrective Action and Appendix sheet.
- Discuss any corrective actions or observations, resolutions, and deadlines.

142

10. Audit Close-Out (cont'd)

- INDOT is to follow up with the Producer on any outstanding Corrective Actions.
- INDOT reviews and addresses all Corrective Actions, comparison test results, QCP changes that were submitted during the audit, and verify that each page and item in the audit packet is complete.
- The Audit Close-Out page is signed and dated by the INDOT DTE or Area Supervisor.
- All documentation from the audit should be sent to INDOT OMM and the Producer.

143

Review

- INDOT Responsibilities prior to audit:
  - Familiarize yourself with the QCP
  - Obtain any documentation that may be helpful during the audit
    - DMFs
    - approved lists
    - ITMs or other test methods, especially ITM 583
    - IA Paperwork if applicable

144

145

Review (cont'd)

- Producer responsibilities prior to audit
  - Maintain Diary and daily test results
  - Obtain any QCP changes
  - Equipment Calibration/Verification
  - Have paperwork readily available for the audit

145

TROUBLESHOOTING TIPS
A Guide to Diagnosing HMA Mix Problems

INDOT Certified Asphalt Lab Technician Program
Chapter Six

1

Meet the Team

BRAD CRUEA
Quality Control Manager – Indianapolis
Milestone Contractors, L.P.

2

WHAT IS QUALITY CONTROL?

- IN MY EYES……Quality Control is a set of procedures and tests performed to ensure a manufactured product (like Hot Mix Asphalt) meets or exceeds the required specifications for the owner/customer.

3

WHAT IS QUALITY ASSURANCE?

- Quality Assurance is the owner/customer performing their own tests to confirm that the manufactured product is in specification.

4

Quality Control vs Quality Assurance

- QC/QA
  - This is the interaction between contractor and INDOT to ensure the taxpayers of Indiana or getting what they paid for!!
  - This section will focus on Quality Control

5

HMA is Accepted (Judged OK) by how close these properties are to the DMF target

- Volume of Effective Binder (Vbe) (35%)
  - VMA – Air Voids
- Air Voids (30%)
- Mat Density (35%)
- Binder Content (not a pay factor)

6

Some common tests in maintaining Quality Control

- Gradations
  - Stockpiles
  - Mixture
  - RAP

Controlling gradation will control your mix!

- Binder Content (extraction or ignition)
- Bulk Specific Gravity (G_{mb}) / lab compacted (Pill Heights), cores
- Maximum Specific Gravity (G_{mm})
- Eyes, if something doesn't look right, it's probably not right!

Representative Samples

7

7

General Relationships – AIR VOIDS

Property	Applicable Test(s)	Function of / Relative Impact
Air Voids $=G_{mm} - G_{mb} / G_{mm}$	G_{mm}	Binder Content /moderate
		Absorption /high
		Gradation / slight except when using different Aggregate w/ different G_{sb}
		Aggr. Specific Gravity /high
	G_{mb}	Binder Content / slight

8

General Relationships - VMA

Property	Applicable Test(s)	Function of / Relative Impact
VMA $=100- (G_{mb\ x\ Ps}) / G_{sb.}$	G_{mb} (G_{sb})	Gradation / very high, especially %passing #200
		Particle shape / high
		Compactive effort /moderate
		Aggregate strength / moderate
		Binder Content / slight

9

General Relationships - Vbe

Property	Applicable Test(s)	Function of / Relative Impact
Vbe	VMA - AV	Gradation
		Binder Content
		Absorption
		Low Vbe – (VMA low, AV low)…… Gradation Change
		High Vbe – (Vma high, AV low) or Low Vbe – (VMA low, AV high).. Gradation and Binder Change

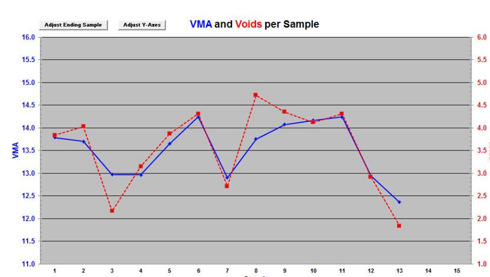
10

Let's back up to VMA

- VMA is mainly a result of gradation. So I like to look at 5 things that effect VMA! (Remember, if you can control VMA, you can control Air Voids)
  - Shape
  - Texture
  - Strength
  - Gradation
  - Type and Amount of Compaction

11

VMA Drives Air Voids



12

Where Do We Look for Gradation Control?

- Aggregate & RAP stockpiles
- Cold feed system
- Mixing and load-out systems
- Dust systems

13

Gradation Control-Stockpiles

- Segregation
- Handling Segregation (from supplier to yard to mixture)
- Contamination

14

Gradation Control- Feeders

- Improperly calibrated
- Run Empty or bridges
- Overflow from adjacent feeder
- Wrong material
- Incorrect proportional set-up

15

Gradation Control-Load out

Truck Silo Segregation

16

Gradation Control -Dust

- Primary Collector
  - Knock-out box
  - Feed system into plant
- Secondary Collector
  - Baghouse
  - Pod w/ vane feeder
- Mineral Filler bin
  - Weigh hopper

17

Binder Content Control

- Mix Segregation
  - Plot %binder vs.% passing #8 or #4
- Flow Meter calibration
- Aggregate moisture correction (only slight)
- Aggregate or RAP weigh bridge calibration
- Rap binder content
- RAP aggregate type (dolomite/burn-off)
- Start-up, shut down and switching mixes

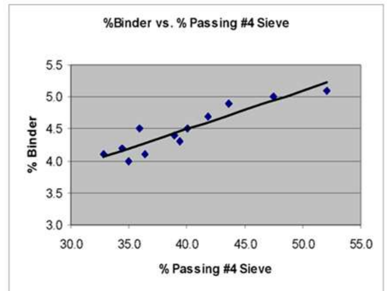
18

19

Drum Plant

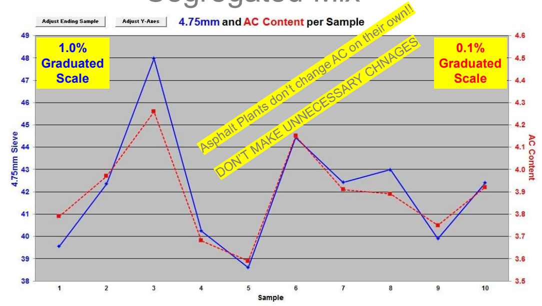
19

	% P #4	%Binder
1	47.5	5.0
2	38.9	4.4
3	35.0	4.0
4	39.4	4.3
5	52.1	5.1
6	43.6	4.9
7	36.4	4.1
8	32.8	4.1
9	41.8	4.7
10	34.4	4.2
11	40.1	4.5
12	35.9	4.5
Minimum	32.8	4.0
Maximum	52.1	5.1
Average	39.8	4.5



20

Segregated Mix



21

22

Start out on the Right Foot

- Before you start production, check:
  - Stockpiles, know what's in you piles!
  - Correct JMF input to plant
  - Plant calibrations (all meters and scales)
  - Test equipment calibration
- Communicate with your plant operator

22

23

Do a trial run on new JMF before starting major production

- 100± tons
- Don't sample first or last load
- Possibly place on commercial project
- Cost of trial vs. cost of failure of removal

23

24

Tips

- Retest to verify results as needed
- Eliminate the obvious first (save time)
- Be careful not to overreact
- Keep track of all your changes so you can find patterns. Where you've been helps determine where to go.
- Gather as much data as you can before making decisions

24

CHAPTER 1

INTRODUCTION

SAFETY

FIRE HAZARDS

PERSONAL PROTECTIVE EQUIPMENT

FIRST AID

ASPHALT SAFETY REMINDERS

TERMINOLOGY

ROUNDING

MEAN

STANDARD DEVIATION

VOLUMETRICS

CHAPTER 1

INTRODUCTION

Welcome! If you are reading this, you are involved in the production, inspection, or testing of Hot Mix Asphalt in the State of Indiana. You may work for a Contractor, a Consultant, INDOT, or a local agency, but no matter who you work for, you are all integral to delivering quality Hot Mix Asphalt to the taxpayers and customers of Indiana.

The INDOT Certified Asphalt Lab Technician Program consists of a course and exam which will provide a basic background to the production of Hot Mix Asphalt and the materials that go into HMA, as well as the testing of HMA and INDOT specifications. The program is designed to target testing lab technicians in a Contractor Quality Control lab, but concepts learned will apply to all attendees.

This program began in 1986 as a way to train Contractor personnel who were required to begin testing their own materials. Up until that point, INDOT would design the mixtures, help set up the plant, test the mixtures, and then if test results were failing, would penalize the Contractor. To allocate the responsibility for Quality properly, INDOT went to a QC/QA model to test and accept Hot Mix Asphalt.

Quality Control/Quality Assurance (QC/QA) is often used synonymously with the term Quality Assurance (QA). AASHTO defines Quality Assurance as "All those planned and systematic actions necessary to provide confidence that a product will perform satisfactorily in service." This definition considers QA to be an all encompassing concept which includes quality control (QC), acceptance, and independent assurance (IA).

A better understanding of the QC/QA concept may be made if the characteristics of the specifications are considered. These include:

1. QC/QA recognizes the variation in materials and test methods.
2. QC/QA uses a statistical basis that is applied and modified with experience and sound engineering judgement.
3. QC/QA places the primary responsibility on the Contractor for production control.
4. QC/QA makes a clear delineation between process control and acceptance testing.

The advantages of this type of specification include the proper allocation of responsibility for quality between the Contractor and INDOT, more complete records, and statistically based acceptance decisions. The Contractor has a greater choice of materials and may design the most economical mixtures to meet specifications. Finally, acceptance test results are provided upon completion of the tests during the contract so that the Contractor knows if the operations are producing a quality product.

SAFETY

Safety is the business of everyone on the job. The Technician may be working with hazardous materials and should be alert to proper precautions. This involves having the proper protective equipment and ventilation system in the working place. Knowledge of the proper use of hazardous materials is essential to a safe working environment.

The safety record for handling, storing and sampling asphalt materials is good. Nonetheless, there have been accidents resulting in property damage, personal injury, and loss of life. To prevent such mishaps, the Technician is required to know and follow good safety practices. When an accident does occur, the Technician is required to know how to react and what first aid treatment is appropriate.

There are two main types of safety hazards in the Asphalt and Paving industry.

1. Fire including explosion hazards
2. Health hazards including eye contact, skin contact, or inhalation of fumes.

FIRE HAZARD

Fire prevention is extremely important because asphalt products are utilized at high temperatures. A major safety issue in handling hot asphalt is exposure to a source of ignition. Controlling possible ignition sources (sparks, electricity, incandescent material, open flames, lighted cigarettes, or other sources) in the vicinity of asphalt operations is a safety priority.

PERSONAL PROTECTIVE EQUIPMENT

OSHA requires employers to use personal protective equipment (PPE) to reduce employee exposure to hazards when engineering and administrative controls are not feasible or effective. PPE is necessary to protect workers from asphalt burns and irritation. In addition, many of the solvents used to cut asphalt can be absorbed through unprotected skin into the bloodstream, where they can travel throughout the body and cause damage to many different organs.

PPE recommended when handling heated asphalt:

- Chemical goggles and a 200 mm (8 inches) minimum-sized face shield
- Loose clothing in good condition with collars closed and cuffs buttoned at the wrist
- Thermally insulated gloves with gauntlets that extend up the arm and worn loosely so that they can easily be flipped off if covered with hot asphalt
- Boots with tops at least 150 mm (6 inches) high and laced without openings
- Pants without cuffs which extend over the tops of the boots
- Safety shoes at least 15 centimeters (cm) high and laced
- Barrier creams and lotions leave a thin film on skin and act as a barrier against skin irritants worn with protective clothing

FIRST AID

Whenever a person is injured from exposure to asphalt fumes, cold asphalt, or hot asphalt, obtain first aid/medical attention immediately. To prevent the possibility of future medical complications, have the victim examined by a physician eve in the injury does not appear serious.

Asphalt Fumes

- Move victim to fresh air
- Administer oxygen if breathing is difficult
- Start artificial respiration if breathing stops
- Have victim examined by a physician

Cold Asphalt

- Remove cold asphalt from skin with waterless hand cleaner
- Wash skin thoroughly with soap and water
- Removed contaminated clothing and shower victim at once
- Flush out contaminants from eyes for at least 5 minutes with water, lifting upper and lower eyelids occasionally
- Have victim examined by a physician

Hot Asphalt (Burns)

- Apply cold water or ice pack to asphalt skin burns
- If burns cover more than 10 percent of body (approximately the skin area of one arm or half a leg), apply lukewarm water, or warmer if needed to alleviate pain, but heat in the asphalt must be reduced as rapidly as possible. Lukewarm water reduces the temperature of the asphalt material and skin without causing shock, which may be induced by applying cold water or ice to major burns.
- Do no remove asphalt from skin
- Do not cover the burned area with a bandage
- Have a physician examine the burn immediately

FIGURE 1.1 FIRST AID FOR ASPHALT BURNS

Hydrogen sulfide is a product of the reaction between hydrogen and sulphur naturally present in asphalt materials. In low concentration, hydrogen sulfide smells like rotten eggs and is not dangerous. In higher concentration such as the air space in a storage tanks or other closed areas, hydrogen sulfide may not have a smell. If the concentration is high enough one breath is enough to be lethal.

To prevent overexposure to hydrogen sulfide fumes, follow these guidelines:

1. Keep your face at least two feet away from asphalt material tank hatch openings
2. Stay upwind of open hatches
3. Avoid breathing fumes when opening hatch covers or taking samples

In case of overexposure to hydrogen sulfide fumes, do the following:

1. Move victim immediately to fresh air
2. Administer oxygen if breathing is difficult
3. Start artificial respiration if breathing stops
4. Have the victim examined by a physician immediately

ASPHALT SAFETY REMINDERS

- When working with any asphaltic materials, avoid prolonged contact of material with skin
- Excessive breathing of asphalt materials should be avoided
- Wear PPE to protect against asphalt spatters
- When chipping or chiseling old blacktop, wear eye protection. Also, don’t chisel with a carpenter’s hammer because it isn’t designed for this type of job and may chip
- Keep all asphalt materials away from high heat. Keep solvent-tinned materials away from open flames
- Close containers after each use
- Always follow the manufacturer’s instructions for the product being used

TERMINOLOGY

Asphalt mixture has been called surprisingly by many different names. Hot Mix Asphalt (HMA), bituminous paving mix(ture), bituminous concrete, bituminous mix(ture), asphalt paving mix(ture), asphaltic concrete or plain "asphalt" are just a few of the synonyms used for this material. The term "asphalt mixture" is used to help standardize the wording and minimize confusion. When the Standard Specifications are referenced in the manual, QC/QA HMA will be used for mixtures in accordance with Section 401, HMA will be used for mixtures in accordance with Section 402, and SMA (Stone Matrix Asphalt) will be used for mixtures in accordance with Section 410.

Asphalt materials include Performance Graded (PG) Asphalt Binders, Asphalt Emulsions, Cutback Asphalt, Utility Asphalt, and Asphalt used for coating corrugated metal pipe. HMA used for Quality Assurance requires PG binders to be used for the asphalt material. The term "binder" is used when referring to this material.

Additional terms related to asphalt mixture include the following:

AASHTO - American Association of State Highway and Transportation Officials

Absorption - The increase in the mass of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass

Actual Binder Content - The binder content determined in accordance with ITM 586 or the total of the binder content determined in accordance with ITM 571 and the binder absorption percent from the DMF

Aggregate Base - A layer of aggregate placed on a subgrade or subbase to support a surface course

Air-Cooled Blast Furnace Slag (ACBF) - Material resulting from solidification of molten blast-furnace slag under atmospheric conditions

Apparent Specific Gravity - The ratio of the weight in air of a unit volume of the impermeable portion of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature

Air Voids - Internal spaces in a compacted mix surrounded by asphalt-coated particles, expressed as a percentage by volume of the total compacted mix

Artificial Aggregates - Aggregates that are manufactured or by-products of an industrial process. Blast furnace slag, steel slag and wet bottom boiler slag are examples of by-product artificial aggregates.

Asphalt Emulsion – An emulsion of asphalt and water that contains a small amount of an emulsifying agent. Emulsified asphalt droplets may be either anionic (negative charge), cationic (positive charge), or nonionic (neutral).

ASTM - American Society for Testing and Materials

Base Course – The layer in the pavement system immediately below the binder and surface courses. The base course consists of crushed aggregate or other stabilized material.

Binder – Asphalt that is classified according to the Standard specifications for Performance Graded Asphalt Binder, AASHTO Designation MP1. The binder may be either unmodified or modified asphalt.

Bulk Specific Gravity - The ratio of the weight in air of a unit volume of material (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight of an equal volume of gas-free distilled water at a stated temperature

Bulk Specific Gravity (SSD) - The ratio of the mass in air of a unit volume of material, including the mass of water within the voids filled to the extent achieved by submerging in water for a specified time (but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature

Certified Aggregate Producer - A Plant/Redistribution Terminal that meets the requirements of ITM 211 and is approved by the Department

Certified HMA Producer - An asphalt mixture plant that meets the requirements of ITM 583 and is approved by the Department

Coarse Aggregate - Aggregate that has a minimum of 20 percent retained on the No. 4 (4.75 mm) sieve

Decant - A test utilizing water to determine the amount of material that is passing the No. 200 sieve. The decantation test is conducted on both fine and coarse aggregate and is usually done in conjunction with the sieve analysis test.

Deleterious - Undesirable aggregate material

Density - The weight per unit volume of a substance

Dolomite - Carbonite rock containing at least 10.3% elemental magnesium when tested in accordance with ITM 205

Equivalent Single Axle Load (ESAL) – The effect on pavement performance of any combination of axle loads of varying magnitude equated to the number of 80-kN (18,000-lb.) single-axle loads that are required to produce an equivalent effect.

Fine Aggregate - Aggregate that is 100 percent passing the 3/8 in. (9.5 mm) sieve and a minimum of 80 percent passing the No. 4 (4.75 mm) sieve

Independent Assurance – Independent Assurance testing is conducted by INDOT personnel to verify the reliability of the results obtained in acceptance sampling and testing. Certified Asphalt Technicians are checked annually by Independent Assurance Technicians for the sampling and testing procedures that are conducted at the asphalt mixture plant.

Intermediate Course – The hot mix asphalt course immediately below the surface course, generally consisting of larger aggregates and less asphalt (by weight) than the surface course

Leveling Course – A course of hot mix asphalt of variable thickness used to eliminate irregularities in the contour of an existing surface prior to placing the subsequent course.

Maximum Particle Size - The sieve on which 100 percent of the material will pass

Mineral Filler - Dust produced by crushing stone, portland cement, or other inert mineral matter having similar characteristics. Mineral filler is required to be in accordance with the gradation requirements for size No.16.

National Institute of Standards and Technology (NIST) - A federal technology agency that develops and applies technology, measurements, and standards for testing equipment

Nominal Maximum Particle Size - The smallest sieve opening through which the entire amount of the aggregate is permitted to pass. The Nominal Maximum Particle Size for asphalt mixtures is defined as one sieve size larger than the first sieve to retain more than 10 percent.

Performance Graded (PG) – Asphalt binder grade designation used in Superpave that is based on the binder's mechanical performance at critical temperatures and aging conditions

Polish Resistant Aggregates - Dolomite containing less than 10.3% elemental magnesium, crushed limestone, or gravel meeting the requirements of ITM 214. Aggregates meeting these requirements are maintained on the INDOT Approved List of Polish Resistant Aggregates.

Prime Coat – An application of asphalt primer to an absorbent surface. The prime coat is used to prepare an untreated base for an asphalt surface. The prime penetrates or is mixed into the surface of the base and plugs the voids, hardens the top and helps bind the mixture to the overlying course.

Quality Assurance Materials - Certified Materials controlled by aggregate gradations determined by the Certified Aggregate Producer

Quality Control Plan (QCP) - A document written by the Producer that is plant-specific and includes the methods of sampling, testing, calibration, verification, inspection and anticipated frequencies used by the Producer

Qualified Technician - An individual who has successfully completed the written and proficiency testing requirements of the Department Qualified Laboratory and Technician Program

Reclaimed Asphalt Pavement (RAP) – Excavated asphalt pavement that has been pulverized, usually by milling, and is used like an aggregate in the recycling of asphalt pavements

Reclaimed Asphalt Shingles (RAS) – Pre-consumer asphalt shingles that are a waste from a shingle manufacturing facility or post-consumer asphalt shingles that are tear-off materials from roofs

Specific Gravity - The ratio of the mass of a unit volume of a material to the mass of the same volume of gas-free distilled water at a stated temperature

Standard Specification Materials - Certified Materials controlled by aggregate gradations as defined in the Department Standard Specifications and the construction contract documents

Steel Furnace Slag (SF) - A material derived from the further refinement of iron to steel

Subbase – The course in the asphalt pavement structure immediately below the base course. If the subgrade soil has adequate support, this course may serve as the subbase.

Subgrade – The soil prepared to support a pavement structure or a pavement system. The subgrade is the foundation of the pavement structure.

Superpave – Short for "Superior Performing Asphalt Pavement", a performance-based system for selecting and specifying asphalt binders and for designing asphalt mixtures

Tack Coat – A relatively thin application of asphalt applied to an existing asphalt or concrete pavement surface at a prescribed rate. Asphalt emulsion diluted with water is the preferred type. Tack coat is used to form a bond between an existing surface and the overlying course.

Water-Injection Foaming - Water-Injection Foaming is a process that allows a reduction in the temperature at which mixtures are produced and placed

Wet Bottom Boiler Slag - A material which is a by-product from coal combustion at electrical generating plant

ROUNDING

The Specifications designate specific quantities of material to be sampled, material test values, and test equipment calibration measurements. As such, a standard method for rounding values is essential. The method required is the "5 up" procedure. There are two rules for rounding numbers:

1. When the first digit discarded is less than 5, the last digit retained should not be changed.

Examples:

2.4 becomes 2
2.43 becomes 2.4
2.434 becomes 2.43
2.4341 becomes 2.434

2. When the first digit discarded is 5 or greater, the last digit retained should be increased by one unit.

Examples:

2.6 becomes 3
2.56 becomes 2.6
2.416 becomes 2.42
2.4157 becomes 2.416

The Specifications require that test values and calculations be determined to the nearest decimal place as indicated in Figure 1.2.

FIGURE 1.2 REQUIRED DECIMAL PLACES

Property	Nearest Whole Unit (0)	First Decimal Place (0.0)	Second Decimal Place (0.00)	Third Decimal Place (0.000)
CAA	X			
Density (Mix Design)	X			
FAA	X			
Asphalt Mixture Temperature	X			
Tensile Strength	X			
VFA	X			
Control Limits		X		
Dust/Effective Binder		X		
Five-Point Moving Average		X		
Gradation		X		
Target Mean		X		
Air Voids			X	
Binder Content			X	
Density (Pavement)			X	
Draindown			X	
Asphalt Mixture Moisture			X	
VMA			X	
Bulk Specific Gravity				X
Maximum Specific Gravity				X

MEAN

The simple mathematical average of any group of numbers is the mean. In other words, the mean is the sum of all the measurement values divided by the number of measurements. The symbol for the mean is $\overline{x}$. As an example, the mean for five numbers would be calculated as follows:

$$\overline{x} = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{5}$$

STANDARD DEVIATION

Whereas the mean is an average of all the data values, the standard deviation is an average value of the dispersion of data from the mean. Standard deviation is usually signified by a small s or the Greek letter Sigma (s). For the Certified Hot Mix Asphalt Program, s is used.

The procedure used to compute the standard deviation is to subtract the mean from each value, square this difference, sum, divide by one less than the number of values, and take the square root. These steps may be expressed in terms of a formula as follows:

$$s = \sqrt{\frac{\sum(x_i - \overline{x})^2}{n - 1}}$$

where $\bar{x}$ is the arithmetic mean, n is the number of sample values and ∑ indicates the summation of all values.

Note that squaring the deviations from the mean removes the negative signs. Dividing by n - 1 gives us approximately an average squared deviation. Taking the square root puts the result back into the same units as the original values.

Example:

x_i	$x_i - \overline{x}$	$(x_i - \overline{x})^2$	
14.3	1.7	2.89	
11.2	-1.4	1.96	
14.1	1.5	2.25	
12.6	0.0	0.00	
12.9	0.3	0.09	
12.7	0.1	0.01	
13.2	0.6	0.36	
11.4	-1.2	1.44	
12.3	-0.3	0.09	
11.6	-1.0	1.00	
126.3		10.09	(Sum of squared differences)

$n = 10$

$$\bar{x} = \frac{\sum x_i}{n} = 12.6$$

$$\sqrt{\frac{10.09}{9}} = \sqrt{1.121} = 1.06 \qquad s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}} =$$

FIVE POINT MOVING AVERAGE

The moving average is a useful tool for tracking trends of the mean. The Certified HMA Producer Program requires that the moving average be the average of the most recent five data points.

For a moving average of five test values, the group of the first five measurements is averaged. When an additional test value is obtained, the first value is dropped, the sixth value is added, and the new group averaged. When a seventh value is obtained, the second value is dropped, and the new group averaged, and so on. An example of this procedure is as follows:

Data: 4.8, 5.3, 5.0, 4.7, 5.1, 5.5, 4.6

$$\text{First Average} = \frac{4.8+5.3+5.0+4.7+5.1}{5}$$

$$= \frac{24.9}{5} = 5.0$$

The first number, or 4.8, is dropped and the sixth value, or 5.5, is added and the second average is:

$$\text{Second Average} = \frac{5.3+5.0+4.7+5.1+5.5}{5}$$

$$= \frac{25.6}{5} = 5.1$$

Next, the 5.3 is dropped and 4.6 is added:

$$\text{Third Average} = \frac{5.0+4.7+5.1+5.5+4.6}{5}$$

$$= \frac{24.9}{5} = 5.0$$

VOLUMETRICS

Hot mix asphalt properties are most affected by volume not weight; however, production and testing of asphalt mixture is by weight. Specific gravity is the means to convert from units of weight to volume. The definition of specific gravity and equations relating specific gravity to density and volume are as follows:

Specific Gravity – the ratio of the weight of a given volume of an object to the weight of an equal volume of water at 77° F.

Density

$$D = G \times 62.416$$

where:

D = Density in lb/ft^3

G = Specific Gravity

62.416 = Density of Water in lb/ft^3 at 77° F

Volume

$$V = \frac{W}{G \; x \; 62.416}$$

where:

V = Volume in ft^3

W = Weight in lb

G = Specific Gravity

62.416 = Density of Water in lb/ft^3 at 77° F

CHAPTER 2

AGGREGATE FUNDAMENTALS, SAMPLING, AND TESTING

AGGREGATES

- *WHAT IS AN AGGREGATE*
- *USES OF AGGREGATES*
- *ORIGINS OF AGGREGATES*
  - *NATURAL SAND AND GRAVEL, CRUSHED STONE, SLAG*
- *DISTRIBUTION OF AGGREGATES*
  - *GLACIAL DEPOSITS AND BEDROCK DEPOSITS*
- *AGGREGATE TYPES*
  - *NATURAL AGGREGATES AND ARTIFICIAL AGGREGATES*
- *CLASSIFICATIONS OF AGGREGATES*
  - *FINE AGGREGATES AND COARSE AGGREGATES*
- *PHYSICAL PROPERTIES*
  - *ABSORPTION AND SPECIFIC GRAVITY, SURFACE TEXTURE, ABRASION RESISTANCE, SOUNDNESS, PARTICLE SHAPE, DELETERIOUS MATERIALS*
- *CONSENSUS PROPERTIES*
  - *COARSE AGGREGATE ANGULARITY*
  - *FLAT & ELONGATED PARTICLES*
  - *FINE AGGREGATE ANGULARITY*
- *HMA SURFACE AGGREGATES*
  - *DOLOMITE AGGREGATES, POLISH RESISTANT AGGREGATES, SANDSTONE AGGREGATES, SLAG AGGREGATES*
- *STOCKPILING*

SAMPLING AND TESTING

- *METHODS OF SAMPLING (BIN, BELT, STOCKPILE, TRUCK, CAR, BARGE)*
- *SIZE OF ORIGINAL SAMPLE*
  - *REDUCING A SAMPLE TO TEST SIZE*
  - *SIZE OF TEST SAMPLE (AFTER SPLITTING)*
  - *GRADATION*
  - *SIEVE ANALYSIS TEST*
- *MOISTURE CONTENT*

CHAPTER 2

AGGREGATE FUNDAMENTALS, SAMPLING, AND TESTING

An asphalt mixture pavement is composed of binder and aggregate blended together. The individual material properties of each component may affect the overall performance of the pavement. If pavements are to perform long term and withstand specific traffic and loading, the materials making up the pavements are required to be of high quality.

This section covers in detail the sources of aggregates in Indiana, as well as material properties of aggregates that are necessary for high quality pavements. Many of the tests are not required to be conducted by the Technician; however, a thorough understanding of the materials and test procedures to determine quality is a necessary background for the Technician. Converting that understanding into a working knowledge assists the Technician in making accurate, reliable, day-to-day decisions.

AGGREGATES

WHAT IS AN AGGREGATE?

Aggregates are granular materials that have been mined for use as a building material in the construction industry. They include aggregates from natural and artificial origins, such as stone, sand and gravel, and slag.

USES OF AGGREGATES

Streets, bridges, roads and sidewalks are made of concrete or asphalt which is mostly made up of aggregates combined with a binder that acts like glue. Concrete is used in foundations and basements for houses. Other buildings sometimes use concrete throughout their structures.

But did you know that many items you use every day have aggregates in them? Your toothpaste has aggregates in it. Glass is made from sand, which is an aggregate. Minerals and aggregates are in plates, dishes, pots and pans, baby powder, household cleaners, makeup, medicines, paints, pencils, fertilizers, wallboard, and more including some of the foods you eat! How many times have you heard that your cereal, for instance, is fortified with vitamins and minerals?

Any object that hasn't been grown had to be mined! Aggregates, minerals and metals all come from the ground. You can look at objects all around you and know which were grown and which were mined. If it is metal, it was mined. If it is wood, it was grown. If it is cotton or wool, it was grown. Paper comes from trees, which are grown. Pencils are grown and mined because wood is grown and graphite is mined. The ink on this paper came from mining. But what about plastic? Is it grown or mined? Plastic comes from petroleum products, which are mined.

ORIGIN OF AGGREGATES

The four main types of mineral aggregates in Indiana, gravel and natural sand, crushed stone, and slag. They all have different origins.

NATURAL SAND AND GRAVEL

Natural Sand

A mineral particle or rock fragment that is larger than coarse silt but smaller than gravel. It is a widespread but highly variable resource in Indiana that was formed mostly by glacial actions of large ice sheets and then sorted by running water. Sand can be used as fill, or more often the coarser parts find use as components of concrete or asphalt pavement. Sand, a finer granular material, also is important in concrete and in making mortar and in snow and ice control. Very fine-grained sand finds use in foundries to make molds. It is also used in sandblasting, glass-making, or even as golf-course sand. The size of sand ranges from .0625mm (.002 in) to less than 2mm (.08 in).

Gravel

The term gravel applies to a range of particle sizes, rather than a specific rock or mineral type. Gravel is colored by the rock types present. It is a collection of rock particles that are at least .08 inches in diameter sizes but may also include boulders over 10 inches in diameter. Gravel is loose rock that is often rounded in shape from being worn by water at some point. Gravel can be used alone as fill, for gravel roads, or residential driveways. Gravel can also be used as a component of concrete or asphalt pavement. Gravel is greater than or equal to 2mm (.08 inch) in size. It can include larger rocks such as boulders (over 10 inches).

Most of the gravels and natural sands used today are a product of the Ice Ages. Indiana has experienced multiple glacial advances and retreats between 2.6 million years ago and as recent as 11,700 years ago. Geologists concur that glaciers may have been up to 1 mile thick. As the glaciers advanced southward, rock was scraped beneath them. When the glaciers melted, the flowing water carried the rock fragments and deposited them downstream. The scraping action of the ice and flowing waters gave the gravels and natural sands the rounded appearance.

In addition, gravel and sand are obtained from postglacial or modern stream deposits. Another word for stream processes is fluvial. Areas in Indiana where fluvial deposits are mined are largely restricted to the river bars, bottom lands, and flood plains of the Ohio River and the lower reaches of the White and Wabash Rivers.

Gravel and sand are unconsolidated granular materials resulting from the natural disintegration of rocks. They disintegrate primarily from the abrading action of water or ice on rock material. In Indiana, deposits which are found beyond the physical limits of the glaciers, are likely to be found in greater abundance in stream bottoms and floodplains.

CRUSHED STONE

Crushed stone produced within Indiana originates from sedimentary bedrock deposits. There are three general classes of rocks: igneous, sedimentary, and metamorphic. Igneous rocks were formed from hot volcanic magma--molten mineral material. Sedimentary rocks were formed from the hardened deposits of the weathered remains of rocks, organic materials, and sediment. Metamorphic rocks were originally igneous or sedimentary rocks but were changed by pressure and/or heat. Across the United States, variations of the above noted rock types are utilized for crushed stone aggregate. Indiana bedrock is comprised of the sedimentary rock types, limestone and dolostone. Construction aggregates within Indiana primarily consist of these two sedimentary rock types. Sandstone from southern Illinois, a sedimentary rock type, is permitted for use in hot mix asphalt surface courses.

SLAG

There are different types of slag used as construction aggregate in the state of Indiana:

1. Blast Furnace Slag - a non-metallic material removed in the molten state of iron production. The further refinement of this blast furnace slag results in three aggregate variations: air cooled slag, expanded slag, and granulated slag.
2. Steel slag - a material derived from the further refinement of iron to steel.

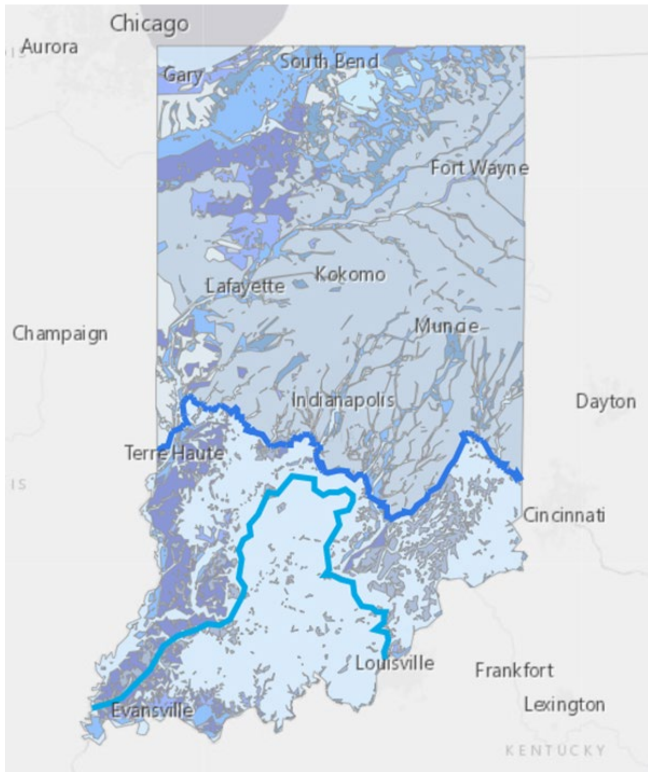
DISTRIBUTION OF AGGREGATES

Aggregate types vary by geographic location throughout the State of Indiana. The composition of each type of aggregate also varies.

Glacial Deposits

Glaciers once blanketed five-sixths of Indiana. They carried sand and gravel deposit which are in great abundance in the northern part of the state, but also may be found along any river in Indiana. Figure 2.1 shows the southern boundaries of two of the major glacial advances which moved across the prehistoric Indiana landscape. The size of the gravel and the type of minerals and rocks found in the deposits varies from place to place. Gravel becomes smaller as it travels downstream. Occurrence of gravel decreases from northeastern to southwestern Indiana.

FIGURE 2.1 MAJOR GLACIAL ADVANCES IN INDIANA



The composition of a deposit also varies from place to place. In some deposits, 10 to 20 different types of rocks may be found. Granite, gneiss, and schist (igneous and metamorphic rocks) or limestone, dolostone, chert, sandstone, siltstone, and shale (sedimentary rocks) are typically found. Porous chert, siltstone, sandstone, ocher, and shale are deleterious, meaning that the material does not perform well in certain applications in highway construction.

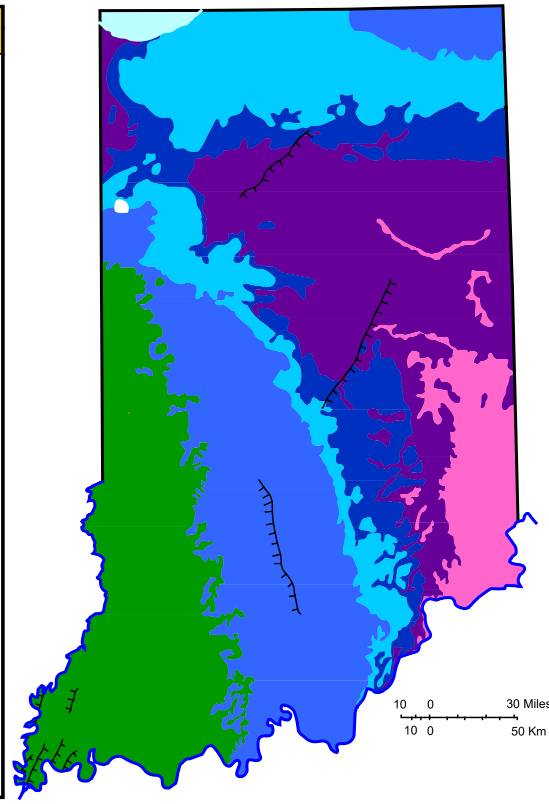
Bedrock Deposits

As shown in the bedrock map of Indiana (Figure 2.2), the bedrock belongs to five geologic periods which are listed from the oldest to youngest: Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian.

FIGURE 2.2 BEDROCK UNITS IN INDIANA

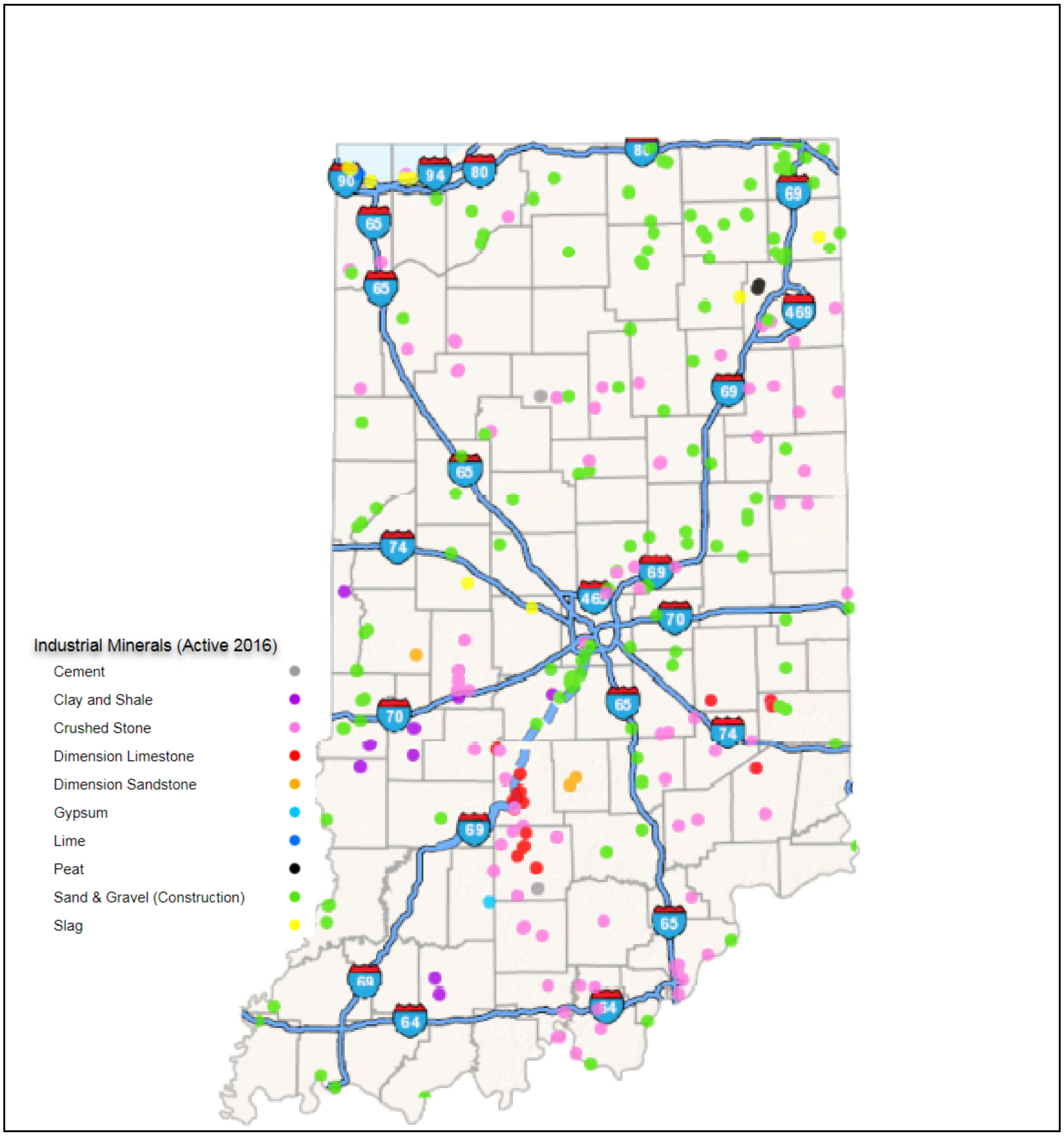
EON	ERA	PERIOD	Millions of Years Ago
PHANEROZOIC	CENOZOIC	QUATERNARY	1.75± 0.05
		TERTIARY ***	65 ± 0.5
	MESOZOIC	CRETACEOUS **	135 ± 5
		JURASSIC **	203 ± 3
		TRIASSIC **	250 ± 3
	PALEOZOIC	PERMIAN **	295 ± 5
		PENNSYLVANIAN	325
		MISSISSIPPIAN	355 ± 5
		DEVONIAN	410 ± 8
		SILURIAN	435 ± 6
		ORDOVICIAN	500
		CAMBRIAN *	540 ± 5
PROTEROZOIC	PRECAMBRIAN *		
ARCHEAN			4,600

* Not exposed at the surface ** Not present *** Scattered deposits



Comparing the map of the quarry locations (Figure 2.3), to the bedrock map (Figure 2.2), almost all of Indiana's crushed stone quarries are in areas underlain by rock of Mississippian, Devonian, or Silurian Ages (Figure 2.2). During these periods, thick beds of high-grade limestone or dolostone were formed. Rock types formed during other geologic periods are either inaccessible or do not possess the minimum quality requirements needed for highway construction.

FIGURE 2.3 DISTRIBUTION OF AGGREGATE RESOURCES IN INDIANA



Since most of Indiana once was covered by glaciers, the deposits left by these glaciers have impacted the location of quarry sites in the state. Quarry sites are more easily developed in southern Indiana than in northern Indiana where the overburden may reach several hundred feet in depth. In the glaciated parts of Indiana, quarry sites are limited to areas where streams have eroded to bedrock or areas where bedrock was usually high in pre-glacial times, such as ancient coral reefs. Many quarries have been developed in areas where sand and gravel deposits were mined to the bedrock surface.

AGGREGATE TYPES

The aggregates used in highway construction are all mineral aggregates. Aggregates are composed of a naturally occurring solid chemical element or compound formed as a product of an inorganic process. There are two distinct types of aggregate: natural, and artificial.

Natural Aggregates

Rock or stone (either term may be used) fragments which are used in their natural state are considered natural aggregates. Crushed stone, sand, and gravel are natural aggregates.

Crushed Stone

Crushed stone is produced from quarries where the bedrock is blasted (shot) with explosives and further fragmented by mechanical crushing. All crushed stone fragments are angular in shape and all faces of the fragments are created by the crushing operation.

The most common sedimentary rock types found in Indiana are limestone, dolostone, sandstone, shale, and siltstone. Only limestone and dolostone are routinely used for highway construction, although some sandstone from southern Illinois is allowed for high friction HMA surface.

Sand and Gravel

Sand and gravel are generally found together. These aggregates may be mined from a water-filled pit (a deposit below the water table) or from a cut bank deposit (a deposit above the water table). If the aggregates come from a pit, the aggregate is referred to as "pit-run" material. A cut-bank deposit is termed "bank-run" material.

Sand from these deposits are referred to as natural sand, while sand made by crushing stone, pieces of gravel, or slag are commonly called manufactured sand.

The sand and gravel found in the deposits have a variety of assorted sizes. Further processing is required including screening, washing, and some crushing. The crushing is done to produce aggregates of the proper size and angularity.

Artificial Aggregates

These aggregates are processed either from blast furnace slag or steel slag.

CLASSIFICATIONS OF AGGREGATES

Aggregates are separated into two classifications: coarse aggregates, and fine aggregates. The No. 4 sieve generally determines the difference between coarse aggregate and fine aggregate for most highway construction work.

Fine Aggregates

Fine aggregate is defined as aggregate that is 100 percent passing the 3/8 in. sieve and a minimum of 80 percent passing the No. 4 sieve.

Coarse Aggregates

Coarse aggregate is defined as aggregate that has a minimum of 20 percent retained on the No. 4 sieve.

PHYSICAL PROPERTIES

The physical properties of aggregates are those that refer to the physical structure of the particles that make up the aggregate.

Absorption and Specific Gravity

The internal pore characteristics are very important properties of aggregates. The size, number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and resistance to freezing and thawing action. Absorption is the particle's ability to take in a liquid. Porosity is a ratio of the volume of the pores to the total volume of the particle. Permeability refers to the particle's ability to allow liquids to pass through. If the rock pores are not connected, a rock may have high porosity and low permeability.

Density and Specific Gravity

Density is the weight per unit of volume of a substance. Specific gravity is the ratio of the density of the substance to the density of water.

The following chart illustrates these relationships for some common substances.

FIGURE 2.4 TYPICAL VALUES

Typical Specific Gravity Chart	
Substance	Specific Gravity
Wood (oak)	0.7
Water	1
Coal	1.6
Gypsum	2.3
Blast Furnace Slag	2.4
Limestone	2.6
Quartz	2.6
Shale	2.6
Gravel	2.7
Trap Rock	2.9
Steel Slag	3.5
Iron	7.9
Lead	11
Gold	19

The density and the specific gravity of an aggregate particle is dependent upon the density and specific gravity of the minerals making up the particle and upon the porosity of the particle. These may be defined as follows:

1. All of the pore space (bulk density or specific gravity)
2. Some of the pore space (effective density or specific gravity)
3. None of the pore space (apparent density or specific gravity)

As an example, specific gravity information about a particular aggregate helps to determine the amount of asphalt needed in hot mix asphalt. If an aggregate is highly absorptive, the aggregate continues to absorb asphalt, after initial mixing at the plant, until the mix cools down completely. This process leaves less asphalt for bonding purposes; therefore, a more porous aggregate requires more asphalt than a less porous aggregate. The porosity of the aggregate may be taken into consideration in determining the amount of asphalt required by applying the three types of specific gravity measurements.

Surface Texture

Surface texture is the pattern and the relative roughness or smoothness of the aggregate particle. Surface texture plays a big role in developing the bond between an aggregate particle and asphalt cement. A rough surface texture gives the asphalt cement something to grip, producing a stronger bond. Surface texture also affects the workability of hot mix asphalt.

Some aggregates may initially have good surface texture but may polish smooth later under traffic. These aggregates are unacceptable for final wearing surfaces. Limestone usually falls into this category. Dolomite does not, in general, when the magnesium content exceeds the minimum required in the INDOT Standard Specifications.

Abrasion Resistance

For a coarse aggregate to be satisfactory for a pavement, the aggregate is required to be tough enough to withstand the action of rolling during construction and the action of traffic without breaking down under the loads. The test used for evaluating this property is the Los Angeles Abrasion test (AASHTO T 96). Briefly, this test requires the aggregate to be placed in a metal drum along with steel balls, and the drum rotated 500 times. Another test that is conducted to evaluate AS aggregates for use with SMA mixtures is the Micro-Deval Test (AASHTO T 327). The Micro-Deval Test is a measure of abrasion resistance and durability of mineral aggregates resulting from a combination of actions including abrasion and grinding with stainless steel balls in the presence of water.

Soundness

In asphalt pavements, particularly surface mixtures, aggregates are subjected to harsh conditions. Weather extremes create conditions conducive to aggregate breakdown. The soundness of an aggregate refers to the aggregate's inherent ability to withstand these extremes. This aggregate quality is verified through tests involving exposure to chemicals, such as sodium sulfate, and by exposure to rapid freezing and thawing cycles.

Aggregates which disintegrate badly under the forces of weather are termed unsound. Shale is a typical unsound material because water enters into the aggregate and freezes, causing the aggregate to expand and disintegrate. Also, exposure to air (oxidation) causes shale to flake. Unsound aggregates are obviously unsatisfactory for use in asphalt mixtures, particularly for surface asphalt mixtures, which are more exposed to the weather. INDOT subjects aggregates to three different test methods to evaluate soundness:

1. The sodium sulfate test in AASHTO T 104
2. The brine freezing and thawing test in ITM 209
3. The freezing and thawing test in AASHTO T 103

Particle Shape

Aggregates come in many shapes and sizes. For our purposes, aggregates are grouped into two broad categories, angular and rounded. Angular particles are newly broken. They have not been subjected to forces of nature such as stream polishing, weathering, and wind erosion. Crushed stone and crushed gravel are examples of products which contains angular particles. In stream sediments and glacial till in Indiana, rounded particles are common. Products such as natural sand and gravel contain rounded particles.

The shape of the aggregate particle can greatly affect workability and strength of asphalt mixtures. Irregular angular particles in crushed stone and crushed gravel have a tendency to interlock and are therefore optimal for strength in concrete and asphalt mixtures. A percentage of natural sand is allowed to be added, depending on the application. For requirements for crushed materials in certain applications, consult the current INDOT Standard Specifications book.

Deleterious Materials

Deleterious materials in aggregates are materials which are undesirable for use in asphalt mixture. Therefore, the Specifications limit the amount of deleterious materials depending on the quality required in the final product. Deleterious concerns vary by aggregate type and are also often area specific. Some examples of deleterious materials include: Chert, shale, wood, trash, coal, limonite, and ochre.

Chert is a rock composed of microcrystalline silica. When lightweight chert (less than 2.45 specific gravity) is present in aggregate used to produce asphalt mixture, the chert may undergo expansion sufficient to cause pop-outs when the chert particles are located close to the surface. In addition, the binder is unable to coat chert particles which may lead to raveling of the pavement. Once either problem is initiated, the rate of deterioration of the surface is accelerated.

CONSENSUS PROPERTIES

Coarse Aggregate Angularity

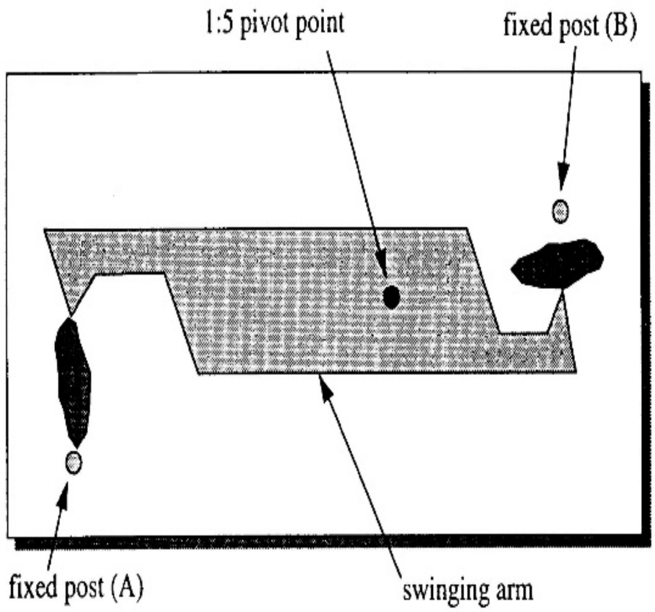
Crushed particles (coarse aggregate angularity) are necessary in asphalt mixture to assist in resisting shoving and rutting under traffic. The internal friction among the crushed aggregate particles prevents the aggregates from being moved past each other and provides for a stable mix. The test procedure used to determine coarse aggregate angularity is ASTM D 5821.

The crushed particle requirement applies for asphalt mixture when ONLY gravel is used because stone is by definition 100% crushed. Crushed particles are defined as those particles having one or more sharp, or slightly blunt edges. Fractured faces that have an area less than 25 percent of the maximum cross-sectional area of the particle are not considered crushed.

Flat and Elongated Particles

Flat and elongated particles are undesirable because they have a tendency to break during construction and under traffic. This characteristic is defined as the percentage by weight of coarse aggregates that have a length in excess of five times its width in accordance with ASTM D 4791. Figure 2.5 is an illustration of the device used to measure flat and elongated particles.

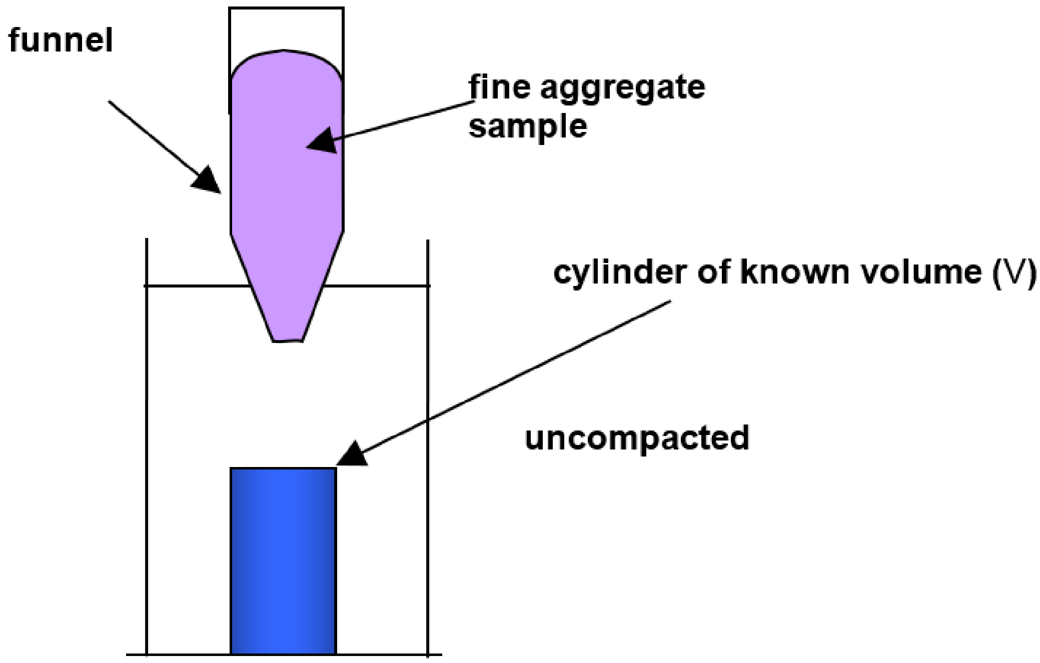
FIGURE 2.5 FLAT AND ELONGATED PARTICLE TEST



Fine aggregate angularity (FAA), like the crushed content of coarse aggregate, is necessary to achieve a high degree of internal friction and therefore high shear strength for rutting resistance. FAA is defined as the percent air voids present in loosely compacted aggregates finer than the No. 8 sieve.

The test used for determining the Fine Aggregate Angularity is the Uncompacted Void Content of Fine Aggregate Test (AASHTO T 304). In the test, a sample of fine aggregate is poured into a small calibrated cylinder by flowing through a standard funnel (Figure 2.6). By determining the weight of fine aggregate (W) in the filled cylinder of known volume (V), void content may be calculated as the difference between the cylinder volume and fine aggregate volume collected in the cylinder. The fine aggregate bulk specific gravity (GSB) is used to compute fine aggregate volume.

FIGURE 2.6 FINE AGGREGATE ANGULARITY



HMA SURFACE AGGREGATES

Dolomitic Aggregates

There is a special requirement to be met when dolomitic coarse aggregates are used in asphalt mixture. These aggregates are specified for high traffic applications to obtain high-friction, skid-resistant asphalt mixture surface courses. ITM 205 is used to ensure that the aggregate is a carbonate rock containing at least 10.3 percent elemental magnesium.

Polish Resistant Aggregates

Aggregates that meet the requirements of ITM 214 may be used in place of dolomitic aggregates in asphalt mixture surface mixtures. The procedure for approval requires initial lab testing, placement of a test section on an INDOT contract, and subsequent skid testing for two years.

Sandstone Aggregates

Coarse Sandstone is required to meet the Class B quality requirements and may only be used in asphalt mixture surface mixtures. The definition of sandstone is described in Section 904.01.

Slag Aggregates

Steel furnace slag for use in SMA is required to meet additional requirements for control of the specific gravity in accordance with Section 904.01.

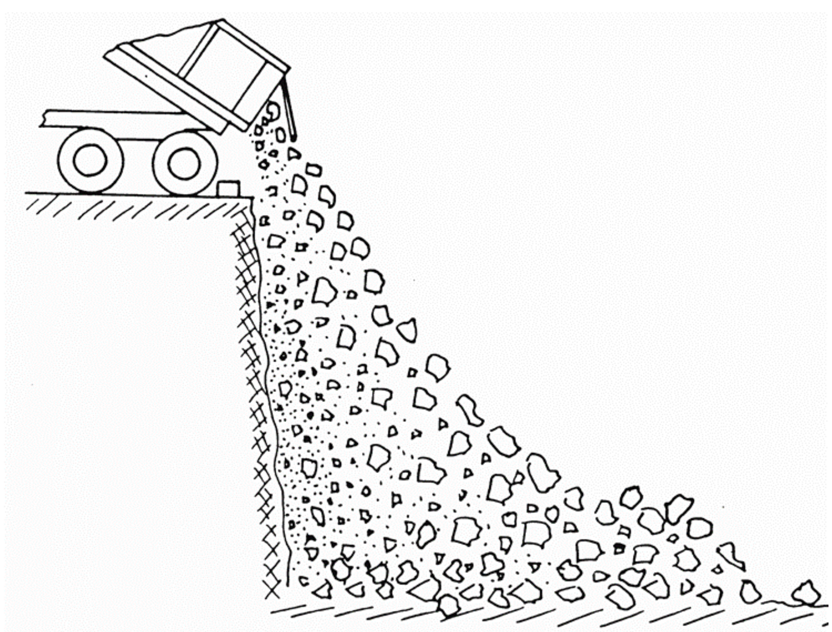
STOCKPILING

Segregation is probably the greatest problem of stockpiling and handling aggregates, but certainly other problems such as degradation and contamination may adversely affect the aggregate quality. Every possible precaution is required to be taken to protect aggregate quality from initial stockpiling to the point where the material is loaded into the asphalt mixture plant.

The majority of aggregate stockpiles at the asphalt mixture plant are built by dumping individual truckloads of material. The best truck-built stockpiles are those that are constructed one dump high with each dump placed against previously dumped material. This procedure, because of the low profile, reduces the roll-down segregation; however, these stockpiles require a large area. A technique that helps reduce the required area is to restock some dumps on top of other dumps with a large end loader operating from ground level. In this procedure, care is required to be taken to place the upper lift back from the edge far enough that a long-sloped face is not made that would cause segregation.

Occasionally aggregate is dumped over a quarry or pit face to form a stockpile. This procedure causes considerable segregation, particularly with larger and long graded aggregates. In general, the larger particles roll to the outside and base of the stockpile. The extent of segregation varies with the height of fall, gradation of the material, moisture, and other conditions. Segregation typically occurs as shown in Figure 2.7.

FIGURE 2.7 AGGREGATE SEGREGATION



Because of the various sampling locations and the availability of equipment, there are several methods of taking aggregate samples. Uniformity of obtaining the sample cannot be emphasized enough. The uniformity eliminates one variable in the test results.

METHODS OF SAMPLING

Bin Sampling

Bin samples taken at asphalt mixture plants are required to be taken at the discharge chute of the bin. In this procedure, a number of small samples are taken at short intervals and combined to make the total sample. Each of these samples are required to include the entire cross section of the flow of material from the chute at the moment taken. If the rate of flow from the discharge chute cannot be controlled, obtaining a sample from the bin may be impractical or impossible. Therefore, a mechanical sampling device that supports the weight of sample or a diversion chute may be required.

Belt Sampling

Belt sampling material consists of taking samples of materials directly from conveyor belts. To ensure proper safety practices are followed, a belt sampling consists of:

1. Make sure that the belt is carrying a normal load of material which is not segregated
2. Have the plant operator stop the belt
3. Take a complete cross section of the material, being careful to include all the material on the belt and only the material in the cross section. A template is recommended. Remove most of the sample with a scoop or shovel and the remainder with a brush
4. Take as many complete cross sections as necessary to obtain a sample that meets the minimum sample size

Stockpile Sampling

The primary control of aggregates at the asphalt mixture plant is done by sampling stockpiles of the finished materials. Therefore, a uniform and representative method of sampling (ITM 207) is required. Coarse aggregate samples are taken with a square bit shovel. The size of the shovel is required to be large enough so that the sample meets the minimum weight requirements of the test conducted on the sample. Fine aggregate samples are taken with a sampling tube or fire shovel.

Coarse aggregate is required to be sampled in the following manner:

1. Locate the area of the stockpile from which plant loading begins
2. Using a front-end loader, dig into the stockpile and set aside a small pile of 10 to 15 t of material. This is required to be done in the same manner as the plant is being loaded. When forming the small pile, the loader bucket is required to be as low as possible and the operator is required to roll the material from the bucket rather than dumping the material. Reducing the distance the material is allowed to free-fall reduces the amount of segregation that may occur in the small pile. Each additional bucket load of material is required to be taken and dumped in the same manner as set out above and is required to be placed uniformly over the preceding one.
3. Thoroughly mix the small pile. Using the loader bucket, go to the end of the oblong pile and roll the material over. Keeping the loader bucket as low as possible, push the bucket into the material until the front of the bucket passes the midpoint of the original pile. The loader bucket is required to then be slowly raised and rolled forward thus producing a smooth mixing of the material. Go to the opposite end of the pile and repeat this mixing procedure. If the pile does not appear to be reasonably uniform, additional mixing is required to be done.
4. The pile is now ready for sampling. Do not strike off the top. The sample is taken at the center of the volume which is approximately one-third of the height of the pile. The sample consists of not less than 6 full shovels of material taken at equal increments around the pile. The shovel is inserted full-depth horizontally into the material and raised vertically. Care is required to be taken to retain as much of the material as possible on the blade of the shovel (Figure 2.8).

FIGURE 2.8 STOCKPILE SAMPLING


CATERPILLAR


CATERPILLAR

Fine aggregates are sampled using the same technique used to sample coarse aggregates, except a sampling tube or fire shovel is used instead of the large shovel.

Truck, Car, or Barge Sampling

Direct sampling from trucks, railroads cars, or barges is not recommended. There are a number of factors which may influence the quality of the material before the aggregate is used. Therefore, material being shipped by trucks, railroad cars, or barges are required to be sampled at the point of delivery after the aggregate has been stockpiled.

SIZE OF ORIGINAL SAMPLE

The following is a list of recommended minimum sample sizes to be used as a guide when collecting materials.

MATERIAL	SAMPLE SIZE
No. 2 coarse aggregate	220 lb
No. 5 coarse aggregate	110 lb
No. 8 coarse aggregate	55 lb
No. 9 coarse aggregate	35 lb
No. 11 & No. 12 coarse aggregate	25 lb
All sands	25 lb

The weight of the sample depends on the maximum particle size of the material being tested. As a rule, a larger top size material requires a larger sample. A 35 lb sample of No. 5 coarse aggregate would not be as representative of that material as a 35 lb sample of natural sand. The size of sample for materials that do not meet a specific INDOT size are required to be the same as the INDOT size the aggregate gradation is comparable to.

REDUCING A SAMPLE TO TEST SIZE

The total sample is required to be reduced to a sample size that may be continually tested. Time does not allow the Technician to test the total sample. The key to sample reduction is to ensure that the sample remains representative of the material in the stockpile. This practice is commonly referred to as splitting a sample. AASHTO R 76 details three different methods to reduce a sample to the proper test size.

1. Using a mechanical splitter is the most accepted method of reducing to test size all coarse aggregate material smaller than gradation size No. 2.

2. Using a sand splitter is the accepted method for fine aggregate that is drier than the saturated-surface-dry condition. As a quick check to determine this condition, if the sand retains the shape that is molded in the hand, the sand is considered wetter than saturated-surface-dry
3. The miniature stockpile is the method used for fine aggregate that has free moisture on the particle surfaces
4. Quartering may be used when a mechanical splitter is not available

SIZE OF TEST SAMPLE (AFTER SPLITTING)

The original sample is required to be reduced to test sample size which falls within the minimum and maximum weight in the following table.

AGGREGATE SIZE	MINIMUM (suggested)	MAXIMUM (suggested)
No. 2	11300 g	---
No. 5 and No. 8	6000 g	8000 g
No. 9	4000 g	6000 g
No. 11	2000 g	---
No. 12	1000g	---
Fine Aggregate	300 g	---

GRADATION

Particle gradation is determined by a sieve or gradation analysis of aggregate samples. A sieve analysis requires passing the sample through a series of sieves, each of which has openings of specific sizes (Figure 2.9). Sieves are designated by the size of their openings. Coarse particles are trapped in the upper sieves; medium-sized particles pass through to the mid-level sieves; fines pass through to the lowest sieves.

The aggregate gradation considers the percentage by weight of the total sample that passes through each sieve. This is determined by weighing the contents of each sieve following the sieve analysis, then calculating the percentage passing each sieve.

FIGURE 2.9 SIEVE ANALYSIS

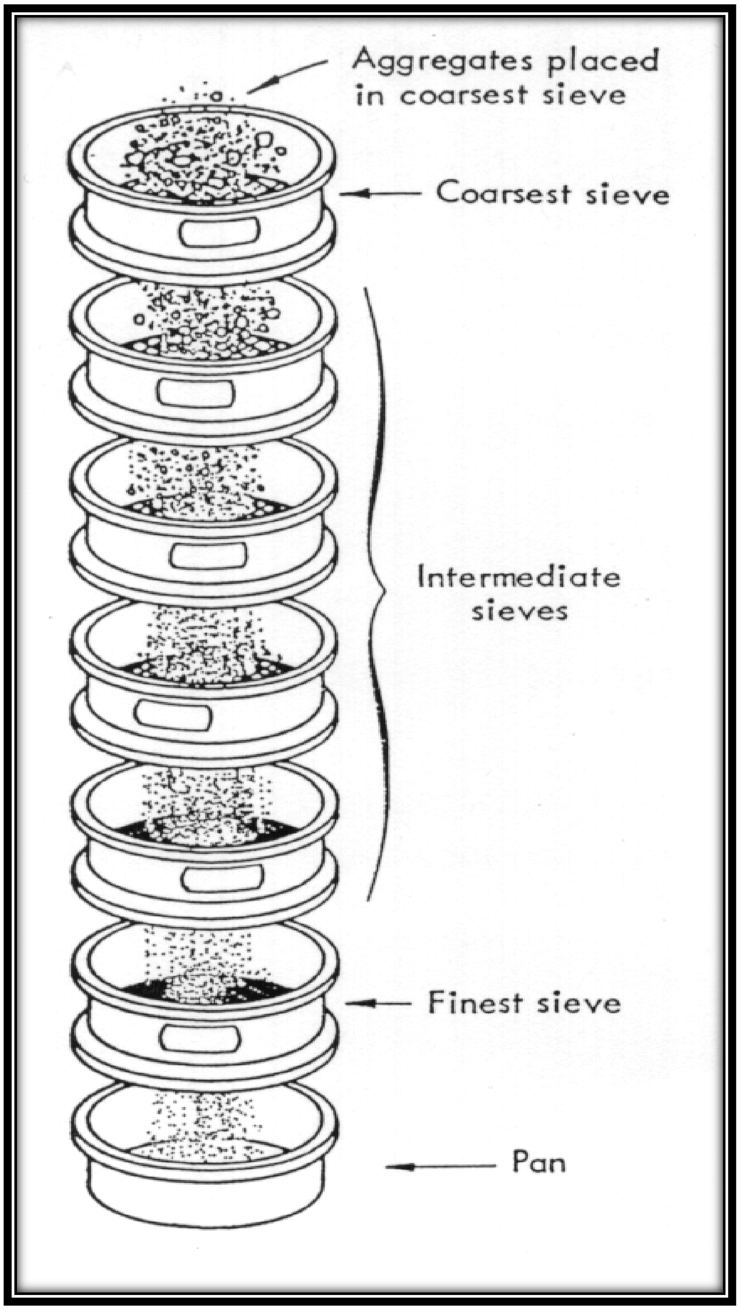
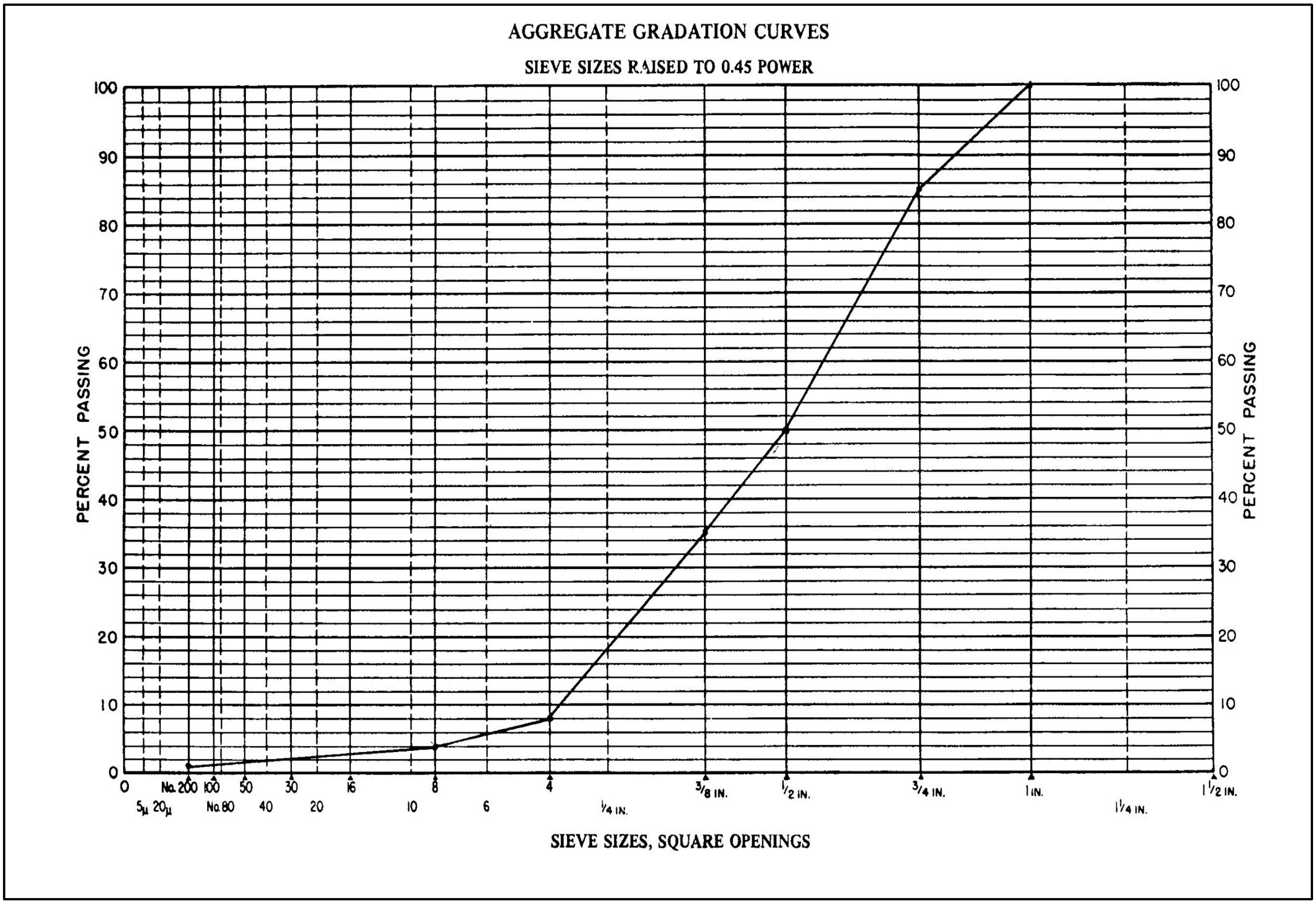


FIGURE 2.10. GRADATION CHART



For the purpose of description, certain terms are used in referring to aggregate fractions. They are:

Coarse aggregate - Material that has a minimum of 20 percent retained on the No. 4 sieve

Fine aggregate - Material that is 100 percent passing the 3/8 in. sieve and a minimum of 80 percent passing the No. 4 sieve

Top Size or Maximum Particle Size – The sieve on which 100 percent of the material will pass.

Nominal Maximum Particle Size – Smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

> *Note: These definitions of particle size are referring to individual aggregates. Please note these are different definitions than the similar terms for aggregate gradation used in mix design found in Chapter 4.*

Aggregate gradation specifications for a given contract may be presented graphically. Figure 2.10 is a typical gradation chart. On the chart, sieve sizes are presented horizontally and the percent passing each sieve is shown vertically.

Sieve Analysis Test

Sieve analysis is used primarily to determine the particle-size distribution of materials. The results determine compliance of the particle-size distribution with the applicable requirements. The test is conducted on both the fine and coarse aggregates in accordance with AASHTO T 27, with exceptions as noted in Section 904.06.

The procedure for a sieve analysis is as follows:

1. The dried sample is placed in the top sieve of properly nested sieves. The sieves are nested in sequence with the smallest sieve placed on the pan and stacked by increasing size.
2. The shaking time is required to be sufficient to ensure that the sample is divided into fractional sizes. The actual shaking time is required to be determined in accordance with ITM 906. The following times are minimum for shakers:

Coarse Aggregate, Size 9 or larger	5 Minutes
Coarse Aggregate, Smaller than Size 9	10 Minutes
Fine Aggregates	15 Minutes

3. At the conclusion of sieving, the material retained on each sieve is carefully transferred to a weigh pan and weighed. The weight retained of the material on each sieve is recorded on the Gradation Analysis sheet. The weight may not exceed the allowable amount on each sieve as indicated in the Figure 2.11.

The larger sieves (above the No. 16) are cleaned with a small trowel or piece of flat metal. The sieves between the No. 16 and No. 50 are cleaned with a wire brush. Sieves under the No. 50 are cleaned with a soft bristle brush. Care is required to be taken not to damage the sieves.

4. The weight passing each sieve is calculated next by subtracting the weight retained on the largest sieve from the total sample weight. The weight retained on the next largest sieve is subtracted from the weight of material still remaining from the first subtraction. This process is continued for all sieves.

Example:

1 in.	5942.1 - 690.6	=	5251.5
3/4 in.	5251.5 - 2492.7	=	2758.8
3/8 in.	2758.8 - 1397.1	=	1361.7
No. 4	1361.7 - 997.0	=	364.7
No. 8	364.7 - 264.5	=	100.2
Pan material		=	88.1

FIGURE 2.11 APPROXIMATE SIEVE OVERLOAD

TABLE 1 APPROXIMATE SIEVE OVERLOAD				
SCREEN **SIZE**	STANDARD **15 in. x 23 in.**	STANDARD **14 in. x 14 in.**	**12 in.** **DIAMETER**	**8 in.** **DIAMETER**
3 in.	40.5 kg	23.0 kg	12.6 kg	-------------
2 in.	27.0 kg	15.3 kg	8.4 kg	3.6 kg
1-1/2 in.	20.2 kg	11.5 kg	6.3 kg	2.7 kg
1 in.	13.5 kg	7.7 kg	4.2 kg	1.8 kg
3/4 in.	10.2 kg	5.8 kg	3.2 kg	1.4 kg
1/2 in.	6.7 kg	3.8 kg	2.1 kg	890 g
3/8 in.	5.1 kg	2.9 kg	1.6 kg	670 g
No. 4	2.6 kg	1.5 kg	800 g	330 g
8 in. diameter sieves, No. 8 to No. 200 shall not exceed 200g / sieve				
12 in. diameter sieves, No. 8 to No. 200 shall not exceed 469g / sieve				

FIGURE 2.12 GRADATION EXAMPLE

TOTAL WEIGHT: 5942.1g				
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	g	g	%	%
1 in.	0 g	5942.1 g	%	%
¾ in.	690.6 g	5251.5 g	%	%
½ in.	2492.7 g	2758.8 g	%	%
⅜ in.	1397.1 g	1361.7 g	%	%
No. 4	997.0 g	364.7 g	%	%
No. 8	264.5 g	100.2 g	%	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	88.1 g	g	%	%
DECANT ORIGINAL	**FINAL**	**GRAMS LOSS**	**PERCENT LOSS**	**PERCENT REQUIRED**
g	g	g	%	%

The percent passing is calculated for each sieve by using the following formula:

$$\% \text{ Passing} = \frac{Weight\ passing\ each\ sieve}{Original\ dry\ sample\ weight} x\ 100$$

Example:

3/4 in.	$\frac{5251.5}{5942.1}$ x 100	=	88.4%
1/2 in.	$\frac{2758.8}{5942.1}$ x 100	=	46.4% etc.

5. If the test has been done accurately, the sum of all the fractional weights retained (including the material in the pan) is approximately equal to the original dry weight. If the two weights differ by more than 0.3 percent, based on the original dry sample weight, the results are considered invalid.

$$\frac{Original\ Dry\ Weight - Summation\ Weights\ Measured}{Original\ Dry\ Weight}\ x\ 100$$

Example:

$$\frac{5942.1 - 690.6 + 2492.7 + 1397.1 + 997.0 + 264.5 + 88.1}{5942.1}\ x\ 100 =$$

0.2% = valid test

FIGURE 2.13 GRADATION EXAMPLE

TOTAL WEIGHT: 5942.1g				
SIEVE SIZE	**WEIGHT RETAINED**	**WEIGHT PASSING**	**PERCENT PASSING**	**PERCENT REQUIRED**
1½ in.	g	g	%	%
1 in.	0 g	5942.1 g	100 %	%
¾ in.	690.6 g	5251.5 g	88.4 %	%
½ in.	2492.7 g	2758.8 g	46.4 %	%
⅜ in.	1397.1 g	1361.7 g	22.9 %	%
No. 4	997.0 g	364.7 g	6.1 %	%
No. 8	264.5 g	100.2 g	1.7 %	%
No. 16	g	g	%	%
No. 30	g	g	%	%
No. 50	g	g	%	%
No. 100	g	g	%	%
No. 200	g	g	%	%
PAN	88.1 g	g	%	%
DECANT ORIGINAL	**FINAL**	**GRAMS LOSS**	**PERCENT LOSS**	**PERCENT REQUIRED**
g	g	g	%	%

Moisture Content

The moisture of the aggregates is required to be determined to adjust aggregate weights for moisture content and to determine the amount of binder to add to the asphalt mixture.

For moisture content, the sample is required to be reduced to test size and the test conducted as quickly as possible after the sample has been taken. Any delay in conducting the test after the sample has been obtained may allow the material to lose moisture and cause inaccurate results.

The test procedure for moisture content is:

1. Weigh the sample before drying and record the weight
2. Dry the sample and allow to cool to room temperature
3. Weigh the sample and record the weight
4. Determine the moisture percent using this formula:

$$\% \text{ Moisture} = \frac{Weight\ Wet - Weight\ Dry}{Weight\ Dry} \times 100$$

CHAPTER 3

ASPHALT BINDER

CHAPTER 3

ASPHALT BINDER

Asphalt mixture is composed of aggregates bound together with asphalt binder. Performance of the pavement is affected by properties of the aggregates, properties of the asphalt binder and proportions of each. The required properties as listed in the specifications are based on anticipated traffic and climate where the pavement is to be built.

This section discusses the properties of asphalt binders. Most asphalt binder tests are not done by contractor people; however, an understanding asphalt binder properties and test procedures is useful background for some day-to-day decisions.

ASHPALT

SOURCE AND NATURE OF ASPHALT

Asphalt is extracted from crude oil that is composed of hydrocarbon molecules, that is, molecules containing mostly of hydrogen and carbon. Crude oil is a mixture of different size molecules that have different boiling points. Figure 3.1 shows the boiling point ranges of different molecules in the crude oil. Oil refineries use distillation to “boil off” different size molecules as shown in Figure 3.1. For example, a molecule of diesel fuel boil between 575F and 700F. Crude oil is heated to 900F and since asphalt binder boils at a higher temperature, a residue is left.

Not all crude oil produces acceptable asphalt binder. Figure 3.1 shows different crude oils. Generally, crude oils with small amounts of asphalt binder in them, such as the Barrow Island crude (from Alaska) cannot be used to produce asphalt binder. Other crudes with a high percentage of asphalt binder, such as Boscan crude, produce good quality asphalt binders. In Indiana, most crude oil comes from Western Canada and produces good quality asphalt binders.

FIGURE 3.1 TYPICAL DISTILLATION TEMPERATURES AND PRODUCTS

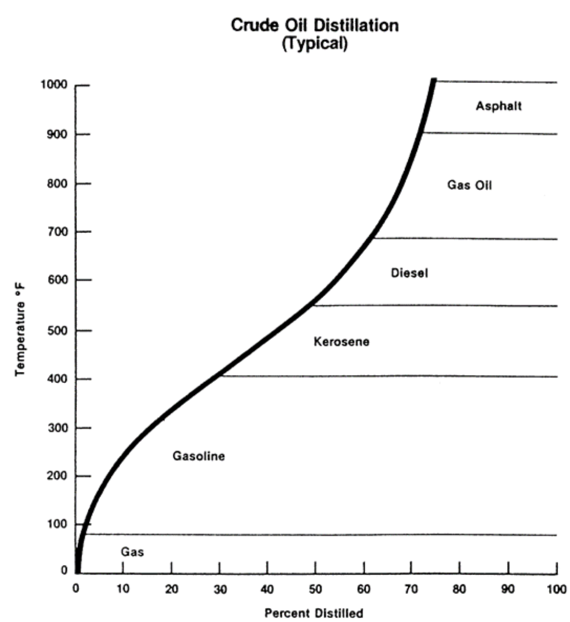


FIGURE 3.2 TYPICAL REFINING PROCESS

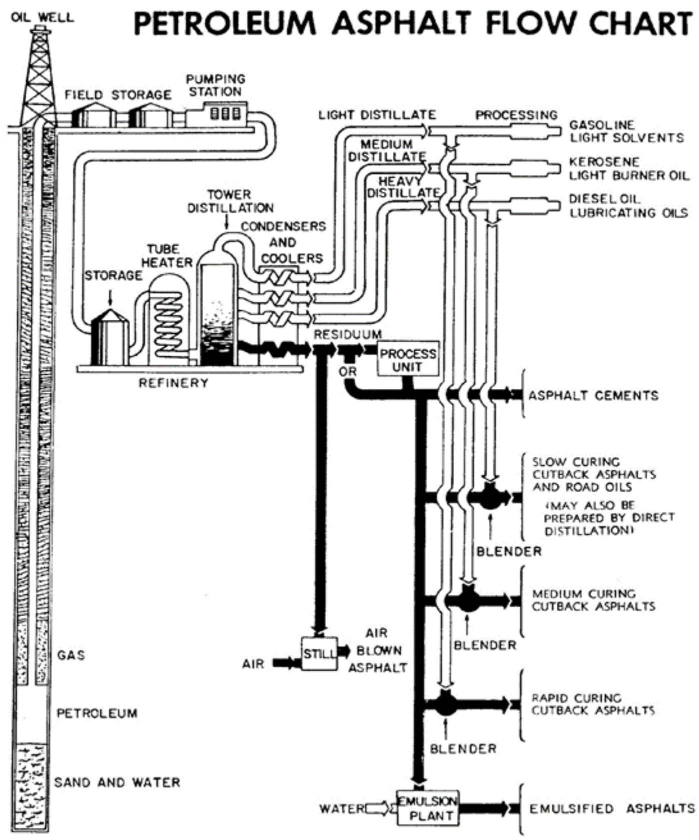


FIGURE 3.3 NOT ALL CRUDE OIL IS THE SAME

Many materials have a melting point, that is, a temperature at which it turns from solid to liquid. For example, water at 33°F is a liquid. At 31°F it is a solid, ice. At 32°F water changes from liquid to solid. Asphalt binder does not have one temperature at which it changes from liquid to solid.

At very high temperatures, greater than 400°F, asphalt binder is a pure liquid. At very cold temperatures, about -50°F or colder, it is a pure solid. At any temperature in between, it has both liquid and solid behavior at the same time. As temperature increases, the proportion of liquid behavior increases until it becomes a pure liquid. The opposite happens as temperature decreases.

Asphalt binder behavior depends on

- Temperature
- Time of loading
- Age

Temperature is the most commonly understood factor. Most people know that if asphalt is heated it becomes soft. And if it is heated enough, it will turn to liquid. Time of loading is less obvious. Asphalt binder will react with a different stiffness depending on how fast a load is placed.

So, for example, if you go to a swimming pool and someone asks, “How stiff is the water in the pool? How hard is it?” The response might be, “Huh. What are you talking about?” and you swish your hand in the water and say, “It’s not very hard at all. It’s water!”

And they say, “Why don’t you climb up that 30 foot high diving platform and dive off. Don’t worry that you don’t know how to dive. After all, the water is soft.”

When you hit the water at 50 mph, the water is not very soft. It’s pretty hard. It is the same water in the pool. In one case we put a load on slowly, by swishing our hand through the water. In the other case, we put it on quickly.

Asphalt binder works the same way. Cars and trucks moving at highway speed put a load on the pavement much faster than trucks coming to a stop at a red light.

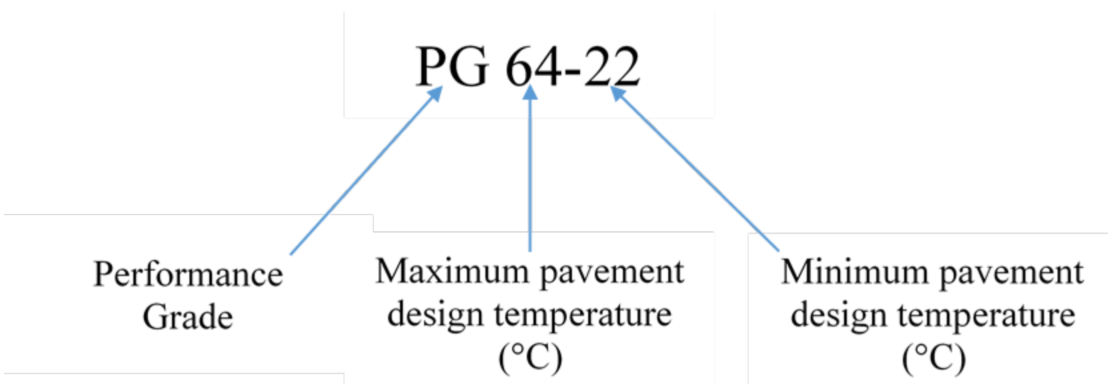
Asphalt binder changes as it ages. Oxygen reacts with the asphalt molecules and the binder becomes harder and more brittle. The rate at which asphalt binder ages depends on the length of time it is exposed to high temperature, and access to oxygen during time in service. Low density on the road allows air to permeate into the pavement and accelerate aging.

PERFORMANCE GRADED BINDER

In 1987, the Strategic Highway Research Program (SHRP) began developing a new system for specifying asphalt materials. The final product of the SHRP asphalt research program is a system called Superpave, short for Superior Performing Asphalt Pavements. Superpave represents an improved system for specifying binder and mineral aggregates, developing asphalt mixture designs, and analyzing and establishing pavement performance prediction. The system includes a binder specification and an asphalt mixture design system.

SHRP specifications for asphalt binder are known as Performance Graded asphalt binder specifications. An asphalt binder is graded by an upper temperature (in degrees C) above which the binder becomes too soft and a low temperature (in degrees C) below which the asphalt binder becomes too stiff. An example of how this grading system works is indicated in Figure 3-4. This asphalt binder is rated for an upper pavement temperature of 64°C (147°F) and a lower temperature of -22°C (-8°F). The specification limits for the PG Binders are listed in Section 902.01.

FIGURE 3.4 PG GRADING SYSTEM



The PG asphalt binder specification is based on the following tests:

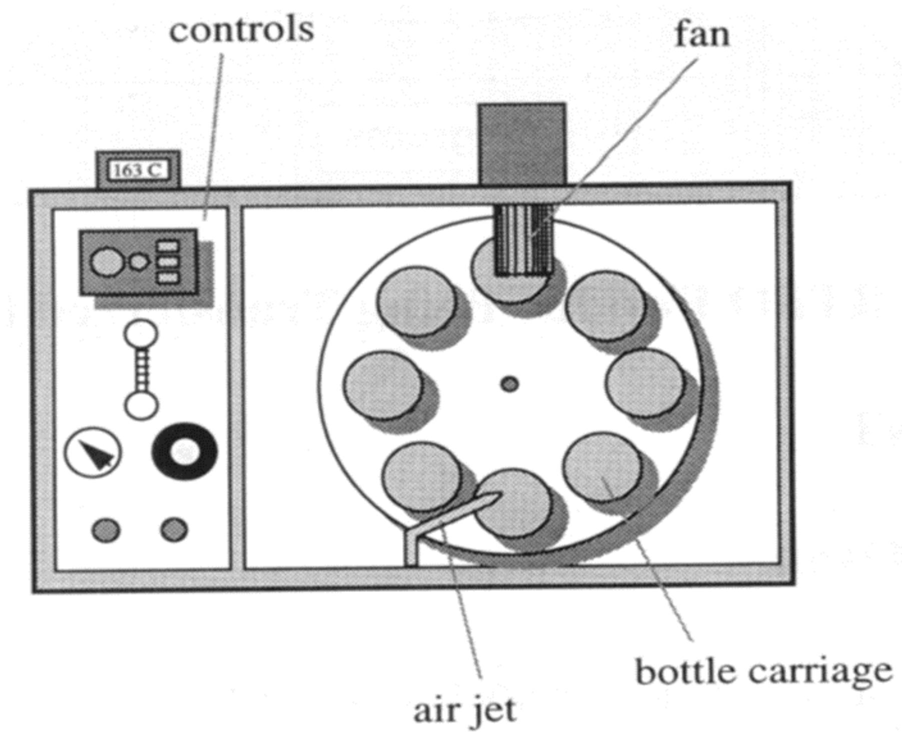
1. Aging
2. Dynamic Shear
3. Bending Beam
4. Viscosity
5. Flash Point

Asphalt Binder Aging

In the PG specification, two types of aging are simulated. Short term aging represents aging that happens during construction. Long term aging represents aging that occurs during service.

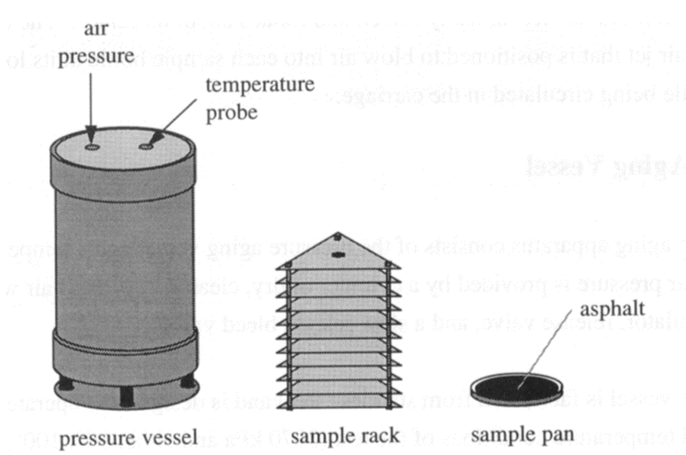
Rolling Thin Film Oven, AASHTO T 240, (RTFO) (Figure 3.5) is used for short term aging. For long term aging the RTFO asphalt binder is conditioned with a Pressure Aging Vessel (PAV) (Figure 3.6).

FIGURE 3.5 ROLLING THIN FILM OVER (RTFO)



The PAV test (AASHTO R 28) uses a pressurized container into which pans containing RTFO residue binders are placed. Samples in the PAV are subjected to pressure for 20 hours.

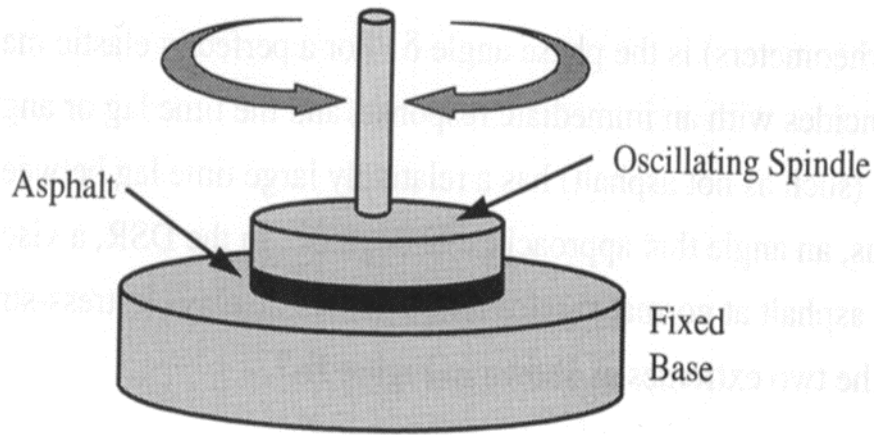
FIGURE 3.6 PRESSURE AGING VESSEL



Dynamic Shear

Stiffness at high temperature is measured using dynamic shear (AASHTO T 315). A sample of asphalt about the size and thickness of a quarter is placed between two plates as shown in Figure 3.7.

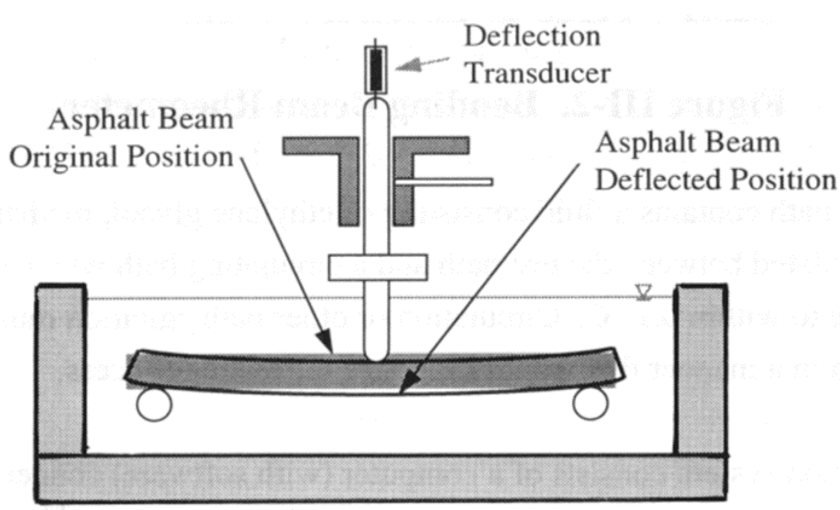
FIGURE 3.7 DYNAMIC SHEAR RHEOMETER



Bending Beam

Low temperature stiffness of the binder is evaluated using the bending beam rheometer (AASHTO T 313). A beam of asphalt binder (about 6 inches long, ¾ inch wide and ¼ inch thick) is supported at each end and loaded in the middle. Deflection is measured for 5 minutes and a stiffness versus time curve is developed. Figure 3.8 provides a schematic view of the test apparatus.

FIGURE 3.8 BENDING BEAM



HANDLING

The Technician is required to be aware of the potential sources of contamination that may exist where asphalt materials are stored or handled. Changes in volume that the asphalt material undergoes when heated or cooled are required to also be understood. This knowledge is especially important when comparing asphalt material quantities measured at different temperatures.

Please see Chapter 1 for more information about safety when handling asphalt materials.

STORAGE

The Technician is not required to test the binder or asphalt emulsion for Specification purposes. However, the Technician is required to be aware that these materials are tested for compliance based on samples from the asphalt mix plant, not the asphalt refinery. Therefore, the Technician is required to know what plant conditions could change the physical properties of these materials and possibly cause the materials to become out of Specification.

Three major problems may cause the asphalt binder to be outside of the Specifications. The first is contamination. If hot oil is used to heat the binder tank, then any leak in the system that allows hot oil to escape into the asphalt binder will cause the binder to become softer. Another source of contamination is fuel oil. If binder is contaminated with significant quantities of fuel oil because of flushing pumps and lines, then the binder stiffness drops.

A second and more prevalent problem is the effect that extended heating in storage tanks has on the binder. When binder is heated, the binder slowly increases in stiffness. The rate of change in viscosity is dependent on the size of tank, surface area, amount of circulation, temperature, etc. The problem of compliance with the Specifications generally is found after extended storage (e.g. long rainy periods). Material failure may be avoided by reducing heat and circulation during these periods. When the Technician has some doubts about the material, the binder is required to be tested to determine compliance. This greatly minimizes the number of problems and penalties associated with failures.

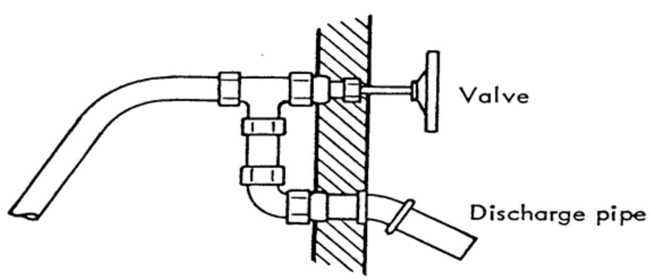
A third problem encountered with binder is improper storage. Modified binders include additives to improve (extend) the grade to encompass a wider temperature range for performance. Many of these modified binders are required to be stored under special conditions to maintain their properties. Material supplier recommendations for storage and handling are required to be followed.

SAMPLING

Normally binder samples are taken from a sampling valve on a storage tank. A few important rules to follow when sampling the binder are:

1. To ensure that samples are representative of the entire shipment, take the samples from the sampling valves provided for that purpose (Figure 3.9). Dip samples taken from the top of a tank are not normally representative. Other sampling methods are described in AASHTO T 40.
2. Use only new, clean dry sample containers
3. Allow at least 4 quarts of the binder to drain out of the valve before taking samples. This draining cleans out the valve and the lines and helps to provide a representative sample.
4. Seal filled containers immediately with clean, dry, tight fitting lids. Wipe any spilled material from the container with a clean, dry cloth; never with a cloth dipped or soaked in solvent.
5. Label all containers clearly. Do not label container lids, because once the labeled lid is removed, identifying the sample in the container is difficult. Do all labeling with a wick marking pen. Use tags only when there is no danger of the tags being lost in transit.
6. Follow all safety precautions for handling and storing hot binder. The binder is hot when sampled; therefore, protective clothing (gloves, face shield, long-sleeved shirt) to protect from burns and splattering is required.

FIGURE 3.9 SAMPLING DEVICE FOR STORAGE TANKS



BINDER VOLUME

SPECIFIC GRAVITY

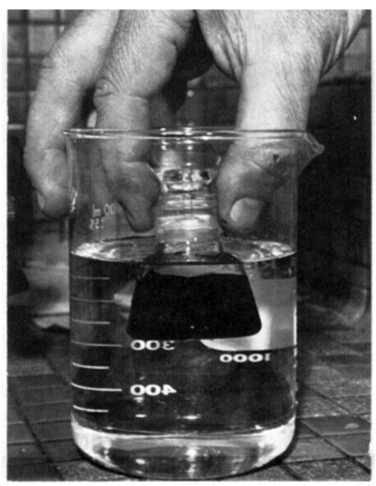
Specific gravity is the ratio of the weight of a volume of material to the weight of an equal volume of water, both at a specified temperature. As an example, a substance with a specific gravity of 1.6 weighs 1.6 times as much as an equal volume of water.

Knowing the specific gravity of the binder being used is important for two reasons. First, binder expands when heated and contracts when cold. This means that the volume of a given amount of binder is greater at higher temperatures than at lower temperatures. Specific gravity measurements provide a yardstick for making temperature-volume corrections.

Second, specific gravity of the binder is essential in the determination of the percentage of voids (air spaces) in the compacted pavement.

Specific gravity is usually determined by the pycnometer method as shown in Figure 3.10. Because specific gravity varies with the expansion and contraction of binder at different temperatures, results are normally expressed in terms of Specific Gravity at a given temperature for both the material and the water used in the test. (Example: Sp.Gr. 1.05 at 60°F/60°F means that the specific gravity of the binder is 1.05 when both the binder and the water are at 60°F).

FIGURE 3.10 DETERMINING SPECIFIC GRAVITY USING PYCNOMETER



TEMPERATUR VOLUME RELATIONSHIPS

Changes in volume of the binder may be a source for confusion in the plant when binder is required to be converted from weight to volume. When binder is shipped and stored, the basis of payment is weight. This procedure eliminates confusion in payment. However, binder in asphalt plants is metered rather than weighed. When this occurs, the Technician is required to know how to convert weight to volume and volume to weight. The density or specific gravity of binder is the ratio of weight to volume at a specified temperature. Normally this temperature is 60°F. As the temperature of the binder increases the weight to volume ratio drops. If the binder is being metered, the density of the binder at 60°F and the temperature of the binder are required to be known. Also, important to know is if the meter is compensating for this temperature and converting the registered volume back to 60°F. If not, then the binder content in the asphalt mixture is less than expected.

Another use of the temperature to volume relationship is to determine inventory. If the storage tank is gauged and a volume is determined, then that volume is required to be reduced to a volume at 60°F. This value may then be converted to weight. Examples of converting a tank gauge volume to volume at 60°F and then to a weight are as follows:

Example

Volume of binder is measured to be 6505 gallons at a temperature of 290°F. The specific gravity of the binder is 1.021. The volume of binder at the standard base temperature of 60°F is:

Volume correction factor of 0.9220 is read for the observed temperature of 290°F.

Vol. @ 60°F = Vol. @ (actual temp.) x Vol. Conversion Factor

Volume @ 60°F = 6505 x 0.9220

= 5998 gallons

To convert volume at 60°F to Tonnage:

$$\text{Tonnage} = \frac{Vol.@60°\text{F}\ x\ Specific\ Gravity\ @60°\text{F}}{2000 lb/t}\ x\ 8.33\ lb/gal$$

$$\text{Tonnage} = \frac{5998\ x\ 1.021}{2000} \text{ x } 8.33 = 2.55 \text{ t}$$

FIGURE 3.11 TEMPERATURE VOLUME CORRECTIONS FOR BINDER

GROUP O (°F)

GROUP 0—SPECIFIC GRAVITY AT 60°F ABOVE 0.966

LEGEND: t = observed temperature in degrees Fahrenheit
M = multiplier for correcting oil volumes to the basis of 60°F

t	M	t	M	t	M	t	M	t	M
0	1.0211	50	1.0035	100	0.9861	150	0.9689	200	0.9520
1	1.0208	51	1.0031	101	0.9857	151	0.9686	201	0.9516
2	1.0204	52	1.0028	102	0.9854	152	0.9682	202	0.9513
3	1.0201	53	1.0024	103	0.9851	153	0.9679	203	0.9509
4	1.0197	54	1.0021	104	0.9847	154	0.9675	204	0.9506
5	1.0194	55	1.0017	105	0.9844	155	0.9672	205	0.9503
6	1.0190	56	1.0014	106	0.9840	156	0.9669	206	0.9499
7	1.0186	57	1.0010	107	0.9837	157	0.9665	207	0.9496
8	1.0183	58	1.0007	108	0.9833	158	0.9662	208	0.9493
9	1.0179	59	1.0003	109	0.9830	159	0.9658	209	0.9489
10	1.0176	60	1.0000	110	0.9826	160	0.9655	210	0.9486
11	1.0172	61	0.9997	111	0.9823	161	0.9652	211	0.9483
12	1.0169	62	0.9993	112	0.9819	162	0.9648	212	0.9479
13	1.0165	63	0.9990	113	0.9816	163	0.9645	213	0.9476
14	1.0162	64	0.9986	114	0.9813	164	0.9641	214	0.9472
15	1.0158	65	0.9983	115	0.9809	165	0.9638	215	0.9469
16	1.0155	66	0.9979	116	0.9806	166	0.9635	216	0.9466
17	1.0151	67	0.9976	117	0.9802	167	0.9631	217	0.9462
18	1.0148	68	0.9972	118	0.9799	168	0.9628	218	0.9459
19	1.0144	69	0.9969	119	0.9795	169	0.9624	219	0.9456
20	1.0141	70	0.9965	120	0.9792	170	0.9621	220	0.9452
21	1.0137	71	0.9962	121	0.9788	171	0.9618	221	0.9449
22	1.0133	72	0.9958	122	0.9785	172	0.9614	222	0.9446
23	1.0130	73	0.9955	123	0.9782	173	0.9611	223	0.9442
24	1.0126	74	0.9951	124	0.9778	174	0.9607	224	0.9439
25	1.0123	75	0.9948	125	0.9775	175	0.9604	225	0.9436
26	1.0119	76	0.9944	126	0.9771	176	0.9601	226	0.9432
27	1.0116	77	0.9941	127	0.9768	177	0.9597	227	0.9429
28	1.0112	78	0.9937	128	0.9764	178	0.9594	228	0.9426
29	1.0109	79	0.9934	129	0.9761	179	0.9590	229	0.9422
30	1.0105	80	0.9930	130	0.9758	180	0.9587	230	0.9419
31	1.0102	81	0.9927	131	0.9754	181	0.9584	231	0.9416
32	1.0098	82	0.9923	132	0.9751	182	0.9580	232	0.9412
33	1.0095	83	0.9920	133	0.9747	183	0.9577	233	0.9409
34	1.0091	84	0.9916	134	0.9744	184	0.9574	234	0.9405
35	1.0088	85	0.9913	135	0.9740	185	0.9570	235	0.9402
36	1.0084	86	0.9909	136	0.9737	186	0.9567	236	0.9399
37	1.0081	87	0.9906	137	0.9734	187	0.9563	237	0.9395
38	1.0077	88	0.9902	138	0.9730	188	0.9560	238	0.9392
39	1.0074	89	0.9899	139	0.9727	189	0.9557	239	0.9389
40	1.0070	90	0.9896	140	0.9723	190	0.9553	240	0.9385
41	1.0067	91	0.9892	141	0.9720	191	0.9550	241	0.9382
42	1.0063	92	0.9889	142	0.9716	192	0.9547	242	0.9379
43	1.0060	93	0.9885	143	0.9713	193	0.9543	243	0.9375
44	1.0056	94	0.9882	144	0.9710	194	0.9540	244	0.9372
45	1.0053	95	0.9878	145	0.9706	195	0.9536	245	0.9369
46	1.0049	96	0.9875	146	0.9703	196	0.9533	246	0.9365
47	1.0046	97	0.9871	147	0.9699	197	0.9530	247	0.9362
48	1.0042	98	0.9868	148	0.9696	198	0.9526	248	0.9359
49	1.0038	99	0.9864	149	0.9693	199	0.9523	249	0.9356

GROUP O continued (°F)

GROUP O—SPECIFIC GRAVITY AT 60°F ABOVE 0.966

LEGEND: t = observed temperature in degrees Fahrenheit
M = multiplier for correcting oil volumes to the basis of 60°F

t	M	t	M	t	M	t	M	t	M
250	0.9352	300	0.9187	350	0.9024	400	0.8864	450	0.8705
251	0.9349	301	0.9184	351	0.9021	401	0.8861	451	0.8702
252	0.9346	302	0.9181	352	0.9018	402	0.8857	452	0.8699
253	0.9342	303	0.9177	353	0.9015	403	0.8854	453	0.8696
254	0.9339	304	0.9174	354	0.9011	404	0.8851	454	0.8693
255	0.9336	305	0.9171	355	0.9008	405	0.8848	455	0.8690
256	0.9332	306	0.9167	356	0.9005	406	0.8845	456	0.8687
257	0.9329	307	0.9164	357	0.9002	407	0.8841	457	0.8683
258	0.9326	308	0.9161	358	0.8998	408	0.8838	458	0.8680
259	0.9322	309	0.9158	359	0.8995	409	0.8835	459	0.8677
260	0.9319	310	0.9154	360	0.8992	410	0.8832	460	0.8674
261	0.9316	311	0.9151	361	0.8989	411	0.8829	461	0.8671
262	0.9312	312	0.9148	362	0.8986	412	0.8826	462	0.8668
263	0.9309	313	0.9145	363	0.8982	413	0.8822	463	0.8665
264	0.9306	314	0.9141	364	0.8979	414	0.8819	464	0.8661
265	0.9302	315	0.9138	365	0.8976	415	0.8816	465	0.8658
266	0.9299	316	0.9135	366	0.8973	416	0.8813	466	0.8655
267	0.9296	317	0.9132	367	0.8969	417	0.8810	467	0.8652
268	0.9293	318	0.9128	368	0.8966	418	0.8806	468	0.8649
269	0.9289	319	0.9125	369	0.8963	419	0.8803	469	0.8646
270	0.9286	320	0.9122	370	0.8960	420	0.8800	470	0.8643
271	0.9283	321	0.9118	371	0.8957	421	0.8797	471	0.8640
272	0.9279	322	0.9115	372	0.8953	422	0.8794	472	0.8636
273	0.9276	323	0.9112	373	0.8950	423	0.8791	473	0.8633
274	0.9273	324	0.9109	374	0.8947	424	0.8787	474	0.8630
275	0.9269	325	0.9105	375	0.8944	425	0.8784	475	0.8627
276	0.9266	326	0.9102	376	0.8941	426	0.8781	476	0.8624
277	0.9263	327	0.9099	377	0.8937	427	0.8778	477	0.8621
278	0.9259	328	0.9096	378	0.8934	428	0.8775	478	0.8618
279	0.9256	329	0.9092	379	0.8931	429	0.8772	479	0.8615
280	0.9253	330	0.9089	380	0.8928	430	0.8768	480	0.8611
281	0.9250	331	0.9086	381	0.8924	431	0.8765	481	0.8608
282	0.9246	332	0.9083	382	0.8921	432	0.8762	482	0.8605
283	0.9243	333	0.9079	383	0.8918	433	0.8759	483	0.8602
284	0.9240	334	0.9076	384	0.8915	434	0.8756	484	0.8599
285	0.9236	335	0.9073	385	0.8912	435	0.8753	485	0.8596
286	0.9233	336	0.9070	386	0.8908	436	0.8749	486	0.8593
287	0.9230	337	0.9066	387	0.8905	437	0.8746	487	0.8590
288	0.9227	338	0.9063	388	0.8902	438	0.8743	488	0.8587
289	0.9223	339	0.9060	389	0.8899	439	0.8740	489	0.8583
290	0.9220	340	0.9057	390	0.8896	440	0.8737	490	0.8580
291	0.9217	341	0.9053	391	0.8892	441	0.8734	491	0.8577
292	0.9213	342	0.9050	392	0.8889	442	0.8731	492	0.8574
293	0.9210	343	0.9047	393	0.8886	443	0.8727	493	0.8571
294	0.9207	344	0.9044	394	0.8883	444	0.8724	494	0.8568
295	0.9204	345	0.9040	395	0.8880	445	0.8721	495	0.8565
296	0.9200	346	0.9037	396	0.8876	446	0.8718	496	0.8562
297	0.9197	347	0.9034	397	0.8873	447	0.8715	497	0.8559
298	0.9194	348	0.9031	398	0.8870	448	0.8712	498	0.8556
299	0.9190	349	0.9028	399	0.8867	449	0.8709	499	0.8552

ASPHALT SUPPLIER CERTIFICATION PROGRAM

The Asphalt Supplier Certification Program (ASC) is a program in which a qualified asphalt supplier is allowed to manufacture and ship PG binders without complete pre-testing of the PG binder by INDOT or the supplier. PG binders are required to be supplied by an approved supplier in accordance with ITM 581.

PG binders that are shipped to asphalt mixture plants are required to have a shipping report indicating that the material was manufactured in accordance with the ASC program. Also, the supplier is required to furnish instructions with each PG binder concerning the proper storage and handling of the material.

CHAPTER 4

ASPHALT VOLUMETRICS

CHAPTER 4

MIX DESIGN

In Asphalt Mixture, binder and aggregate are blended together. The relative proportions of these materials determine the physical properties of the asphalt mixture and ultimately how the asphalt mixture performs as a finished pavement. The design method for determining the suitable proportions of binder and aggregate in the asphalt mixture is the Superpave Method.

MIX CHARACTERISTICS AND BEHAVIOR

When a sample of asphalt mixture is prepared in the laboratory, the asphalt mixture is analyzed. The analysis focuses on five characteristics of the asphalt mixture and the influence those characteristics are likely to have on asphalt mixture behavior. The five characteristics are:

1. Mix Density
2. Air Voids
3. Voids in the Mineral Aggregate (VMA)
4. Voids Filled with Asphalt (VFA)
5. Binder Content

Before mix properties are discussed in detail, the Technician is required to understand that paving mix properties are most affected by volume even though production and testing of asphalt mixture is by weight. The difference between weight and volume of asphalt mixture is given in Figure 4.1. Although asphalt mix is made by combining weights of the different materials, the mix design is based on the volume of each material.

In the center of Figure 4.1 the boxes represent four components:

- Aggregate
- Air voids
- Asphalt binder (broken into two components)
    - Absorbed asphalt (inside the aggregate)
    - Effective asphalt (outside the aggregate)

The left side of the figure shows volumes of

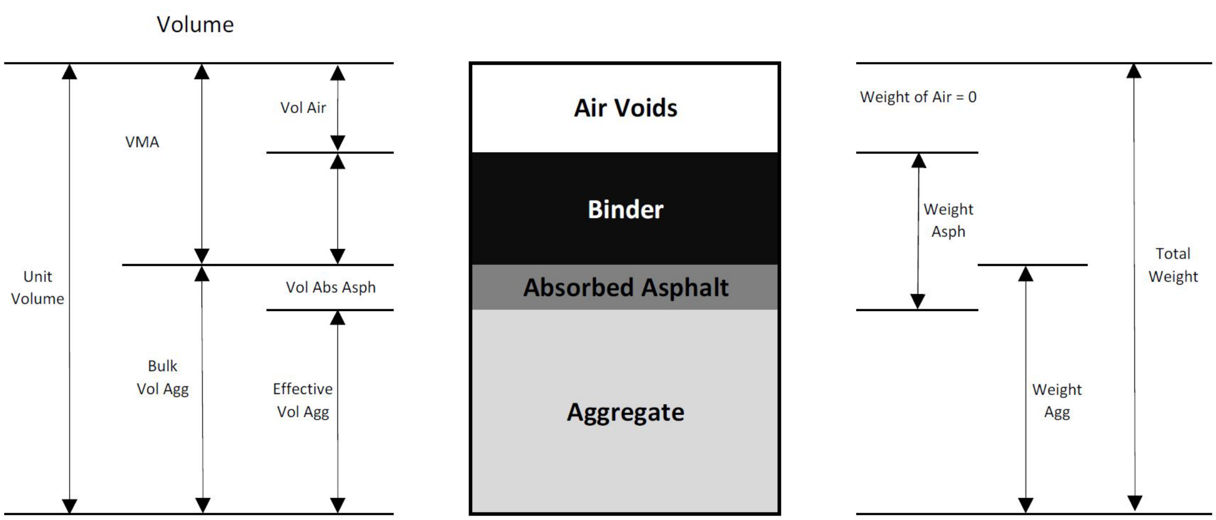
- Aggregate (shown two ways)
    - Calculated using bulb specific gravity
    - Calculated using effective specific gravity
- Asphalt (broken into two categories)

- Absorbed volume
    - Non-absorbed volume
- Air voids

Pavement performance of the asphalt mixture is influenced by the volume of materials, not the weight. They are defined as follows:

- Air voids
    - Pockets of air between the asphalt coated aggregates
- Voids in the Mineral Aggregate (VMA)
    - Space between the compacted aggregate particles.
        - VMA is composed of two components
            - Air voids
            - Asphalt volume not absorbed into the aggregate
- Voids Filled with Asphalt (VFA)
    - The percentage of VMA filled with asphalt.
    - For example, if two thirds of the VMA is asphalt, then the VFA is 67%.

FIGURE 4.1 COMPONENT DIAGRAM OF COMPACTED SAMPLE OF HOT MIX ASPHALT



BULK SPECIFIC GRAVITY

The generic term, "density" refers to weight per unit volume, for example, 150 pounds per cubic foot. Bulk specific gravity is similar except it is related to the density of water. For example, if the density is 150 lb/ft^3, then the bulk specific gravity is 2.404 calculated as ($\frac{150\ lb/ft3}{62.4\ lb/ft3}$).

There are two common uses for the term “density”. Don’t be confused by them. Often people will talk about the density being achieved on a project, such as, “The average density is 93.2%”. This is really compaction.

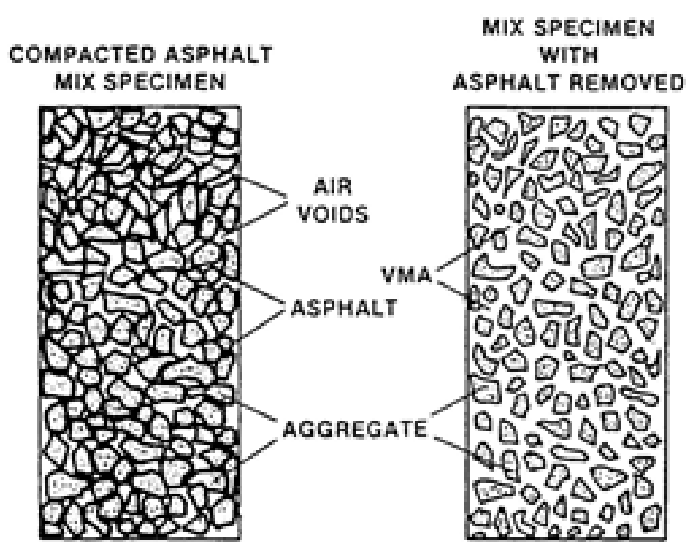
In mix design, the term “density” refers to density of the gyratory compacted specimens. It is measured as bulk specific gravity.

VOIDS IN MINERAL AGGREGATES

Voids in the mineral aggregate (VMA) are the void spaces between the aggregate particles in the compacted paving asphalt mixture. See Figure 4.2. The space between the compacted aggregate particles (VMA) in the mix is calculated.

VMA is the space available for the volume of asphalt binder that is not absorbed, V_{be}, and the volume of air voids necessary in the asphalt mixture. Minimum VMA and V_{be} is specified in section 401.05 of INDOT specifications. For example, if the mixture being designed is a 9.5-mm mixture, the minimum VMA is 16.0%. Since design air voids are fixed at 5.0% the minimum volume of effective asphalt binder, V_{be}, is 11.0%. Hence, V_{be} is the main control of minimum asphalt content.

FIGURE 4.2 ILLUSTRATION OF VMA IN COMPACTED SPECIMEN



Factors that influence the packing of aggregate particles include:

Gradation

- This is the main tool used by mix designers to control VMA. Changing gradation, changes the amount of space between the aggregate (VMA).

Shape

- Cubical particles will compact to a tighter configuration (have lower VMA) than the same gradation of flat “potato-chip” shaped particles.

Texture

- Particles with a rough, “sand-papery” texture will resist compaction, that is, they will have a higher VMA.

Angularity

- Particles with sharp edges will resist compaction more than particles with rounded edges, that is, they will have a higher VMA.

Aggregate hardness

- Aggregates formed from softer rock, such as soft limestone, will compact more tightly because edges of the particles will break off.

Type and amount of compaction

- For any set of aggregates (gradation, shape, texture, angularity and hardness) the more compaction that is applied, the less space will remain between the aggregate particles.

Although the list of factors that impact compaction of aggregates is lengthy, many of the factors are outside the control of the mix designer. In the end, the main tool to control VMA is gradation. For a given mix design

- Compaction type (Superpave gyratory) and compaction amount (the number of design gyrations) is designated by the mix specification and cannot be changed by the designer.
- Hardness of the aggregate is usually not a choice of the designer. The availability of alternate sources of aggregate with different hardness are usually not choices given to the designer. They must attempt to design using the aggregates available.
- Shape, texture and angularity are available to the designer in that natural sand versus manufactured sand are choices the designer can make. At the same time, aggregate specifications in the mix design will limit the degree of freedom.

AIR VOIDS

Air voids are small pockets of air between the coated aggregate particles in the compacted asphalt mixture. A pavement needs a minimum percentage of air voids to prevent the pavement from flushing, shoving, and rutting. High air voids will lead to shortened pavement life from accelerated aging.

Air voids are important. Asphalt binder has both liquid behavior and solid behavior at the same time. At high temperature, 350 to 400°F , asphalt binder is a liquid and can be poured. At low temperature, -40 to -50°F , asphalt binder is a solid. Anywhere in between it has both liquid and solid behavior at the same time. And it is continually changing. At high temperature the stiffness of asphalt binder is lower and the percent of stiffness coming from the liquid behavior is greater than at low temperature.

To understand why HMA needs air voids, consider fresh concrete (with no air entrainment). The concrete mix is saturated (with water) since all space between the aggregate particles is filled. If the concrete won't trowel nice and smooth, one way to make it more workable is to vibrate it by smacking it with the trowel. After a few hits (pumping up and down) with the trowel, it become soft and putty-like.

Consider what is happening in the concrete. When a trowel hits the fresh concrete a load pulse (pressure) goes down into the concrete. This pressure goes into the water (liquid phase) of the concrete. If there is only one pulse, the pressure will dissipate as it spreads down into the concrete and outwards. It is like dropping a pebble into a pond and watching the wave go outwards and disappear.

If another load pulse is applied before the pressure disappears then pressure will start to build up in the liquid. Once the pressure builds high enough, the rocks are pushed a part and the concrete become soft and putty-like.

Now, consider a spot on an asphalt pavement on a hot summer day. A truck approaches and the steering axle applies a load and takes it off. Very shortly after, the first drive axle applies a load, then the second drive axle. And just a short time later, the two trailer axles. And if there is a line of trucks then there are 10 or 15 or 20 or 25 loads applied to the pavement.

At summer temperatures the asphalt binder in the pavement is not liquid, but it has a higher percentage of liquid behavior than at cooler temperatures. If the asphalt pavement has zero percent air voids, that is, if it is saturated, then pressure from the repeated load pulses builds up and the pavement has a lower stiffness when the last axle of the last truck crosses the point. So, the pavement will rut.

So, what do air voids do? Air voids act like shock absorbers. Air is very compressible and instead of pressure building up in the asphalt binder, the air voids are slightly compressed. As a result, the pavement has the same stiffness when the last axle of the last truck is applied as when the first axle was applied. And the pavement does not rut.

Air void content is related to the durability, that is, a long life, of an asphalt mixture. If air voids are too low, it will lead to rutting and flushing. If too high the voids provide passageways into the asphalt mixture for air and water to enter. This can lead to accelerated aging of the asphalt binder or stripping where water peels the asphalt binder off the rocks.

VOIDS FILLED WITH ASPHALT

Voids filled with asphalt (VFA) are the void spaces that exist between the aggregate particles in the compacted paving asphalt mixture that are filled with binder. VFA is expressed as a percentage of the VMA that contains binder.

VFA can be thought of as degree of saturation. If VFA is 100%, that is, air voids are zero, then there will be no "shock absorbers". If the VFA is low, then there are too many air voids. Air and water will be able to enter the pavement.

BINDER CONTENT

The amount of asphalt binder in the mixture is critical. Low asphalt binder will lead to accelerated aging and cracking regardless of whether the air voids are correct or not. The mix design system is setup to ensure enough asphalt binder will be used. If there is too much asphalt binder, the mixture becomes softer and the pavement will rut, even if the correct amount of air voids is present.

The design asphalt binder content will depend on the amount of non-absorbed asphalt binder and the amount of absorbed asphalt binder. The amount of non-absorbed asphalt content is determined from VMA and air voids. For example, if the VMA requirement is a minimum of 14.0% (for a 19.0-mm mixture) and the design air voids are 5.0%, then the minimum asphalt volume is 9.0% (14.0 minus 5.0). This will be about 4.0% by weight.

The amount of absorbed asphalt binder will depend on the aggregate absorption. For a medium absorptive aggregate (1.5% water absorption) the amount of absorbed asphalt binder will be about 0.9%. The total asphalt content will be about 4.9%.

Effective binder content is calculated based on the aggregate bulk specific gravity (G_{sb}) and the aggregate effective specific gravity (G_{se}). The higher the aggregate absorption, the greater the difference between G_{se} and G_{sb}.

PLANT PRODUCED ASHPALT MIXTURE

Asphalt mixture characteristics are determined in a lab mix design to ensure that the combination of aggregates and binder meet Specification criteria and give long term performance; however, there may be subtle differences between the laboratory designed asphalt mixture and what is actually produced by the mixing plant. Plant type and environmental controls all have an effect on the asphalt mixture properties and may produce asphalt mixture with different characteristics than those designed in the lab. For these reasons, specimens are prepared by the Technician from plant produced asphalt mixture to verify proper density, air voids and VMA from the original laboratory design.

PROPERTIES CONSIDERED IN MIX DESIGN

Good asphalt mixture pavements function well because they are designed, produced and placed in such a way as to give them certain desirable properties. There are several properties that contribute to the quality of asphalt mixture pavements. They include stability, durability, impermeability, workability, flexibility, and fatigue resistance.

Ensuring that asphalt mixture has each of these properties is a major goal of the mix design procedure. Therefore, the Technician is required to be aware what each of the properties measure, how the property is evaluated, and what the property means in terms of pavement performance.

RUT RESISTANCE

Rut resistance of an asphalt mixture pavement is the ability of the mixture to resist shoving and rutting under loads (traffic). It is mostly related to stiffness of the mixture. If the mixture is too soft, it will rut. If the stiffness is sufficiently high, the pavement will not rut.

Stiffness (rut resistance) of an asphalt mixture depends on aggregate properties and asphalt binder properties and amount. Internal friction among the aggregate particles (inter-particle friction) is related to aggregate characteristics such as shape and surface texture. Asphalt binder glues the rocks together and the stiffness of the mixture depends on having the correct grade (not too soft) and amount of asphalt binder. Low asphalt content or hard asphalt binders (for the temperature environment they need to endure) produces higher rut resistance but leaves the mixture susceptible to cracking.

In general, the more angular the shape of the aggregate particles and the rougher the surface texture, the higher the stiffness of the asphalt mixture. Mixture stiffness is influenced by asphalt binder stiffness. Stiffness increases as stiffness of the binder increases. For example, PG 76 asphalt binders are stiffer than PG 64 binders. Mixture stiffness will decrease if the asphalt binder content is too high.

Insufficient stability in a pavement has many causes and effects. Figure 4.3 lists some of them.

FIGURE 4.3 CAUSES AND EFFECTS OF PAVEMENT INSTABILITY

LOW STABILITY	
Causes	**Effects**
Excess binder in asphalt mixture	Washboarding, rutting, and flushing or bleeding
Excess medium size sand in asphalt mixture	Tenderness during rolling and for a period after construction, and difficulty in compacting
Rounded aggregate, little or no crushed surfaces	Rutting and channeling

DURABILITY

The durability of an asphalt mixture pavement is the ability of the asphalt mixture pavement to resist changes in the binder oxidation and disintegration of the aggregate. These factors may be the result of weather, traffic, or a combination of the two.

Generally, durability of an asphalt mixture may be enhanced by three methods. They are: using maximum binder content, using a sound aggregate, and designing and compacting the asphalt mixture for maximum impermeability.

Maximum binder content increases durability because the greater volume of asphalt binder does not age (harden) as rapidly. Consequently, the binder retains the original characteristics longer. Also, maximum binder content effectively seals off a greater percentage of interconnected air voids in the pavement, making the penetration of water and air difficult. A certain percentage of air voids is required to be left in the pavement to allow for expansion of the binder in hot weather.

A lack of sufficient durability in a pavement may have several causes and effects. Figure 4.4 presents a list of some of them.

FIGURE 4.4 CAUSES AND EFFECTS OF LACK OF DURABILITY

POOR DURABILITY	
Causes	**Effects**
Low binder content	Dryness or raveling
High void content through design or lack of compaction	Early hardening of binder followed by cracking or disintegration
Water susceptible (hydrophilic) aggregate in asphalt mixtures	Films of binder strip from aggregate leaving a raveled, or mushy pavement

IMPERMEABILITY

Impermeability is the resistance of an asphalt mixture pavement to the passage of air and water into or through the mixture. This characteristic is related to the void content of the compacted asphalt mixture, and much of the discussion on voids in the mix design relates to the impermeability. Even though void content is an indication of the potential for passage of air and water through a pavement, the character of these voids is more important than the number of voids. The size of the voids, whether or not the voids are interconnected, and the access of the voids to the surface of the pavement all determine the degree of impermeability.

Although impermeability is important for the durability of a compacted paving asphalt mixture, virtually all asphalt mixture used in highway construction is permeable to some degree. This is acceptable as long as the permeability is within specified limits. Causes and effects of permeability in normal dense-graded asphalt mixture pavements are shown in Figure 4.5.

FIGURE 4.5 CAUSES AND EFFECTS OF PERMEABILITY

MIX TOO PERMEABLE	
Causes	**Effects**
Low binder content	Thin binder films that causes early aging and raveling
High void content in design asphalt mixture	Water and air may easily enter pavement causing oxidation and disintegration
Inadequate compaction	Results in high voids in pavement leading to water infiltration and low strength

WORKABILITY

Workability describes the ease with which a paving asphalt mixture may be placed and compacted. Workability may be improved by changing mix design parameters, aggregate sources, and/or gradation.

Harsh asphalt mixtures (asphalt mixtures containing a high percentage of coarse aggregate) have a tendency to segregate during handling and also may be difficult to compact. Through the use of trial mixes in the laboratory, additional fine aggregate and perhaps binder may be added to a harsh asphalt mixture to make the mixture more workable. Care is required to be taken to ensure that the altered asphalt mixture meets all the other design criteria.

Excess fines may also affect workability. Depending on the characteristics of the fines, the fines may cause the asphalt mixture to become tough or gummy, making the mixture difficult to compact. Workability is especially important where excessive hand placement and raking (luting) around manhole covers, sharp curves, and other obstacles is required. Asphalt mixture used in such areas is required to be highly workable.

Asphalt mixture that may be too easily worked or shoved is referred to as tender asphalt mixture. Tender asphalt mixture is too unstable to place and compact properly. This problem often is caused by a shortage of mineral filler, too much medium sized sand, smooth rounded aggregate particles, or excess moisture in the asphalt mixture.

Figure 4.6 lists some of the causes and effects related to workability of paving mixes.

FIGURE 4.6 CAUSES AND EFFECTS OF WORKABILITY PROBLEMS

POOR WORKABILITY	
Causes	**Effects**
Large maximum size particle	Rough surface, difficult to place
Excessive coarse aggregate	May be hard to compact
Too low an asphalt mixture temperature	Uncoated aggregate, not durable, rough surface, hard to compact
Too much medium sized sand	asphalt mixture shoves under roller, remains tender
Low fines content	Tender asphalt mixture, highly permeable
High fines content	Asphalt mixture may be dry or gummy, hard to handle, not durable

FATIGUE RESISTANCE

Fatigue resistance is the pavement's resistance to repeated bending under wheel loads (traffic). Air voids (related to binder content) and binder viscosity have a significant effect on fatigue resistance. As the percentage of air voids in the pavement increases, either by design or lack of compaction, pavement fatigue life (the length of time during which an in-service pavement is adequately fatigue-resistant) is drastically shortened. Likewise, a pavement containing binder that has aged and hardened significantly has reduced resistance to fatigue.

The thickness and strength characteristics of the pavement and the supporting strength of the subgrade also have an effect on the pavement life and prevention of load associated cracking.

Thick, well supported pavements do not bend as much under loading as thin or poorly supported pavements. Therefore, thick well supported pavements have longer fatigue lives.

Figure 4.7 presents a list of causes and effects of poor fatigue resistance.

FIGURE 4.7 CAUSES AND EFFECTS OF POOR FATIGUE RESISTANCE

POOR FATIGUE RESISTANCE	
Causes	**Effects**
Low asphalt binder content	Fatigue cracking
High design voids	Early aging of binder followed by fatigue cracking
Lack of compaction	Early aging of binder followed by fatigue cracking
Inadequate pavement thickness	Excessive bending followed by fatigue cracking

SUPERPAVE MIX DESIGN METHOD

The Superpave mix design method is a volumetric mix design process. An analysis of specimens and the maximum specific gravity sample are conducted to evaluate such properties as voids in mineral aggregate (VMA); voids filled with asphalt (VFA), air voids, and the dust/effective binder ratio. The mix designer uses this information to determine the parameters that require adjustment before fabricating additional specimens. This process is repeated several times until the designed aggregate structure and the binder content produce specimens with the desired volumetric properties. Using the information obtained from this procedure, the mix designer then proceeds with preparing two specimens at four binder contents in preparation for determining the optimum binder content required to produce the four percent air voids at N_{des} gyrations.

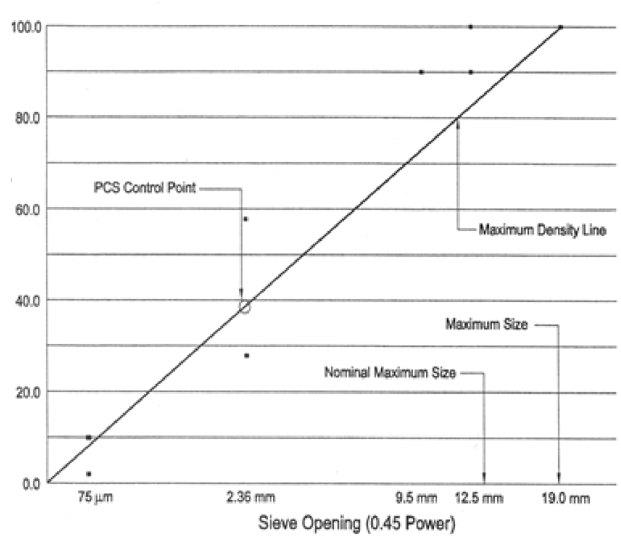
AGGREGATES

The volumetric mix design begins with evaluating potential materials for use in the asphalt mixture. The evaluation of aggregates is made for such properties as sand equivalency, fine and coarse aggregate angularity, and flat and elongated particles. By conducting these tests on individual aggregates prior to developing trial blends, the mix designer develops a history of the material, and may make a determination of the potential use of these materials in the design mixture. This evaluation includes the aggregate portion of any recycled materials that may be proposed for use.

Once the mix designer has selected the potential aggregates for use in the designed mixture, the aggregates are proportioned to comply with the composition limits specific to the nominal maximum particle size. If the mix designer has had no prior experience in working with the aggregates required for the mixture, several trial blends may be necessary as a time saving design technique. The 0.45 power gradation chart is used to plot the combined gradation of the asphalt mixture. Figure 4.8 illustrates several important features for a 12.5 mm asphalt mixture that the aggregate gradation is required to meet. These are explained as follows:

1. Maximum Size -- One sieve size larger than the nominal maximum size.
2. Nominal Maximum Size -- One sieve size larger than the first sieve to retain more than 10 percent.
3. Maximum Density Line -- a gradation in which the aggregate particles fit together in their densest possible arrangement. This is a gradation to avoid because there would be insufficient space between the aggregates for the required volume of asphalt binder.
4. Primary Control Sieve (PCS) Control Points -- values that define whether a gradation is coarse-graded or fine-graded. A gradation passing below the PCS Control Point is considered coarse-graded, and a gradation passing above the PCS Control Point is considered fine-graded. All 9.5 mm surface mixtures are required to have gradations that are less than or equal to the PCS control point, making them coarse-graded. Coarse-graded surface mixtures are desired for the increased amount of macro-texture they have which improves wet-weather friction.

FIGURE 4.8 SUPERPAVE GRADATION LIMITS FOR ½ IN. MIXTURE



AGGREGATE BLENDING

Building a pavement with an asphalt mixture requires more than binder, aggregate, and equipment. A good operation also requires knowledge, skill, and workmanship. Part of this knowledge and skill is the ability to blend aggregates to maintain the job mix formula.

A common problem in asphalt mixture construction is combining two or more aggregates with different gradations, to produce an aggregate blend that meets gradation specifications for a particular asphalt mixture. As previously stated, all particles required in the asphalt mixture are not usually found in one single stockpile. The asphalt mixture is made by blending different aggregate sizes together to meet the gradation requirements for the specified type of asphalt mixture.

Design Mix Formula

In the simplest form, a design mix formula consists of two parts:

1. The combined gradation of the aggregates to be used in the production of asphalt mixture
2. The binder content necessary to produce a satisfactory asphalt mixture meeting all the specification requirements

Method for Combining Aggregates

Mathematical procedures have been developed to determine an optimum combination of aggregates and computer programs are available to facilitate this process. Although these procedures and programs are available, the Trial and Error Method, guided by a certain amount of reasoning, remains one of the easiest procedures to determine a satisfactory combination.

Trial and Error Method

The proportions of each of the aggregates to be used in an asphalt mixture are required to be determined to produce a combined gradation that meets the required Specifications. The "Trial and Error Method" is the method that is shown for combining the aggregates (Figures 4.9 and 4.10. First, each of the steps is discussed and then applied to an example problem.

Step 1 – OBTAIN THE REQUIRED DATA

1. The gradation of each material is required to be determined.
2. The design limits for the type of mix are required to be obtained (Section 400). Enter this information on the worksheet.
3. Select a target value for the combined gradation. Normally, this value is the percentage passing the No. 8 sieve. For example, the design limits for 25.0 mm Base mixture for the No. 8 sieve are 19.0-45.0. The combined gradation is required to be checked on this sieve first to verify that this value is within 19.0-45.0.

Step 2 – ESTIMATE THE PROPORTIONS

After the target value has been selected, the next step is to estimate the correct percentage of each aggregate needed to get a combined gradation near the target value.

Step 3 – CALCULATE THE INDIVIDUAL PROPORTIONS

This calculation determines the percentage of each aggregate for the asphalt mixture. On the form, the "% for Mix" is obtained by multiplying the "Percent Used" (as a decimal) by the "% Passing" value.

Step 4 – CALCULATE THE COMBINED GRADATION

This calculation indicates the results of the estimate from STEP 2. The method of calculating the combined gradation is shown in the example problem.

Step 5 – COMPARE THE RESULTS WITH THE TARGET VALUE

If the calculated gradation is close to the target value, the problem has been solved; if not, an adjustment in the proportions is required to be made and the calculation conducted again. The second trial should be closer due to the information obtained from the first trial. The trials are continued until proportions of each aggregate are found that come close to the target value. If the aggregates do not combine within the design range, then another material of a different gradation is required to be added to the blend.

Example (Combination of Two Aggregates)

An example problem using two aggregates is shown in Figures 4.9 and 4.10. The No. 5 stone is designated Aggregate 1 and the No. 24 sand is designated Aggregate 2. The target gradation is for a 25.0 mm base mixture.

Step 1 – Enter the known data:

1. Percent passing from the gradation of each aggregate component
2. Target specification for 1 in. base asphalt mixture

Step 2 – Estimate the proportions. How much of each of the two aggregates are needed to produce a combined gradation close to the target value. (trial blend #1).

The first estimate might be 50% of Aggregate 1 and 50% of Aggregate 2. The proportions of each aggregate used are required to total 100%. Enter these figures on the line marked "Percent Used".

Step 3 – Calculate the individual proportions on each sieve for each of the two aggregates and enter in the column "% for Mix". This is done by multiplying "% Passing" column by "Percent Used" (as a decimal). A sample calculation is shown at the bottom of Figure 4.9.

Step 4 – Calculate the combined gradation. Add the two "% of Mix" columns horizontally for each sieve and enter in the column "Combined Gradation %".

Step 5 – Compare this combined gradation with the Specification Limits %. Note that the combined gradation is not very close to the Specification Limits and is on the fine side. An adjustment is required to be made. For a trial blend #2, increase Aggregate 1 to 70% and lower Aggregate 2 to 30% as shown in Figure 4.10

Since this combined gradation is within the Specification Limits, the desired results have been obtained.

Example (Combination of More than Two Aggregates)

The same basic steps are followed when combining more than two aggregates (Figure 4.11).

FIGURE 4.9 FIRST TRIAL BLENDING #5 STONE AND #24 SAND

SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

Trial Blend #1

MATERIAL	#5 Stone		#24 Sand								COMB. GRAD. %	DMF %	SPEC. LIMITS
SOURCE	2211		2284										
Gsb	2.610		2.625										
PERCENT USED	50%		50%										
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX			
1 1/2 in.	100	50.0	100	50.0							100		100
1 in.	93.2	46.6	100	50.0							96.6		90-100
3/4 in.	71.4	35.7	100	50.0							85.7		
1/2 in.	37.9	19.0	100	50.0							69.0		
3/8 in.	23.3	11.7	100	50.0							61.7		
No. 4	7.4	3.7	99.0	49.5							53.2		≤39.5
No. 8	4.7	2.4	70.4	35.2							37.6		19.0-26.8
No. 16	3.9	2.0	50.0	25.0							27.0		≤18.1
No. 30	3.2	1.6	32.9	16.5							18.1		≤13.6
No. 50	2.9	1.5	14.4	7.2							8.7		≤11.4
No. 100	2.2	1.1	3.5	1.8							2.0		
No. 200	1.6	0.8	1.5	0.8							1.6		1.0-7.0
PAN													

EXAMPLE: No. 8 Sieve 4.7 x .50 = 2.4%

FIGURE 4.10 SECOND TRIAL BLENDING #5 STONE AND #24 SAND

SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

Trial Blend #2

MATERIAL	#5 Stone		#24 Sand										
SOURCE	2211		2284										
Gsb	2.610		2.625										
PERCENT USED	70%		30%										
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	COMB. GRAD. %	DMF %	SPEC. LIMITS
1 1/2 in.	100	70.0	100	30.0							100		100
1 in.	93.2	65.2	100	30.0							95.2		90-100
3/4 in.	71.4	50.0	100	30.0							80.0		
1/2 in.	37.9	26.5	100	30.0							56.5		
3/8 in.	23.3	16.3	100	30.0							46.3		
No. 4	7.4	5.2	99.0	29.7							34.9		≤39.5
No. 8	4.7	3.3	70.4	21.1							24.4		19.0-26.8
No. 16	3.9	2.7	50.0	15.0							17.7		≤18.1
No. 30	3.2	2.2	32.9	9.9							12.1		≤13.6
No. 50	2.9	2.0	14.4	4.3							6.3		≤11.4
No. 100	2.2	1.5	3.5	1.0							2.5		
No. 200	1.6	1.1	1.5	0.4							1.5		1.0-7.0
PAN													

EXAMPLE: No. 8 Sieve 4.7 x .70 = 3.3

FIGURE 4.11 THIRD BLENDING TRIAL TO INCLUDE #11 STONE

SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

MATERIAL	#5 Stone		#11 Stone		# 24 Sand								
SOURCE	2211		2211		2284								
Gsb	2.160		2.610		2.628								
PERCENT USED	55%		15%		30%								
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	COMB. GRAD. %	DMF %	SPEC. LIMITS
1 1/2 in.	100	55.0	100	15.0	100	30.0					100		100
1 in.	93.2	51.3	100	15.0	100	30.0					96.3		90-100
3/4 in.	71.4	39.3	100	15.0	100	30.0					84.3		
1/2 in.	37.9	20.8	100	15.0	100	30.0					65.8		
3/8 in.	23.3	12.8	85.9	12.9	100	30.0					55.7		
No. 4	7.4	4.1	15.1	2.3	99.0	29.7					36.1		≤39.5
No. 8	4.7	2.6	3.0	0.5	70.4	21.1					24.2		19.0-26.8
No. 16	3.9	2.1	2.1	0.3	50.0	15.0					17.4		≤18.1
No. 30	3.2	1.8	1.8	0.3	32.9	9.9					12.0		≤13.6
No. 50	2.9	1.6	1.5	0.2	14.4	4.3					6.1		≤11.4
No. 100	2.2	1.2	1.3	0.2	3.5	1.1					2.5		
No. 200	1.6	0.9	1.0	0.2	1.5	0.5					1.6		1.5-7.0
PAN													

Troubleshooting Tips

Once the blend has been completed, the results are plotted on a 0.45 power gradation chart. For example, take a look at the blend in Figure 4.12. The No. 8 sieve is right on target and all the other sieves are within specification limits. Is this a good mixture?

Plot the blend on the 0.45 power chart (Figure 4.13). Notice that although the asphalt mixture does indeed comply with the Specifications, there is a severe dip on the ½ in. and ⅜3/8 in. sieves. The asphalt mixture may be susceptible to segregation.

This asphalt mixture cannot be improved with available materials. The easiest procedure would be to add some minus ½ in. material. Take a look at Figures 4.14 and 4.15. Notice that the addition of No. 11 stone improves the dip in the gradation band resulting in an asphalt mixture far less likely to segregate.

All problems are not this easy to correct; however, by plotting the blends, potential troublesome asphalt mixture may be spotted.

FIGURE 4.12 EXAMPLE BLEND USING #5 STONE AND #24 SAND

SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

Mix #1

MATERIAL	#5 Stone		#24 Sand										
SOURCE	2211		2284										
Gsb	2.610		2.625										
PERCENT USED	75%		25%										
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	COMB. GRAD. %	DMF %	SPEC. LIMITS
1 1/2 in.	100	75.0	100	25.0							100		100
1 in.	93.2	69.9	100	25.0							94.9		90-100
3/4 in.	71.4	53.6	100	25.0							78.6		
1/2 in.	37.9	28.4	100	25.0							53.4		
3/8 in.	17.5	13.1	100	25.0							38.1		
No. 4	7.4	5.6	99.4	24.9							30.5		≤39.5
No. 8	4.7	3.5	77.9	19.5							23.0		19.0-26.8
No. 16	3.9	2.9	59.7	14.9							17.8		≤18.1
No. 30	3.2	2.4	41.1	10.3							12.7		≤13.6
No. 50	2.9	2.2	15.5	3.9							6.1		≤11.4
No. 100	2.2	1.7	5.3	1.3							3.0		
No. 200	1.6	1.2	2.0	0.5							1.7		1.0-7.0
PAN													

FIGURE 4.13 PLOT OF EXAMPLE BLEND CONTAINING #5 STONE AND #24 SAND

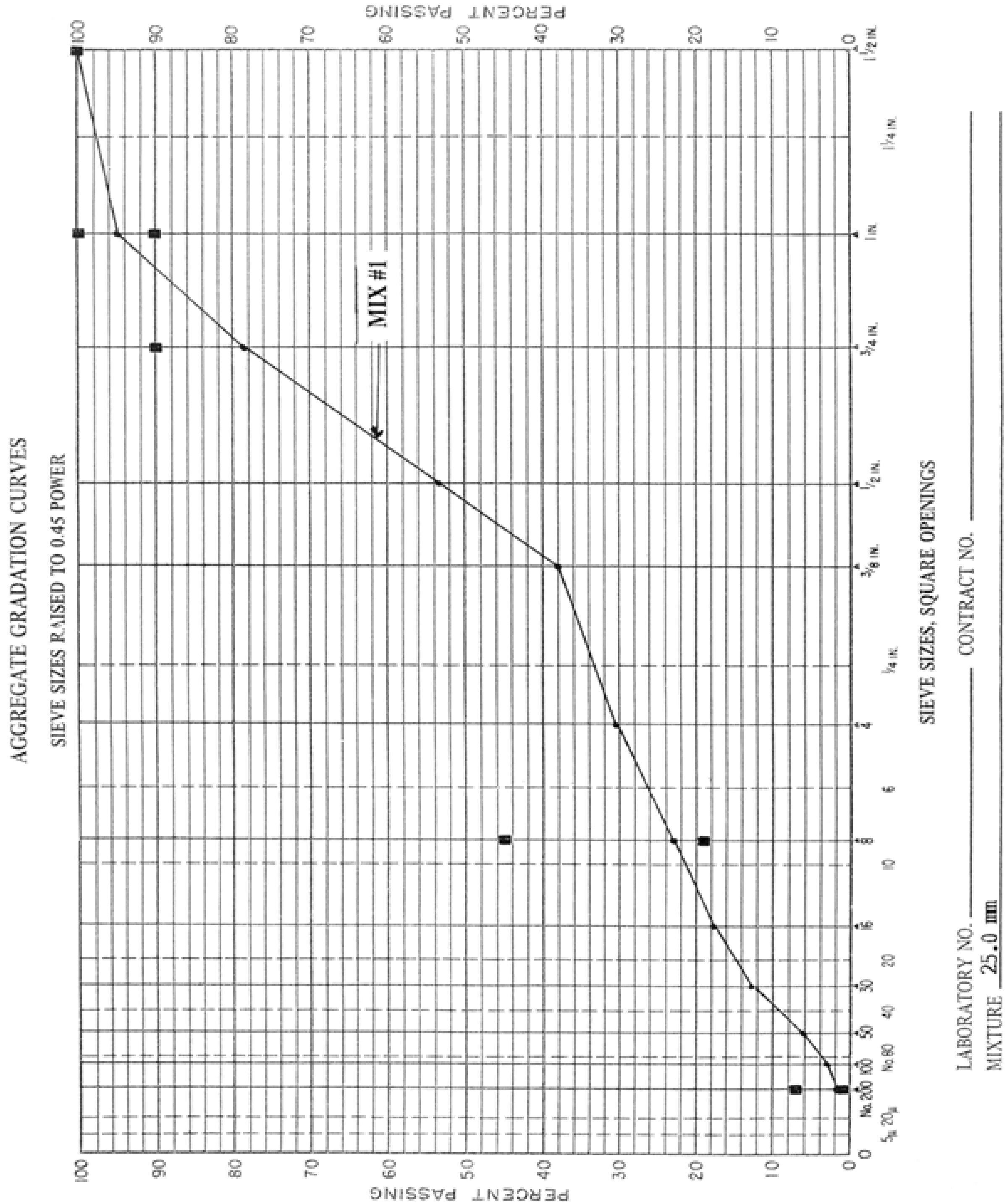


FIGURE 4.14 EXAMPLE BLEND WITH #11 STONE ADDED TO #5 STONE AND #24 SAND

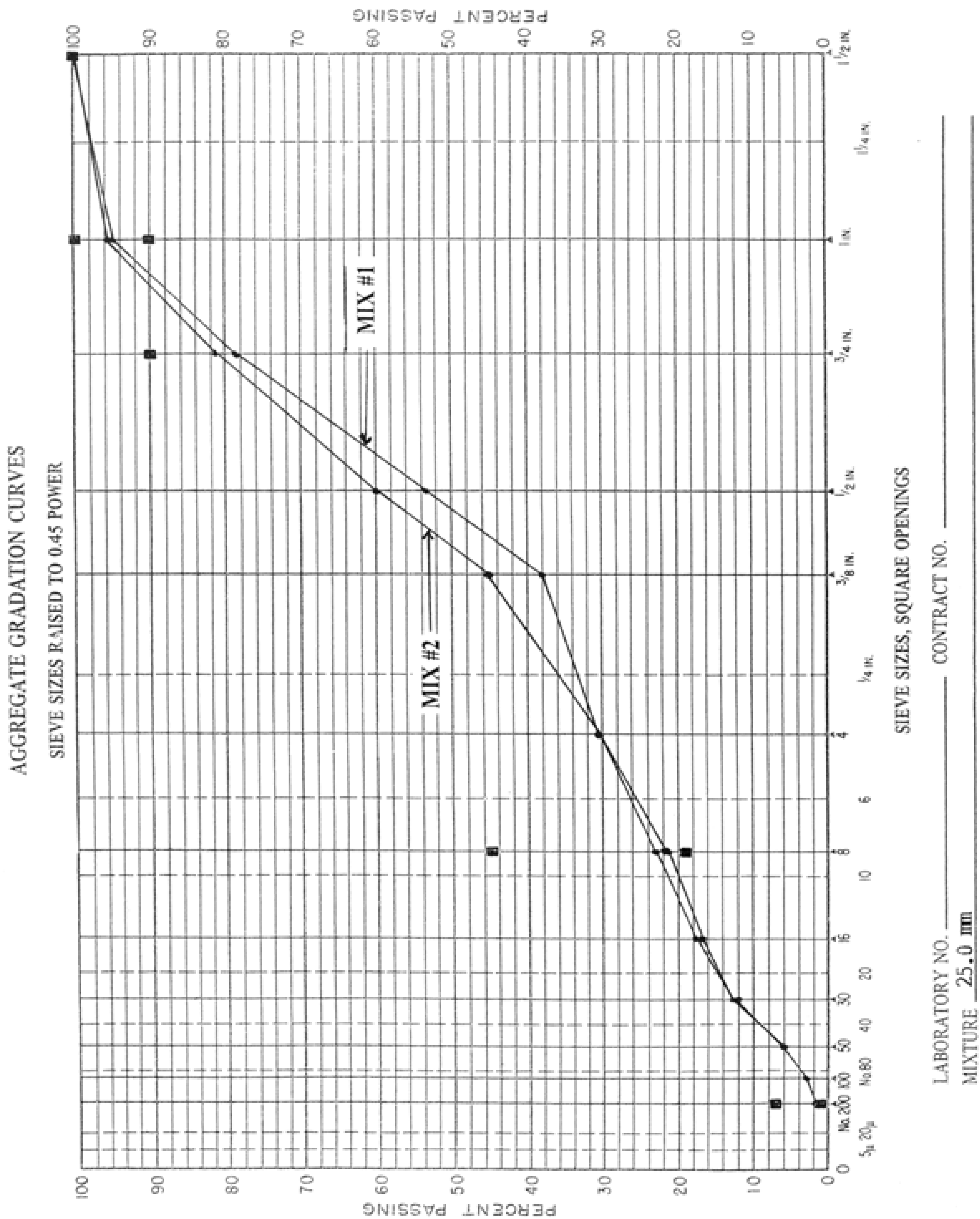
SUPERPAVE AGGREGATE BLEND WORKSHEET

DATE: 7/1/2002
CONTRACT: R-22110
MIXTURE: 25.0 mm

Mix #2

MATERIAL	#5 Stone		#11 Stone		#24 Sand								
SOURCE	2211		2211		2284								
Gsb	2.160		2.610		2.625								
PERCENT USED	65%		11%		24%								
SIEVES	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	% PASS.	% FOR MIX	COMB. GRAD. %	DMF %	SPEC. LIMITS
1 1/2 in.	100	65.0	100	11.0	100	24.0					100		100
1 in.	93.2	60.6	100	11.0	100	24.0					95.6		90-100
3/4 in.	71.4	46.4	100	11.0	100	24.0					81.4		
1/2 in.	37.9	24.6	100	11.0	100	24.0					59.6		
3/8 in.	17.5	11.4	85.9	9.4	100	24.0					44.8		
No. 4	7.4	4.8	15.1	1.7	99.4	23.9					30.4		≤39.5
No. 8	4.7	3.1	3.0	0.3	77.9	18.7					22.1		19.0-26.8
No. 16	3.9	2.5	2.1	0.2	59.7	14.3					17.0		≤18.1
No. 30	3.2	2.1	1.8	0.2	41.1	9.9					12.2		≤13.6
No. 50	2.9	1.9	1.5	0.2	15.5	3.7					5.8		≤11.4
No. 100	2.2	1.4	1.3	0.1	5.3	1.3					2.8		
No. 200	1.6	1.0	1.0	0.1	2.0	0.5					1.6		1.0-7.0
PAN													

FIGURE 4.15 PLOT OF EXAMPLE BLEND WITH #11 STONE PLUS #5 STONE AND #24 SAND



RECYCLED MATERIALS

Recycled materials may be used in QC/QA HMA and HMA mixtures provided that the recycled mixture adheres to the same criteria as a mixture without any recycled materials. Recycled materials may consist of reclaimed asphalt pavement (RAP), or reclaimed asphalt shingles (RAS), or a blend of both. RAP is the product resulting from the cold milling or crushing of an existing asphalt mixture pavement. RAS can be waste from either a shingle manufacturing facility or roof tear-off materials.

RAP materials cannot contribute more than 25.0 percent by weight of total binder content for any mixture while RAS materials cannot contribute more than 15.0 percent, or 3.0% RAS by mass of the total mixture

The RAP coarse aggregate shall pass the maximum size sieve for the mixture being produced and the RAS shall be 100 % passing the ½ in. sieve. RAP used in ESAL category 3, 4, or 5 surface mixtures shall be 100 % passing the ⅜ in. sieve and 95-100 % passing the No. 4 sieve.

Binder replacement is determined from the following formula:

Binder Replacement, % = $\dfrac{(\text{A x B}) + (\text{C x D})}{\text{E}} \text{ x } 100\%$

where:

A = RAP, % Binder Content
B = RAP, % in Mixture
C = RAS, % Binder Content
D = RAS, % in Mixture
E = Total, % Binder Content in Mixture

Example:

RAP, % Binder Content = 4.0
RAP, % in Mixture = 15.0
RAS, % Binder Content = 20.0
RAS, % in Mixture = 3.0

Total, % Binder Content in Mixture = 4.8

Binder Replacement, % = $\dfrac{(0.04 \text{ x } 0.15) + (0.20 \text{ x } 0.03)}{0.048} \text{ x } 100 = 25.0\,\%$

SUPERPAVE SPECIMENS

From the aggregate blend, the mix designer estimates the binder demand needed for the selected aggregate structure and proceeds with preparing a maximum specific gravity sample and a set of 150 mm specimens for compaction in the Superpave gyratory compactor. The gyratory simulates the mix densities achieved under the actual pavement climate and loading conditions. This device is capable of accommodating large aggregate, recognizing potential tender mix behavior and similar compaction problems, and is well suited for mixing plant quality control operations. The compactor is designated the Superpave Gyratory Compactor (SGC).

Figure 4.16 illustrates a generic SGC and Figure 4.17 illustrates the SGC mold configuration and compaction parameters. The internal angle of gyration of the SGC is required to be 1.16 ± 0.02°.

FIGURE 4.16 SUPERPAVE GYRATORY COMPACTOR

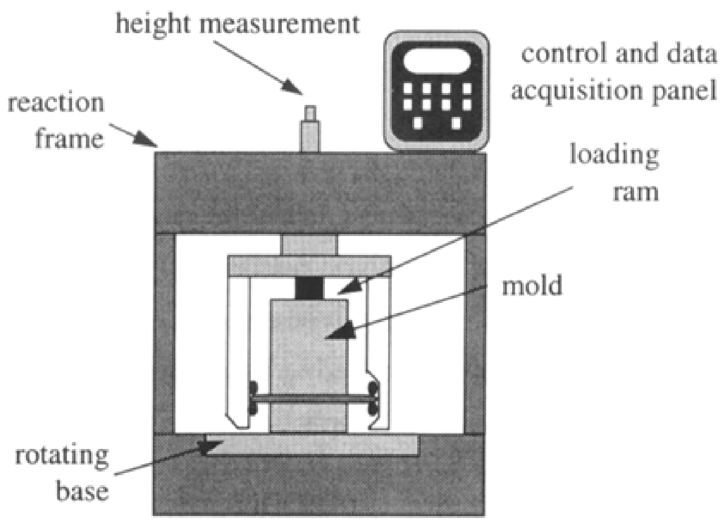
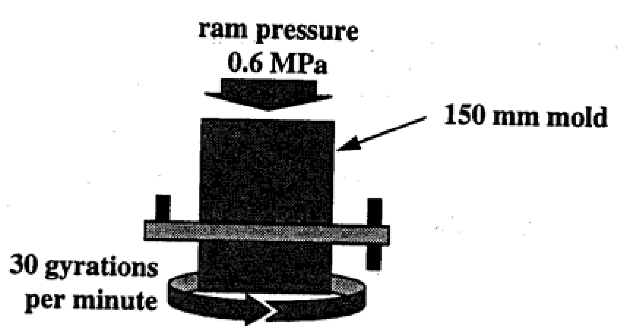


FIGURE 4.17 SUPERPAVE GYRATORY COMPACTOR MOLD CONFIGURATION AND COMPACTION PARAMETERS



Specimens compacted with the Superpave gyratory compactor in the mix design are analyzed at a different number of gyrations depending on the traffic for the contract and whether the mixture is a dense graded, open graded, or a SMA mixture. The procedure used for preparing Superpave specimens is AASHTO T 312. Three gyration levels are of interest:

N_{des} = design number of gyrations
N_{ini} = initial number of gyrations
N_{max} = maximum number of gyrations

FIGURE 4.18 SUPERPAVE GYRATORY COMPACTIVE EFFORT

GYRATORY COMPACTION EFFORT					
ESAL	**N_{ini}**	**N_{des}**	**N_{max}**	**Max. % G_{mm}@N_{ini}**	**Max.% G_{mm} @N_{max}**
DENSE GRADED					
<3,000,000	5	30	40	91.5	97.0
3,000,000 to < 10,000,000	6	50	75	91.5	97.0
> 10,000,000	6	50	75	91.5	97.0
OPEN GRADED					
ALL ESAL	NA	20	NA	NA	NA
SMA					
ALL ESAL	NA	75		NA	NA

The compactive efforts N_{ini} and N_{max} are used to evaluate the compatibility of the asphalt mixture, while N_{des} is used to select the binder content. A maximum percentage of the maximum theoretical density (G_{mm}) requirement at N_{ini} insures an adequate aggregate structure in the asphalt mixture. A maximum percentage of the maximum theoretical density (G_{mm}) requirement at N_{max} assures that the asphalt mixture does not compact excessively under the anticipated traffic, resulting in permanent deformation or rutting.

Specimens in the mix design are compacted to N_{des} at each increment of binder content to evaluate the required air voids and VMA. After a mix design binder content has been estimated, two specimens are compacted to N_{des} at each of the following four binder contents:

1. The estimated design binder content, P_b (design)
2. 0.5 percent below P_b (design)
3. 0.5 percent above P_b (design)
4. 1.0 percent above P_b (design)

Figure 4.18 lists the requirements at the optimum binder content for Maximum % G_{mm} at N_{max} and Maximum % G_{mm} at N_{ini}. The Maximum % G_{mm} at N_{max} is determined by compacting the mixture to N_{max}, measuring the bulk specific gravity, and calculating the % G_{mm} using the Maximum Specific Gravity value at the optimum binder content. The Maximum % G_{mm} at the N_{ini} is determined by the following formula:

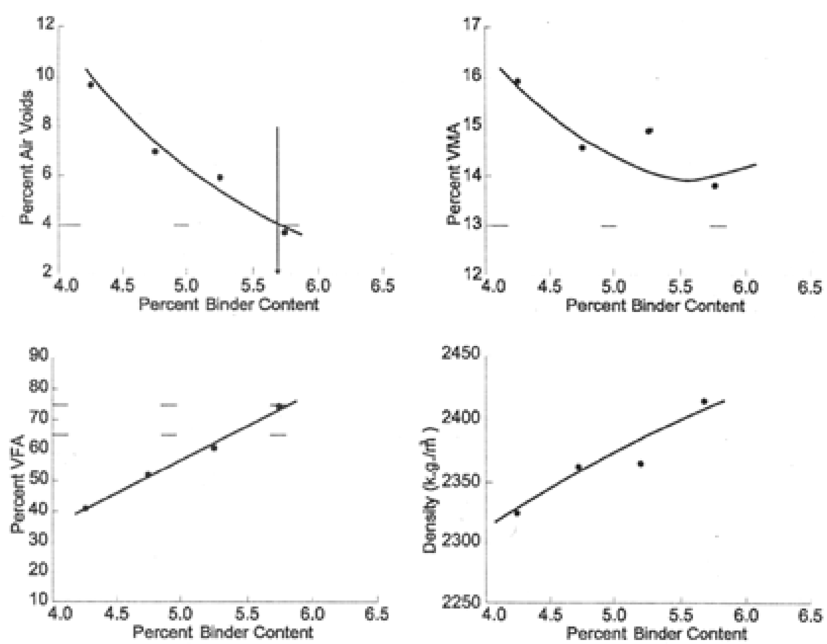
$$\%G_{mm} = 100x\frac{G_{mb}xh_d}{G_{mm}xh_i}$$

where:

G_{mb} = bulk specific gravity at N_{des}
G_{mm} = theoretical maximum specific gravity at N_{des}
h_d = height of specimen at N_{des}
h_i = height of specimen at N_{ini}

An example of the plots of the data is shown in Figure 4.19.

FIGURE 4.19 GYRATORY DENSIFICATION DATA



MAXIMUM SPECIFIC GRAVITY

To determine the maximum specific gravity (Figure 4.20) when weighing in water (AASHTO T 209), the dry fine fraction of the mixture is first broken into pieces no larger than 1/4 in.

diameter. The entire dry loose mixture is weighed, placed in a tared vacuum container, and covered with water. A partial vacuum of 25.0 to 30.0 mm Hg is applied to the container for 15 ± 2 minutes. The container and contents are agitated during the vacuum period by a mechanical device. At the end of the vacuum period, the vacuum is gradually released. The container and contents are suspended in a water bath and the weight determined after 10 ± 1 min immersion. The container is immediately emptied and weighed totally submerged in the water bath.

FIGURE 4.20 MAXIMUM SPECIFIC GRAVITY

Calculations to determine the maximum specific gravity are as follows:

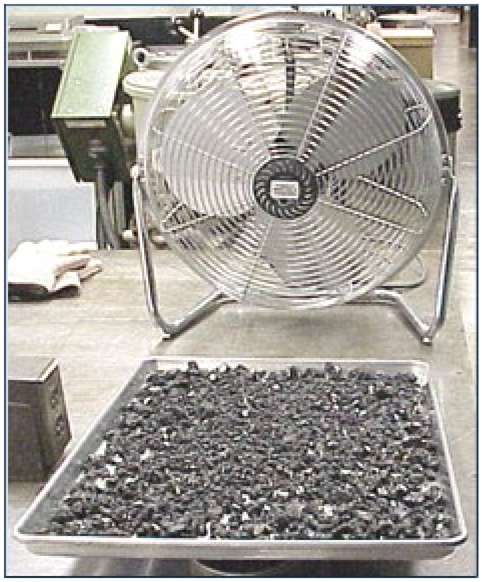
$$\text{Maximum Specific Gravity } (G_{mm}) = \frac{A}{A-(C-B)}$$

where:

A = weight of oven dry sample in air, g
B = weight of container in water, g
C = weight of container and sample in water, g

A supplemental procedure for mixtures containing porous aggregate is recommended when the asphalt mixture contains an individual aggregate with water absorption of 1.5 percent or greater. The procedure requires the sample to be spread before an electric fan to remove the surface moisture (Figure 4.21). The sample is weighed at 15-minute intervals until the loss in weight is less than 0.05 percent for this interval. This weight is designated the surface dry weight.

FIGURE 4.21 MAXIMUM SPECIFIC GRAVITY SUPPLEMENTAL PROCEDURE



Calculations to determine the maximum specific gravity using the supplemental procedure are as follows:

$$\text{Maximum Specific Gravity } (G_{mm}) = \frac{A}{A_1 - (C - B)}$$

where:

A = weight of oven dry sample in air, g
A_1 = weight of surface dry sample, g
B = weight of container in water, g
C = weight of container and sample in water, g

BULK SPECIFIC GRAVITY – DENSE GRADED MIXTURES AND SMA

To determine the bulk specific gravity (Figure 4.22) of dense graded mixtures, the compacted specimens are extruded from the mold, cooled to room temperature, and the dry weight recorded. (A cooling period of 10 ± 1 minutes in front of a fan is necessary before extruding the specimens to assure the specimens are not damaged). Each specimen is then immersed in water at 77 ± 1.8° F for three to five minutes, and the immersed weight is recorded. The specimen is removed from the water, surface dried by blotting with a damp cloth, and the surface dry weight recorded in air (AASHTO T 166 – Method A).

FIGURE 4.22 BULK SPECIFIC GRAVITY

The bulk specific gravity of the specimen is calculated as follows:

$$\text{Bulk Specific Gravity } (G_{mb}) = \frac{A}{B - C}$$

where:

A = weight of specimen in air, g
B = weight of surface-dry specimen in air, g
C = weight of specimen in water, g

The bulk specific gravity may be converted to density by multiplying by 62.416 lb/ft^3.

Upon completion of the test, the percent water absorbed by the specimen is calculated as follows:

$$\text{Percent Water Absorbed by Volume} = \left(\frac{B - A}{B - C}\right) \times 100$$

If the percent water absorbed by the specimen exceeds 2.0 %, the specimen bulk specific gravity will be measured using the automatic sealing device (AASHTO T 331).

Each specimen is sealed in a plastic bag using a vacuum sealing device (Figure 4.23), weighed in air, and then weighed submerged in water at 77° F. The specimen is removed from the bag and weighed to determine the amount of water that is absorbed.

FIGURE 4.23 VACUUM SEALING DEVICE

The bulk specific gravity of the specimen is calculated as follows:

$$G_{mb} = \frac{A}{B - E - \left(\frac{B - A}{F_T}\right)}$$

where:

A = weight of dry specimen in air, g
B = weight of dry, sealed specimen, g
E = weight of sealed specimen in water, g
(weight of absorbed water is subtracted)
Ft = apparent specific gravity of plastic sealing material at 77°F

BULK SPECIFIC GRAVITY – RECYCLED MATERIALS

ITM 584 is used to calculate the G_{sb} of a combined aggregate blend when recycled materials are used in an asphalt mixture. The bulk specific gravity of RAP or RAS that is used in these calculations is typically not measured.

1. The Bulk Specific Gravity of the recycled aggregate from RAP is assumed to be 2.640 unless testing of extracted material shows it to be outside the range of 2.620 to 2.660. The INDOT will test it to determine the value.
2. Gsb of the mineral matter in RAS is assumed to be 2.500.

DUST/CALCULATED EFFECTIVE BINDER RATIO

The dust/calculated effective binder ratio is computed as the ratio of the percentage by weight of aggregate finer than the No. 200 sieve to the calculated effective binder content expressed as a percent of total mix. The dust proportion is calculated as follows:

$$\text{Dust/Calculated Effective Binder Ratio} = \frac{P_{200}}{P_{be}}$$

where:

P_{200} = aggregate content passing the No. 200 sieve, percent by weight of aggregate

P_{be} = effective binder content, percent by total weight of mixture

The asphalt absorption (P_{ba}) is first calculated and then the effective binder content (P_{be}) is determined.

Asphalt Absorption (P_{ba}) = 100 x $\frac{G_{se}-G_{sb}}{G_{sb}\ x\ G_{se}}$ x G_b

where:

G_{se} = effective specific gravity of aggregate
G_{sb} = bulk specific gravity of aggregate
G_b = specific gravity of binder

Effective Binder Content (P_{be}) = P_b - $\left(\frac{Pba}{100} \times Ps\right)$

where:

P_b = binder content, percent by total weight of mixture
P_s = aggregate content, percent by total weight of mixture

AIR VOIDS

Once the bulk specific gravity and maximum specific gravity of the asphalt mixture have been determined, the air voids (V_a) are calculated as follows:

Air Voids (V_a) = 100 x $\frac{G_{mm}-G_{mb}}{G_{mm}}$

where:
G_{mm} = Maximum Specific Gravity of asphalt mixture
G_{mb} = Bulk Specific Gravity of asphalt mixture

VOIDS IN THE MINERAL AGGREGATE

The voids in the mineral aggregate (VMA) is determined on the basis of bulk specific gravity of the aggregate and is expressed as a percentage of the bulk volume of the compacted mix. Therefore, VMA is calculated by subtracting the volume of the aggregate determined by the bulk specific gravity from the bulk volume of the compacted asphalt mixture as follows:

Voids in the Mineral Aggregate (VMA) = 100 - $\frac{G_{mb}\times P_s}{G_{sb}}$

where:

G_{mb} = Bulk Specific Gravity of asphalt mixture
G_{sb} = Bulk Specific Gravity of aggregate(obtained from DMF)

P_s = Aggregate, percent by total weight of asphalt mixture

The percent of aggregate by total weight of asphalt mixture (P_s) is determined by subtracting the actual binder content by total weight of asphalt mixture (P_b) supplied on the design mix formula from 100.

$$Ps = 100 - P_b$$

MOISTURE SUSCEPTIBILITY

The final process required in the volumetric mix design is to check the moisture susceptibility of the asphalt mixture. The procedure used is AASHTO T 283, except that the loose mixture curing is replaced by mixture conditioning for 2 h in accordance with AASHTO R 30. Regardless of the mixture designation, all Superpave mixtures are required to meet a minimum tensile strength ratio (TSR) of 80 %.

EXAMPLE CALCULATIONS

A sample of the aggregate and compacted asphalt mixture is known to have the following properties. The density, air voids, VMA, VFA, and Dust/Calculated Effective Binder Ratio are determined as follows:

Effective Specific Gravity of Aggregate (G_{se}) = 2.726
Specific Gravity of Binder (G_b) = 1.030
Bulk Specific Gravity of Mix (G_{mb}) = 2.360
Bulk Specific Gravity of Aggregate (G_{sb}) = 2.715
Maximum Specific Gravity of Mix (G_{mm}) = 2.520
Binder Content (P_b) = 5.0 percent of weight of total mix
Aggregate Passing No. 200 (P 200) = 5.3

Density $D = G_{mb} \times 62.416 \text{ lb/ft}^3$

$= 2.360 \times 62.416 = 147.3 \text{ lb/ft}^3$

Air Voids $V_a = 100 \times \dfrac{G_{mm} - G_{mb}}{G_{mm}}$

$= 100 \times \left(\dfrac{2.520 - 2.360}{2.520}\right)$

$= 100 \times .063 = 6.3\ \%$

VMA $P_s = 100 - Pb$

$= 100 - 5.0$

$= 95.0\ \%$

VMA $= 100 - \dfrac{G_{mb} \times P_s}{G_{sb}}$

$= 100 - \left(\dfrac{2.360 \times 95.0}{2.715}\right)$

$= 100 - 82.6 = 17.4\ \%$

VFA VFA $= \left(\dfrac{VMA - Va}{VMA}\right) \text{ x } 100$

$= \left(\dfrac{17.4 - 6.3}{17.4}\right) \text{ x } 100 = 64\ \%$

Dust/Calculated Effective Binder Ratio

P_{ba} $= 100 \text{ x } \dfrac{2.726 - 2.715}{2.715 x 2.726}\ x\ 1.030$

$= 100 \text{ x } \dfrac{0.11}{7.401} \text{ x } 1.030$

$= 0.15$

P_s $= 100 - 5.0 = 95.0$

P_{be} $= 5.0 - \left(\dfrac{0.15}{100} \times 95.0\right)$

$= 5.0 - 0.1$

$= 4.9$

$P200/P_{be}$ $= \dfrac{P_{200}}{P_{be}} = \dfrac{5.3}{4.9} = 1.1$

STONE MATRIX ASPHALT

Stone Matrix Asphalt (SMA) is a tough, stable, rut-resistant mixture that relies on coarse aggregate-to-coarse aggregate contact to provide strength and a rich mortar binder to provide durability. The coarse aggregate-to-coarse aggregate contact is obtained by designing with an aggregate skeleton that consists of a large percentage of very durable coarse aggregate. The mortar consists of asphalt binder, mineral filler (material passing the No. 200 sieve), and a stabilizing additive of either cellulose or mineral fibers.

The primary advantage of SMA is the expected extended life as compared to conventional dense-graded mixtures. This extended life is the result of better rut resistance and the potential to reduce reflection cracks. Other potential advantages are the reduction in tire splash and spray, and traffic noise.

The mix design requirements of SMA that are different than dense-graded mixtures include the following:

1. A minimum VMA of 17.0 is required for 9.5 mm SMA mixtures, 16.0 for 12.5 mm SMA mixtures, and 15.0 for 19.0 mm SMA mixtures.
2. A draindown test (AASHTO T 305) to determine the amount of mortar that drains from the SMA at the plant-production temperature is conducted.

CHAPTER 5

ASPHALT PLANTS

DRUM PLANTS

DRUM MIX PLANT COMPONENTS

AGGREGATE STORAGE AND FEED

COLD AGGREGATE STORAGE AND FEEDING

BINDER METERING

AGGREGATE MOISTURE DETERMINATION

DRUM MIX OPERATION

SURGE BIN AND WIEGH SCALES

HOT MIX ASPHALT STORAGE

SUMMARY OF DRUM MIXERS

EFFECT OF PLANT ON ASPHALT MIXTURE PROPERTIES

DUST CONTROL AND COLLECTION SYSTEMS

DRUM/WET WASH

DRUM/BAGHOUSE

PLANT INSPECTION AND SCALE CHECK

DRUM PLANT

PLANT TROUBLESHOOTING

SAFETY

CHAPTER 5

HOT MIX ASPHALT PLANT OPERATIONS

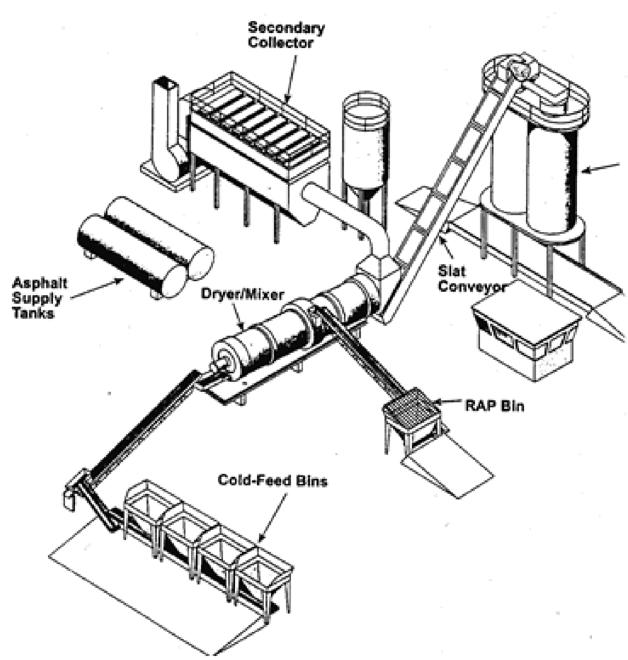
An asphalt mixture plant is an assembly of mechanical and electronic equipment where aggregates, recycled materials or other additives are blended, heated, dried and mixed with binder to produce asphalt mixture meeting specified requirements. The plant may be stationary (located at a permanent location) or portable (moved from contract to contract). There are numerous types of plants, including batch plants, continuous mix plants, parallel-flow drum plants, counter flow drum plants, and double barrel drum plants to name a few. In general, most plants may be categorized as either a batch plant, or a drum mix plant (Figure 5.1). The information presented in this chapter covers these two types of plants.

In the batch-type mixing plant, hot aggregate, recycled materials and binder are added in designated amounts to make up one batch. After mixing, the asphalt mixture is discharged from the pugmill in one batch.

In the drum-type mixing plant, the aggregate and other materials are dried, heated, and mixed with the binder in the drum in a continuous process.

Regardless of the type of mixing plant, the basic purpose is the same. That purpose is to produce an asphalt mixture containing proportions of binder and aggregate that meets all the specification requirements.

FIGURE 5.1 TYPICAL DRUM PLANT



DRUM PLANTS

These operations include:

1. Cold aggregate storage and feeding
2. Dust control and collection
3. Mix storage
4. Recycled materials storage and feeding

Also common to all plants is the importance of uniformity and balance, both in materials used and in plant operations. Uniformity encompasses materials, material proportioning, and continuous operation of all plant components. Changes in material characteristics, proportions, and intermittent stops and starts in plant operations make producing an asphalt mixture meeting Specifications extremely difficult.

Balance requires careful coordination of all elements of production. Balancing material quantities to plant production, and balancing plant production and pavement placing operations guarantee a continuous, uniform production and placement effort.

Uniformity and balance are best ensured by careful preparation. Materials are required to be sampled and tested and plant components carefully inspected and calibrated before production begins.

Drum mixing is a relatively simple process of producing asphalt mixture. The mixing drum from which this type of plant obtains the drum mixing name is very similar in appearance to a batch plant dryer drum. The difference between drum mix plants (Figure 5.2) and batch plants is that in drum mix plants the aggregate is not only dried and heated within the drum, but also mixed with the binder. There are no gradation screens, hot bins, weigh hoppers, or pugmills in a drum mix plant. Aggregate gradation is controlled at the cold feed.

As the aggregates (correctly proportioned at the cold feed) are introduced into the drum mix plant for drying, the binder is also introduced into the drum. The rotation of the drum provides the mixing action that thoroughly blends the binder and the aggregates. As the asphalt mixture is discharged from the drum, the mixture is carried to a surge bin and subsequently loaded into trucks.

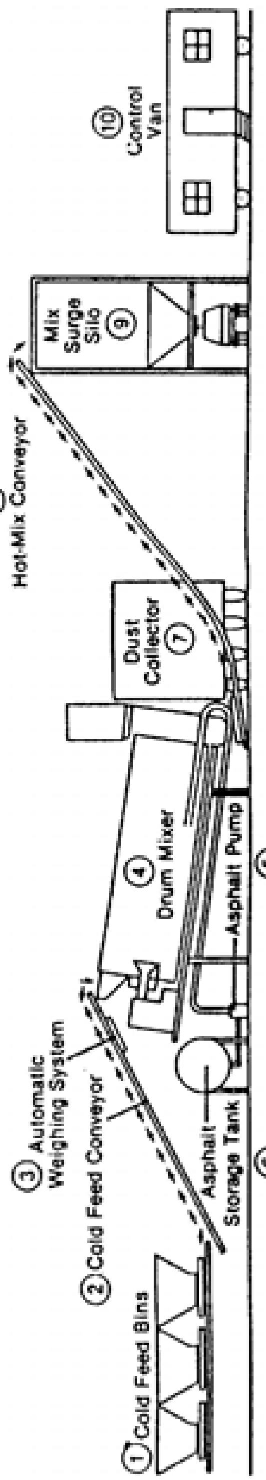
FIGURE 5.2 TYPICAL DRUM MIX PLANT

DRUM MIX PLANT COMPONENTS

The fundamental components of the drum mix plant (Figure 5.2) are:

1. Aggregate cold-feed bins
2. Conveyor and aggregate weighing system
3. Drum mixer
4. Dust collection system
5. Hot mix conveyor
6. Mix surge bin
7. Control van
8. Binder storage tank

FIGURE 5.3 BASIC DRUM MIX PLANT



Referring to (Figure 5.3), the following is a brief, general description of the sequence of processes involved in a typical drum mix plant operation: controlled gradations of aggregates are deposited in the cold feed bins (1) from which the aggregates are fed in exact proportions onto a cold-feed conveyor (2). An automatic aggregate weighing system (3) monitors the amount of aggregate flowing into the drum mixer (4). The weighing system is interlocked with the controls on the binder storage pump (5), which draws binder from a storage tank (6) and introduces binder into the drum where binder and aggregate are thoroughly blended by the rotating action of the drum. A dust collection system (7) captures excess dust escaping from the drum. From the drum, the asphalt mixture is transported by hot mix conveyor (8) to a surge bin (9) from which the mixture is loaded into trucks and hauled to the paving site. All plant operations are monitored and controlled from instruments in the control van (10).

The mixing process is essentially similar in all drum mixing plants; however, there are several plant designs available. These include the parallel-flow drum, as shown in (Figure 5-10), the counter-flow drum, which has the burner located near the outlet end of the drum, and the unitized counter-flow drum (Double Barrel), which has an outer mixing drum that surrounds the dryer drum.

The production of asphalt mixture meeting contract Specifications is most easily done when the various parts and functions of the plant are in balance; that is, when all parts are properly coordinated to work together as a smooth working unit. Also essential for consistent and high-quality asphalt mixture is uniform (uninterrupted) plant operation. Accurate proportioning of materials is entirely dependent on the uniform flow of those materials. Plant stops and starts adversely affect asphalt mixture quality.

To ensure balance and uniformity necessary to produce asphalt mixture to meet Specifications, the following control equipment is required:

1. Separate cold feed controls for each aggregate size
2. Interlocking controls of aggregate cold feed, binder delivery, and additive delivery to the drum
3. Automatic burner controls
4. A dust collector constructed to waste or return the material uniformly as directed
5. Sensors to measure temperature of the asphalt mixture at drum discharge
6. Gate controls on surge hopper
7. Moisture compensator

Controls and monitoring devices are usually housed in the control van, where there is good visibility of the entire operation.

AGGREGATE STORAGE AND FEED

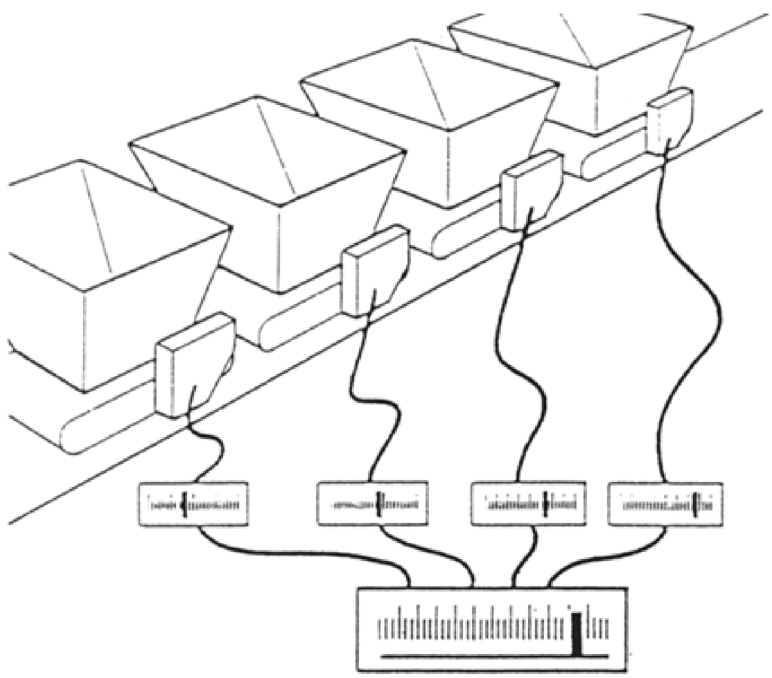
In a drum mix plant, asphalt mixture gradation and uniformity are entirely dependent on the cold feed system. Proper care is required to be exercised not only in production of the aggregate, but also in storage. The Producer is required to provide for receiving and handling aggregates in such a way that there is no danger of contamination or intermingling. Among other things, this means providing clean surfaces on which to place the materials.

Stockpiles are required to be properly graded and contain different-sized fractions to properly control the gradation of the asphalt mixture.

Segregated stockpiles, if uncorrected prior to plant production, result in asphalt mixture gradation difficulties. Segregation may be prevented by constructing stockpiles in lifts not exceeding the height a loader may place the material and by removing aggregate from the upper areas of the stockpile, thereby minimizing sloughing of the side slopes. Regardless of the method of handling, all efforts are required to be directed at delivering the correct, uniformly-graded aggregate blend to the mixing plant.

Since the typical drum mix plant, unlike a batch plant, does not incorporate a gradation screening unit, the aggregate is required to be proportioned prior to entry into the mixing drum. The most efficient way to accomplish this is with a multiple-bin cold feed system equipped with precision belt feeders for the control of each aggregate. Under each bin is a belt feeder onto which the aggregate is proportioned. Precise controls (Figure 5.4) are used here to feed the exact proportions onto the belt.

FIGURE 5.4 MASTER COLD FEED CONTROL



The plant is required to be equipped with provisions to obtain representative samples of the full flow of material on the cold feed belt. The Technician is required to conduct a sieve analysis of the dried aggregate from these samples.

Cold feed control consists of the following:

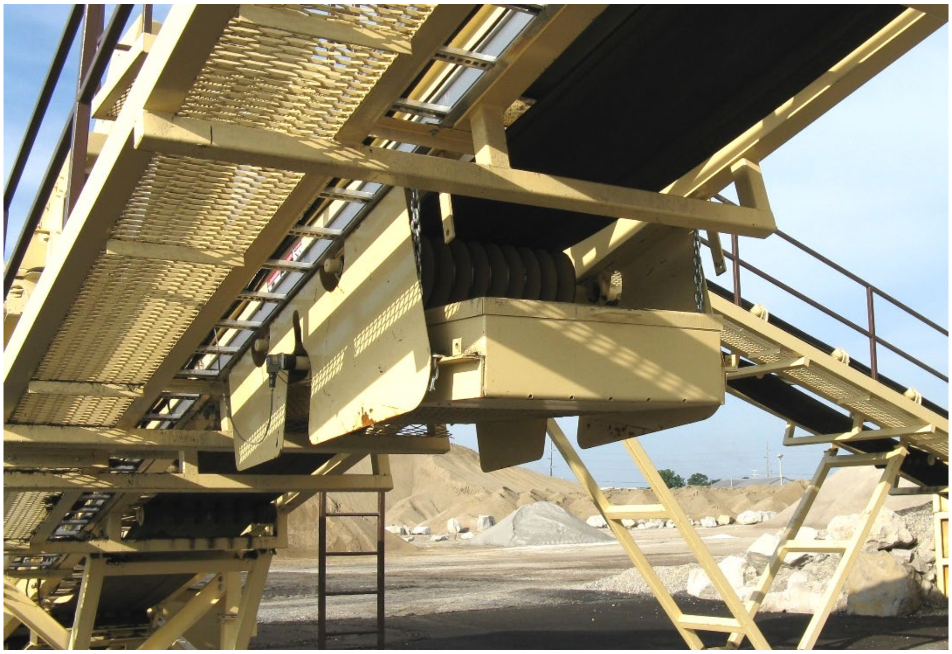
1. Conduct a sieve analysis of the aggregate in each bin
2. Calibrate feeders - both gates opening and belt speed
3. Establish bin proportions
4. Set gate openings and be drive speeds

Once calibrated, the gate openings are required to be checked frequently to ensure the proper settings. All settings are considered temporary because the cold aggregate used in the mix may vary in gradation and moisture content, which may require adjustment of the gates or belt speed to maintain a uniform flow. To calibrate the aggregate metering system and to plot a cold-feed control chart, a sampling device or method to obtain samples is necessary. The device is required to permit the flow of aggregate samples. Such devices are usually installed at the end of the conveyor belt just prior to entry into the drum mixer.

Drum mix plants require a continuous weighing system on the cold feed conveyor belts. In-line belt weighters, also called weigh bridges (Figure 5.5) are continuous belt-weighing devices used for this purpose. Combined aggregates passing over the conveyor belt are continuously weighed and a readout (in the control trailer) indicates the weight of the flow over the scale at any given instance. No material may be diverted from the conveyor belt after passing the belt weigher.

Figure 5.5 illustrates that one of the conveyor idlers (designated the weigh idler) of the belt weigher is mounted on a pivoted scale carriage. As the loaded belt passes over this idler, the weight is read in tons per hour and a reading is displayed at the control console in the control van or trailer. This reading is normally corrected to account for moisture in the aggregate (since dry-aggregate data is used to establish the required percentage of binder) and is a key reading in monitoring plant operations.

FIGURE 5.5 TYPICAL IN-LINE BELT WEIGHER



The in-line belt weigher is usually located midway between the head and tail pulley of the cold feed belt conveyor. This location tends to lessen variations in reading caused by impact loading, roll-back of aggregate, or changes in belt tension. Means may be provided for conveniently diverting aggregates into trucks, front-end loaders, or other containers for checking the accuracy of the belt weigher. The device is required to be within ± 0.5 percent when tested for accuracy.

In drum mix plants the aggregate is weighed before drying. Since the undried material may contain an appreciable amount of moisture that may influence the aggregate weight, an accurate measurement of aggregate moisture content is important. From the measurement, adjustments may be made to the automatic binder metering system to ensure that the amount of binder delivered to the drum is proportionate to the amount of aggregate minus the aggregate moisture content.

The Technician is required to monitor the moisture content of the cold feed aggregate before beginning each day of operation and again about the middle of the day and adjust the moisture control equipment accordingly. If the moisture content is believed to vary during the day, the aggregate is required to be checked more frequently. Provisions are required to be made for electronically correcting wet aggregate weight readings to dry aggregate weight readings.

Cold Aggregate Storage and Feeding

The cold aggregate feed is the first major component of the mixing plant. The cold feeder may be charged by one or a combination of three methods:

1. Open top bins with several compartments. Materials are usually fed by a front-end loader
2. Tunnels under stockpiles separated by bulkheads. Materials are stockpiled over the tunnel by belt conveyor, or front-end loader
3. Bunker or large bins. Materials are usually fed by trucks, car unloaders, or bottom dump freight cars emptying directly into the bunkers

When charging the cold bins (Figure 5.6), segregation and degradation of the aggregate are problems that may occur. These problems may be prevented by taking the same precautions outlined for proper stockpiling. Enough materials are required to be maintained in all bins to provide a constant and uniform flow.

FIGURE 5.6 TYPICAL COLD FEED SYSTEM

When a front-end loader is used to charge the bins, the operator should not pick up material from the storage stockpile at ground level. The scoop is held high enough above the ground to prevent contamination.

When trucks are used to charge the bins, the aggregate is deposited directly above the feeder.

When the stockpile is replenished by overhead belts or elevated conveyors, the free-falling materials is controlled by baffles.

Aggregate feeder units are located beneath storage bins or stockpiles, or in positions that ensure a uniform flow of aggregates.

Openings located at the bottom of the bins deposit the different aggregates on a belt conveyor, and/or bucket lines, which carry the aggregates to the dryer. Feeder controls regulate the amount of aggregate flowing from each bin, thereby providing a continuous, uniform flow of properly-graded aggregate to the plant.

The most common type of cold feeder used in a plant is the continuous belt type.

FIGURE 5.7 CONTINUOUS BELT FEEDER

The key element in the continuous belt feeder is how to control or regulate the flow of material from each bin. Every manufacturer has a different control method.

Typical control variations are:

1. Gate opening
    a. Fixed
    b. Adjustable
2. Belt
    a. One speed (on or off)
    b. Adjustable speed

The most common configuration is the adjustable gate with an adjustable belt speed.

Calibrating and Setting Feeders

The cold aggregate feeder is calibrated, set, and secured to ensure a uniform flow of aggregate. This calibration is the responsibility of the Producer.

The feeder is calibrated for each type and size of aggregate. Manufacturers often furnish approximate calibrations for their equipment, but the only accurate way to set a cold feed is to prepare a calibration chart for each of the aggregates to be used in the asphalt mixture. The Technician is required to examine the calibration charts of the cold feed systems to be aware of the production rate settings and how adjustments are made during production.

Calibration is simply determining the "Flow Rate" of a material graphed against the "Control" used by the particular system. Each material is calibrated for three to four control settings spanning the working production range anticipated for the material.

Control Setting

Each manufacturer has a method to control the flow of material from the cold feeds. The variable speed short belt feeder under each cold feed is the most common. The operator may adjust the RPM of the belt from the control room. Therefore, control is expressed as RPM or a percentage of the belt's total speed potential.

This same concept is used with vibrating units. The vibrator may be adjusted from the control room and expressed as a percent of maximum vibration potential.

Adjustable gates are employed on most cold feeds. The gate height is measured by the height of the opening. This gate height is required to not change when using the variable speed control.

There may be variations and modifications of these concepts. Each plant is unique; however, the plants are required to have some means to control the cold feeder. The system is required to be completely understood and controlled in a positive way to provide a uniform flow of material.

Flow Rate

Flow rate may be determined by a variety of methods that are basically pre-determined by the configuration of the plant. The most common and accurate method of determining flow rate is to physically weigh the material delivered at a specific control setting over a measured period of time. A divert chute on the intake of the dryer is the simplest, most accurate, and quickest method to do the calibration. Material may be weighed on a weigh bridge, if available, or completely processed through the plant and weighed on the plant scales. The flow rate is then converted to tons per hour. Moisture content is required to be considered in this procedure.

The degree of accuracy is only as good as the method used to determine the flow rate for each control setting. Therefore, the larger the sample measured, the more accurate the data received. Using an entire truck load of material provides dependable numbers.

Calibration Chart

After understanding the plant "Control" system and determining the best method to obtain a "Flow Rate", a calibration is required to be done. This process determines a flow rate at four different control settings for each cold feed. The process may be time-consuming, but the benefits are worth much more than the time spent. After multiple calculations have been done for each bin used during production, the calibration chart is prepared. On the chart, control settings are plotted on a horizontal scale, and the flow rate is plotted on the vertical scale.

For larger production plants, more than one bin is required to be calibrated for each material. This back-up cold feed calibration allows continuation of production if a cold feed bin fails mechanically.

Another common practice for large production rates is to use two cold feeders to supply the same size of material. This practice allows for slower machinery rates and tends to reduce segregation.

FIGURE 5.8 CALIBRATION CHART

Gross Weight	Tare Weight	**Net Weight**	Gross Comp.	Tare Comp.	Net Comp.	% Error
79,140	36,700		42,720	0		
81,040	36,700		87,210	42,720		
80,290	36,700		130,670	87,210		
78,620	36,700		172,660	130,670		

BINDER METERING

The drum mixer is typically equipped with a device (Figure 5.9) to add binder to the aggregate inside the drum mixer. The binder metering and delivery system is a continuous mechanical proportioning system interlocked with the aggregate weight system to ensure an accurate binder content of the asphalt mixture. The weight of aggregate going into the mixer, as measured by the weigh belt, is the basis for determining the quantity of binder delivered into the drum.

FIGURE 5.9 BINDER INLET

The proportioning of binder is accomplished by establishing the necessary rate of binder delivery in gallons per minute to match the aggregate delivery in tons of dry aggregate per hour. The binder delivery rate is increased or decreased proportionately according to the corrected dry weight measurement of aggregate passing over the belt scale. The rate of binder delivery is indicated on a rate meter on the control panel.

The rates of delivery of aggregate and binder are sometimes recorded on continuously recording circular graphs located in the control van. The graphs provide both monitoring and a permanent record of the proportioning of binder and total aggregate.

AGGREGATE MOISTURE DETERMINATION

Since aggregate in a drum mix operation is weighed before drying, moisture content of the aggregate is required to be determined. The weighing of aggregate and the metering of binder are interlocked electronically in drum mix operations. To ensure proper metering of binder, adjustments for aggregate moisture are made. The moisture content of the aggregate is required to be properly determined prior to the start of mixing and subsequently thereafter as changes occur in the condition of the aggregate.

To determine the moisture content of aggregate, a representative sample is required. Generally, representative samples are easier to obtain from storage bins or stockpiles.

Regardless of the size of the aggregate, the procedure (AASHTO T 255) for making an aggregate moisture determination is basically the same. The steps for this procedure are outlined as follows.

1. Obtain a representative sample of the material for the production
2. Reduce the sample to a size that may be handled by the weighing device by either a sample splitter or the quartering method
3. Weigh the aggregate sample and record the weight (Wet Weight)
4. Dry the aggregate sample thoroughly. The sample is dried to constant weight on a hot plate or in an oven at a temperature of 230° F.
5. Accurately weigh the dried sample and record the weight (Dry Weight). In weighing and handling the sample, extreme care is required to be taken to avoid any loss of the material, as this affects the accuracy of the results.

The percent moisture is determined by the following formula:

$$\%Moisture = \frac{Wet\ Weight - Dry\ Weigh}{Dry\ Weight}\ x\ 100$$

Example

Wet Weight = 1225 g

Dry Weight = 1175 g

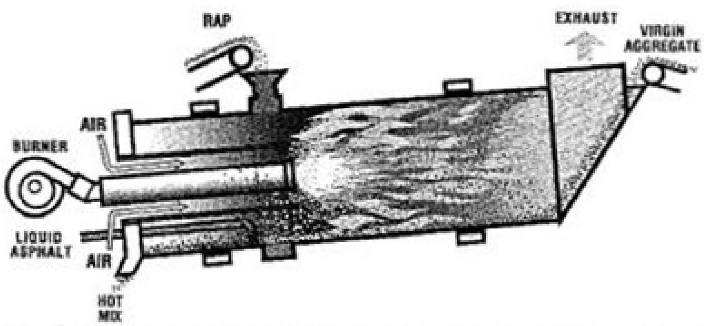
$$\%Moisture = \frac{1225 - 1175}{1175} x\ 100 = 4.3\%$$

DRUM MIX OPERATION

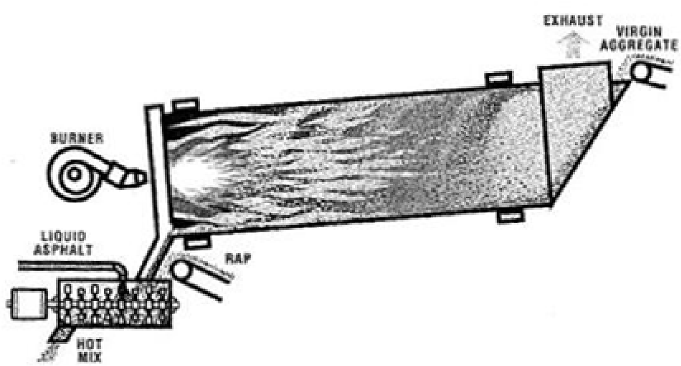
The heart of the drum mix plant is the mixer. The mixer is similar in design and construction to a conventional batch plant rotary dryer, except that a drum mixer not only dries aggregate but also blends the aggregate and binder together into the asphalt mixture.

The drum mixer may be configured in two main variations: parallel-flow and counterflow. The benefits of counterflow over parallel-flow are the ability to use more RAP without higher emissions, and less damage to the virgin binder. The binder in counterflow drums are not exposed to the open flame and hot exhaust gas stream as much as in parallel-flow drums. Unitized counterflow drums and separate dryer and mixing drums separate the binder completely from the open flame and hot exhaust gases (Figure 5.10).

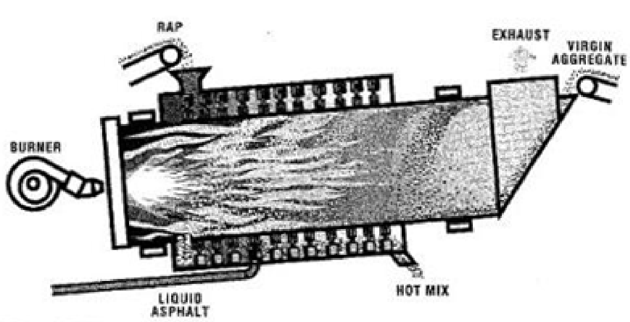
FIGURE 5.10 COUNTERFLOW DRUM MIXERS



COUNTERFLOW DRUM-MIXER FLOW



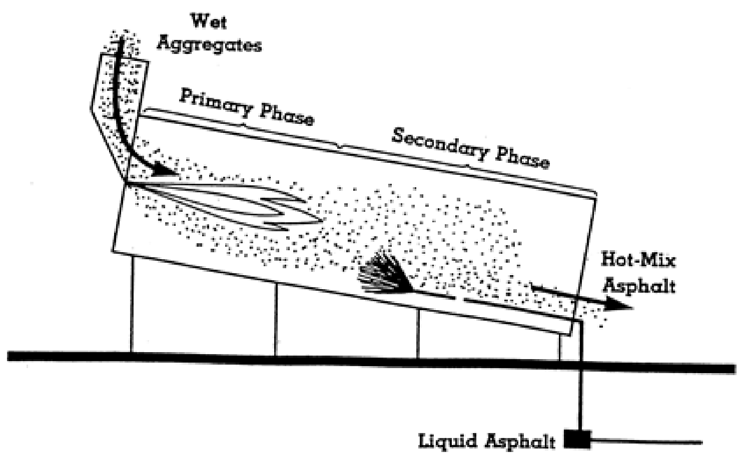
SEPARATE DRYER AND MIXER FLOW



DOUBLE-BARREL UNITIZED DRYER/MIXER FLOW

The drum mixer may be divided into two sections or zones: a primary or radiation zone, and a secondary or convection/coating zone (Figure 5.11).

FIGURE 5.11 ZONES IN PARALLEL-FLOW DRUM MIXER



Aggregates enter the primary zone, where heat from the burner dries and heats them. The aggregate continues to the secondary zone, where binder is added and aggregates and binder are thoroughly blended. Continued convection drying also occurs in the secondary zone. The mixture of hot binder and moisture released from the aggregate produces a foaming mass that traps the fine material (dust) and aids in the coating of the larger particles.

Within the drum, the aggregate not only rotates with the revolving motion of the drum but also spreads out sufficiently to make heating and drying of all particles quick and efficient. To direct the aggregate flow and spread the aggregates into a veil across the cross-section of the drum, drum mixers are equipped with flights.

Spiral flights, located at the charging (burner) end of the drum, direct wet aggregate into the drum in such a way as to attain uniform drum loading. Tapered lifting flights then pick up the aggregates and drop them in an even veil through the burner flame. Subsequent flights direct the aggregate through the drum and continue to drop the material in veils through the cross-section of the drum.

Mix temperature is monitored continuously by a sensing device at the discharge end of the drum mixer. The temperature recorder and other indicators are located in the control van along with the burner controls.

A suitable means is required to be provided for inspecting and sampling the mixture after the discharge from the drum.

Burner Operation and Control

The purpose of the burner inside the drum mixer is to provide the heat necessary to heat and dry the aggregates used in the final mix. The burners provide this heat by burning oil, gas, or both.

When oil is burned, low pressure air drafts are used to atomize the fuel oil for burning. Burners using natural gas and LPG may be low-pressure or high-pressure units. In all cases, the fuel feed and air blower are required to be balanced to ensure that the proper proportions of fuel and air are being introduced into the burner for efficient combustion. Lack of balance may lead to incomplete burning of the fuel, which, especially in the case of fuel oil or diesel fuel, may leave an oily coating on the aggregate particles. Such imbalances between fuel feed and air flow may be corrected by either decreasing the fuel feed rate or increasing the blower or draft air.

SURGE BIN AND WEIGH SCALES

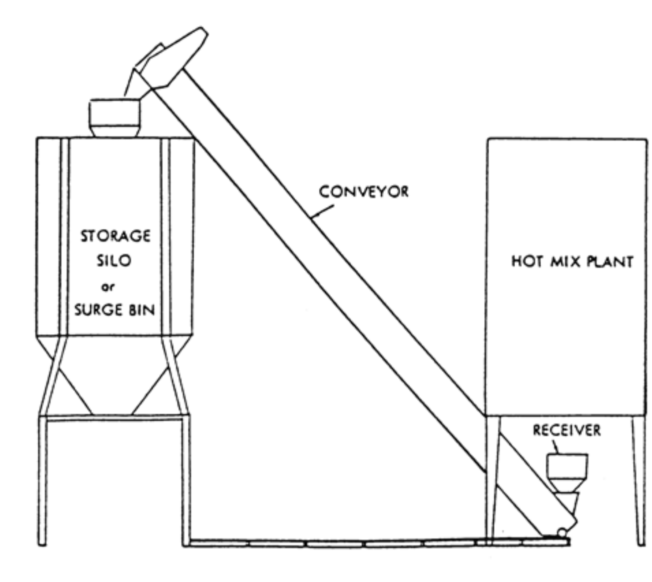
In a drum mixer operation, which produces a continuous flow of asphalt mixture, the plant is required to have a surge bin for temporary storage of the material and for controlled loading of trucks. A weigh system may be connected to the holding bin of the surge bin to monitor the amount of material loaded into each truck. Weight measurements are normally recorded by the weigh system control panel, located in the control van or trailer.

Hot Mix Asphalt Storage

To prevent plant shutdowns due to temporary interruptions of paving operations or shortages of trucks to haul asphalt mixture from the plant to the paving site, most plants are equipped with surge bins (storage silos) for temporary storage of asphalt mixture. When a surge bin is used, the asphalt mixture is deposited by conveyor or hot elevator into the top of the bin (Figure 5.12) and is discharged into trucks from the bottom.

Surge bins work well if certain precautions are followed but may cause segregation of the asphalt mixture if not used properly. A good practice is to use a baffle plate or similar device at the discharge end of the conveyor used to load the bin. The baffle helps to prevent the segregation of the asphalt mixture as the mixture drops into the bins. A good recommendation is to keep the hopper at least one-third full to avoid segregation as the hopper empties and to help keep the mix hot.

FIGURE 5.12 TYPICAL STORAGE STRUCTURE CONFIGURATION



SUMMARY OF DRUM MIXES

Close control of aggregate gradation in the cold bins, and the control of aggregate and binder feeding into the drum mixer are essential in providing uniform asphalt mixture using a drum mix plant. Drum mix plant inspection procedures are required to be followed to ensure that materials are proportioned correctly and properly mixed at the desired temperature. These procedures include inspecting the proportioning equipment, sampling and testing the aggregate gradation, determining aggregate moisture content, and monitoring asphalt mixture temperature.

EFFECT OF PLANT ON ASPHALT MIXUTRE PROPERTIES

Asphalt mixture properties may vary depending on the type of plant and the environmental controls on the plant. The reason for these changes may be explained by how the plants function. Each plant/environmental control combination and the mix properties affected are discussed as follows.

DUST CONTROL AND COLLECTION SYSTEMS

Enforcement of air pollution regulations or codes is usually done by the local pollution agency. However, since the dust control system is integrated with plant operation, the Technician is required to at least be aware of the controls and equipment necessary to meet these standards. The Technician is required to also be aware of how this equipment may affect asphalt mixture properties.

Mixing plant manufacturers recognize the problem of air pollution and have developed equipment that restricts the escape of pollutants from the plants. Even so, during the operation of a plant, some gaseous and particulate pollutants may escape into the air. These pollutants are required to be limited to meet established clean air regulations. The Producer is required to be familiar with the state and local laws concerning air pollution.

More definitive standards are based on the quantity of particulates coming from the stack. The most common requirement sets an upper limit on the mass of the particles being released as compared to the volume of gas released with them. Other standards relate the quantity of particulates emitted to the mass of the material being produced.

A major air pollution concern at a plant is the combustion unit. Dirty, clogged burners and improper air-fuel mixtures result in excessive smoke and other undesirable combustion products. Continual close attention to the cleanliness and adjustment of the burners and accessory equipment is important.

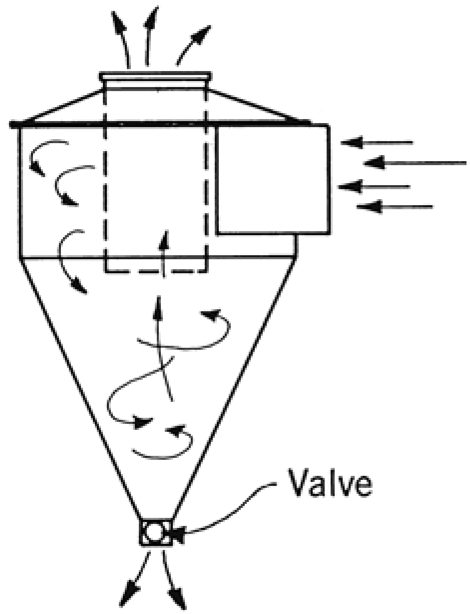
Another source of air pollution at a plant is aggregate dust. Dust emissions are greatest from the plant rotary dryer. Dust collectors commonly are used in the plant to meet anti-air pollution requirements. The types of dust collectors that are commonly used to capture the dust from the dryer are the centrifugal dust collectors, wet scrubbers, drop boxes, and baghouses (fabric filters). When the aggregate is especially dusty, two or more of these devices may need to be used in sequence. If the dust system returns the material to the plant, the return system is required to be calibrated.

Some of the dust emitted from a plant is fugitive dust. This is dust escaping from parts of the plant other than the primary dust collectors. A scheduled maintenance program is required to keep fugitive dust to a minimum.

Centrifugal Dust Collectors

Centrifugal dust collectors (cyclone type collectors) operate on the principle of centrifugal separation. The exhaust from the top of the dryer draws the smoke and fine materials into the cyclone where they are spiraled within the centrifuge (Figure 5.13). Larger particles hit the outside wall and drop to the bottom of the cyclone, and dust and smoke are discharged through the top of the collector. The fines at the bottom of the cyclone are collected by a dust-return auger and may be returned to the plant or wasted.

FIGURE 5.13 CYCLONE DUST COLLECTOR



Centrifugal dust collectors have been the most common type used, especially in rural areas. However, under today's more stringent pollution laws, the centrifugal dust collectors are usually used in combination with either a wet scrubber or a baghouse.

Wet Scrubbers

The purpose of a wet scrubber is to entrap dust particles in water droplets and remove the particles from the exhaust gases. This is done by breaking up the water into small droplets and bringing those droplets into direct contact with the dust-laden gases. As the figure illustrates, gases from the dryer are introduced into a chamber through one inlet, while water is sprayed into the chamber from nozzles around the periphery.

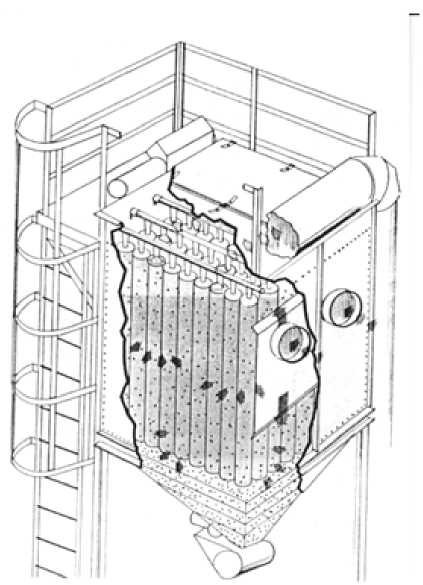
Wet scrubbers are relatively efficient devices but have certain drawbacks. First, the dust entrapped in the water is not recoverable. Second, the waste water containing the dust is required to be properly handled to prevent another source of pollution, since more than approximately 300 gallons per minute may be used. Most wet scrubbers are used in combination with a cyclone collector. The cyclone collects coarser materials and the wet scrubber removes the finer particles. Due to the drawbacks, wet scrubbers are no longer in common use.

Baghouses (Fabric Filters)

A baghouse (Figure 5.14) is a large metal housing containing hundreds of synthetic, heat-resistant fabric bags for collecting fines. The fabric bags are usually silicone-treated to increase their ability to collect very fine particles of dust. A baghouse functions much the same way as a vacuum cleaner. A large vacuum fan creates a suction within the housing, which draws in dirty air and filters the air though the fabric of the bags. To handle the huge volume of exhaust gases from the aggregate dryer, a very large number of bags (a typical unit may contain as many as 800) are required.

A baghouse is divided into a dirty gas chamber and a clean gas chamber. The filter bags are contained in the dirty gas chamber, into which the air from the dryer enters. The flow of air carrying the dust particles passes through the fabric of the filter bags, depositing the dust on the surface of the bag. The air then continues to the clean gas chamber. During the operation, the fabric filter traps large quantities of dust. Eventually, the dust accumulates into a "dust cake", that is required to be removed before the dust reduces or stops the flow of gas through the filter. There are many ways of cleaning the bags in a collector, but the most common methods are to flex the bags, back-flush the bags with clean air, or both flex and back-flush. Dust removed from the bags drops into an auger at the bottom of the baghouse and is transferred to a storage silo. The dust may then be returned to the plant or wasted.

FIGURE 5.14 TYPICAL BAGHOUSE



Drum/Wet Wash

In a drum plant, the aggregate drying and mixing chamber are located within the drum. Many of the fines being carried to the dust collection system are captured in the binder veil. This reduces the loading on the environmental equipment. If a wet wash system is used, then any fines that get past the binder veil are removed from the asphalt mixture. The amount of fines removed depends on several factors. The greatest factor is the total length of the drum and the length of the drum used for mixing. As both increase, less fines will enter into the environmental collection system.

The environmental controls in the drum/wet wash combination have less to do with the asphalt mixture properties. Asphalt mixtures produced from these plants are generally lower in Air Voids and VMA than Batch/Wet Wash combinations. The Certified Asphalt Technician may supervise all sampling and testing of materials, the maintenance of control charts, and the maintenance of the diary, however, the Certified Asphalt Technician shall not conduct sampling and testing.

Drum/Baghouses

If a baghouse is utilized in a drum plant, the fines that are returned to the drum are added near the binder inlet. This is done so that the fines are immediately wetted and captured in the asphalt mixture. Asphalt mixtures produced by Drum/Baghouse combinations tend to be lower in Air Voids and VMA than other plant combinations.

PLANT INSPECTION AND SCALE CHECK

All plants which produce asphalt mixture for INDOT are required to be inspected prior to becoming a Certified HMA Plant, annually thereafter, and when the plant is moved. This inspection verifies that all meters, scales, and other measuring devices are calibrated to accuracy within 0.5% throughout their range.

DRUM PLANT

The load cells and binder supply system are checked for accuracy on a drum plant. Since asphalt mixture proportioning for a drum plant is done by a moving weight system, the computer monitors are required to be checked for accuracy (Figure 5.15).

The load cell on each aggregate belt is required to be checked. This check is done by running material across the load cell into a tared truck. The computer inventory is required to match the actual weight by 0.5 percent. This check is required to meet accuracy requirements three consecutive times. A truck load of material is used for each check to obtain better accuracy.

The binder system check uses a tared distributor that is required to check against the pump reading on the flow meter and the computer monitor. These units are required to match the weight in the distributor by 0.5 percent accuracy. Whether the pump and/or the computer are temperature compensating is required to be checked. The agreement is required to match the 0.5 percent accuracy three consecutive times and be in the working range of the plant.

The fines return system is required to also be checked to 0.5 percent accuracy as is done with a batch plant.

FIGURE 5.15

Date 8-7-01

Producer R-Paving Inc. Plant Location Reddington, IN Number 9999

Scales and Meter shall be checked to the maximum capacity for which they will be used. The allowable difference between the scale reading and the actual weight applied shall be 0.5% or less. Meter variation shall also be 0.5% or less.

DRUM PLANT

COLD AGGREGATE FEED SYSTEM (Belt Scale Check) Main Belt & Recycle Belt

Gross Weight	Tare Weight	Net Weight	Gross Comp.	Tare Comp.	Net Comp.	% Error
43280	21000	22280	22260	0	22260	0.09
43240	21000	22240	44490	22310	22180	0.27
43250	21000	22250	64370	42180	22190	0.27

ASPHALT METER CHECK

Gross Weight	Tare Weight	Net Weight	Computer Weight	% Error	Meter Gallons	Meter Weight	% Error
31100	28560	2540	2530	0.39			
33700	31120	2580	2570	0.39			
36280	33720	2560	2565	0.20			

Conversion Factor: Temp. Corr. Factor x Weight @ 60F

Fines Return System

Make Wayne Serial No. 410 R 1 Dial Capacity 500 lb

Load Applied	50	100	150	200	250	300	350	400	
Scale Reading	50	100	150	200	249	299	349	399	
Error lbs.	0	0	0	0	1	1	1	1	
% Error	0	0	0	0	0.40	0.33	0.29	0.25	

Signature

DRUM PLANT/COLD FEED

Each plant manufacturer has a somewhat different type of control panel for the cold aggregate feed system and binder metering system; however, all drum mixing plant aggregate and binder proportioning systems perform basically the same. Form IT 667 may be used to calibrate a drum plant. The entire calibration is required to be done at the same master control bin setting, which is recorded.

To calibrate a drum plant, each belt system with a load cell is checked: main collector belt, recycle belt, individual feeder belts, etc. To do a proper check, sufficient quantities of material to simulate normal production rates are passed over the load cell and into a tared truck. (Note: For a batch plant you only have the weight in the truck and there is no load cell). A beginning and ending computer inventory for the material is recorded and compared to the actual weight of the material in the truck. Three consecutive tests are required to be within 0.5 percent to ensure adequate accuracy (Figure 5.16).

Once the load cells have been checked, the calibration of each individual bin flow rates may be determined. At least three different flow rates for each bin spanning the normal production rate are determined. This may be done using the computer monitor readings at various control settings. The recommended method is to use a tared truck on a timed interval, as described next and on Form IT-667 (Figure 5.17).

Step 1 -- Determine Control Setting vs Flow Rate

Each bin contains material to be used and the gate height is measured and recorded. The timed method runs material across the load cells at three different dial control settings for each individual bin. The material is run into a tared truck and weighed at each control setting. Therefore, for each bin used, the dial (control) setting, time in minutes, and weight in tons are known. The ton per hour may be calculated for each setting (Figure 5.16)

Step 2 -- Plot Cold Feed Control Graph

From this data a Cold Feed Control Graph can be drawn for each bin which plots Flow Rate vs Control Setting (Figure 5.19). (This step is not needed for Batch Plant Cold Feed set up).

Step 3 -- Determine Plant Control Setting

The next step in the calibration is to use the Cold Feed Control Graph and the anticipated production rate at which the plant produces material to determine the Control Settings for each individual bin (Figure 5.20).

First determine Total Aggregate Flow Rate by multiplying the desired Production Rate times the % of Aggregate in the asphalt mixture. Next multiply that Total Aggregate Flow Rate times the % which each Individual Bin contributes to the asphalt mixture to obtain the Flow Rate desired from each bin (Note: This % per bin is obtained from the mix design or is obtained by trial and error using IT-651A). Using the Cold Feed Control Graph (1) locate the Flow Rate for that bin, (2) move to the Control Line for that bin, and (3) move to the resulting Control Setting. Follow the procedure for all bins. The control settings are supplied to the plant operator to produce the required mixture.

Step 4 -- Check for Accuracy of Calibration

To ensure the proper gradation has been determined, a composite aggregate sample is obtained. Set the established individual Bin Control Settings and start the aggregate flow into the drier. When a uniform material flow is on the main belt, stop the operation.

In a safe manner completely remove 2 to 5 ft of material from the belt. Split this sample to proper sample size. Conduct a gradation test and compare the data to the design mix formula. If agreement is not obtained, investigate to determine the discrepancy.

FIGURE 5.16

IT-667

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

Drum Mix Plant Calibration

Contract RS-21111 Date 8-7-01

Producer R-Paving Plant Location Reddington, IN Number 9999

Type Mix 25.0 mm Coarse Agg. Source Harding, Inc.

Master Control Setting ________ (To remain at same setting while calibrating all bins)

Step I — Determine Control Setting vs. Flow Rate

COLD AGGREGATE BIN FEEDERS CALIBRATION

Bin No.	Agg. Size	Setting Gate	Setting Dial	Gross Weight	Tare Weight	Net Weight	Time Mins.	Pounds/ Minute	Tons/ Hour
3	5 St.	8 in.	2	70293	37560	32733	10	3273.3	98.2
3	5 St.	8 in.	4	60420	37560	22860	6	3810.0	114.3
3	5 St.	8 in.	6	63340	37560	25780	6	4296.7	128.9
3	5 St.	8 in.	8	64044	37560	26484	5	5296.8	158.9
2	12 St.	5 in.	2	41260	37560	3700	10	370.0	11.1
2	12 St.	5 in.	3	44027	37560	6467	10	646.7	19.4
2	12 St.	5 in.	4	48660	37560	11100	10	1110.0	33.3
2	12 St.	5 in.	5	55027	37560	17467	10	1746.7	52.4
1	24 Sd.	6 in.	2	45660	37560	8100	10	810	24.3
1	24 Sd.	6 in.	4	46360	37560	8800	6	1466.7	44.0
1	24 Sd.	6 in.	6	51200	37560	13640	6	2273.3	68.2
1	24 Sd.	6 in.	8	53894	37560	16334	5	3266.8	98.0

Step 2 — Plot "Cold Feed Control" Graph from above data.

Step 3 — Determine Plant Control Setting Bin.

— Mix Production rate x (100 − %bit) = T (total aggregate)

(100 − 4.5)

225 t/hr x 95.5% = (T) 214.9 t/hr

— Determine Flow Rate for each Cold Feed

Bin	Agg. Size	T	x	P	=	T* (per bin)	=	Bin Control Setting**
1	24	214.9	x	.25	=	T_1 53.7	=	47%
2	12	214.9	x	.15	=	T_2 32.2	=	39%
3	5	214.9	x	.60	=	T_3 128.9	=	60%
4			x		=	T_4	=	
5			x		=	T_5	=	

*TPH − T x P

$$\text{lb/min} = \frac{T \times P \times 2000}{60}$$

T = Agg. Production Rate

P = % of Aggregate for Bin from Form IT-651A or JMF

**From "Cold Feed Control" Graph

State Form 7844 (R2/12-88) Signature ____________________

FIGURE 5.17

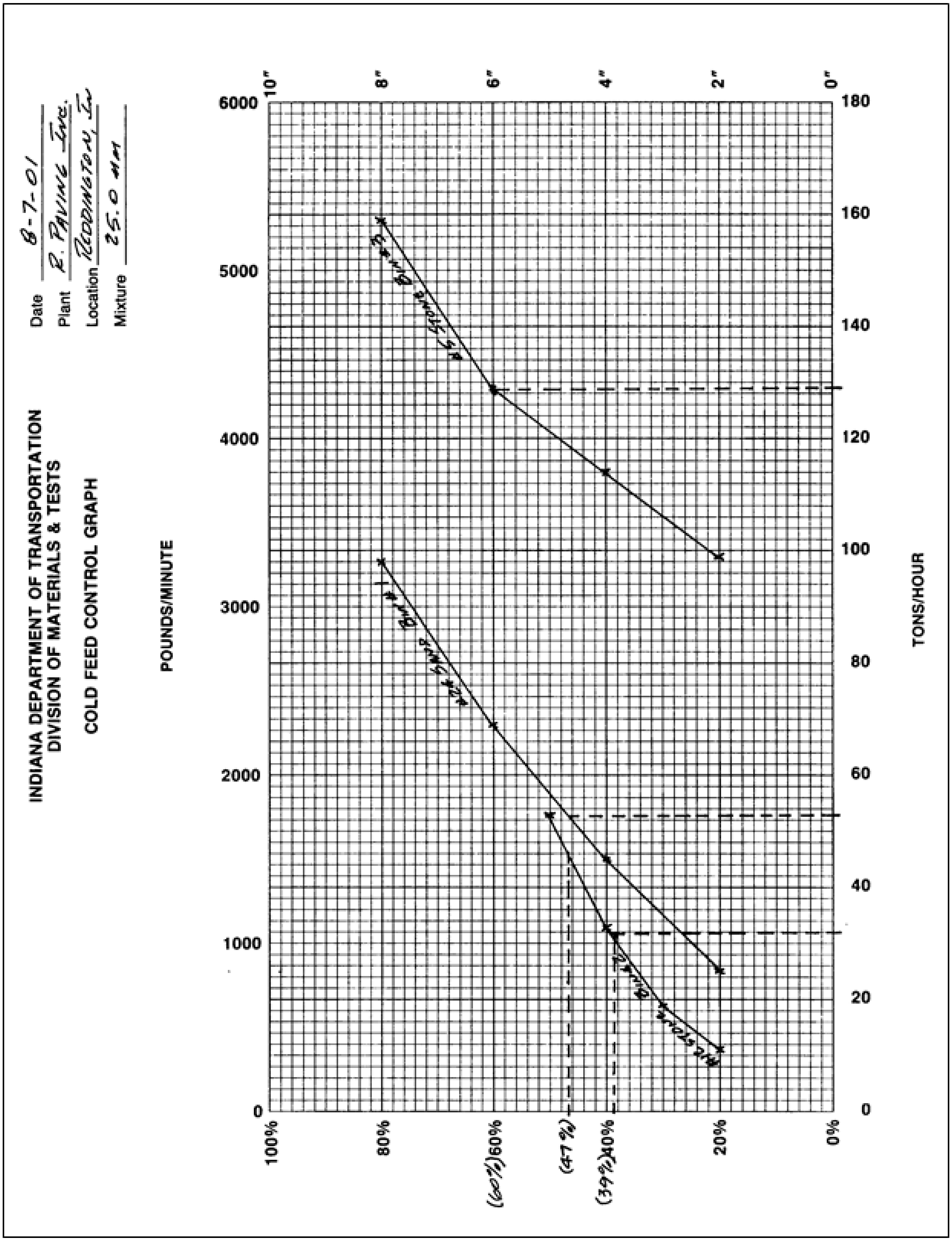
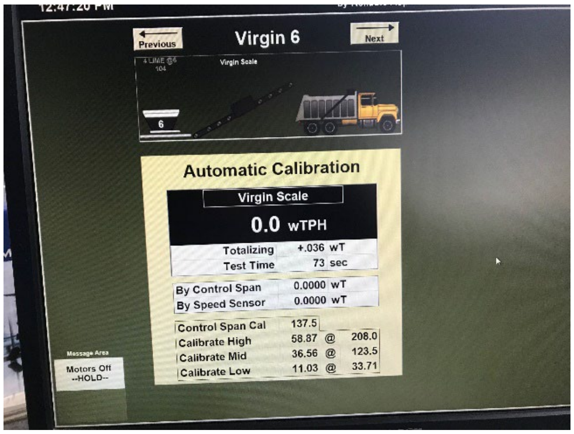
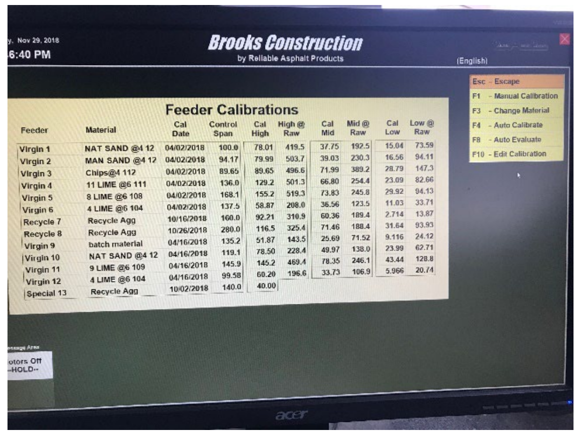

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS & TESTS
COLD FEED CONTROL GRAPH
Date 8-7-01
Plant R. Paving Inc.
Location Reddington, In
Mixture 25.0 mm
POUNDS/MINUTE
TONS/HOUR
0
1000
2000
3000
4000
5000
6000
0
20
40
60
80
100
120
140
160
180
10"
8"
6"
4"
2"
0"
100%
80%
(60%)60%
(47%)
(39%)40%
20%
0%

FIGURE 5.18 COMPUTER VERSION





PLANT TROUBLESHOOTING

Temperature control is stressed in all phases of asphalt mixture production, since this is a primary factor in controlling quality. A visual inspection may often detect whether or not the temperature of a load of asphalt mixture is within the proper range. Blue smoke rising from a truckload of asphalt mixture is often an indication of overheating. If the asphalt mixture temperature is too low, the asphalt mixture may appear sluggish when deposited in the truck and may show a non-uniform distribution of binder. An abnormally high peak in a truckload may also indicate under heating.

A high peak in the truckload may also be an indication that the binder content of the asphalt mixture is too low. On the other hand, if the asphalt mixture slumps (fails to peak properly) in the truck, the binder content may be too high or there may be excessive moisture.

SAFETY

The Technician is required to always be safety-conscious and alert for potential dangers to personnel and property. Safety considerations are very important.

Dust is particularly hazardous. Dust is not only a threat to lungs and eyes, but may contribute to poor visibility, especially when trucks, front-end loaders, or other equipment are working around the stockpiles or cold bins. Reduced visibility in work traffic is a prime cause of accidents.

Noise may be a double hazard. Noise is harmful to hearing and may distract workers' awareness of moving equipment or other dangers.

Moving belts transporting aggregates and belts to motors and sprocket and chain drives are also hazardous. All pulleys, belts and drive mechanisms are required to be covered or otherwise protected. Loose clothing that may get caught in machinery is never worn at a plant.

Good housekeeping is essential for plant safety. The plant and yard are required to be kept free of loose wires or lines, pipes, hoses, or other obstacles. High voltage lines, field connections, and wet ground surfaces are other hazards to the Technician. Any loose connections, frayed insulation or improperly grounded equipment are required to be reported immediately.

Plant workers are not allowed to work on cold bins while the plant is in operation. No one may walk or stand on the aggregates in the bins or on the bunkers over the feeder gate openings.

Burner flames and high temperatures around plant dryers are obvious hazards. Control valves that may be operated from a safe distance are required to be installed on all fuel lines. Flame safety devices also are required to be installed on all fuel lines. Smoking is not permitted near binder or fuel storage tanks. Leaks in oil heating lines and steam lines or jacketing on the binder distribution lines are dangerous. Safety valves are required to be installed in all steam lines and be in working order. Screens, barrier guards, and shields as protection from steam, hot binder, hot surfaces, and similar dangers are required to be used.

When handling heated binder, chemical goggles or a face-shield are required. All shirt collars are required to be worn closed and cuffs buttoned at the wrist. Gloves with gauntlets that extend up the arm are required to be worn loosely so the Technician may flip them off easily if covered with hot binder. Pants without cuffs are required to be extended over boot tops.

The Technician is required to exercise extreme care when climbing around the screen deck, inspecting the screens and hot bins, or collecting hot bin samples. Covered or protected ladders or stairways to provide safe access to all parts of the plant are required to be provided. All stairs and platforms are required to have secure handrails. All workers around the plant are required to always wear a hard hat when not under cover.

Truck traffic patterns are planned with both safety and convenience in mind. Trucks entering the plant to pick up a load of asphalt mixture do not cross the path of loaded trucks leaving the plant. Also, trucks should not have to back up.

CHAPTER 6

AUDITS, EQUIPMENT, CALIBRATION, AND QUALITY CONTROL TROUBLESHOOTING

CERTIFICATIONS

HMA PLANT

PRODUCER PERSONNEL

AUDIT GENERAL INFORMATION

DOCUMENTS

HMA LABORATORY

HMA PLANT

QUALITY CONTROL PLAN

CONTROL LIMITS – QC/QA HMA AND SMA

TARGET VALUES

RESPONSE TO TEST RESULTS

CONTROL CHARTS

DIARY

MATERIALS SAMPLING AND TESTING

AGGREGATES

PG BINDER

MIXTURE PLANT AND PAVEMENT SAMPLING

FREQUENCY OF TESTS

HMA PLANT

DOCUMENTATION

MATERIAL STOCKPILES

PROCESS CONTROL

FIELD LABORATORY

TEST EQUIPMENT CALIBRATION

COMPARISON TESTING

AUDIT CLOSE-OUT

MIXTURE TROUBLESHOOTING

VOLUMTERIC CONTROL

CHAPTER 6

QUALITY CONTROL PROCEDURES

The foundation for a successful Quality Assurance program is the quality control maintained by the Producer to assure that all materials submitted for acceptance conform to the contract requirements. To accomplish this, the Producer is required to have a functional plan to keep the process in control, quickly determine when the process goes out of control, and respond adequately to bring the process back into control.

Quality control is a system of:

"Inspection, analysis, and action applied to a portion of the product in a manufacturing operation to estimate overall quality of the product and determine what, if any, changes must be made to achieve or maintain the required level of quality."

This section includes the minimum requirements of the Indiana Certified Hot Mix Asphalt Producer Program (Program) in accordance with ITM 583. The mixtures included in this Program include QC/QA HMA in accordance with Section 401, HMA in accordance with Section 402, and Stone Matrix Asphalt (SMA) in accordance with Section 410.

The most common Quality Control tools:

- Gradation
    - Stockpiles
    - Mixture
    - RAP
- Binder Content (extraction or ignition)
- Bulk Specific Gravity (G_{mb})/lab compacted (Pill Heights), cores
- Maximum Specific Gravity (G_{mm})
- Eyes

CERTIFICATIONS

HMA PLANT CERTIFICATION

Each Producer requesting to establish a Certified Plant is required do so in writing to the Asphalt Engineer, Division of Materials and Tests. Upon receipt of the request for certification, the District is notified to inspect the plant and laboratory.

The plant inspection, including the correction of any deficiencies and calibration of all meters, scales and other measuring devices, is required to be completed prior to certification.

Each plant meeting the requirements of the Program is certified upon the approval of the QCP. Movement of the Certified Plant to a new location requires submittal of a QCP Annex, and verification of the calibration of all meters, scales, and other measuring devices.

The Producer, in accordance with ITM 581, shall submit a written request to the Asphalt Engineer, Division of Materials and Tests, to in-line blend SBR polymer latex at the HMA plant.

In the event of a change in ownership of the Certified HMA Plant, the certification shall expire on the date of such change. The new ownership may avoid expiration by submitting a statement to the Asphalt Engineer, Division of Materials and Tests indicating recognition of intent to operate in accordance with the requirements of both documents prior to providing mixture to the Program.

Producer Personnel Certification

The Producer personnel required to be identified include a Management Representative, Level 1 Asphalt Technician, and a Certified Asphalt Technician, and a Qualified Technician, if applicable.

Management Representative

The Management Representative shall be responsible for all aspects of mixture production and control at the HMA plant and on the pavement as required by the Program.

Level 1 Asphalt Technicians

The Level 1 Asphalt Technician is a is both a Qualified and Certified Asphalt Technician. They shall conduct or supervise all sampling and testing of materials, the maintenance of control charts, and the maintenance of the diary.

Certified Asphalt Technicians

The Certified Asphalt Technician is an individual who has successfully completed the requirements of the ICAT Program. They may supervise all sampling and testing of materials, the maintenance of control charts, and the maintenance of the diary, however, the Certified Asphalt Technician shall not conduct sampling and testing used for acceptance.

Qualified Technicians

The Qualified Technician is an individual who has successfully completed the written and proficiency testing requirements of the Department Independent Assurance and Qualified Acceptance Personnel Program. They may conduct all sampling and testing used for acceptance of materials under the direct supervision of a Certified Asphalt Technical or Level 1 Asphalt Technician until the next opportunity to take the QC/QA HMA Certified Technician exam is available.

AUDIT GENERAL INFORMATION

Types of Audits

Each INDOT Certified Hot Mix Asphalt Producer is required to have an audit performed by INDOT personnel every calendar year. There are three types of audits. A Full Audit is performed on all Certified HMA plants that produced INDOT HMA mixtures. A No Production Audit is performed on all Certified HMA plants that do not produce INDOT HMA mixtures. A Partial Audit is performed on Certified HMA plants that have already or will have an audit performed within that same calendar year.

Audit General Instructions

INDOT Audit Team Members should review the current QCP, previous audits, and coordinate with the Independent Assurance (IA) Technician for a comparison testing schedule (if applicable) prior to performing the audit. A list of the following information should be brought to the audit:

- Count and review the number of assigned DMFs on ITAP and the number of SMA DMFs from the Producer. Review the Contract Record worksheets for the current calendar year, if applicable.
- Approved list of Level 1 Asphalt Technicians, Certified Technicians, and Qualified Technicians
- Approved list of PG Binder Suppliers
- Approved list of Anti-Adhesive materials
- IA comparison paperwork, if applicable
- Current copy of ITM 583

Every item in the audit packet has a bracket that is to be filled in. A check mark is made if the item is found to be satisfactory. If the item is not applicable, “NA” is put in the bracket. If the item is not found to be unsatisfactory then an “X” is made. A Corrective Action sheet is to be prepared for every item with an “X”. Any unsatisfactory or deficient items that are resolved during the audit will be noted on the Corrective Action Sheet as “NA, Corrected” indicating the item has been corrected. Any unsatisfactory item that occurred in the past and cannot be corrected will be noted on the Corrective Action Sheet as “NA, Observation”. For test result values outside of the control limit for Air Voids, Binder Content, VMA, Dust/Effective Binder Ratio, and/or Vbe will be noted in the Appendix Test Results Outside of Control Limits.

HMA LABORATORY

Each Certified HMA plant laboratory is required to have the following current documents on file:

1. Indiana Department of Transportation Standard Specifications (Includes applicable Special Provisions)
2. Indiana Certified Asphalt Technician (ICAT) Manual
3. All applicable Indiana, AASHTO, and ASTM Test Methods
4. Testing equipment calibrations or verifications
5. Mix design, DMF for each mixture
6. Fines correction data for the mixture and recycled materials for each DMF, if applicable
7. Type A certifications for PG binder materials
8. Type A certifications for the SBR polymer latex
9. PG 70-22 binder test reports from an AASHTO accredited laboratory whenever PG 64-22 are in-line blended with SBR polymer latex
10. Process control test results
11. Type D certifications issued to active Department contracts

HMA PLANT

Each Certified HMA Plant is required to have these current documents on file:

1. The Quality Control Plan (QCP) for the Certified Plant
2. Bill of ladings of the binder from each Supplier for a minimum period of three complete calendar years
3. Weigh tickets from most current date of production of HMA and adhere to the requirements of section 109.01(b) of INDOT Standard Specifications
    a. Net weight, ticket, serial number, date, contract number, source of material, material designation (size or type), DMF number, truck designation, time weighed, gross weight/tare weight (if applicable)
4. Instructions from the ASC Supplier concerning storage and handling of the binder
5. Flow meter calibration reports and flow computer printouts whenever in-line blending with SBR polymer latex
6. IDEM Legitimate Use Approval letter from the post-consumer asphalt shingle processing company, if applicable.
7. HMA plant calibrations for each DMF
8. Daily diary
9. Annual calibrations of the HMA plant scales and verification of meters
10. Fiber certification from the manufacturer
11. Instructions from the manufacturer concerning storage and handling of fibers

QUALITY CONTROL PLAN

Each Producer providing QC/QA HMA, HMA, or SMA under the Certified Hot Mix Asphalt Producer Program is required to have a written Quality Control Plan (QCP) that is plant specific and is the basis of control. The QCP contains, but is not limited to, the methods of sampling, testing, calibration, verification, inspection, and anticipated frequencies.

Production of mixture shall not begin before the QCP has been approved. The Producer is required to submit two copies of the QCP to the Department for review. One copy to the District Testing Engineer where the certified plant is located and one copy to the Division of Materials and Tests. Acceptance or rejection of the QCP will be made within 15 days of receipt of the QCP. One approved copy will be returned to the Producer.

The QCP includes the following information for each HMA Plant.

1. The location of the HMA Plant site, including the county and reference to the nearest identifiable points such as highway and towns.
2. The name, telephone number, fax number, email address, duties, and employer of the Management Representative, Level 1 Asphalt Technician(s), Certified Asphalt Technician(s), and Qualified Technician(s) if applicable. The duties of all other personnel responsible for implementation of the QCP are also included.
3. A list of test equipment that is calibrated or verified, the test methods and frequency of calibration or verification of the equipment, and a statement of accessibility of the laboratory to Department personnel. If the laboratory is not located at the HMA Plant, the location of the laboratory is required to be designated, and the procedure for transporting the mixture to the laboratory included.
4. A plant site layout diagram that includes the location of the stockpile area, binder tanks, fuel tank, fiber supply, anti-adhesive supply, field laboratory, visitor parking area and major components of the mixing plant.
5. A plan for controls of the aggregate and recycled material stockpiles. Controls for identification of stockpiles by signing or other acceptable methods, techniques for construction of proper stockpiles, and cold bin loading procedures to prevent overflow of material from one bin into another are required to be included.
6. A plan for the identification of the grade of binder in each storage tank and the use of more than one binder grade in a binder tank. The sampling location is required to be indicated.
7. A plan for in-line blending SBR polymer latex at the HMA plant to include a QCP in accordance with ITM 581 as an addendum to the plant QCP.
8. A plan for the production of HMA with a water-injection foaming device. The necessary plant modifications, plant production start-up process, planned mixture production temperature ranges, and moisture testing on mixtures sampled at the plant for each DMF shall be included.

9. The procedure for the consistent uniform addition of baghouse fines when returned into the HMA plant.
10. The procedure for the consistent uniform addition of fibers into the HMA plant.
11. The procedure for using an anti-adhesive agent for the truck bed, and a statement that the agent is on the Department's list of Approved Anti-Adhesive Materials.
12. The procedure for sealing the surge bin when used for extended storage of the mixture up to one working day and the method to prevent the discharge when the mixture falls below the top of the cone. The written approval of the surge bin is required to be included.
13. The procedure for loading mixture into the trucks.
14. A sampling plan that includes locations, test methods, devices, techniques, frequencies, and sample reduction procedures.
15. A testing plan that includes the types of tests and test methods.
16. A description of any other process control techniques that may be used beyond the minimum required by INDOT. These controls may include, but are not limited to:
    a. Different types or greater frequencies of material testing
    b. Visual checks and monitoring of HMA plant production
17. A statement of the procedure for handling addenda to the QCP including a time schedule for submittal.
18. A documentation plan with details on control charting, test data, and the diary. Copies of the forms may be included.

The last page of the QCP is the authentication page and is required to have two signatures. One signature shall be the Producer Management Representative, the date of submittal, and the corporate title of the Producer Management Representative. The other signature will be for approval of the QCP by the State Materials Engineer, Division of Materials and Tests.

A QCP checklist (Chapter 9) is provided to assure that all the applicable items required in ITM 583 are addressed in the QCP.

Addenda are defined as an addition or deletion to the QCP. Each page of the QCP that is revised is required to include the HMA plant number, date of revision, and means of identifying the revision. The addenda are required to be signed and dated by the Management Representative and subsequently signed and dated when approved by the District Testing Engineer.

Revisions for HMA plant major components, Level 1 Asphalt Technicians, Certified Asphalt Technicians, Qualified Asphalt Technicians, and movement of the HMA plant are submitted in the format of a QCP Annex per ITM 583 as they occur. Upon approval by the District Testing Engineer, the QCP Annex is placed in the Appendix of the QCP until such time that the revisions are incorporated as addenda into the QCP.

Revisions, other than items on the QCP Annex, are maintained on an Addenda Summary Sheet. The Addenda Summary Sheet is a page of the QCP Appendix that is used to record a brief description of the revision until such time that the revision is incorporated into the QCP.

Addenda may be submitted at the audit close-out meeting or anytime during the calendar year. The addenda are required to include items on the QCP Annex, items on the Addenda Summary Sheet, and any other necessary revisions at the time of submittal. Upon incorporation into the QCP as addenda, the QCP annex and items on the Addenda Summary Sheet are removed from the QCP Appendix.

CONTROL LIMITS – QC/QA HMA AND SMA

TARGET VALUES

The target values are identified on the DMF or identified by the Producer.

FIGURE 6.1 CONTROL LIMITS FROM THE TARGET VALUES

Parameter	**Maximum % Passing, Control Limits (±)**		
	Aggregate Stockpiles	**Blended Aggregate Base and Intermediate Mixtures**	**Blended Aggregate Surface Mixtures**
3/4 in.	± 10.0	± 10.0	
1/2 in.	± 10.0	± 10.0	± 10.0
No. 4	± 10.0	± 10.0	± 10.0
No. 8	± 10.0	± 10.0	± 8.0
No. 16	± 8.0	± 8.0	± 8.0
No. 30	± 6.0	± 6.0	± 4.0
No. 50	± 6.0	± 6.0	± 4.0
No. 100	± 6.0	± 6.0	± 3.0
No. 200	± 2.0	± 2.0	± 2.0
Parameter			Control Limits
Binder Content of Mixture and RAP, %			± 0.7
Binder Content of RAS, %			± 3.0
Vbe, %, above design minimum (QC/QA HMA, SMA)			+2.0
VMA @ N_{des}, % (QC/QA HMA)			± 1.0
VMA @ N_{75}, Min. % (9.5 mm SMA)			17.0
VMA @ N_{75}, Min. % (12.5 mm SMA)			16.0
Target Air Voids, % (Dense Graded Mixtures and SMA)			± 1.0
Target Air Voids, % (Open Graded Mixtures)			± 3.0
2.36 mm (No. 8) sieve % passing (9.5 mm Surface Mixtures Only)			+ 4.0

RESPONSE TO TEST RESULTS

The Producer is required to take corrective action when the control limits for QC/QA HMA and SMA or Specification Limits for HMA mixtures are exceeded. Corrective action includes, but is not limited to, investigation for assignable cause, correction of known assignable cause, or retesting. All corrective actions are required to be documented in the Diary.

The Producer is required to take action to restore the 2.36 mm sieve % passing gradation for a 9.5 mm HMA surface mixture when it is determined to be greater than the PCS control point of 47%.

The Producer is required to take action to restore the aggregate degradation value for SMA mixture in accordance with ITM 220 when it is determined to be greater than 3.0%.

The Producer is required to take action to restore the dust/calculated effective binder ratio when it is determined to be outside the specification limits as defined in 401.05.

The Producer is required to take corrective action when the moisture content of the mixture exceeds 0.30 percent for samples taken at the plant, or when the moisture content of the surface mixture sampled from the pavement exceeds 0.10 percent. The Producer is required to take action to restore the volume of effective binder, Vbe, when it is determined to be less than the design minimum or more than the design maximum as shown in Figure 6.2.

FIGURE 6.2 CONTROL LIMITS FOR Vbe

Mixture Designation	Minimum Vbe, %	Maximum Vbe, %
9.5 mm SMA	13.0	15.0
12.5 mm SMA	12.0	14.0
19.0 mm SMA	11.0	13.0
4.75 mm	13.0	15.0
9.5 mm	11.0	13.0
12.5 mm	10.0	12.0
19.0 mm	9.0	11.0
25.0 mm	8.0	10.0

The Producer in-line blending SBR latex at the HMA plant is required to take corrective action if the latex solids content is more than 0.2% below the lower target limit for more than 15 minutes of production.

CONTROL CHARTS

A control chart is a graphic representation of data shown with prescribed limits that indicate whether a process is in control. Although not required by the Certified HMA Producer Program, control charts may prevent the production of nonconforming material when used in a timely manner.

The control chart should have a means of designating the target mean, control limits, individual test results, and a moving average of the test results.

Control Chart Interpretation

The moving average is useful in determining the accuracy of the process. Averages tend to lessen the effect of erratic data points that may reflect errors not related to the actual material (sampling, testing, etc.). The presence of unusual patterns or trends may be evidence of non-conformance during the period of the pattern. Any of the following potential nonconforming conditions concerning the moving average may be reason for an investigation of the process.

1. Seven or more points in a row are above or below the target mean
2. Seven or more points in a row are consistently increasing or decreasing

DIARY

The Producer is required to maintain a diary at the HMA Plant. The diary is an open format book with at least one page devoted to each day mixture is produced. The diary is kept on file either by hard copy or electronically for a minimum period of three years.

Entries in the diary include at least the following:

1. The type of mixture and quantity produced, DMF number, and the contract number or purchase order for each mixture
2. The time that the samples were obtained and the time the test was completed
3. Nonconforming tests and the resulting corrective action taken
4. Any significant events or problems

The diary entry is to be signed by the Level 1 Asphalt Technician, Certified Asphalt Technician, or Management Representative. On occasion the diary may be signed by another person;

however, the diary is required to be counter-signed by the Level 1 Asphalt Technician, Certified Asphalt Technician, or Management Representative.

MATERIAL SAMPLING AND TESTING

The most important consideration in sampling is to be certain that the sample taken is representative of the material. The Producer is required to designate the sampling and sample reduction procedures, sampling location, devices, techniques, and size of samples necessary for testing. Sampling is conducted on uniform tonnage increments on a random basis.

Aggregate/Recycled Materials Sampling

Aggregate samples may be obtained from stockpiles, belts, or hot bins depending on the type of plant and control of aggregate gradation selected. The procedures for these methods of sampling are described in Chapter 2. If RAP and/or RAS is used in the mixture, the procedure for sampling this material is ITM 207.

Binder Sampling

Two one-quart samples are obtained from either the Certified Plant binder tank or injection line in accordance with AASHTO R 66. The procedure for sampling binder is described in Chapter 3.

Mixture Sampling

The sampling procedures for mixture at the plant or from the pavement are included in ITM 580. For truck sampling at the plant, a square bit shovel of the appropriate size for the required sample is used. For plate sampling from the pavement, a metal square plate with a minimum size of 8 in. is used. Procedures for sampling are discussed in Chapter 7.

MATERIALS TESTING

The Producer is required to designate the types of tests and test methods to be used for control of the aggregates, recycled material, and mixture. Mixture testing is required to be completed within two working days of the time the sample was taken. The Producer is required to keep the test results on file either by hard copy or electronically for a minimum period of three years.

Aggregate Testing

Gradation

Gradations done on blended aggregate or aggregate stockpile samples are conducted using AASHTO T 27. If RAP is used in the mixture, the test procedure for the gradation is AASHTO T 30.

Moisture Content

AASHTO T 255 is the test procedure used for determination of the total moisture content of the cold feed belt or belt discharge aggregate samples for a drum plant.

Mixture Testing

The analysis of the mixture to meet the requirements of the Program includes several tests. Detailed procedures of these tests include:

Mixture Calibration

A plant calibration is required to be made for each mixture to be produced in accordance with the following methods:

- Batch Plants -- the percentage of the total aggregate to be obtained from each hot bin and the RAP belt
- Drum Plants -- the percentage of the total aggregate to be obtained from each cold bin and the RAP bin

Moisture Content

ITM 572 outlines the procedure for determination of the moisture content. Of particular importance is that the sample be placed immediately into an oven bag when obtaining the sample so that an accurate moisture content may be obtained.

Binder Content

Several methods are allowed for determination of the binder content. The most common procedures are the Ignition Method (ITM 586) and the Extraction Methods (ITM 571) Method A Centrifuge Extractor, Method B Vacuum Extractor, Method C Continuous-Flow Filterless high speed centrifuge without Extractor, and Method D Automatic Extractor.

Extracted Aggregate Gradation

After the binder content has been determined in accordance with ITM 571, the sieve analysis of the aggregate is made using AASHTO T 30, except the decantation through the No. 200 sieve is not required. If ITM 586 is used, the aggregate sample is first decanted and then the sample is sieved in accordance with AASHTO T 30.

Coarse Aggregate Angularity

If gravel is used in the mixture or the RAP contains gravel, the coarse aggregate angularity (crushed content) is determined after the sieve analysis. ASTM D 5821 is the procedure used for determination of both one and two faced crushed particles.

Mixture Specimen Preparation

Specimens to determine the air voids and VMA are compacted to Ndes in accordance with AASHTO T 312. The compaction temperature is 300 ± 9°F for dense graded mixtures and SMA, and 260 ± 9°F for open graded mixtures.

Bulk Specific Gravity

AASHTO T 166 is the procedure used for determination of the bulk specific gravity of the gyratory specimens for dense graded and SMA mixtures. The bulk specific gravity of the gyratory specimens for open graded mixtures, OG 19.0 mm and OG 25.0 mm, is determined in accordance with AASHTO T 331.

Maximum Specific Gravity

AASHTO T 209 is the procedure used for determination of the maximum specific gravity of the mixture. The supplemental procedure for mixtures containing porous aggregates may be required if the aggregate absorbs water during the test. The requirement of the supplemental procedure can be found on the DMF.

Draindown

AASHTO T 305 is the procedure used to determine the amount of binder that drains from the mixture during production. This is a requirement for open graded mixtures and SMA.

Temperature

The best procedure to determine the temperature of the mixture is with a dial and armored-stem thermometer. The stem is required to be inserted sufficiently deep (at least 6 in.) into the mixture, and the material is required to be in direct contact with the stem.

The gun-type infrared thermal meter, which measures reflective heat from the surface, may also be used. This device detects only surface heat and may not be accurate for material within the truck. To overcome this problem, the instrument may be directed at the stream of mixture at the discharge gate of the mixer or surge bin.

FREQUENCY OF TESTS

The frequency of tests is determined by the Producer and is required to be included in the QCP for the following items:

1. Aggregates
    a. Stockpiles
    b. Blended Aggregate
2. Binder
3. Recycled Materials
    a. Actual Binder Content
    b. Gradation

    c. Moisture Content
    d. Coarse Aggregate Angularity
    e. Bulk Specific Gravity of Recycled Aggregate
4. Mixture Sampled at the HMA plant
    a. Actual Binder Content
    b. Gradation
    c. Aggregate degradation value (for SMA mixtures only) - once per lot
    d. Moisture Content
    e. Temperature
    f. Draindown (for open graded and SMA mixtures only)
5. Mixture Sampled from the Pavement
    a. Air Voids
    b. VMA
    c. Actual Binder Content
    d. Gradation
    e. Dust/calculated effective binder ratio
    f. Moisture Content (for surface mixtures only)
    g. Bulk Specific Gravity
    h. Maximum Specific Gravity
    i. Volume of Effective Binder, Vbe

HMA

HMA mixture produced concurrently with QC/QA HMA mixture is required to be sampled and tested in accordance with the requirements established for QC/QA HMA. All other HMA is required to be sampled at the HMA plant or the roadway and tested for binder content, coarse aggregate angularity for mixtures containing gravel, gradation, and air voids in accordance with the following minimum frequency:

1. The first 250 tons and each subsequent 1000 tons of each DMF in a construction season for base and intermediate mixtures
2. The first 250 tons and each subsequent 600 tons of each DMF in a construction season for surface mixtures

FIELD LABORATORY

A laboratory is required to be provided and maintained at the plant site with the necessary equipment and supplies for conducting quality control testing.

Performance of quality control tests at laboratory facilities other than the plant-site are allowed provided the laboratory facilities are owned by the Producer, transportation to an offsite laboratory is defined in the QCP, all test procedure criteria are satisfied, and the test results are furnished in writing to the plant-site laboratory within two working days. INDOT is allowed access to inspect any laboratory used for quality control testing and to witness quality control activities.

TEST EQUIPMENT CALIBRATION

The equipment furnished for testing is required to be properly calibrated and maintained within the calibration limits described in the applicable test method. A record of calibration results is maintained at the field laboratory for the equipment listed in the following table:

FIGURE 6.3 CALIBRATION AND VERIFICATION FREQUENCY FOR TESTING EQUIPMENT

Equipment	Requirement	Min Freq	Procedure
Balances	Standardize	12 mo.	ITM 910
Gyratory Compactor	Verify Ram Pressure, Angle of Gyration, Frequency of Gyration, LVDT	1 mo.	ITM 908
Gyratory Compactor Internal Angle	Verification	12 mo.	AASHTO T 344
Gyratory Mold and Plate Dimensions	Verification	12 mo.	AASHTO T 312
Ignition Oven	Conduct Lift Test	Weekly	Operators Manual
Ignition Oven Balance	Standardize	12 mo.	ITM 910
Mechanical Shakers	Verify Sieving Thoroughness	12 mo.	ITM 906
Ovens	Verify Temperature Settings	12 mo.	ITM 903
Sieves	Verify Physical Condition	12 mo.	ITM 902
Thermometers	Verification	12 mo.	ITM 909
Vacuum Chamber	Verification	3 mo.	ITM 905
Calipers	Verification	12 mo.	ITM 916

The equipment used to calibrate or verify the testing equipment is required to be NIST traceable and calibrated or verified in accordance with the following frequencies:

FIGURE 6.4 CALIBRATION AND VERIFICATION FREQUENCY FOR EQUIPMENT USED TO CALIBRATE OR VERIFY TESTING EQUIPMENT

Calibration Equipment	Testing Equipment	Minimum Frequency
Master Ring used with the Bore Gauge	Gyratory Compactor Molds – AASHTO T 312	36 mo.
Dynamometer or Load Cell & Proving Ring	Gyratory Compactor – AASHTO T 312	24 mo.
Height Gage Blocks	Gyratory Compactor – AASHTO T 312	24 mo.
Height Billet	Gyratory Compactor – AASHTO T 312	24 mo.
Vacuum Gage	Vacuum Systems – ITM 905	12 mo.
Weights, Min. Class 3	Balances – ITM 910	12 mo.

COMPARISON TESTING

Testing procedures required by the QCP will be observed to verify that they comply with the Sampling, Sample Reduction, and Testing Procedures checklist. IA comparison testing that occurs every 2 years will be adequate.

If comparison testing is performed as part of the audit, the Producer's Level 1 Asphalt Technician will obtain a sample of the mixture, blended aggregate, and recycled material (if applicable). A separate blended aggregate sample is only required if specified by the QCP. The samples obtained will be split by the Producer's Certified Technician and the Department's portion given to the INDOT audit team member. Samples are required to be tested by the Producer and INDOT.

Comparison tests required for an INDOT audit are the gradation, binder content of RAP, and binder content of the mixture are within the following limits:

FIGURE 6.5 COMPARISON TESTING ALLOWABLE DEVIATION

Sieves	Deviation (± %)	Binder Content	Deviation (± %)
1 in.	5	RAP	0.5
¾ in.	5	Mixture	0.5
½ in.	5		
No. 8	3		
No. 30	3		
No. 200	3		

AUDIT CLOSE-OUT

A meeting with the Producer is to be conducted at the end of the audit. Any addenda on the Addenda Summary Sheet, QCP Annex, Corrective Action, and Appendix sheets will be submitted at this time. The results of the audit are discussed with the Producer and outstanding matters will be completely resolved or solutions with deadlines will be established. Corrective Action sheets requiring longer than two weeks must be addressed by the DTE. An Audit Close-Out meeting is to be held when all items indicated on Corrective Action Sheets have been addressed and all Comparison testing results (if applicable) have been reviewed.

The DTE will verify the audit package is prepared properly and completed. Upon completion of the Audit Close-Out meeting, all documents will be sent to the Asphalt Engineer, Division of Materials and Tests.

MIXTURE TROUBLESHOOTING

Mixture troubleshooting starts with knowing some common QC tools:

Gradation
Binder Content
G_{mb} of lab specimens and cores
G_{mm}
And your Eyes

Using these common tools during production will help you find general relationships with properties and provide good troubleshooting skills.

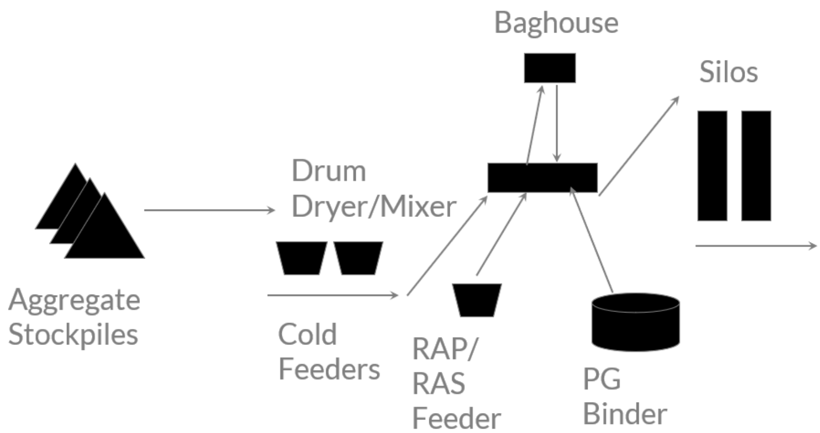
During production there are other means available to make a quick determination of the properties of the mixture. For example, Air voids and VMA may be approximated by estimating the bulk specific gravity (G_{mb}) of the mixture. This estimation of G_{mb} is made from the height of the gyratory specimens when a constant sample mass is used.

Verification of a mix design prior to production is one of the best procedures to prevent potential problems. Using current gradations from your stockpiles should always be done when setting up a blend. Usually mix designs are not developed at the same time as a project, so consequently, modifications to the blend is necessary. And never forget that materials going through a drum will change in shape and gradation so keep this in mind when establishing blends in the field.

Figure 6.7 shows the relationships between certain volumetric properties of HMA. These properties are used in determining changes that may be made when troubleshooting HMA.

In troubleshooting, it is important to realize the possible issues that can occur. See Figure 6.6 to identify possible problem areas in the material flow schematic.

FIGURE 6.6 MATERIAL FLOW SCHEMATIC



The following are initial areas to check when issues arise.

- Aggregate & RAP stockpiles
- Cold feed system
- Mixing and load-out systems
- Dust systems

GRADATION CONTROL ISSUES

In gradation control, there are several processes that can include troubleshooting issues.

Stockpiles

Stockpiles can have issues with segregation and contamination. This can occur from the supplier to the yard mixture.

Control Feeders

Control Feeders can be improperly calibrated causing issues with material flow. The feeders can have issues from being allowed to run empty. Overflow can also occur from adjacent feeders causing more complications. Another issue that occurs is having the wrong material in the feeder or have the incorrect proportional set-up on the feeder system.

Load Out

For load out, issues can occur with silo segregation and truck segregation. In a silo, high absorption or length of time in the silo can cause the issues. When looking at truck segregation, issues with not emptying the cone or triple dumping can occur.

Dust Control

Dust control is another issue that can cause problems with material flow. Make sure to always check the primary collector, secondary collector, and mineral filler bin

BINDER CONTROL

The following problems can occur with binder control:

- Mix Segregation
    - Plot %binder vs.% passing #8 or #4
- Flow Meter calibration
- Aggregate moisture correction (only slight)
- Aggregate or RAP weigh bridge calibration
- Rap binder content
- RAP aggregate type (dolomite/burn-off)
- Start-up, shut down and switching mixes
- Refer to “Appendix C” in your QC Manual

VOLUMETRIC CONTROL

Verification of the volumetric mixture properties is one of the most important duties of the Technician. Changes in the material or control at the HMA plant may result in the air voids and VMA falling outside of the Specification limits. The general trend is that the design air voids and VMA will decrease during production at the plant. This section contains information concerning the steps that may be taken to correct a deficient volumetric property. In order to use these guidelines, the mixture composition is required to be reasonably close to the designed mixture.

VMA

Figure 6.8 is a flow chart for VMA adjustment for plant – produced mixture. The amount of material passing the No. 200 sieve and the relative proportions of coarse and fine aggregate may significantly affect the VMA. A loss of VMA is a common problem during production.

FIGURE 6.7 COMMON SCENARIOS

What if?	Probable effect on Acceptance Properties	Probable cause(s)
$G_{mb}\uparrow$ & $G_{mm}\surd$	VMA↓ AV↓ Binder√	Aggr. Structure
$G_{mb}\downarrow$ & $G_{mm}\surd$	VMA? AV? Binder?	
$G_{mb}\uparrow$ & $G_{mm}\uparrow$	VMA? AV? Binder?	
$G_{mb}\downarrow$ & $G_{mm}\downarrow$	VMA? AV? Binder?	
$G_{mb}\downarrow$ & $G_{mm}\downarrow$	VMA? AV? Binder?	
$G_{mb} > G_{mm}$		

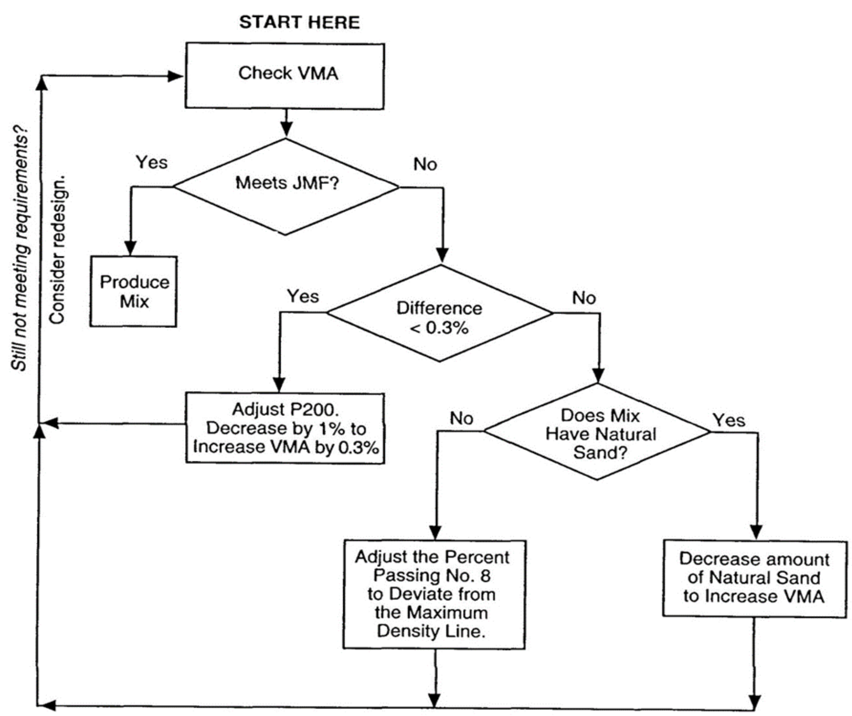
What if? (compared to DMF)	Probable effect on Acceptance Properties	Probable cause(s)
$G_{mb}\uparrow$ & $G_{mm}\surd$	VMA↓ AV↓ Binder√	Aggr. Structure
$G_{mb}\downarrow$ & $G_{mm}\surd$	VMA↑ AV↑ Binder√	Aggr. Structure
$G_{mb}\uparrow$ & $G_{mm}\uparrow$	VMA? AV? Binder?	
$G_{mb}\downarrow$ & $G_{mm}\downarrow$	VMA? AV? Binder?	
$G_{mb} > G_{mm}$		

What if? (compared to DMF)	Probable effect on Acceptance Properties	Probable cause(s)
$G_{mb}\uparrow$ & $G_{mm}\uparrow$	VMA↓ AV? Binder↓	Aggr. Structure/ composition G_{sb} change ↑ ? Low binder Absorption (low effective binder)

What if? (compared to DMF)	Probable effect on Acceptance Properties	Probable cause(s)
$G_{MB}\downarrow$ & $G_{MM}\downarrow$	VMA↑ AV? Binder↑	Aggr. Structure/ composition G_{sb} change ? high binder Absorption (effective binder)

What if? (compared to DMF)	Probable effect on Acceptance Properties	Probable cause(s)
G_{MB} > G_{MM}	PANIC	TEST ERROR

FIGURE 6.8 VMA ADJUSTMENT PROCESS



VMA = Voids in Mineral Aggregate
AV = Air Voids
P200 = Percent passing 0.075 mm (#200) sieve

NOTE: This flow chart is intended to provide guidance for adjustment of VMA. Due to differences in properties of specific mixes, the effect of the adjustments may be variable.

Gradation changes may be caused by a mechanical problem with the plant. A comparison of the blended aggregate and extracted aggregate gradations is a good technique to verify if this problem exists. Also, there is, in most cases, some "rounding" of the edges of the coarse aggregate particles as they pass through the drum. This rounding of the aggregate lowers the VMA.

Dust variation in the mixture may be caused by variations in the minus No. 200 sieve material of the aggregates; however, a change in the dust is more likely to be the result of the inconsistent return of fines from the plant baghouse. Specifications require that if dust is returned into the mixture, the system is required to return the material at a constant rate during production. A check on the fines return system is required to be made to verify this constant rate of return of fines.

Adjusting for low VMA is the more common problem a Technician needs to correct. Procedures for increasing the VMA include:

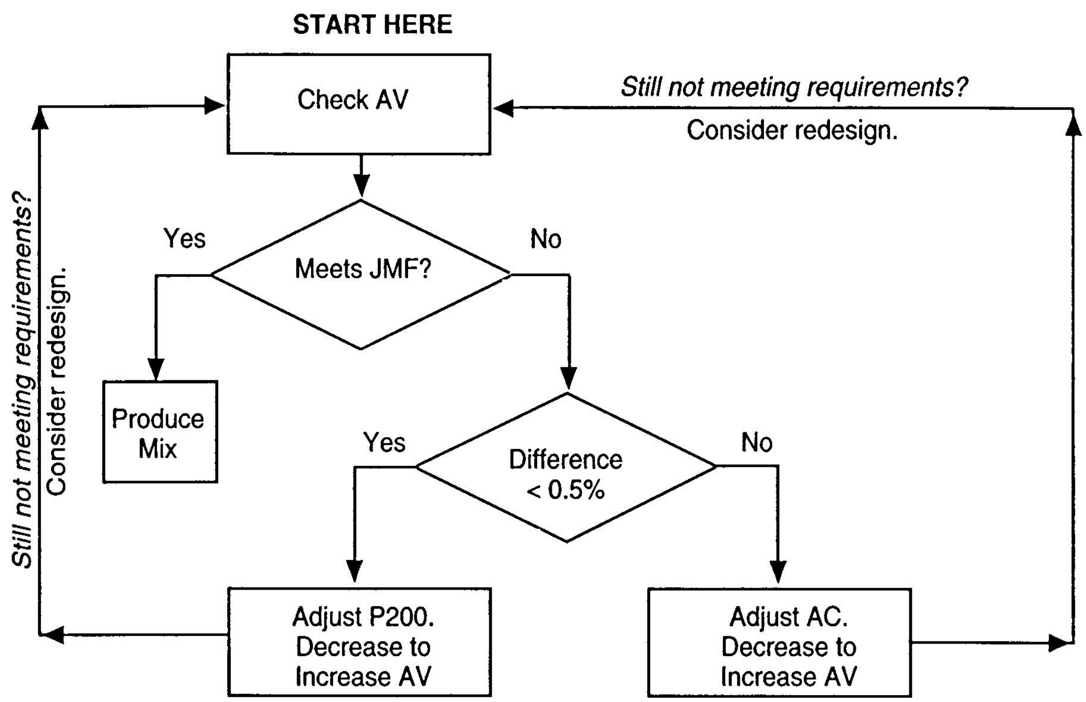
1. Reduce the amount of material passing the No. 200 sieve
2. Reduce the amount of natural sand in the mixture
3. Adjust the aggregate gradation away from the Maximum Density Line

Air Voids

Figure 6.9 is a flow chart for adjusting air voids for plant-produced mixture. Air voids are influenced by a combination of VMA, percent passing the No. 200 sieve, and the binder content. Adjustments of the air voids are dependent on the magnitude of the variance between the production and DMF values. If the difference is greater than 0.5 percent, consideration should be given to adjusting the binder content; if the difference is less than 0.5 percent, the percent passing the No. 200 sieve may be adjusted.

A comparison of the production bulk specific gravity (G_{mb}) and maximum specific gravity (G_{mm}) values to the DMF and previous production values should also be done. Different G_{mb} values may be caused by an aggregate gradation change (especially the P 200) or by a particle shape change from aggregate breakdown. Different G_{mm} values may be caused by a binder content, aggregate absorption, or aggregate specific gravity change.

FIGURE 6.9 AIR VOIDS ADJUSTMENT PROCESS



VMA = Voids in Mineral Aggregate
AV = Air Voids
P200 = Percent passing 0.075 mm (#200) sieve

NOTE: This flow chart is intended to provide guidance for adjustment of AV. Due to differences in properties of specific mixes, the effect of the adjustments may be variable.

The air voids, as with the VMA, may need to be increased in most cases when the Specifications are not being met. Procedures for increasing the air voids include:

1. Reduce the binder content
2. Reduce the amount passing the No. 200 sieve
3. Change the relative proportion of coarse and fine aggregate

TROUBLESHOOTING TIPS

To prevent issues, start off with the right steps and be diligent in your preparation. Before you start production, check stockpiles, correct JMF input to plant, plant calibrations (all meters and scales), test equipment calibration, and communicate with your plant operator.

Conduct a trial run on new JMF before starting major production. Use 100± tons. Don't sample the first or last load. When doing this, think of the cost of trial vs. cost of failure of removal. Some additional tips for troubleshooting:

- Retest to verify results as needed
- Eliminate the obvious first
- Be careful not to overreact
- Keep track of all your changes so you can find patterns
- Gather as much data as you can before making decisions

CHAPTER 7

PERCENT WITHIN LIMITS (PWL) AND FIELD TESTING

RANDOM NUMBERS

DESIGN MIX FORMULA

MIXTURE ADJUSTMENT FACTOR

LOT/SUBLOT – QC/QA HMA

ACCEPTANCE SAMPLES

MIXTURE ACCEPTANCE

QC/QA HMA
HMA

PAY FACTORS – QC/QA HMA (DENSE GRADED MIXTURE ≥ 1 LOT)

PWL - MIXTURE
PWL – DENSITY
PAY FACTORS

QUALITY ASSURANCE ADJUSTMENT – QC/QA HMA ≥ 1 LOT

PAY FACTORS – QC/QA HMA (DENSE GRADED MIXTURE < 1 LOT AND OPEN GRADED MIXTURES)

MIXTURE
DENSITY

QUALITY ASSURANCE ADJUSTMENT – QC/QA HMA < 1 LOT AND OPEN

GRADED MIXTURES

MIX APPEAL – QC/QA HMA

SMOOTHNESS

CHAPTER 7

QUALITY ASSURANCE PROCEDURES

The acceptance criteria for QC/QA HMA set out in the Quality Assurance Specifications are based on air voids @ N_{des}, Volume of Effective Binder, density and smoothness. The Specifications establish controls for temperature of the mixture, testing of aggregates for quality, and testing of binder. The acceptance criteria for HMA mixtures are based on binder content and air voids. The acceptance criteria for SMA mixtures are binder content and gradation.

This section includes the procedures for obtaining acceptance samples, minimum requirements for mixture properties in accordance with Sections 401 (QC/QA HMA), and 402 (HMA) and the procedures for determining pay factors.

RANDOM NUMBERS

The Producer personnel required include a Management Representative and a Certified Asphalt Technician Sampling for mixture tests is done on a random basis using ITM 802. A table of Random Numbers, as shown in Figure 7.1, can be used to determine the random quantity or random location. Random numbers generated by software may also be used. The numbers occur without aim or reason and are in no particular sequence. Therefore, samples obtained are truly random or chance and eliminate any bias in obtaining samples.

To use the random number table to determine the random ton to sample, select without looking one block in the table. After selecting the block, the top left number in the block is the first random number used. This number is the beginning number. Proceed down the column for additional numbers and proceed to the top of the next column on the right when the bottom of the column is reached. When the bottom of the last column on the right is reached, proceed to the top of the column at the left. If all numbers in the table are used, select a new starting number and proceed in the same manner.

To use this table to determine the location of the pavement sample, again select a block in the table and start with the top left number. This number is used to determine the test site station. The adjacent number within the block is used to determine the transverse distance to the random site. Proceed down by pairs until the bottom numbers are reached and proceed to the adjacent top block to the right, if available. When the bottom pair of numbers on the right are reached, proceed to the top block on the left in the table.

FIGURE 7.1 RANDOM NUMBERS

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.310	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.246
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.218	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

DESIGN MIX FORMULA

The Producer is required to submit for the Engineer's review a Design Mix Formula (DMF) for each mixture. This information is recorded in a format acceptable to the Engineer. DMF Entry is an online application that is used for this purpose (Figure 7.2). INDOT personnel are required to have an accepted copy of the DMF prior to production of any mixture.

MIXTURE ADJUSTMENT FACTOR

A Mixture Adjustment Factor (MAF) is used to adjust the mixture planned quantity and lay rate prior to paving operations, and the pay quantity upon completion of production of the mixture.

The MAF is calculated by dividing the maximum specific gravity (G_{mm}) from the mixture design by the following values:

Mixture
9.5 mm – 2.465
12.5 mm – 2.500
19.0 mm – 2.500
25.0 mm – 2.500

If the calculated MAF is equal to or greater than 0.980 and equal to or less than 1.020, the MAF value is considered to be 1.000. If the calculated MAF is less than 0.980, then 0.020 is added to the value. If the calculated MAF is greater than 1.020, 0.020 is subtracted from the value. The planned quantity and lay rate are adjusted by multiplying by the MAF. The accepted quantity for payment is adjusted by dividing by the MAF.

Example:

Mixture	=	9.5 mm Surface
Planned Quantity	=	9750.00 tons
Placed Quantity	=	9500.00 tons
Mix Design Gmm	=	2.360
Lay Rate	=	165 lb/yd^2

MAF = $\frac{2.360}{2.465} = 0.957$

MAF = 0.957 + 0.020 = 0.977

Adjusted Planned Quantity = 0.977 x 9750.00 = 9525.75 tons

Adjusted Lay Rate = 0.977 x 165 lb/yd^2 = 161 lb/yd^2

Adjusted Pay Quantity = $\frac{9500.00}{0.977}$ = 9723.64 tons

The MAF does not apply to open graded mixtures.

LOT/SUBLOT – QC/QA HMA AND SMA

Quality Assurance Specifications consider a lot as 5000 t of Base or Intermediate QC/QA HMA, and 3000 t of Surface QC/QA HMA. The lots are divided into five sublots of equal tons. For Base and Intermediate QC/QA HMA therefore, a sublot is 1000 t, and for Surface QC/QA HMA, a sublot is 600 t. Partial sublots of 100 t or less are added to the previous sublot. Partial sublots greater than 100 t constitute a full sublot. Partial lots of four sublots or less are added to the previous lot, if applicable. QC/QA SMA specifications define a lot as 4000 t of Intermediate, and 2,400 t of Surface. The lots are divided into four sublots of equal tons. For Intermediate SMA, a sublot is 1000 t, and for Surface SMA, a sublot is 600 t.

ACCEPTANCE SAMPLE

Sampling of mixture for acceptance is made from the pavement in accordance with ITM 580. INDOT determines the random site and the Contractor obtains the samples under INDOT supervision. INDOT takes immediate possession of the samples.

A specific ton in each sublot is selected and the mixture from the truck containing that ton is sampled. This truck is determined by checking the weigh tickets. An example of how to determine what ton is to be sampled is indicated on form TD 452. These random tons are not shown to the Contractor so that there is no possible influence on the construction operations.

Once the truck that contains the random ton is identified, the approximate total length of mixture that the truck places is determined by knowing the weight of the truck, the paving width, and the quantity placed. When placing variable depth, such as a crown correction, the average depth is used. The following relationship is used to calculate this approximate length that a truck would place.

Length of Load = $\frac{Load\ Weight\ (t)}{Avg.Planned\ Quatity\ \left(\frac{\mathrm{lb}}{\mathrm{yd2}}\right)\ x\ Width\ of\ Paving\ (ft)}\ x\ 18000$

(Nearest Foot)

FIGURE 7.2 DESIGN MIX FORMULA

Aggregate

Product Name and Add'l Info	Source #	Source Name	Q-Number	Ledges	Gsb (I)	Abs % (I)	Mix%
#8 CS	2312	Hanson Aggregates Midwest - S. Harding	Q962011	101-5	2.605	1.46	18.0
#11 Dolomite	2421	US Aggregates Inc - Delphi, IN	Q972034	Hanna 2 L1-4	2.735	0.97	11.0
#12 CS	2312	Hanson Aggregates Midwest - S. Harding	Q962011	101-5	2.604	1.59	9.0
#12 Dolomite	2421	US Aggregates Inc - Delphi, IN	Q972034	Hanna 2 L1-4	2.735	0.97	9.0
#24 SS	2312	Hanson Aggregates Midwest - S. Harding	Q962011	101-5	2.561	2.17	23.5
minus 3/4" RAP	3304	nt ...		plant	2.640	1.00	28.0
BHF	3304	nt ...		Plant	2.800	1.00	1.5

Gradation and Additives

Sieve Size	Pct Passing	Acceptable Range
37.5 mm		
25.0 mm	100	100.0
19.0 mm	96.7	90.0 - 100.0
12.5 mm	87.7	< 90.0
9.5 mm	80	
4.75 mm	54.7	
2.36 mm	33.9	23.0 - 49.0
1.18 mm	21.4	
600 µm	13.9	
300 µm	8.9	
150 µm	6.3	
75 µm	5.4	2.0 - 8.0

+		Type/Source	Source#
	Binder	70-22 Asphalt Materials, Inc. - Indi...	7105
	Binder	64-22 Asphalt Materials, Inc. - Indi...	7105
	Binder	76-22 Asphalt Materials, Inc. - Indi...	7105

	Fine RAP	Coarse RAP	RAS
% In Mixture	0.0 %	28.0 %	0.0 %
Binder % extracted	0.0 %	4.1 %	0.0 %

Binder % RAS: 0.0 % | Binder Repl.%: 22.6 % | Virgin Binder%: 4.0 %

Design Notes

New DMF using 2022 Gsb and absorption values.

Reference History	Submitter
No records available.	

Mix Details

Use Case Details

PG Grade, Design TSR	64-22
Mixture Designation	19.0 mm
Maximum Particle Size	25.0 mm
Mixture Courses	☑ Base ☑ Inter ☐ Surf
401 ESAL Categories	☐ 2 ☑ 3 ☑ 4
402 Mix Types	☑ B ☑ C ☑ D
INDOT Agg.Blend Gsb	2.632
Established Gsb	2.632 as of 10/26/20...
INDOT Agg.Blend Abs%	1.41 %
Base PG-Plant Max Temp (°F)	315
Lab Compaction Temp (±9°F)	300

Mix Details

Ignition Oven Test Temperature	900 F / 482 C
Binder, actual, %	5.1 %
Binder, calculated effective, %	4.2 %
Gyrations, Nini/Ndex/Nmax	6/50/75
Mass gyratory pill @Ndes, g	4700
Adj. Mass gyratory pill @Ndes, g	
Gmm	2.491
Gmm w/dry back?	No
Gmm % @Nini/Nmax	85.1 % / 95.6 %
Gmb @Ndes	2.366
VMA @Ndes, %	14.7 %

Mix Details

Air Voids @Ndes, %	5.0 %
Calculated Air Voids, %	5.02 %
VFA @Ndes, %	66.0 %
Coarse agg. ang. 1/2 face, %	98 % / 97 %
Fine aggregate angularity	45.0
Polish Resistance, Vol HF Agg. %	
Dust/calculated effective binder	1.3
Tensile strength ratio, %	94.4 %
Draindown, %	0.06 %
ΔPb, %	-0.31 %

FIGURE 7.3 CONTRACTS ASSIGNED TO DMF

+	Contract ID	CLN	Item Code	Item Description	PG Grade	Contract Status	Date Added
	B-40439	0039	304-12623	HMA PATCHING FULL DEPTH, TYPE B		Active	11/07/2022
	B-40439	0042	401-07404	QC/QA-HMA, 4, 76, INTERMEDIATE, 19.0 mm	76-22	Active	11/07/2022
	B-40439	0048	402-10087	HMA FOR TEMPORARY PAVEMENT, D		Active	11/07/2022
	B-40439	0146	801-52817	TEMPORARY CROSSOVER, B		Active	11/07/2022
	R-41536		401-07398	QC/QA-HMA, 3, 70, INTERMEDIATE, 19.0 mm	70-22	Active	10/28/2022

The length the truck places is multiplied by the first random number to obtain a longitudinal distance. This distance is measured from the location of the paver when the truck containing the random ton begins unloading into the paver or material transfer device. The transverse test site location is determined by multiplying the width of pavement by the second random number and rounding to the nearest whole ft. This distance is measured from the right edge of pavement when looking in the direction of increasing station numbers. If the transverse location is less than 1 ft from either edge of pavement, at a location where the course thickness is less than 2.0 times the maximum particle size, or within the width of the roller drum used to form shoulder corrugations, then another random location is selected to obtain an acceptable sampling location. The first 300 t of the first sublot of the first lot for each mixture pay item is not sampled. If the random ton selected for the sublot is within this first 300 t, then 300 is added to the random ton selected and the sample is obtained from the truck containing that ton. The following example indicates how these random locations are determined.

Example:

Width of Pavement	12 ft
Load Weight	20 t
Mixture	9.5 mm Surface
Planned Quantity	110 lb/yd^2
Ending Station of Paver of Previous Load	158+00
Random Numbers	.256, .561

Test Site Station

Length of Load = $\frac{20}{110\ x\ 12}\ x\ 18000 = 273\ ft$

Longitudinal Distance = 273 x .256 = 70 ft

Random Station = (158+00) + 70 = 158+70

Transverse Distance

Distance = 12 x .561 = 6.7 ft (say 7 ft)

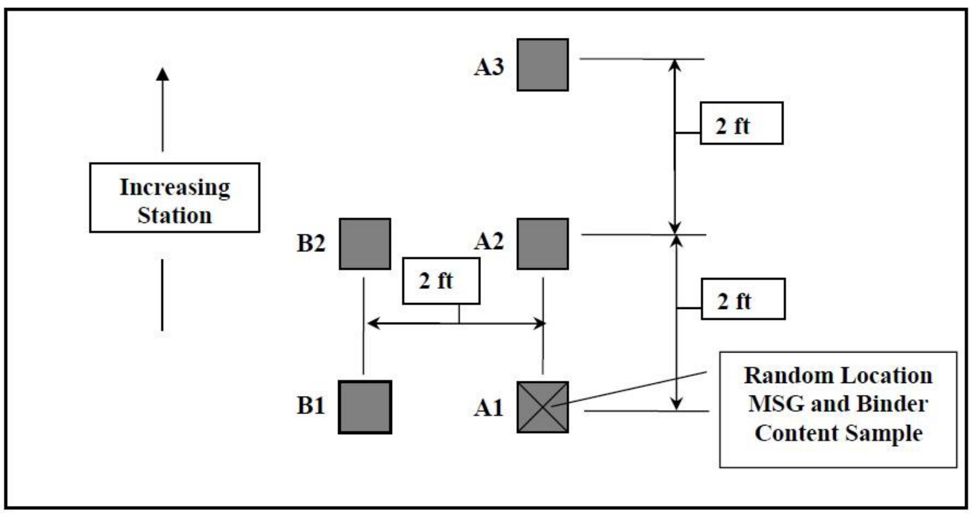
For contracts controlled by volumetrics for QC/QA HMA (401), several samples are required. The first plate sample location is determined by the random sampling procedure and this material is used for the maximum specific gravity and binder content samples. This plate is designated A1. A second plate sample is placed longitudinally 2 ft upstation from the first plate at the same transverse offset. This sample is used for the gyratory specimens and is designated A2. A third plate is placed longitudinally 2 ft upstation from the second plate at the same transverse offset.

This sample is used to determine the aggregate bulk specific gravity within the mixture. This plate sample will be designated A3.

If an appeal by the Producer of the INDOT test results is accepted, backup samples are tested. These samples are obtained at the same time as the acceptance samples. The backup sample plate for the maximum specific gravity and binder content is placed transversely 2 ft from the first plate towards the center of the mat and is designated B1. The backup sample for the gyratory specimens is placed transversely 2 ft from the second plate towards the center of the mat and is designated B2.

The following diagram indicates an example of an arrangement of the plate samples when additional samples are required for QC/QA HMA:

FIGURE 7.4 PLATE SAMPLING LAYOUT



Example:

Width of Pavement	12 ft
Load Weight	20 t
Mixture	9.5 mm Surface
Planned Quantity	110 lb/yd^2
Ending Station of Paver of Previous Load	158+00
Random Numbers	.256, .561

Test Site Station

Length of Load = $\frac{20}{110\ x\ 12}\ x\ 18000 = 273\ ft$

Longitudinal Distance = 273 x .256 = 70 ft

Random Station = (158+00) + 70 = 158+70

Transverse Distance

Distance = 12 x .561 = 6.7 ft (say 7 ft)

MSG and Binder Content Sample

Random Location = 158 + 70

Transverse Distance = 7 ft

Gyratory Specimens Sample

Random Location = (158 + 70) + 2 ft

= 158 + 72

Transverse Distance = 7 ft

Backup Sample for MSG and Binder Content

Random Location = 158 + 70

Transverse Distance = 7-2 = 5 ft

Backup Sample for Gyratory Specimens

Random Location = (158 + 70) + 2 ft

= 158 + 72

Transverse Distance = 7-2 = 5 ft

Areas placed with wideners or other specialty paving equipment are not subject to plate sampling. If a random sampling location falls within an area placed by this equipment, another randomly selected location is determined. If an entire sublot falls within an area placed by this equipment, the previous sublot is used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

The size of the plate used to obtain a sample is dependent on the test(s) conducted on the material. The following minimum sample weights are required:

FIGURE 7.5 MINIMUM PLATE SAMPLE WEIGHTS

Mixture Designation	Minimum Weights (g)	
	MSG and Binder Content	Gyratory Specimens
4.75 mm	3000	11000
9.5 mm	11000	11000
12.5 mm	11000	11000
19.0 mm, OG 19.0 mm	11000	11000
25.0 mm, OG 25.0 mm	11000	11000

FIGURE 7.6 SAMPLE YIELDS FOR VARIOUS LIFT THICKNESS AND PLATE SIZES

Approximate Sample Yield for Various Lift Thickness and Plate Sizes								
Lift Thickness (inches)	**Lay Rate (lb/syd)**	**Plate Size, inches**						
		8	**9**	**10**	**11**	**12**	**14**	**16**
		Sample Weight (g)						
1.25	137.5	3100	3900	4800	5900	7000	9500	12400
1.5	165	3700	4700	5800	7000	8400	11400	14900
1.75	192.5	4300	5500	6800	8200	9800	13300	17300
2.0	220	5000	6300	7700	9400	11100	15200	19800
2.25	247.5	5600	7100	8700	10500	12500	17100	22300
2.5	275	6200	7800	9700	11700	13900	19000	27800
2.75	302.5	6800	8600	10600	12900	15300	20900	27300
3.0	330	7400	9400	11600	14100	16700	22800	29700
3.25	357.5	8100	10200	12600	15200	18100	24700	32200
3.5	385	8700	11000	13500	16400	19500	26600	34700
3.75	412.5	9300	11800	14500	17600	20900	28500	37200
4.0	440	9900	12500	15500	18700	22300	30300	39600
4.25	467.5	10500	13300	16400	19800	23600	32100	41900
4.5	495	11100	14000	17300	21000	25000	34000	44400
4.75	522.5	11700	14800	18300	22100	26400	35900	46900
5.0	550	12300	15600	19300	23300	27700	37800	49300
5.25	577.5	12900	16400	20200	24500	29100	39700	51800
5.5	605	13600	17200	21200	25600	30500	41500	54300
5.75	632.5	14200	17900	22200	26800	31900	43400	56700
6.0	660	14800	18700	23100	28000	33300	45300	59200

FIGURE 7.7 SAMPLE YIELD FOR VARIOUS LIFT THICKNESS AND MOLD SIZE

Approximate Sample Yield for Various Lift Thicknesses and Mold Sizes						
Lift Thickness (inches)	**Lay Rate (lb/yd²)**	**Mold Size, inches**				
		8	**10**	**12**	**14**	**16**
		Sample Weight (g)				
1.25	137.5	2400	3800	5400	7400	9700
1.5	165	2900	4500	6500	8900	11600
1.75	192.5	3400	5300	7600	10400	13600
2.0	220	3900	6100	8700	11900	15500
2.25	247.5	4400	6800	9800	13300	17400
2.5	275	4800	7600	10900	14800	19400
2.75	302.5	5300	8300	12000	16300	21300
3.0	330	5800	9100	13100	17800	23200
3.25	357.5	6300	9800	14200	19300	25200
3.5	385	6800	10600	15300	20800	27100
3.75	412.5	7300	11300	16300	22200	29100
4.0	440	7700	12100	17400	23700	31000
4.25	467.5	8200	12900	18500	25200	32900
4.5	495	8700	13600	19600	26700	34900
4.75	522.5	9200	14400	20700	28200	36800
5.0	550	9700	15100	21800	29700	38700
5.25	577.5	10200	15900	22900	31100	40700
5.5	605	10700	16600	24000	32600	42600
5.75	632.5	11100	17400	25100	34100	44500
6.0	660	11600	18200	26100	35600	46500

MIXTURE ACCEPTANCE

QC/QA HMA

Acceptance of QC/QA HMA mixtures for Vbe, and air voids at Ndes for each lot is based on tests conducted by INDOT. INDOT randomly selects the location(s) within each sublot for sampling in accordance with the ITM 802. Samples from the pavement are obtained from each sublot in accordance with ITM 580.

A binder draindown test in accordance with AASHTO T 305 for open graded mixtures is required once per lot and may not exceed 0.50 %.

The Engineer will make available the sublot acceptance test results after receiving the sublot quality control results from the Producer.

HMA

Acceptance of HMA mixtures is done on the basis of a Type D certification submitted by the Producer to the Project Engineer on a contract. The certification is required to be submitted with the first truck of each type of mixture each day. If no test results are available, the Producer indicates on the form that test results are required to be obtained within the first 250 tons and each subsequent 1000 tons for base and intermediate mixtures, and the first 250 tons and each subsequent 600 tons for surface mixtures.

PAY FACTORS – QC/QA HMA (DENSE GRADED ≥ 1 LOT)

Pay factors for dense graded QC/QA HMA mixtures with original pay item quantities greater than or equal to one lot are determined in accordance with the procedures for Percent Within Limits (PWL) designated in ITM 588. The PWL method uses the average and standard deviation of the lot tests to estimate the percentage of the lot that is within the specification limits. The procedure for determining the PWL of the lot is as follows:

PWL – MIXTURE

1. Determine the average of the lot mixture properties for air voids at N_{des} and Vbe as follows:

$$\bar{x} = \sum_{i=1}^{n} \frac{x_i}{n}$$

where:

$\bar{x}$ = average of the lot mixture property values
x_i = sublot mixture property value
n = number of mixture sublot samples in the lot

The air voids and Vbe lot average values are reported to the nearest 0.01 %.

2. Determine the standard deviation of the lot mixture property as follows:

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

where:

s = standard deviation of the lot mixture property

x_i = sublot mixture property value

$\bar{x}$ = average of the lot mixture property values

n = number of mixture sublot samples in the lot

The standard deviation values for air voids and Vbe are reported to the nearest 0.01.

3. Calculate the Upper Quality Index for each mixture property by subtracting the lot average of each mixture property from the Upper Specification Limit (Figure 7.8) and dividing the result by the standard deviation of the lot mixture property as follows:

$$Q_U = \frac{USL - \bar{x}}{s}$$

where:

Q_u = Upper Quality Index

USL = Upper Specification Limit

$\bar{x}$ = average of the lot mixture property values

s = standard deviation of the lot mixture property

The air voids and Vbe Upper Quality Index values are reported to the nearest 0.01.

FIGURE 7.8 SPECIFICATION LIMITS

SPECIFICATION LIMITS		
Mixture		
	LSL*	USL**
Air Voids(Va) at N_{des}, %	3.60	6.40
Vbe at N_{des}, %	Spec	Spec + 2.50
Density		
	LSL*	USL**
Roadway Core Density ($\%G_{mm}$), %	93.00	Not Applicable
* LSL, Lower Specification Limit ** USL, Upper Specification Limit		

4. Calculate the Lower Quality Index for each mixture property by subtracting the Lower Specification Limit (Figure 7.8) from the lot average of each mixture property and dividing the result by the standard deviation of the lot mixture property as follows:

$$Q_L = \frac{\bar{x} - LSL}{s}$$

where:

QL = Lower Quality Index
LSL = Lower Specification Limit
$\bar{x}$ = average of the lot mixture property values
s = standard deviation of the lot mixture property

The air voids and Vbe Lower Quality Index values are reported to the nearest 0.01

5. Determine the percentage of material that will fall within the Upper and Lower Specification Limits (Table of Quality Index Values found in ITM 588 in Chapter 8) with QU or QL using the column appropriate to the total number of measurements, n.
6. Determine the percent of material that will fall within the limits for each mixture property by adding the percent within the Upper Specification Limit (PWL_U) to the percent within the Lower Specification Limit (PWL_L), and subtracting 100 from the total as follows: Total PWL = (PWL_U + PWL_L) - 100

PWL – DENSITY

1. Determine the average of the lot density values as follows:

   $$\bar{x} = \sum_{i=1}^{n} \frac{x_i}{n}$$

   where:

   $\bar{x}$ = average of the lot density values

   xi = core density value

   n = number of cores in the lot

   The density (% Gmm) lot average value is reported to the nearest 0.01 %.

2. Determine the standard deviation of the lot density as follows:

   $$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

   where:

   s = standard deviation of the density of the lot

   $\bar{x}$ = average of the lot density values

   xi = core density value

   n = number of cores in the lot

   The standard deviation value is reported to the nearest 0.01.

3. Calculate the Lower Quality Index for in-place density (% Gmm) by subtracting the Lower Specification Limit (Figure 7.7) from the average of the density of the lot and dividing the result by the standard deviation of the density of the lot as follows:

   $$Q_L = \frac{\bar{x} - LSL}{s}$$

   where:

   QL = Lower Quality Index

   LSL = Lower Specification Limit

   $\bar{x}$ = average of the lot density values

   s = standard deviation of the density of the lot

   The density Lower Quality Index value is reported to the nearest 0.01.
4. Determine the PWL for density by entering the table of Quality Index Values (Figure 7.8) using the column appropriate to the total number of measurements, n.
5. Determine the percent within the lower specification limit (PWL_L) for density as follows:
   Total PWL = PWL_L

PAY FACTORS

Pay factors (PF) are calculated for the air voids at N_{des}, Vbe, and in-place density (% G_{mm}). The appropriate pay factor for each property is calculated as follows:

Estimated PWL > 90

Pay Factor = PF = ((0.50 x PWL) + 55.00)/100

Estimated PWL > 70 and ≤ 90:

Pay Factor = PF = ((0.40 x PWL) + 64.00)/100

Estimated PWL ≥ 50 and ≤ 70

Pay Factor = PF = ((0.85 x PWL) + 32.5)/100

Air voids, Vbe, and in-place density PF values are reported to the nearest 0.01.

If the Lot PWL for any one of the properties is less than 50 or a sublot has an air void content less than 1.0 %, the lot is referred to the Division of Materials and Tests as a failed material.

A composite pay factor for each lot based on the mixture properties and density is determined by a weighted formula as follows:

Lot Pay Factor = 0.30 (PF_{VOIDS}) + 0.35 (PF_{VBE}) + 0.35 ($PF_{DENSITY}$)

where:

Lot PF = Lot Composite Pay Factor for Mixture and Density

PF VOIDS = Lot Pay Factor for Air Vois at N_{des}

PF VBE = Lot Pay Factor for Vbe

PF DENSITY = Lot Pay Factor for In-Place Density (%G_{mm})

QUALITY ASSURANCE ADJUSTMENT – QC/QA HMA ≥ 1 LOT

The pay factors are used to calculate a quality assurance adjustment (q) for the lot. The adjustment for mixture properties and density is calculated as follows:

$$q = L \times U \times (\text{Lot PF} - 1.00)/MAF$$

where:

q	= quality assurance adjustment for mixture properties and density of the lot
L	= Lot quantity
U	= Unit price for the material, $/Ton
Lot PF	= Lot Pay Factor
MAF	= Mixture Adjustment Factor

The following example indicates how the Pay Factors and the Quality Assurance Adjustment for PWL are determined for QC/QA mixtures ≥ 1 Lot:

Example: 19.0 mm Intermediate

Sublot 1 = 1000 tons
Sublot 2 = 1000 tons
Sublot 3 = 1000 tons
Sublot 4 = 1000 tons
Sublot 5 = 1000 tons

Unit Price = $60.00/ton
MAF = 1.000
Air Voids DMF = 5.0 %
Vbe spec minimum = 9.0 %

	Sublot 1	Sublot 2	Sublot 3	Sublot 4	Sublot 5
% Binder	4.80	4.90	5.20	5.20	5.30
Air Voids	3.80	3.50	3.20	4.70	4.60
VMA	13.80	13.90	12.60	12.80	13.70
Vbe	10.00	10.40	9.40	8.10	9.10
Density (%MSG)	93.10	93.30	94.20	92.90	95.50

Air Voids

$$\bar{x} = \frac{3.80 + 3.50 + 3.20 + 4.70 + 4.60}{5} = 3.96$$

s = 0.67

USL = 6.40

$$Q_U = \frac{USL - \bar{x}}{s} = \ 6.40 - 3.96 / 0.67 = 3.64$$

From Figure 7.8 for n = 5 the PWL_U is 100

LSL = 3.60

$$Q_L = \frac{\bar{x} - LSL}{s} = \ 3.96 - 3.60 / 0.67 = 0.54$$

From Figure 7.8 for n = 5 the PWL_L is 69

Total PWL = (PWL_U + PWL_L) – 100 = (100 + 69) – 100 = 69

Pay Factor (Estimated PWL > 70) = ((0.85 x PWL) + 32.5)/100

= ((0.85 x 69) + 32.5)/100

= 0.91

Pay Factors for the Vbe, and Density are indicated in Figures 7.11 thru 7.14 and are as follows:

Pay Factor (Vbe) = 0.89
Pay Factor (Density) = 0.95

Lot Pay Factor = + 0.30 (PF_{VOIDS}) + 0.35 (PF_{VBE}) + 0.35 ($PF_{DENSITY}$)
= + 0.30 (0.91) + 0.35 (0.89) + 0.35 (0.95)
= + 0.273 + 0.312 + 0.333 = 0.918 = 0.92

The Quality Assurance Adjustment for the Lot is calculated as follows:

Quality Assurance Adjustment ($) = L x U x (Lot PF – 1.00)/MAF
L = Lot quantity
U = Unit Price for Material, $/Ton
Lot PF = Lot Pay Factor
MAF = Mixture Adjustment Factor

Quality Assurance Adjustment = 5000.00 tons x $60.00 x (0.92 – 1.00)/1.000
= - $24,000.00

INDIANA DEPARTMENT OF TRANSPORTATION

HOT MIX ASPHALT ANALYSIS FOR QUALITY ASSURANCE

CONTRACT NO. ____________ PLANT NO. __________ LOT NO. ______ DATE ___________

MIXTURE _________________________________ DMF NO. __________________________

Mixture & Density	$\bar{x}$	S	Qu			Q_L			Total PWL
			USL	$Q_U = \frac{USL - \bar{x}}{s}$	PWL_U	LSL	$Q_L = \frac{\bar{x} - LSL}{s}$	PWL_L	
Air Voids	3.96	0.67	6.40	3.64	100	3.60	0.54	69	69
Vbe	9.40	0.89	11.5	2.36	100	9.00	0.45	66	66
Density (% MSG)	93.80	0.1.01				93.00	0.79	78	78

Air Voids		Vbe		Density		Lot Pay Factor	Quality Assurance Adjustment
Pay Factor	0.30xPF	Pay Factor	0.35xPF	Pay Factor	0.35xPF		
0.91	0.273	0.89	0.312	0.95	0.333	0.92	- $24,000

Estimated PWL > 90

Pay Factor = PF = ((0.50 x PWL) + 55.00)/100

Estimated PWL > 70 and ≤ 90:

Pay Factor = PF = ((0.40 x PWL) + 64.00)/100

Estimated PWL ≥ 50 and ≤ 70

Pay Factor = PF = ((0.85 x PWL) + 32.5)/100

Lot Pay Factor = 0.30 (PF_{VOIDS}) + 0.35 (PF_{VBE}) + 0.35 ($PF_{DENSITY}$)

Quality Assurance Adjustment ($) = L x U x (Lot PF – 1.00)/MAF

L = Lot quantity
U = Unit Price for Material, $/Ton
Lot PF = Lot Pay Factor
MAF = Mixture Adjustment Factor

PAY FACTORS – QC/QA HMA (DENSE GRADED MIXTURE < 1 LOT AND OPEN GRADED MIXTURES)

After the tests are conducted, the test data is evaluated for compliance with the Specifications. CAA and temperature tests are taken in accordance with standard procedures and recorded. For open graded mixtures, lot numbers begin with number 1 for each type of mixture and are continuous for the entire contract regardless of the number of adjustment periods for that type of mixture. Mixtures with original pay item quantities less than 300 tons will be accepted by Type D Certification.

When the required tests for one sublot are completed, the difference between the test values and the required value is determined and pay factors calculated. A composite pay factor for each sublot is determined for the air voids @ N_{des}, Vbe, and density of the mixture as follows:

Dense Graded Mixture:

$$SCPF = 0.30(PF_{VOIDS}) + 0.35(PF_{VBE}) + 0.35(PF_{DENSITY})$$

Open Graded Mixture:

$$SCPF = 0.20(PF_{BINDER}) + 0.35(PF_{VOIDS}) + 0.45$$

where:

SCPF	=	Sublot Composite Pay Factor for Mixture and Density
PF VOIDS	=	Sublot Pay Factor for Air Voids at N_{des}
PF VBE	=	Sublot Pay Factor for Vbe
PF DENSITY	=	Sublot Pay Factor for Density

If the SCPF for an open graded sublot is less than 0.85, the pavement is evaluated by INDOT. If the Contractor is not required to remove the mixture, quality assurance adjustments of the sublot are assessed or other corrective actions taken as determined by INDOT.

MIXTURE

Sublot test results for mixture properties are assigned pay factors in accordance with the following:

FIGURE 7.9 OPEN GRADED BINDER CONTENT

Binder Content	
Open Graded Deviation from DMF (±%)	**Pay Factor**
≤ 0.2	1.05
0.3	1.04
0.4	1.02
0.5	1.00
0.6	0.90
0.7	0.80
0.8	0.60
0.9	0.30
1.0	0.00
>1.0	Submitted to the Division of Materials and Tests*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.	

FIGURE 7.10 AIR VOIDS

Air Voids		
Dense Graded Deviation from Spec (±%)	**Open Graded Deviation** (±%)**	**Pay Factor**
≤ 0.5	≤ 3.0	1.05
> 0.5 and ≤ 1.7	> 3.0 and ≤ 4.0	1.00
	4.1	0.98
1.8	4.2	0.96
	4.3	0.94
	4.4	0.92
1.9	4.5	0.90
2.0	4.6	0.84
	4.7	0.78
	4.8	0.72
	4.9	0.66
	5.0	0.60
> 2.0	> 5.0	Submitted to the Division of Materials and Tests*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03. ** Deviation shall be from 17.5% for OG25.0 mm and OG19.0 mm mixtures and shall be from 12.5% for OG9.5 mm mixtures.		

FIGURE 7.11 Vbe

Volume of Effective Binder, Vbe	
Dense Graded	**Pay Factors**
Deviation from Spec Minimum	
> +3.0	Submitted to the Division of Materials and Tests*
⩾ +2.5 and ⩽ +3.0	1.00 - 0.05 for each 0.1% above +2.5%
≥ +2.0 and < +2.5	1.05 - 0.01 for each 0.1% above +2.0%
> +0.5 and < +2.0	1.05
⩾ 0.0 and ⩽ +0.5	1.05 - 0.01 for each 0.1% below +0.5%
⩾ -0.5 and < 0.0	1.00 - 0.02 for each 0.1% below 0.0%
⩾ -2.0 and < -0.5	0.90 - 0.06 for each 0.1% below - 0.5%
< -2.0	Submitted to the Division of Materials and Tests*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.	

FIGURE 7.12 VBE PAY FACTORS

Vbe					
Deviation*	**PF**	**Deviation***	**PF**	**Deviation***	**PF**
-2.1	fail	**-0.3**	0.94	**1.5**	1.05
-2.0	0.00	**-0.2**	0.96	**1.6**	1.05
-1.9	0.06	**-0.1**	0.98	**1.7**	1.05
-1.8	0.12	**0.0**	1.00	**1.8**	1.05
-1.7	0.18	**0.1**	1.01	**1.9**	1.05
-1.6	0.24	**0.2**	1.02	**2.0**	1.05
-1.5	0.30	**0.3**	1.03	**2.1**	1.04
-1.4	0.36	**0.4**	1.04	**2.2**	1.03
-1.3	0.42	**0.5**	1.05	**2.3**	1.02
-1.2	0.48	**0.6**	1.05	**2.4**	1.01
-1.1	0.54	**0.7**	1.05	**2.5**	1.00
-1.0	0.60	**0.8**	1.05	**2.6**	0.95
-0.9	0.66	**0.9**	1.05	**2.7**	0.90
-0.8	0.72	**1.0**	1.05	**2.8**	0.85
-0.7	0.78	**1.1**	1.05	**2.9**	0.80
-0.6	0.84	**1.2**	1.05	**3.0**	0.75
-0.5	0.90	**1.3**	1.05	**3.1**	fail
-0.4	0.92	**1.4**	1.05	*Spec minimum	

DENSITY

Sublot test results for density are assigned pay factors in accordance with the following:

FIGURE 7.13 DENSITY

Density	
Percentages Dense	**Pay Factors, %**
⩾ 98.0	Submitted to the Division of Materials and Tests*
97.0 - 97.9	1.00
96.6 - 96.9	1.05 - 0.01 for each 0.1% above 96.5
95.0 - 96.5	1.05
94.1 - 94.9	1.00 + 0.005 for each 0.1% above 94.0
93.0 - 94.0	1.00
92.0 - 92.9	1.00 - 0.005 for each 0.1% below 93.0
91.0 - 91.9	0.95 - 0.010 for each 0.1% below 92.0
90.0 - 90.9	0.85 - 0.030 for each 0.1% below 91.0
⩽ 89.9	Submitted to the Division of Materials and Tests*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.	

FIGURE 7.14 DENSITY PAY FACTORS

Density							
Density	**PF**	**Density**	**PF**	**Density**	**PF**	**Density**	**PF**
≤ 89.9	Fail	**91.9**	0.940	**93.9**	1.000	**96.0**	1.050
90.0	0.550	**92.0**	0.950	**94.0**	1.000	**96.1**	1.050
90.1	0.580	**92.1**	0.955	**94.1**	1.005	**96.2**	1.050
90.2	0.610	**92.2**	0.960	**94.2**	1.010	**96.3**	1.050
90.3	0.640	**92.3**	0.965	**94.3**	1.015	**96.4**	1.050
90.4	0.670	**92.4**	0.970	**94.4**	1.020	**96.5**	1.050
90.5	0.700	**92.5**	0.975	**94.5**	1.025	**96.6**	1.040
90.6	0.730	**92.6**	0.980	**94.6**	1.030	**96.7**	1.030
90.7	0.760	**92.7**	0.985	**94.7**	1.035	**96.8**	1.020
90.8	0.790	**92.8**	0.990	**94.8**	1.040	**96.9**	1.010
90.9	0.820	**92.9**	0.995	**94.9**	1.045	**97.0**	1.000
91.0	0.850	**93.0**	1.000	**95.0**	1.050	**97.1**	1.000
91.1	0.860	**93.1**	1.000	**95.1**	1.050	**97.2**	1.000
91.2	0.870	**93.2**	1.000	**95.2**	1.050	**97.3**	1.000
91.3	0.880	**93.3**	1.000	**95.3**	1.050	**97.4**	1.000
91.4	0.890	**93.4**	1.000	**95.4**	1.050	**97.5**	1.000
91.5	0.900	**93.5**	1.000	**95.5**	1.050	**97.6**	1.000
91.6	0.910	**93.6**	1.000	**95.6**	1.050	**97.7**	1.000
91.7	0.920	**93.7**	1.000	**95.7**	1.050	**97.8**	1.000
91.8	0.930	**93.8**	1.000	**95.8**	1.050	**97.9**	1.000
				95.9	1.050	**≥ 98.0**	Fail

ADJUSTMENT QUANTITY – QC/QA HMA < 1 LOT AND OPEN GRADED MIXTURES

The pay factors are used to calculate a quality assurance adjustment quantity (q) for the sublot. The adjustment for mixture properties and density is calculated as follows:

q = L x U x (SCPF - 1.00)/MAF

where:

q = quality assurance adjustment for the sublot

L = Sublot quantity

U = Unit price for the material, $/Ton

SCPF = Sublot composite pay factor

The following example indicates how Quality Assurance Adjustments are determined for QC/QA mixtures < 1 Lot:

Example:

25.0 mm Base

Sublot 1 = 1000 tons

Sublot 2 = 1000 tons

Sublot 3 = 1000 tons

Sublot 4 = 855 tons

Unit Price = $58.00/ton

MAF = 1.000

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
Air Voids	3.80	3.70	3.20	4.70
VMA	12.20	12.10	11.60	13.40
Vbe	8.40	8.40	8.40	8.70
Density (%MSG)	91.10	90.70	89.90	92.90

Deviations for Air Voids and Vbe:

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
Air Voids	-1.2	-1.3	-1.8	-0.3
Vbe	+0.4	+0.4	+0.4	+0.7

Using the pay factor charts, the following values are obtained:

	Sublot 1	Sublot 2	Sublot 3	Sublot 4
Air Voids	1.00	1.00	0.96	1.05
Vbe	1.04	1.04	1.04	1.05
Density (%MSG)	0.86	0.76	0.82 (FAIL)	1.00

Calculations to determine the Quality Assurance Adjustment are indicated in Figure 7.15.

FIGURE 7.15 HMA ANALYSIS FOR QUALITY ASSURANCE

INDIANA DEPARTMENT OF TRANSPORTATION

HOT MIX ASPHALT ANALYSIS FOR QUALITY ASSURANCE

CONTRACT NO. _______________ PLANT NO. _________ LOT NO. __________ DATE ____________

MIXTURE ____ DMF NO. ____________________

Mixture & Density	SUBLOT 1			SUBLOT 2			SUBLOT 3			SUBLOT 4		
	Pay Factor	Mult		Pay Factor	Mult		Pay Factor	Mult.		Pay Factor	Mult.	
Air Voids	1.00	0.30	0.300	1.00	0.30	0.300	0.96	0.30	0.288	1.05	0.30	0.315
Vbe	1.04	0.35	0.364	1.04	0.35	0.364	1.04	0.35	0.364	1.05	0.35	0.368
Density	0.86	0.35	0.301	0.76	0.35	0.266	FAIL	0.35	FAIL	1.00	0.35	0.350
SCPF			0.97			0.93			FAIL			1.03

* Requires submittal to the Materials and Tests Division for Failed Material Investigation

QUALITY ASSURANCE ADJUSTMENTS							
Sublot 1 Quantity L (tons)	Sublot 1 Adjustment ($)	Sublot 2 Quantity L (tons)	Sublot 2 Adjustment ($)	Sublot 3 Quantity L (tons)	Sublot 3 Adjustment ($)	Sublot 4 Quantity L (tons)	Sublot 4 Adjustment ($)
1000.00	**-1,740.00**	1000.00	**-4,060.00**	1000.00	**FAIL**	855.00	**+ 1,487.70**

U = Unit Price for Material, $/Ton

Quality Assurance Adjustment = L x U x (SCPF – 1.00) / MAF

MIX APPEAL – QC/QA HMA

If the Producer's QC test results do not agree with the Department's acceptance test results, a request may be submitted in writing that additional samples be tested. The written request is required to include a comparison of the QC and acceptance test results and be made within seven calendar days of receipt of the written results of the asphalt mixture tests for that lot.

The Contractor may appeal an individual sublot for the binder content, the MSG, the BSG of the gyratory specimens or the BSG of the density cores when the QC results are greater than one standard deviation from the acceptance test results as follows: 0.25 for binder content, 0.010 for the MSG, 0.010 for the BSG of the gyratory specimens and 0.020 for the BSG of the density cores. Upon approval of the appeal, the backup samples are tested as follows:

1. Maximum Specific Gravity -- The sample is dried in accordance with **ITM 572** and mass determined in water in accordance with **AASHTO T 209**
2. Bulk Specific Gravity of the Gyratory Specimens -- New gyratory specimens are prepared and tested in accordance with **AASHTO T 312**
3. Binder Content -- The binder content is tested in accordance with **ITM 571**
4. Bulk Specific Gravity of the Density Core -- Additional cores are taken within seven calendar days unless otherwise directed. The core locations are determined by adding 1.0 ft longitudinally of the cores tested for acceptance using the same transverse offset. The cores are dried in accordance with **ITM 572** and tested in accordance with **AASHTO T 166**, Method A.

The appeal results replace all previous test result(s) for acceptance of the mixture properties and density.

A $500.00 credit adjustment will be included in a quality adjustment pay item for each appealed sublot that did not result in an improvement to the SCPF or LCPF.

SMOOTHNESS

Smoothness is an important aspect of pavement performance. Smoothness of pavement affects many things including:

- Public Safety- vehicles are more controllable
- Ride quality
- Pavement longevity

It is important to measure smoothness at the time of pavement construction.

INDOT measures smoothness by the following methods:

- 16 Foot or 10 Foot Straight Edge
- Inertial Profiler (IRI)

Specific details of smoothness acceptance can be found in section 401.18 of the Standard Specifications.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

SAMPLING STOCKPILED AGGREGATES
ITM No. 207-15T

1.0 SCOPE.

1.1 This test method covers sampling fine and coarse aggregate stockpiles.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 SIGNIFICANCE AND USE. This ITM provides guidance on how to obtain aggregate samples from aggregate stockpiles for control of production at the source or control of the materials at the point of use.

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications, Section 101.

4.0 APPARATUS.

4.1 Square bit shovel

4.2 Fire shovel

4.3 Sampling tube, 3 in. minimum in diameter and 3 ft minimum in length

5.0 SAMPLING.

5.1 Coarse Aggregate Sampling.

5.1.1 Using a front-end loader, dig into the stockpile and set aside a small pile of 10 to 15 t of material. This procedure shall be done in the same manner as if a truck is being loaded for shipment (Figures 1 and 2). When forming the small pile, the loader bucket shall be as low as possible and roll the material from the bucket rather than dumping the material. Reducing the distance the material is allowed to free-fall will reduce the amount of segregation that may occur in the small pile (Figure 3). Each additional bucket load of material shall be obtained and dumped in the same manner as set out above and shall be placed uniformly over the preceding one (Figure 4).

5.1.2 Thoroughly mix the small pile. Using the loader bucket, proceed to the end of the oblong pile and roll the material over. Keeping the loader bucket as low as possible, push the bucket into the material until the front of the bucket is past the midpoint of the original pile. The loader bucket shall then be slowly raised and rolled forward thus producing a smooth mixing of the material (Figures 5, 6, and 7). Proceed to the opposite end of the pile and repeat this mixing procedure. If the pile does not appear to be uniform, additional mixing shall be done.

5.1.3 The pile is now ready for sampling. Do <u>not</u> strike off the top of the stockpile (Figure 8). The sample shall be taken at the center of the volume which is approximately one-third of the height of the pile. The sample shall consist of not less than six full shovels of material taken at equal increments around the pile (Figures 9, 10, and 11). A square bit shovel shall be used. The size of the shovel shall be such that the sample meets the minimum weight (mass) requirements of the test conducted on the sample. The shovel shall be inserted full-depth horizontally into the material and raised vertically. Care shall be taken to retain as much of the material as possible on the blade of the shovel (Figure 12).

5.2 Fine Aggregate Sampling.

5.2.1 Fine aggregate samples are normally obtained as set out above for coarse aggregate, except a fire shovel or sampling tube shall be used.

5.2.2 When fine aggregate stockpiles are constructed so as to not exceed the height of the sampler, and when segregation is not apparent, the samples may be taken directly from the face of the large stockpile. The surface crust of the stockpile is required to be removed from the sampling area.

6.0 SAFETY.

6.1 Samples shall not be obtained by climbing onto stockpiles due to the hazard of burial and suffocation from unstable stockpiles of unconsolidated materials. Also, over-steepened stockpiles that may sluff and engulf personnel in the immediate area should be avoided.

6.2 Personnel requiring additional information concerning specific sampling situations are directed to contact the appropriate District Testing Engineer.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

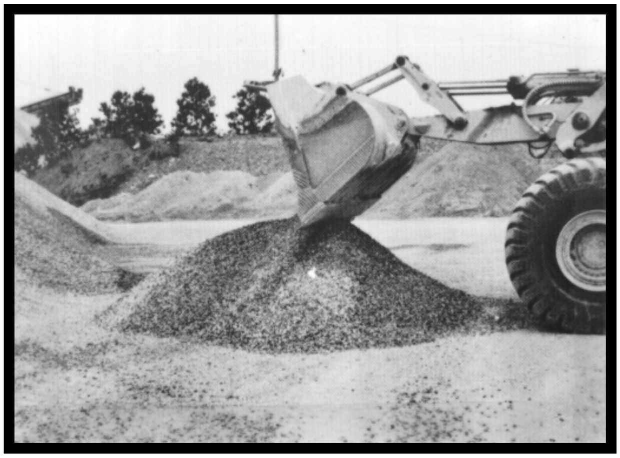


Figure 7

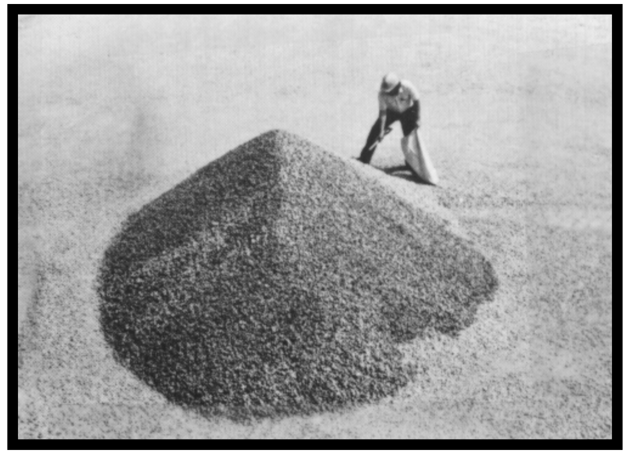


Figure 8

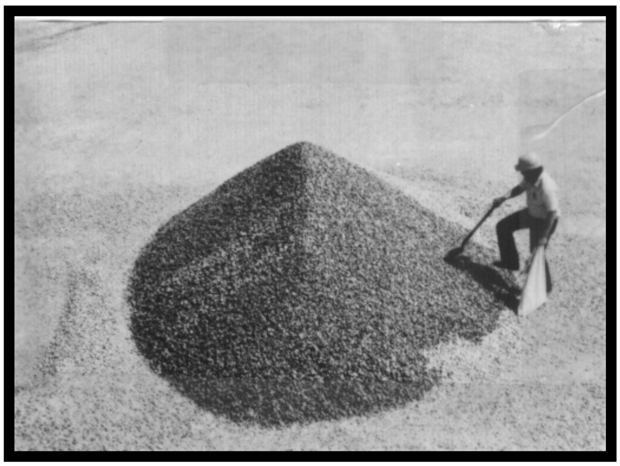


Figure 9

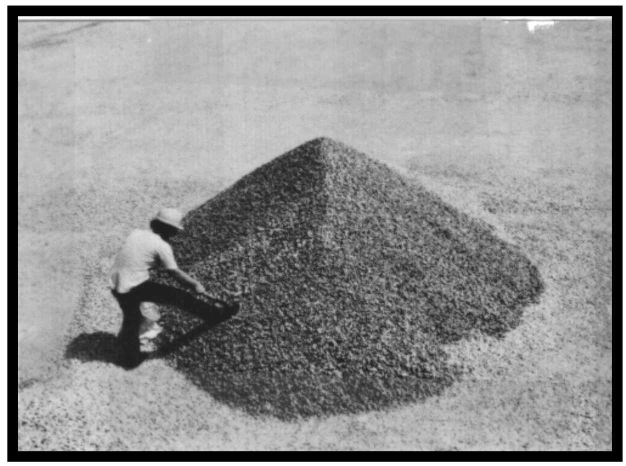


Figure 10

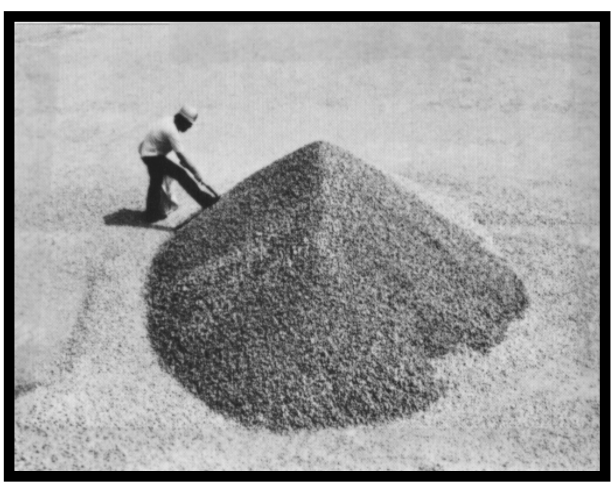


Figure 11

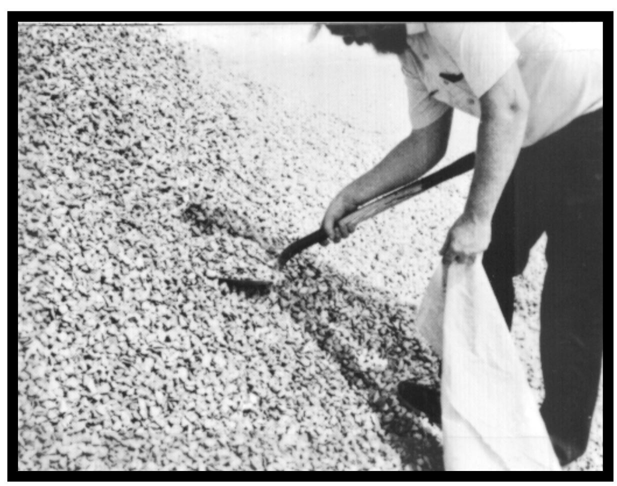


Figure 12

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

QUANTITATIVE EXTRACTION OF ASPHALT AND GRADATION OF EXTRACTED AGGREGATE FROM HMA MIXTURES
ITM No. 571-20

1.0 SCOPE.

1.1 This method of test covers the procedure for the quantitative determination of the asphalt/binder content and gradation of the extracted aggregate of HMA mixtures.

1.2 The HMA mixture is extracted with a suitable solvent, depending on the type of extraction apparatus used. The asphalt content is calculated by determining the difference of the weight (mass) of the HMA mixture and the extracted aggregate, fibers if used, and the fines recovered from the extracted solvent and water rinse, if required. The gradation of the extracted aggregate is then determined.

1.3 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 231 Weighing Devices Used in the Testing of Materials
T 30 Mechanical Analysis of Extracted Aggregate
T 164 Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)

2.2 ITM Standards.

572 Dying HMA Mixtures
580 Sampling HMA
587 Reducing HMA Samples to Test Size

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM shall be used to determine the asphalt content and gradation of the extracted HMA mixture.

5.0 APPARATUS.

5.1 Balance, a Class G2, in accordance with AASHTO M 231

5.2 Electric skillet, with a thermostatic heat control capable of heating to 221°F

5.3 Oven, capable of maintaining the temperature at 221 ± 9°F

5.4 Pans and containers as needed

5.5 Sieves, in accordance with AASHTO T 30

5.6 Spatulas and trowels as needed

5.7 Stiff bristle brush, 1 in. in diameter

5.8 Thermometer, armored with a range of 100°F to 450°F, readable to 5°F

5.9 Wash bottle

6.0 REAGENTS.

6.1 Alternative Extraction Solvent.

6.2 Trichloroethylene

Note 1: INDOT labs will use trichloroethylene exclusively

7.0 SAFETY PRECAUTIONS.

7.1 Provide adequate ventilation and avoid inhalation of vapor. The ventilation fan shall be operating during the testing.

7.2 The exhaust from the vacuum pump shall be vented outside.

7.3 The extraction solvent shall be an approved solvent.

8.0 SAMPLING. Sampling shall conform to the requirements of ITM 580.

9.0 PREPARATION OF SAMPLE.

9.1 If the sample is not sufficiently soft to separate with a spatula or a trowel, place the sample in a large flat pan and heat to a maximum of 221 ± 9°F only until the sample may be handled. Separate the sample as uniformly as possible, using care not to fracture the mineral aggregate.

9.2 Reduce the sample in accordance with ITM 587, minimum weight procedure. The approximate minimum size of the sample shall be in accordance with the following:

Mixture Designation	Minimum Weight (mass) of Sample, g
4.75 mm	1000
9.5 mm	1500
12.5 mm	2000
19.0 mm, OG 19.0 mm	3000
25.0 mm, OG 25.0 mm	4000

9.3 After reduction, place the sample on a flat non-stick surface, and continue to stir the sample using a spatula. When the sample is cool enough to handle with gloves, continue to separate particles using care not to fracture the aggregate.

10.0 PROCEDURES.

10.1 Method A - Centrifuge Extractor.

10.1.1 Method Specific Apparatus. In addition to the apparatus listed in 5.0, the following apparatus is required for Method A.

a) Centrifuge Extractor having controlled variable speed up to 3600 rpm

b) Filter rings, to fit the rim of the centrifuge bowl

c) Continuous-Flow Filterless high speed centrifuge having the ability to reach a minimum speed of 10,000 rpm

d) Aluminum cups for Continuous-Flow Filterless high speed centrifuge

e) Balance conforming to the requirements of AASHTO M 231, Class G1

f) No. 200 sieve

10.1.2 Centrifuge Extractor.

a) Dry the sample to constant weight in accordance with ITM 572. (This is not required if the sampled has been conditioned per Directive 303)

b) Dry the filter to a constant mass at 221 ± 9°F

c) Allow the sample to cool and ensure particles are separated without fracturing

d) Place the sample in a tared extraction bowl and determine the weight

e) Place the bowl on the extractor and cover the sample with solvent

f) Allow the solvent to break down the sample for a minimum of 1 hour, not to exceed 3 hours (soaking period).

g) Assemble the centrifuge extractor with a dry weighed filter paper in place. Clamp the cover on tightly and place a container under the drain to collect the extracted solvent.

h) Start the centrifuge revolving slowly and gradually increase the speed until a steady stream of solvent flows from the drain (approx. 1400 rpm). Continue until the solvent ceases to flow from the drain.

i) Stop the centrifuge. Add a minimum of 500 mL of solvent.

j) Repeat the extraction and solvent addition process in 10.1.2h and 10.1.2i according to the following:

Mixture	Minimum Solvent Additions (after the soak)
Dense Graded/OG	5
SMA	8

k) After the extracted solvent is a light straw color (when viewed against a white background) remove the extractor lid and leave the open bowl in the fume hood to allow fumes to dissipate

l) Carefully remove the filter and inspect the sample for conglomerated material. If found, break the conglomerated material up and saturate with solvent. Reinstall the filter and clamp the bowl into the extractor for solvent additions as needed

m) Remove the lid and allow fumes to dissipate

n) Remove the bowl and rinse the extractor clean using the solvent

o) Dry the extracted aggregate and filter to a constant weight in the oven or skillet at 221 ± 9 °F

p) Collect the extract for mineral matter determination.

10.1.3 Mineral Matter Determination by Continuous-Flow Filterless high speed centrifuge

a) Determine the mass of an empty centrifuge cup to the nearest 0.1 g

b) Place the cup in the filterless centrifuge and position a container to catch the effluent

c) Pour the extract through a No. 200 sieve into the centrifuge feeder bowl and wash any retained material back into the sample.

d) Start the filterless centrifuge and allow it to reach a constant speed

e) Open the feed line to allow extract to be fed at a rate of 100 to 150 mL per minute

f) The remaining extract, if any, added to the feeder bowl and container rinsed several times with solvent

g) Rinse the feed mechanism several times with clean solvent until effluent is colorless

h) Stop the filterless centrifuge and remove the cup

i) Clean the outside of the cup with solvent and place cup into fume hood to allow solvent to evaporate

j) Dry the cup in an oven at 221 ± 9 °F to a constant weight

k) Allow the cup to cool and immediately determine the mass to the nearest 0.1g

l) Report the increase of the cups mass from the original dry mass of the cup as the mass of the mineral matter (cup fines)

10.1.4 Calculation Using Centrifuge.

a) The asphalt content in percent is calculated by the following formula:

$$\text{Asphalt Content, \%} = \frac{W_1 - (W_2 + W_3)}{W_1} \times 100$$

where:

W_1 = weight of sample, g
W_2 = weight of extracted aggregate, g
W_3 = weight of fines in extracted solvent (cup and filter fines), g

10.2 Method B - Vacuum Extractor.

Note 2: It should not be assumed that results from Method B are equivalent to Method A or C.

10.2.1 Method Specific Apparatus. In addition to the apparatus listed in 5.0, the following apparatus is required for Method B:

a) Vacuum extractor

b) Filter paper, medium grade, fast filtering of the diameter required to fit the extractor, (Eaton-Dikeman #633-70)

c) Vacuum pump

d) Pan, round, bowl type, stainless steel

e) No. 200 sieve

10.2.2 Vacuum Extractor for Mixture without Fibers.

a) Weigh approximately 50 g (record exact weight) of a filtering aid, such as celite, into a 1000 mL flask, add 500 mL of extraction solvent, and swirl until the filtering aid is completely in suspension. 100 g of filtering aid may be used if the solvent does not readily pass through the filter. Immediately pour the solution onto the filter. Start the vacuum pump and let the pump run until the pad formed by the filtering aid is surface dry and begins to crack slightly. Collect the solvent which goes through the filter in a flask, and pour the solvent onto the filter.

b) Dry the sample to a constant weight in accordance with ITM 572. Determine the weight of a dry filter paper at 221 ± 9°F

c) If the sample is in an oven bag, remove the sample from the bag, and weigh the sample. Add enough solvent to cover the sample and stir vigorously (Note 3). Stirring shall continue until the sample is completely separated and essentially clean of the asphalt.

Note 3: Soaking the sample after stirring for several minutes may be beneficial in removing the asphalt from the aggregate. Extended soaking is acceptable only for aggregates with low water absorption values.

d) Place a No. 200 sieve on the filter of the extractor and start the vacuum pump

e) Pour the solvent from the initial rinse onto the No. 200 sieve. If the solvent does not readily pass through the filter, lightly scrape the celite to remove the fines. After the solvent has decanted through the filter, pour approximately 500 mL of solvent into the extractor and let this decant through the filter.

f) Add 200 - 400 mL of solvent to the sample again and decant the solvent into the extractor. Repeat this procedure until the aggregate is clean of asphalt and the extracted solvent is a light straw color (when viewed against a white background). Normally, approximately five rinses shall be needed to completely clean the sample (slag mixtures may require additional rinses.). Rinse the asphalt from the side of the extractor and the sieve with solvent.

g) Allow the vacuum pump to run until all of the solvent has been decanted through the filter and the filter has a completely dry appearance.

h) Gently stir the layer of celite to break the crust of fines which has formed on the pad. Caution is required to prevent tearing or puncturing the filter paper.

i) Start the pump and pour water through the No. 200 sieve to remove any film left from the solvent.

j) If the mixture of water and solvent forms a gel, replace the flask that has been used to collect the solvent and collect the water rinse separately.

k) Add enough water to cover the sample and stir well. The water will turn milky-white at this point. After completely stirring, pour the water through the No. 200 sieve, start the vacuum pump, and decant the water into a flask.

l) Repeat 10.2.2 k until the water is clear. Allow the vacuum pump to run until the filter pad is dry.

m) Rinse the fines accumulated on the No. 200 sieve into the extracted aggregate. Remove the filter ring and lift the filter and place the filter into another pan. Dry the filter to a constant weight in the oven or skillet at 221 ± 9°F, and weigh immediately upon removal from the oven or skillet.

n) Dry the extracted aggregate to a constant weight in the oven or skillet at 221 ± 9°F, and weigh.

o) The fines in the extracted solvent and water rinse shall be collected in accordance with 10.1.3.

10.2.3 Calculation without Fibers. The asphalt content in percent is calculated by the following formula:

$$\text{Asphalt Content, \%} = \frac{W_1 - (W_2 + W_3)}{W_1} \times 100$$

where:

W_1 = weight of sample, g
W_2 = weight of extracted aggregate, g
W_3 = weight of fines in extracted solvent and water rinse (cup and filter fines), g

10.2.4 Vacuum Extractor for Mixture with Fibers.

a) The extraction procedure shall be conducted in accordance with 10.2.2.

b) Rinse the fines and fibers accumulated on the No. 200 sieve into the extracted aggregate

c) Dry the extracted aggregate and fibers to a constant weight in the oven or skillet at 221 ± 9°F, and weigh

d) Remove the filter ring, lift the filter and place the filter into a separate bowl. Dry the filter in the oven or skillet at 221 ± 9 °F, and weigh immediately upon removal from the oven or skillet.

e) Place the extracted aggregate and fibers into the necessary series of sieves. After shaking, the fibers shall be removed from the sieves.

f) Place the fibers and three 1 in. washers into the series of sieves on the No. 4 sieve and shake for 10 minutes. Remove the fibers from the sieves and weigh separately.

g) The extracted aggregate weight that is used to calculate the gradation may be determined by subtracting the weight of the fibers determined in 10.2.4 f from the combined weight of extracted aggregate and fibers in 10.2.4 c and weight of fines in 10.2.4 d.

h) The fines in the extracted solvent and water rinse shall be collected in accordance with 10.1.3.

10.2.5 Calculation with Fibers.

a) The asphalt content is calculated by the following formula:

$$\text{Asphalt Content, \%} = \frac{W_1 - (W_2 + W_3 + W_4)}{W_1} \text{ x } 100$$

where:

W_1 = weight of test sample, g
W_2 = weight of extracted aggregate, g
W_3 = weight of fines in extracted solvent and water rinse, g
W_4 = weight of fibers, g

b) The fiber content in the mixture is calculated by the following formula:

$$\text{Fiber Content, lbm/t (kg/Mg)} = \frac{W_4}{W_1} \text{ x } 2000\,(1000)$$

10.3 Fines Correction Factor.

10.3.1 The extraction procedure shall be performed in accordance with 10.2.2 or 10.2.4.

10.3.2 The fines in the extracted solvent and water rinse shall be collected in accordance with 10.1.3.

10.3.3 Calculation with Fines Correction.

a) A fines correction factor shall be determined by the following formula:

$$\text{Fines Correction Factor (C)} = \frac{W_3}{W_5}$$

where:

W_3 = weight of fines in extracted solvent and water rinse, g
W_5 = weight of extracted aggregate passing the No. 200 sieve, g

b) The fines correction factor shall be applied to each subsequent extraction test for each mixture. The correction factor is multiplied by the weight of extracted aggregate passing the No. 200 sieve, and the calculated weight is considered the fines in the extracted solvent and water rinse.

c) The asphalt content in percent is calculated by the following formula:

$$\text{Asphalt Content, \%} + \frac{W_1 - (W_2 + (C \times W_5)}{W_1} \times 100$$

where:

C = fines correction factor
W_1 = weight of sample, g
W_2 = weight of extracted aggregate, g
W_5 = weight of extracted aggregate passing the No. 200 sieve, g

10.4 Method C - Continuous-Flow Filterless high speed centrifuge without Extractor.

Note 4: It should not be assumed that results from Method C are equivalent to Method A or B.

10.4.1 Method Specific Apparatus. In addition to the apparatus listed in 5.0, the following apparatus is required for Method C:

a) Pan, round, bowl type, stainless steel

b) No. 200 sieve

c) Suitable containers to collect the extracted solvent and water rinse

d) Continuous-Flow Filterless high speed centrifuge having the ability to reach a minimum speed of 10,000 rpm

e) Aluminum cups for Continuous-Flow Filterless high speed centrifuge

10.4.2 With Continuous-Flow Filterless high speed centrifuge

a) Dry the sample to a constant weight in accordance with ITM 572 (This is not required if the sampled has been conditioned for per Directive 303)

b) Add enough extraction solvent to cover the sample and stir vigorously (Note 3). Stirring shall continue until the sample is completely separated and essentially clean of the asphalt.

c) Place a No. 200 sieve over the container (placing the No. 200 sieve in a large funnel prior to collecting the solvent in the container is beneficial)

d) Pour the solvent from the initial rinse through the No. 200 sieve into the container

e) Add 200 to 400 mL of solvent to the sample and again pour the solvent through the No. 200 sieve into the container. Repeat this procedure until the aggregate is clean of asphalt. Normally, approximately five rinses shall be required to completely clean the sample (slag mixtures may require additional rinses.). Rinse the asphalt from the sieve with the solvent.

f) Replace the container that has been used to collect the solvent, and collect the water rinse separately.

g) Add enough water to cover the sample and stir well. The water shall turn milky-white at this point. After completely stirring, pour the water through the No. 200 sieve into the container.

h) Repeat 10.4.2 g until the water is clear

i) Rinse the fines accumulated on the No. 200 sieve into the extracted aggregate

j) Dry the extracted aggregate to a constant weight in the oven or skillet at 221 ± 9°F and weigh

k) The fines in the extracted solvent and water rinse shall be collected as in 10.1.3, except weighing may be performed to the nearest 0.1 g. The extracted solvent and water rinse shall be poured through the Continuous-Flow Filterless high speed centrifuge. The amount of material in the centrifuge cup(s) shall be verified to assure that the cup was not overloaded. If the cup was overloaded with fines, then an additional clean cup(s) shall be used, and the extracted solvent and water rinse shall be poured through the centrifuge again. This procedure is repeated until the cup is not overloaded.

10.4.3 Calculation with Continuous-Flow Filterless high speed centrifuge. The asphalt content in percent is calculated by the following formula:

$$\text{Asphalt Content, \%} = \frac{W_1 - (W_2 + W_3)}{W_1} \times 100$$

where:

W_1 = weight of sample, g
W_2 = weight of extracted aggregate, g
W_3 = weight of fines in extracted solvent and water rinse, g

11.0 GRADATION. The gradation of the extracted aggregate shall be in accordance with AASHTO T 30 except that decantation through the No. 200 sieve is not required. The entire sample of extracted aggregate is tested for gradation.

12.0 REPORT. The asphalt content and gradation are reported to the nearest 0.01% and the fiber content is reported to the nearest 0.1 lbm/t.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

DRYING HMA MIXTURES
ITM No. 572-15T

1.0 SCOPE.

1.1 This method of test covers the procedure for drying samples of HMA mixtures. Samples obtained in an oven bag require a moisture content determination. Samples, not requiring a moisture content determination shall be dried to a constant weight (mass).

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 231 Weighing Devices Used in the Testing of Materials

2.2 ASTM Standards.

D 7227 Rapid Drying of Compacted Asphalt Specimens using Vacuum Drying Apparatus

2.3 ITM Standards.

580 Sampling HMA

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM shall be used to dry HMA samples to constant weight. The moisture content of the HMA may also be determined, if required.

5.0 APPARATUS.

5.1 Oven, capable of maintaining the temperature at 221 ± 9°F

5.2 Electric skillet, with a thermostatic heat control capable of heating to 221°F

5.3 Spatulas and trowels as needed

5.4 Pans and containers as needed

5.5 Balance, a Class G2, in accordance with AASHTO M 231

5.6 Vacuum chamber, with pump capable of evacuating a sealed and enclosed chamber to a pressure of 6 mm Hg (6 torr) or less. The device shall have an automatic vacuum, airflow control, and temperature control features to ensure proper drying of the sample at close to room temperature. The vacuum chamber shall have a water removable plate and electronic cold trap with an airflow divider plate.

5.7 Infrared temperature sensor, handheld, accurate to a minimum of ± 9°F

5.8 Paper towel or absorptive cloth

6.0 SAMPLING. Sampling shall conform to the requirements of ITM 580.

7.0 WEIGHING. All measurements for one test shall be done on the same balance.

8.0 PREPARATION OF SAMPLE.

8.1 For samples not requiring determination of the moisture content, separate the samples as uniformly as possible, using care not to fracture the mineral particles.

8.2 The approximate minimum size of the sample for truck and plate samples shall be in accordance with the following:

Mixture Designation	Minimum Weight of Sample, g
4.75 mm	1000
9.5 mm	1500
12.5 mm	2000
19.0 mm, OG19.0 mm	3000
25.0 mm, OG25.0 mm	4000

9.0 PROCEDURES.

9.1 Plate Samples.

9.1.1 Determine the weight of a round, bowl type, metal pan and a spatula at 221 ± 9°F

9.1.2 Place the sample contained in the sealed oven bag (Note 1) in the tared metal pan with the spatula, and place in the oven at 221 ± 9°F

Note 1 - The weight of the oven bag shall be determined and recorded on the bag prior to obtaining the sample. A constant weight of the bag may be used for a particular type of oven bag.

9.1.3 Weigh the sample, bowl, and spatula after 1 h and record the weight

9.1.4 Open the oven bag and place the sample, metal pan, and spatula in the oven

9.1.5 Weigh the sample, metal pan, and spatula at 15 minute intervals until constant weight (Note 2) is achieved. Stir the sample after each weighing if the sample has not reached constant weight.

Note 2 - Constant weight is defined as the weight at which further drying at the required drying temperature does not alter the weight by more than 0.05 percent.

9.2 Truck Samples.

9.2.1 Determine the weight of a round, bowl type, metal pan and a spatula at 221 ± 9°F

9.2.2 Immediately place the sample contained in the sealed oven bag in the tared metal pan with the spatula, and weigh and record the weight

9.2.3 Open the bag and place the sample, metal pan, and spatula into the oven at 221 ± 9°F

9.2.4 Weigh the sample, metal pan, and spatula at 15 minute intervals until a constant weight (Note 2) is achieved. Stir the sample after each weighing if the sample has not reached constant weight.

9.3 Plate and Truck Samples -- No Moisture Content Determination.

9.3.1 Place the sample, sample container, and spatula in the oven at 221 ± 9°F. If a skillet is used, the sample shall be heated to approximately 221°F.

9.3.2 Weigh the sample, sample container or skillet, and spatula at 15 minute intervals until a constant weight (Note 2) is achieved. Stir the sample after each weighing if the sample has not reached constant weight (mass).

9.4 Cores.

9.4.1 Vacuum Drying.

a) Follow manufacturers recommendations for warm up and self test procedures

b) Conduct a daily test to include drying the cold trap and sample chamber. Run the apparatus without any core to verify that the pressure reading on the display is 6 mm Hg (6 torr) or less.

c) Using the handheld infrared thermometer, verify that the surface temperature of the core is 60 - 90°F. Cores not within this temperature range shall be placed in a room temperature environment until the required test temperature is obtained.

d) Remove any standing water from the surface of the core with a paper towel or an absorptive cloth

e) Place the core on top of the sample support plate inside the vacuum chamber

f) Place the lid on the vacuum chamber and press the lid down to ensure secure contact between the lid and vacuum chamber

g) Begin the drying process. When the unit completely stops, weigh the core.

h) Repeat steps e, f and g. If the core has not reached constant weight (Note 3), repeat steps e, f and g until constant weight is obtained.

Note 3 - Constant weight is defined as the weight at which further drying does not alter the weight by more than 0.05 percent when weighed after at least two drying cycles of the vacuum-drying apparatus.

9.4.2 Oven Drying.

a) Dry the core overnight at 125 ± 5°F

b) Weigh the core and record the weight

c) Dry the core at 125 ± 5°F for 2 h

d) Weigh the core and record the weight. If the core has not reached constant weight (Note 2), the core is dried and weighed at 2 h intervals until constant weight is obtained.

10.0 CALCULATIONS. The moisture content is calculated by the following formula:

$$\text{Moisture Content, \%} = \frac{W_1 - W_2}{W_2} \times 100$$

where:

W_1 = original weight of sample, g
W_2 = constant weight of sample, g

11.0 REPORT. The moisture content is reported to the nearest 0.01%.

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

SAMPLING HMA
ITM No. 580-22

1.0 SCOPE.

1.1 This method covers the procedures for sampling HMA from the pavement by a plate or core, or from a truck. The random quantity or location of the sample shall be determined in accordance with ITM 802. Samples obtained for moisture content determination shall be immediately placed in an oven bag and sealed.

1.2 This procedure may involve hazardous materials, operations and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 ITM Standards.

802 Random Sampling
587 Reducing HMA Samples to Testing Size

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM is used to obtain HMA samples for testing purposes.

5.0 APPARATUS.

5.1 Sampling plate with a hole of approximately 3/8 in. diameter. The plate shall be square and have a minimum size of 8 in. The corners of the plates may be rounded (maximum radius of 1 in.) to accommodate placement of the mixture into a container. The plate can be made nonstick by the application of PAM® Original cooking spray or an approved anti-adhesive material that is diluted and used per the manufacturer’s recommendations. The anti-adhesive material shall not contain any solvents or petroleum-based products that could affect asphalt binder properties.

5.2 No. 18 mechanics wire or equivalent

5.3 Masonry nail or equivalent

5.4 Round mold. The mold shall have a height greater than the mixture thickness. The diameter of the mold may vary; however, the mold diameter shall be less than the width of the plate. The mold will be approved by the Engineer.

5.5 Pitchfork

5.6 Square Bit Shovel, appropriate size to obtain the required sample

5.7 Sample container for truck sampled material. A non-absorbent cardboard or paperboard for plate sampled material. Both containers shall be of sufficient stiffness to support the sample and allow safe handling of the material

5.8 Oven bag

5.9 Coring device capable of obtaining a 6.00 ± 0.25 in. core

5.10 Plastic cylinder mold container, with lid, to allow safe transport of the core samples

6.0 SAMPLING. When samples from the pavement are used for acceptance of the HMA, the Department will determine the test site in accordance with ITM 802. The Contractor shall obtain the sample in the presence of the Engineer and shall supply all of the necessary equipment to obtain the sample.

7.0 SAMPLE SIZE.

7.1 Plate Samples.

7.1.1 The minimum size of sample for the plate sample shall be as follows.

Size of Sample				
Mixture Designation	Minimum Weight of Sample, g			
	Moisture	MSG and Binder Content	Gyratory Specimens	Aggregate Bulk Specific Gravity
4.75 mm	1,000	3,000	11,000	N/A
9.5 mm	1,500	11,000	11,000	11,000
12.5 mm	2,000	11,000	11,000	11,000
19.0 mm	3,000	11,000	11,000	11,000
25.0 mm	4,000	11,000	11,000	11,000
OG 19.0 mm	3,000	5,500	11,000	N/A
OG 25.0 mm	4,000	7,000	11,000	N/A

The following table may be used to estimate the approximate yield of sample material from a plate sample for varying plate sizes and lift thicknesses for all mixtures:

Approximate Sample Yield for Various Lift Thicknesses and Plate Sizes								
Lift Thickness	**Lay Rate**	**Plate Size, Inches**						
Inches	**lb/yd²**	**8**	**9**	**10**	**11**	**12**	**14**	**16**
		Sample Weight (g)						
1.25	137.5	3100	3900	4800	5900	7000	9500	12400
1.5	165	3700	4700	5800	7000	8400	11400	14900
1.75	192.5	4300	5500	6800	8200	9800	13300	17300
2.0	220	5000	6300	7700	9400	11100	15200	19800
2.25	247.5	5600	7100	8700	10500	12500	17100	22300
2.5	275	6200	7800	9700	11700	13900	19000	24800
2.75	302.5	6800	8600	10600	12900	15300	20900	27300
3.0	330	7400	9400	11600	14100	16700	22800	29700
3.25	357.5	8100	10200	12600	15200	18100	24700	32200
3.5	385	8700	11000	13500	16400	19500	26600	34700
3.75	412.5	9300	11800	14500	17600	20900	28500	37200
4.0	440	9900	12500	15500	18700	22300	30300	39600
4.25	467.5	10500	13300	16400	19800	23600	32100	41900
4.5	495	11100	14000	17300	21000	25000	34000	44400
4.75	522.5	11700	14800	18300	22100	26400	35900	46900
5.0	550	12300	15600	19300	23300	27700	37800	49300
5.25	577.5	12900	16400	20200	24500	29100	39700	51800
5.5	605	13600	17200	21200	25600	30500	41500	54300
5.75	632.5	14200	17900	22200	26800	31900	43400	56700
6.0	660	14800	18700	23100	28000	33300	45300	59200

The following table may be used to estimate the approximate yield of sample material from a plate sample for varying mold sizes and lift thicknesses for all mixtures:

Approximate Sample Yield for Various Lift Thicknesses and Mold Sizes						
Lift Thickness	**Lay Rate**	**Mold Size, Inches**				
Inches	**lb/yd²**	**8**	**10**	**12**	**14**	**16**
		Sample Weight (g)				
1.25	137.5	2400	3800	5400	7400	9700
1.5	165	2900	4500	6500	8900	11600
1.75	192.5	3400	5300	7600	10400	13600
2.0	220	3900	6100	8700	11900	15500
2.25	247.5	4400	6800	9800	13300	17400
2.5	275	4800	7600	10900	14800	19400
2.75	302.5	5300	8300	12000	16300	21300
3.0	330	5800	9100	13100	17800	23200
3.25	357.5	6300	9800	14200	19300	25200
3.5	385	6800	10600	15300	20800	27100
3.75	412.5	7300	11300	16300	22200	29100
4.0	440	7700	12100	17400	23700	31000
4.25	467.5	8200	12900	18500	25200	32900
4.5	495	8700	13600	19600	26700	34900
4.75	522.5	9200	14400	20700	28200	36800
5.0	550	9700	15100	21800	29700	38700
5.25	577.5	10200	15900	22900	31100	40700
5.5	605	10700	16600	24000	32600	42600
5.75	632.5	11100	17400	25100	34100	44500
6.0	660	11600	18200	26100	35600	46500

7.2 **Truck Samples.** The size of sample for the truck sample shall meet the minimum sample size requirement for the appropriate test method.

7.3 **Cores.** The number of cores taken from the pavement shall result in sufficient weight (mass) to meet the minimum weight requirement for the appropriate test method. A 6 in. diameter core has a weight of approximately 1100 g/in.

8.0 PROCEDURE.

8.1 Plate Samples without a Mold

8.1.1 Place the plate with wire attached at the designated location. If conditions on the project cause the plate to slip, drive a nail into the pavement and place the plate hole onto the nail.

8.1.2 Extend the wire tightly beyond the edge of the paving width. The wire shall not pass under a grade leveler attached to the paver. Trucks, pavers, and/or Material Transfer Devices shall be allowed to cross the plate and wire. If a windrow elevator is used, the paving operation shall be stopped so that the plate may be placed at the designated location between the windrow elevator and the paver.

8.1.3 After the mixture is placed, locate the plate by use of the wire

8.1.4 Raise the plate slightly for insertion of a pitchfork or a shovel that is narrower than the plate

8.1.5 Lift the plate and sample, and place the entire sample into the sample container. Material remaining on the plate shall be removed and placed into the sample container.

8.1.6 Immediately refill the sample hole with HMA

8.2 Plate Samples with a Mold

8.2.1 Place the plate with wire in accordance with 8.1.1 to 8.1.3.

8.2.2 Push a clean mold, by means of a circular motion, down into the mixture directly over the plate. The mold shall not be pushed from side to side.

8.2.3 Raise the mold and plate together, and insert a pitchfork, or a shovel that is narrower than the plate

8.2.4 Lift the mold and plate, being careful to keep the two components tightly together

8.2.5 Discard any excess material on top of the plate that is outside of the mold by scraping the material from the plate

8.2.6 Place the sample inside of the mold into the sample container. Material remaining on the plate shall be removed and placed into the sample container.

8.2.7 Immediately refill the sample hole with HMA

8.3 Cores.

8.3.1 Using a coring device, cut a uniform 6 in diameter pavement sample

8.3.2 Remove the core from the pavement with a device that shall not damage the layer to be tested

8.3.3 Mark the mixture layer that is to be tested with a lumber crayon or permanent marker

8.3.4 The core hole shall be cleaned, dried, and refilled with either HMA of similar or smaller size particles or bridge deck repair material from the QPL of Rapid Setting Patch Materials. The core hole shall be filled within one workday of coring the hole.

8.4 Truck Samples, HMA 4.75 mm Mixtures.

8.4.1 Visually observe the mixture in the truck for determination of uniformity

8.4.2 Insert a shovel into various areas that appear uniform in texture, and place the mixture into the sample container.

8.5 Truck Samples, Open Graded HMA Mixture. Insert a shovel into the mixture between the center of the cone and the front of the truck to obtain one sample. Obtain another sample with the shovel from the mixture between the center of the truck and the back of the truck.

8.6 Truck Samples, Dense Graded HMA Mixture.

8.6.1 Insert a shovel horizontally into the mixture at the approximate mid section of the truck

8.6.2 Lift the shovel vertically to establish a horizontal plane in the mixture

8.6.3 Insert the shovel vertically to establish a vertical face below the horizontal plane

8.6.4 Insert the shovel horizontally into the vertical face at a depth of approximately twice the thickness of the maximum particle size of the material

8.6.5 Lift the shovel vertically to obtain the sample, and place the sample into the sample container

9.0 DOCUMENTATION. After the sample has been obtained, the sample location will be recorded. If the sample is obtained by the Contractor for the Department's acceptance testing, the Contractor representative who obtained the sample and the Department representative who witnessed the sample being taken will be identified on the transmittal information. The following information shall be on all box ends for plate samples and core cylinder containers:

1. A/B sample (A1, A2, A3, B1, B2, Core 1, Core 2)
2. Contract Number
3. DMF/JMF Number
4. Item (CLN) Number
5. Lot/Sublot
6. Material Description: Size, Course, ESAL Category, PG Grade
7. Sample Date
8. SiteManager ID Number

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

CERTIFIED HOT MIX ASPHALT PRODUCER PROGRAM ITM No. 583-22

1.0 SCOPE.

1.1 This procedure covers the requirements for a HMA plant to become a Certified Hot Mix Asphalt Producer. Mixtures produced shall be QC/QA HMA in accordance with 401, HMA in accordance with 402, and Stone Matrix Asphalt (SMA) in accordance with 410.

1.2 This procedure may involve hazardous materials, operations and equipment and may not address all of the safety problems associated with the use of the test method. The user of this ITM is responsible for establishing the appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

REFERENCES. Documents required by the Program may be maintained electronically or by hard copy.

2.1 AASHTO Standards.

R 30	Mixture Conditioning of Hot Mix Asphalt
R 35	Superpave Volumetric Design for Hot Mix Asphalt (HMA)
R 46	Designing Stone Matrix Asphalt (SMA)
R 66	Sampling Bituminous Materials
R 76	Reducing Samples of Aggregate to Testing Size
T 2	Sampling of Aggregates
T 11	Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
T 27	Sieve Analysis of Fine and Coarse Aggregates
T 30	Mechanical Analysis of Extracted Aggregate
T 166	Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens.
T 209	Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures
T 255	Total Evaporable Moisture Content of Aggregate by Drying
T 269	Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
T 275	Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens
T 305	Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures

T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
T 331	Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method
T 344	Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading

2.2 ASTM Standards.

D5821	Determining the Percentage of Fractured Particles in Coarse Aggregate

2.3 ITM Standards.

207	Sampling Stockpiled Aggregates
220	Class AS Aggregate for Use in SMA Mixture
571	Quantitative Extraction of Asphalt/Binder and Gradation of Extracted Aggregate from HMA Mixtures
572	Drying HMA Mixtures
580	Sampling HMA
581	Performance Graded Binder Approved Supplier Certification (ASC) Program
584	Bulk Specific Gravity of Aggregate Blends with Recycled Aggregate
586	Binder Content by Ignition
587	Reducing HMA Samples to Testing Size
588	Percent Within Limits (PWL)
590	Total Aggregate Bulk Specific Gravity Determination from Extracted HMA or SMA Mixture
591	Delta Pb (ΔPb) Determination for Dense Graded HMA or SMA Mixture
902	Verifying Sieves
903	Verifying Ovens
905	Verifying Vacuum Systems
906	Verifying Mechanical Shakers
908	Verifying Calibrations Settings for Superpave Gyratory Compactors
909	Verifying Thermometers
910	Verifying Balances
916	Verification of Calipers

2.4 A Certified HMA plant laboratory shall have the following current documents on file and shall provide to the Department upon request:

2.4.1 Indiana Department of Transportation Standard Specifications (Includes applicable Supplemental Specifications)

2.4.2 Pertinent contract Special Provisions

2.4.3 Indiana Certified Asphalt Technician Program Manual

2.4.4 All applicable ITM, AASHTO, and ASTM Test Methods

2.4.5 Testing equipment calibrations or verifications

2.4.6 Mix design, DMF, for each Mixture

2.4.7 Fines correction data for the mixture and recycled materials for each DMF

2.4.8 Type A certifications for all binder materials

2.4.9 Type A certifications for the SBR polymer latex

2.4.10 PG 64-28 and PG 70-22 binder test reports from an AASHTO accredited laboratory whenever PG 58-28 and PG 64-22 are in-line blended with SBR polymer latex

2.4.11 Process control test results

2.4.12 Type D certifications issued to active Department contracts

2.5 A Certified HMA plant shall have the following current documents on file and shall provide to the Department upon request:

2.5.1 The Quality Control Plan (QCP) for the HMA plant

2.5.2 Bill of ladings of the binder from each Supplier for a minimum period of three complete calendar years

2.5.3 Weigh tickets from most current date of production of HMA

2.5.4 Instructions from the Supplier concerning storage and handling of the binder

2.5.5 Flow meter calibration reports and flow computer printouts whenever in-line blending with SBR polymer latex

2.5.6 The IDEM Legitimate Use Approval letter from the post-consumer asphalt shingle processing company

2.5.7 HMA plant calibrations for each DMF

2.5.8 Daily diary

2.5.9 Annual calibration of HMA plant scales and verification of meters

2.5.10 Fiber certification from the manufacturer

2.5.11 Instructions from the manufacturer concerning storage and handling of fibers

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications Section 101 and the following:

3.1 Addenda. Any addition or deletion to the QCP

3.2 Addenda Summary Sheet. A page of the QCP that is used to record a brief description of addenda until such time that the revisions are incorporated into the QCP

3.3 Actual Binder Content. The binder content determined in accordance with ITM 586 or the total of the binder content determined in accordance with ITM 571 and the binder absorption percent from the DMF

3.4 Certified Asphalt Technician. An individual who has successfully completed the requirements of the Indiana Certified Asphalt Technician (ICAT) Program..

3.5 Certified HMA Plant. A HMA plant that meets the requirements of the Program, continues to be under the same ownership, and is approved by the Department

3.6 Corrective Action. Corrective action shall include, but is not limited to, investigation for cause, correction of known cause, or re-testing

3.7 Coarse Aggregate. Aggregate that has a minimum of 20 percent retained on the No. 4 sieve

3.8 District. The Department District Office responsible for administrating the materials and tests function in a local area of the state

3.9 Fine Aggregate. Aggregate that is 100 percent passing the 3/8 in. sieve and a minimum of 80 percent passing the No. 4 sieve

3.10 Level 1 Asphalt Technician. A Technician that is both a Qualified and Certified Asphalt Technician.

3.11 Mixture. QC/QA HMA, HMA, or SMA produced for the Department's use in accordance with ITM 583 and the Specifications

3.12 Moving Average. Average of the last four or five tests as stated in the QCP

3.13 National Institute of Standards and Technology (NIST). A federal technology agency that develops and applies technology, measurements, and standards

3.14 Division of Materials and Tests. An office of the Indiana Department of Transportation, located at 120 S. Shortridge Rd. in Indianapolis, Indiana 46219-0389

3.15 Producer. A company or owner who shall assume responsibility for a Certified HMA Plant. A Producer, in accordance with ITM 581, may modify a PG binder from a Supplier by in-line blending SBR polymer latex at the HMA plant for immediate use.

3.16 Program. ITM 583, Certified Hot Mix Asphalt Producer Program

3.17 QCP Annex. A page of the QCP, located in the Appendix, that is used to record revisions for HMA Plant major components, Level 1 Asphalt Technicians, Certified Asphalt Technicians, and movement of the HMA Plant

3.18 Qualified Technician. An individual who has successfully completed the written and proficiency testing requirements of the Department Independent Assurance and Qualified Acceptance Personnel Program

3.19 Supplier. A Supplier shall be a refinery or terminal that produces modified or unmodified PG binders in accordance with ITM 581.

3.20 Water-Injection Foaming. Water-injection foaming is a technology that allows a reduction in the temperature at which mixtures are produced and placed.

4.0 SIGNIFICANCE AND USE. The Certified Hot Mix Asphalt Producer Program is a program whereby the Producer takes responsibility for the production of quality mixture in accordance with contract requirements, and the Department monitors the Producers production, sampling, and testing procedures.

5.0 PRODUCER PERSONNEL. The Producer personnel shall include a Management Representative, Level 1 Asphalt Technician, Certified Asphalt Technician, and a Qualified Technician, if applicable.

5.1 Management Representative. The Management Representative shall be responsible for all aspects of mixture production and control at the HMA plant and on the pavement as required by the Program.

5.2 Level 1 Asphalt Technician. The Level 1 Asphalt Technician shall conduct or supervise all sampling and testing of materials, the maintenance of control charts, and the maintenance of the diary.

5.3 **Certified Asphalt Technician.** The Certified Asphalt Technician may supervise all sampling and testing of materials, the maintenance of control charts, and the maintenance of the diary, however, the Certified Asphalt Technician shall not conduct sampling and testing.

5.4 Qualified Technician. The Qualified Technician may conduct all sampling and testing used for acceptance of materials under the direct supervision of a Certified Asphalt Technician or Level 1 Asphalt Technician until the next opportunity to take the QC/QA HMA Certified Technician exam is available.

6.0 LABORATORY.

6.1 Process control testing shall be performed at the HMA Plant or as permitted in 6. 3. The Producer shall provide and maintain a laboratory for process control testing. The laboratory shall have the necessary space, equipment, and supplies for the tests to be performed.

6.2 The laboratory testing equipment shall meet the requirements of the test methods identified for the required sampling and testing, except that an electronic balance shall be provided. The electronic balance shall be readable to 0.1 g and accurate to 0.2 g or 0.1 percent of the test load, whichever is greater, at any point within the range of use. The gyratory compactor shall tilt the specimen mold at an average internal angle of $1.16 \pm 0.02°$ as determined in accordance with AASHTO T 344. The gyratory compactor shall be on the Department's List of Approved Superpave Gyratory Compactors.

6.3 Performance of process control tests at laboratory facilities other than at the HMA Plant will be permitted provided the laboratory facilities are owned by the Producer, all test procedure criteria are satisfied in accordance with 6.2, and the test results are furnished in writing to the HMA Plant within two working days.

6.4 The Engineer shall be permitted access to inspect any laboratory used for process control testing, and witness process control activities during production of mixtures.

7.0 TEST EQUIPMENT CALIBRATION.

7.1 The test equipment furnished by the Producer shall be properly calibrated or verified and maintained within the limits described in the applicable test method.

7.2 The Producer shall calibrate or verify equipment at the frequency indicated.

7.3 The equipment calibration or verification documentation shall be kept on file for a minimum period of three complete calendar years and include:

7.3.1 A description of the equipment calibrated or verified including Model and Serial Number

7.3.2 Name of the person performing the calibration or verification

7.3.3 Identification of the calibration equipment used, if any (namely, standard weights, proving rings, thermometers, etc.)

7.3.4 Last date calibration or verification was performed and next due date

7.3.5 A reference to the procedure used

7.3.6 Detailed records showing the results of the calibration or verification performed

7.4 The testing equipment shall be calibrated or verified in accordance with the following:

Equipment	Requirement	Minimum Frequency	Procedure
Balances	Standardize	12 mo.	ITM 910
Gyratory Compactor	Verify Ram Pressure, Angle of Gyration, Frequency of Gyration, LVDT	1 mo.	ITM 908
Gyratory Compactor Internal Angle	Verification	12 mo.	AASHTO T 344
Gyratory Mold and Plate Dimensions	Verification	12 mo.	AASHTO T 312
Ignition Oven	Conduct Lift Test	Weekly	Operators Manual
Ignition Oven Balance	Standardize	12 mo.	ITM 910
Mechanical Shakers	Verify Sieving Thoroughness	12 mo.	ITM 906
Ovens	Verify Temperature Settings	12 mo.	ITM 903
Sieves	Verify Physical Condition	12 mo.	ITM 902
Thermometers	Verification	12 mo.	ITM 909
Vacuum Chamber	Verification	3 mo.	ITM 905
Calipers	Verification	12 mo.	ITM 916

7.5 The equipment used to calibrate or verify the testing equipment shall be NIST traceable and shall be calibrated or verified in accordance with the following frequencies:

Calibration Equipment	Testing Equipment	Minimum Frequency
Master ring used with the Bore Gauge	Gyratory Compactor Molds – AASHTO T 312	36 mo.
Dynamometer or Load Cell & Proving Ring	Gyratory Compactor – AASHTO T 312	24 mo.
Height Gage Blocks	Gyratory Compactor – AASHTO T 312	24 mo.
Height Billet	Gyratory Compactor – AASHTO T 312	24 mo.
Vacuum Gage	Vacuum Systems – ITM 905	12 mo.
Weights, Min. Class 3	Balances – ITM 910	12 mo.

8.0 DIARY

8.1 The Producer shall maintain a diary at the HMA Plant. The diary shall be an open format book with at least one page devoted to each day mixture is produced.

8.2 The Producer shall keep the diary on file for a minimum period of three complete calendar years.

8.3 Entries in the diary shall as a minimum include:

8.3.1 The type of mixture produced and quantity, DMF number, and the contract or purchase order number for each mixture

8.3.2 The time the sample was obtained and the time the test was completed

8.3.3 Non-conforming tests and the resulting corrective action taken

8.3.4 Any significant events or problems

8.4 The Level 1 Asphalt Technician, Certified Asphalt Technician or Management Representative shall sign the entry in the diary. On occasion the diary may be signed by another person; however, the diary is required to be counter-signed by the Level 1 Asphalt Technician, Certified Asphalt Technician or Management Representative.

9.0 **MATERIALS SAMPLING AND TESTING.** The Producer shall designate the sampling and sample reduction procedures, test methods, sampling locations, and size of samples necessary for the quality control. Mixture shall be sampled in accordance with ITM 580. Testing of the samples shall be completed within two working days. Test values shall be reported to the nearest 0.1 percent, except as follows:

a) Coarse aggregate angularity shall be reported to the nearest 1 percent

b) Mixture temperature shall be reported to the nearest 1°F

c) Mixture moisture content and draindown shall be reported to the nearest 0.01 percent

Rounding shall be in accordance with 109.01(a). The Producer shall keep the test results on file for a minimum period of three complete calendar years.

The VMA shall be calculated in accordance with AASHTO R 35 using the actual binder content from the most recent binder content determination. The maximum specific gravity shall be mass determined in water in accordance with AASHTO T 209. Gyratory specimens shall be compacted at 300 ± 9°F for dense graded mixtures and SMA, and 260 ± 9°F for open graded mixtures. The volume of effective binder, Vbe, in the mixture shall be calculated as the mixture VMA minus the mixture Air Voids.

9.1 QC/QA HMA and SMA Mixtures. The following items shall be addressed in the QCP as a minimum:

9.1.1 Aggregates

a) Stockpile

b) Blended

9.1.2 Binder

9.1.3 Recycled Materials

a) Actual Binder Content

b) Gradation

c) Moisture Content

d) Coarse Aggregate Angularity

e) Bulk Specific Gravity of Recycled Aggregate

9.1.4 Mixture Sampled at the HMA plant

a) Actual Binder Content

b) Gradation

c) Aggregate degradation value (for SMA mixtures only) – once per lot

d) Moisture Content

e) Temperature

f) Draindown (for open graded and SMA mixtures only)

9.1.5 Mixture Sampled from the Pavement

a) Air Voids

b) VMA

c) Actual Binder Content

d) Gradation

e) Dust/calculated effective binder ratio

f) Moisture Content (for surface mixtures only)

g) Bulk Specific Gravity

h) Maximum Specific Gravity

i) Volume of Effective Binder, Vbe

9.2 **HMA Mixtures.** HMA mixture produced concurrently with QC/QA HMA mixture shall be sampled and tested in accordance with 9.1. All other HMA mixture shall be sampled at the HMA plant or the roadway at the Contractor's option and tested for Binder Content, Coarse Aggregate Angularity (mixtures containing gravel), Gradation, and Air Voids in accordance with the following minimum frequency:

9.2.1 The first 250 t and each subsequent 1000 t of each DMF in a construction season for base and intermediate mixtures. If a DMF does not reach 250 t, a minimum of one sample is required for certification

9.2.2 The first 250 t and each subsequent 600 t of each DMF in a construction season for surface mixtures. If a DMF does not reach 250 t, a minimum of one sample is required for certification

10.0 **CONTROL LIMITS.** The control limits shall only apply to QC/QA HMA and SMA mixtures.

10.1 Target mean values shall be as follows:

10.1.1 The target value for the air void content shall be as designated by the Producer.

10.1.2 The target values for the binder content of the mixture and the VMA shall be as indicated on the DMF.

10.2 Control limits for single test values shall be as follows:

Parameter	Maximum % Passing, Control Limits (±)		
	Aggregate Stockpiles	Blended Aggregate Base and Intermediate Mixtures	Blended Aggregate Surface Mixture
3/4 in	10.0	10.0	
1/2 in.	10.0	10.0	10.0
No.4	10.0	10.0	10.0
No.8	10.0	10.0	8.0
No.16	8.0	8.0	8.0
No.30	6.0	6.0	4.0
No.50	6.0	6.0	4.0
No.100	6.0	6.0	3.0
No.200	2.0	2.0	2.0

Parameter	Control Limits
Binder Content of Mixture and RAP, %	± 0.7
Binder Content of RAS, %	± 3.0
Vbe, %, above design minimum (QC/QA HMA, SMA)	+ 2.0
VMA @ Ndes, % (QC/QA HMA)	± 1.0
VMA @ N_{75}, Minimum % (9.5 mm SMA)	17.0
VMA @ N_{75}, Minimum % (12.5 mm SMA)	16.0
Target Air Voids % (Dense Graded Mixtures, SMA)	± 1.0
Target Air Voids % (Open Graded Mixtures)	± 3.0
2.36mm (No. 8) sieve % passing (9.5mm Surface Mixtures Only)	+ 4.0

11.0 RESPONSE TO TEST RESULTS.

11.1 The Producer shall take corrective action when the control limits for QC/QA HMA and SMA or specification limits for HMA Mixtures are exceeded for the appropriate properties of Mixture Binder Content, Air Voids, or VMA.

11.2 The Producer shall document the action taken to restore the 2.36 mm sieve % passing gradation for a 9.5 mm HMA surface mixture when it is determined to be greater than the PCS control point value of 47%.

11.3 The Producer shall document the action taken to restore the aggregate degradation value for SMA mixture in accordance with ITM 220 when it is determined to be greater than 3.0%.

11.4 The Producer shall document the action taken to restore the dust/calculated effective binder ratio when it is determined to be outside specification limits as defined in 401.05.

11.5 The Producer shall document the action taken to restore the volume of effective binder, Vbe, when it is determined to be less than the design minimum or more than the design maximum as follows:

Mixture Designation	Minimum Vbe, %	Maximum Vbe %
9.5 mm SMA	13.0	16.0
12.5 mm SMA	12.0	15.0
19.0 mm SMA	11.0	14.0
4.75 mm	12.0	15.0
9.5 mm	11.0	14.0
12.5 mm	10.0	13.0
19.0 mm	9.0	12.0
25.0 mm	8.0	11.0

11.6 **Moisture Content.** The Producer shall take corrective action when the moisture content of the mixture sampled at the HMA Plant exceeds 0.30 percent or when the moisture content of the surface mixture sampled from the pavement exceeds 0.10 percent.

11.7 The Producer in-line blending SBR latex at the HMA plant shall take corrective action if the latex solids content is more than 0.2% below the lower target limit for more than 15 minutes of production.

11.8 **Documentation.** All corrective action shall be documented in the diary.

12.0 QUALITY CONTROL PLAN.

12.1 Each Producer providing mixture under the Program shall have a written QCP which shall be HMA plant specific and be the basis of control. The QCP shall contain, but not be limited to, the methods of sampling, testing, calibration, verification, inspection, and anticipated frequencies.

12.2 If applicable, the QCP shall include the following information for each HMA Plant:

12.2.1 The location of the HMA Plant site, including the county and reference to the nearest identifiable points such as highways and towns.

12.2.2 The name, telephone number, fax number, email address, duties, and employer of the Management Representative, Level 1 Asphalt

Technician(s), Certified Asphalt Technician(s), and Qualified Technician(s), if applicable. The duties of all other personnel responsible for implementation of the QCP shall be included.

12.2.3 A list of test equipment that is calibrated or verified, the test methods and frequency of calibration or verification of the equipment, and a statement of accessibility of the laboratory to Department personnel.

If the laboratory is not located at the HMA Plant, the location of the laboratory shall be designated, and the procedure for transporting the mixture to the laboratory included.

12.2.4 A HMA plant site layout diagram which shall include the location of the stockpile area, binder tanks, fuel tank, fiber supply, anti-adhesive supply, field laboratory, visitor parking area, and major components of the mixing HMA plant.

12.2.5 A plan for controls of the aggregate and recycled material stockpiles. Controls for identification of stockpiles by signing or other acceptable methods, techniques for construction of proper stockpiles, and cold bin loading procedures to prevent overflow of material from one bin into another shall be included.

12.2.6 A plan for the identification of the grade of binder in each storage tank and the use of more than one binder grade in a binder tank. The sampling location shall be indicated.

12.2.7 A plan for in-line blending SBR polymer latex at the HMA plant to include a QCP in accordance with ITM 581 as an addendum to the plant QCP

12.2.8 A plan for the production of HMA produced with a water-injection foaming device. The necessary plant modifications, plant production start-up process, planned mixture production temperature ranges, and moisture testing on mixtures sampled at the plant for each DMF shall be included.

12.2.9 The procedure for the consistent uniform addition of baghouse fines when returned into the HMA plant.

12.2.10 The procedure for the consistent uniform addition of fibers into the HMA plant.

12.2.11 The procedure for using an anti-adhesive agent for the truck bed, and a statement that the agent is on the Department’s List of Approved Anti-Adhesive Materials.

12.2.12 The procedure for sealing the surge bin when used for extended storage of the mixture up to one working day, and the method to prevent the discharge when the mixture falls below the top of the cone.

12.2.13 The procedure for loading mixture into the trucks.

12.2.14 A sampling plan that includes locations, test methods, devices, techniques, frequencies, and sample reduction procedures.

12.2.15 A testing plan that includes the types of tests, and test methods.

12.2.16 A description of any other process control techniques that may be used. These controls may include, but are not limited to:

a) Different types of material testing

b) Visual checks, and monitoring of HMA plant production

12.2.17 A statement of the procedure for handling addenda to the QCP including a time schedule for submittal.

12.2.18 A documentation plan with details on control charting, test data, and the diary. Copies of the forms may be included.

12.3 The last page of the QCP shall contain two signatures. One signature shall be the Producer Management Representative. The date of submittal and the corporate title of the Producer Management Representative making the signature shall be included. The other signature shall be for approval by the State Materials Engineer, Division of Materials and Tests.

12.4 Production of mixture shall not begin before the QCP has been approved. The Producer shall submit two copies of the QCP to the Department for review. One copy shall be submitted to the District Testing Engineer, and one copy to the Division of Materials and Tests. Acceptance or rejection of the QCP will be made within 15 days of receipt of the QCP. One approved copy will be returned to the Producer.

12.5 The Producer shall transmit all applicable process control changes to the District Testing Engineer for approval. This shall be done in the format of addenda to the QCP. Each page of the QCP that is revised shall include the HMA plant number, date of revision, and means of identifying the revision. The addenda shall be signed and dated by the Management Representative and subsequently signed and dated when approved by the District Testing Engineer.

Revisions for HMA plant major components, Level 1 Asphalt Technicians, Certified Asphalt Technicians, and movement of the HMA plant shall be submitted in the format of a QCP Annex as they occur, and upon approval by the District Testing Engineer shall be included in the Appendix of the QCP. Revisions, other than items on the QCP Annex, shall be maintained on the Addenda Summary sheet in the QCP Appendix.

Addenda may be submitted at the audit close-out meeting or anytime during the calendar year. The addenda shall include items on the QCP Annex, items on the Addenda Summary Sheet, and any other necessary revisions at the time of submittal. Upon incorporation into the QCP as addenda, the QCP Annex and items on the Addenda Summary Sheet shall be removed from the QCP Appendix.

12.6 Movement of the HMA Plant to a new location will require an addendum to the QCP. Verification of the calibration of all meters, scales and other measuring devices in accordance with 14.3 shall be completed.

13.0 CERTIFICATION.

13.1 Each Producer requesting to establish a Certified Plant shall do so in writing to the State Materials Engineer, Division of Materials and Tests.

13.2 Upon receipt of the request for certification, the District Testing Engineer will be notified to inspect the plant and laboratory.

13.3 A plant inspection, including the correction of any deficiencies and calibration of all meters, scales and other measuring devices to an accuracy within 0.5% throughout their range, shall be completed prior to certification.

13.4 Each HMA plant meeting the requirements of the Program will be certified upon the approval of the QCP.

13.5 The Producer, in accordance with ITM 581, shall submit a written request to the Asphalt Engineer, Division of Materials and Tests, to in-line blend SBR polymer latex at the HMA plant.

13.6 In the event of a change in ownership of the Certified HMA Plant, the certification shall expire on the date of such change. The new ownership may avoid expiration by submitting a statement to the State Materials Engineer, Division of Materials and Tests indicating recognition of the details of the Program, the existing QCP, and a clear pronouncement of intent to operate in accordance with the requirements of both documents prior to providing mixture for the Program.

14.0 DEPARTMENT RESPONSIBILITIES.

14.1 The Department will conduct annual audits on a random basis of each HMA Plant.

14.2 The Department will maintain the List of Approved Certified Hot Mix Asphalt Producers. Producers meeting the requirements of the ASC program for in-line blending of SBR polymer latex will be indicated as a Performance-Graded Asphalt Binder Approved Supplier on the List.

14.3 The Department will administer a Certified Asphalt Technician Training Program (ICAT). Certification of the Technicians will be provided by the Department upon passing a certification test. The Department will maintain a list of test methods requiring Qualification in the ICAT Policies and Procedures Manual.

14.4 The removal of a Producer from the Department's List of Approved Certified Hot Mix Asphalt Producers will be the responsibility of the Division of Materials and Tests. The Producer shall have the right to appeal the removal from the Department's List of Approved Certified Hot Mix Asphalt Producers to the Director, Construction Management Division.

15.0 ADJUSTMENT PERIOD. The adjustment period shall only apply to QC/QA SMA mixtures.

15.1 The Producer will be allowed an adjustment period for each DMF in which changes may be made. The adjustment period shall be from the beginning of production and extending until 4000 t of base or intermediate mixtures or 2400 t of surface mixture has been produced. A reduced adjustment period may be allowed.

15.2 The aggregate and recycled materials blend percentage and the amount passing all sieves on the DMF may be adjusted provided the gradation limits do not exceed the requirements of 410.05. Adjustments to the aggregate and recycled materials blend percentage, gradation and the new combined aggregate bulk specific gravity shall be included on the JMF.

15.3 The total binder content on the JMF may be determined by adjusting the DMF a maximum of ± 0.3 percent. The recycled materials binder content may be adjusted as part of the total binder content provided the binder replacement percentage is in accordance with 410.06.

15.4 The JMF shall be submitted for acceptance to the District Testing Engineer one working day after the receipt of the original test results for the binder content and gradation of the adjustment period.

15.5 A DMF will be allowed one adjustment period in a construction season. A new adjustment period will not be allowed for only a binder source change.

HMA QCP ANNEX

Company ____

Plant No. ____________

PLANT MAJOR COMPONENT REVISION

Revision: ____

____

____

LEVEL 1/CERTIFIED ASPHALT TECHNICIAN REVISION

Delete Technician from QCP ____

Add Technician to QCP ____

PLANT MOVEMENT

Existing Location: ____

____

New Location: ____

____

____

District Testing Engineer	Date	Management Representative	Date

INDIANA DEPARTMENT OF TRANSPORTATION
HOT MIX ASPHALT (HMA) TYPE D CERTIFICATION

CONTRACT NUMBER _________________ DATE____________

CERTIFIED HMA PRODUCER____

CERTIFIED HMA PLANT NUMBER _________________ DMF NUMBER ________________

PG BINDER SOURCE _______________ PG BINDER GRADE________________

MIXTURE TYPE AND SIZE ____

DESIGN ESAL __________________

Air Voids _________ (from DMF) Binder Content _________ (from DMF)

This is to certify that the test results for Air Voids and Binder Content represent the HMA mixture supplied to this contract.

Air Voids ______ (± 2.0 % from DMF) Binder Content _______ (± 0.7% from DMF)

* [ ] Test results are not available for submittal. A production sample shall be taken within the first 250 t (250 Mg) and each subsequent 1000 t (1000 Mg) for base and intermediate mixtures and each subsequent 600 t (600 Mg) for surface mixtures.

* ✓ If Applicable

____
Signature of Level 1 or Certified Asphalt Technician

____
Printed Name

FOR PE/PS USE ONLY

PAY ITEM(S) ___________________________________ ACCEPTANCE METHOD: SM9003

SPECIFICATION REFERENCE

__ 304.04 - Patching
__ 304.05 - Widening
__ 402.04 - HMA Pavements
__ 402.07(a) - Rumble Strips
__ 402.07(b) - Wedge & Leveling
__ 402.07(c) - Temporary HMA
__ 503.03(e) - Terminal Joints
__ 507.05(b) - Partial Depth Patching
__ 604.07(c) – Sidewalk
__ 605.07(c) – Curbing
__ 610 - Approaches
__ 610 - Crossovers
__718.04- underdrain
__ 801.11- Temp. Crossovers

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

BULK SPECIFIC GRAVITY of AGGREGATE BLENDS IN HMA MIXTURES
ITM No. 584-19

1.0 SCOPE.

1.1 This test method covers the procedure to determine the bulk specific gravity (Gsb) of a combined aggregate blend used in the HMA mixture.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCED DOCUMENTS.

2.1 AASHTO Standards.

R 35 Superpave Volumetric Design for Hot Mix Asphalt
T 84 Specific Gravity and Absorption of Fine Aggregates
T 85 Specific Gravity and Absorption of Coarse Aggregate

2.2 ITM Standards.

207 Sampling Stockpiled Aggregates
571 Quantitative Extraction of Asphalt and Gradation of Extracted Aggregate from Asphalt Paving Mixture.
590 Total Aggregate Bulk Specific Gravity Determination from Extracted HMA or SMA Mixture

2.3 Other References.

SP-2 Superpave Mix Design by Asphalt Institute

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE.

4.1 This ITM is used to determine the bulk specific gravity of a combined aggregate blend with recycled aggregate used in HMA mixture.

4.2 The bulk specific gravity (Gsb) of a combined aggregate blend is calculated using the bulk specific gravity of the aggregate in the reclaimed asphalt pavement and the actual bulk specific gravity of the other aggregates.

4.3 The bulk specific gravity of an aggregate blend is used to perform a volumetric analysis on compacted HMA in accordance with AASHTO R 35.

5.0 APPARATUS. The apparatus shall be as stated in the referenced test methods.

6.0 SAMPLING. Sampling shall be as stated in the referenced test methods.

7.0 PROCEDURE.

7.1 Identify the coarse aggregate(s), fine aggregate(s) and reclaimed asphalt pavement selected for use in the mix design

7.2 Identify and record the actual percentages for each of the aggregate components used in the combined aggregate blend of the mix design

7.3 Obtain a representative sample of the recycled materials in accordance with ITM 207

7.4 Determine the bulk specific gravity of each of the coarse aggregate(s). The Department HMA Bulk Specific Gravities list shall be used

7.5 Determine the bulk specific gravity of each of the fine aggregate(s). The Department HMA Bulk Specific Gravities list shall be used

7.6 Record the bulk specific gravity of reclaimed asphalt shingles as 2.500

7.7 Record the bulk specific gravity of mineral filler(s) or baghouse fines as 2.800

7.8 Determine and record the total bulk specific gravity of the reclaimed asphalt pavement, $(Gsb)_{RAP,}$ in accordance with ITM 590

7.9 If the total $(Gsb)_{RAP}$ of the recycled aggregate is equal to or greater than 2.620 or equal to or less than 2.660, use 2.640 as the $(Gsb)_{RAP}$. If the $(Gsb)_{RAP}$ is less than 2.620 or greater than 2.660, the Department will obtain a sample of the reclaimed asphalt pavement and determine the $(Gsb)_{RAP}$.

7.10 Calculate and record the bulk specific gravity of the combined aggregate blend as follows:

$$(Gsb)_{TOTAL} = \frac{P_1 + P_2 + \ldots + P_N + P_{RAP} + P_{RAS} + P_{BH} + P_{MF}}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_N}{G_N} + \frac{P_{RAP}}{(Gsb)_{RAP}} + \frac{P_{RAS}}{2.500} + \frac{P_{BH}}{2.800} + \frac{P_{MF}}{2.800}}$$

where:

- $(Gsb)_{TOTAL}$ = bulk specific gravity of the combined aggregate blend
- P_1, $P_{2\ldots}P_N$ = percentages by weight of aggregates 1, 2…N
- P_{RAP}, P_{RAS}, P_{BH}, P_{MF} = percentages by weight of RAP, RAS, Baghouse Fines and Mineral Filler
- G_1, $G_{2\ldots}G_N$ = bulk specific gravities of aggregates 1, 2…N
- $(Gsb)_{RAP}$ = bulk specific gravity of recycled aggregate
- $P_1 + P_2 + \ldots + P_N + P_{RAP} + P_{RAS} + P_{BH} + P_{MF} = 100.0\%$

8.0 REPORT. The Gsb of the combined aggregate blend is reported to the nearest 0.001.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

ASPHALT CONTENT BY IGNITION
ITM No. 586-15T

1.0 SCOPE.

1.1 This method of test method covers the procedure for determination of the asphalt content by ignition in a furnace. The aggregate remaining after ignition may be used to evaluate the gradation of the aggregate in the mixture.

1.2 This procedure may involve hazardous materials, operations and equipment and may not address all of the safety problems associated with the use of the test method. The user of this ITM is responsible for establishing the appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

T 30 Mechanical Analysis of Extracted Aggregate
M 231 Weighing Devices Used in the Testing of Materials

2.2 ITM Standards.

580 Sampling HMA
587 Reducing HMA Samples to Testing Size
802 Random Sampling

2.3 OTHER.

Ignition Oven Operations Manual

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE.

4.1 This ITM shall be used to determine the asphalt content and gradation of the HMA mixture by an ignition oven.

4.2 A mix calibration factor shall be determined for each HMA mixture in a specific oven to account for any loss of aggregate during ignition and any variability between ovens that may occur.

4.3 Each mix calibration factor is unique to an individual ignition oven and not transferable.

5.0 APPARATUS.

5.1 Balance, Class G2, in accordance with AASHTO M 231

5.2 Bowls, spatulas, pans, and wire brushes as required

5.3 Catch pan, sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt falling through the screen mesh are caught

5.4 Ignition Oven, meeting the following requirements**:**

5.4.1 Forced air ignition furnace capable of maintaining a temperature of 1100 ± 9°F

5.4.2 Internal balance, thermally isolated from the oven chamber, and accurate to 0.1 g over the range of use

5.4.3 Capacity to accommodate a sample size of 3500 g

5.4.4 Door designed to refuse entry during the ignition test

5.4.5 Equipped to minimize emissions during the ignition test

5.4.6 Vented into a hood or to the outside

5.4.7 Fan capable of pulling air through the furnace to expedite the test

5.4.8 Automatic shut off that may be set at 0.01% of the sample weight

5.4.9 Alarm indicating when a test is complete

5.4.10 Lift test performed in accordance with the ignition oven operations manual and recorded weekly (see appendix A)

5.4.11 Printed ticket which includes initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content (percent), test time and test temperature

5.5 Oven, capable of maintaining the temperature at 250 ± 9°F

5.6 Safety Equipment as follows:

5.6.1 Safety glasses or face shield

5.6.2 High temperature gloves

5.6.3 Long sleeve jacket

5.6.4 Heat resistant surface capable of withstanding 1202°F

5.6.5 Protective cage capable of surrounding the sample baskets during the cooling period

5.7 Sample Basket(s), of appropriate size that allows the samples to be thinly spread and allows air to flow through and around the sample particles. Sets with two or more baskets shall be nested. The sample shall be completely enclosed with screen mesh, perforated stainless steel plate, or other suitable material.

6.0 CALIBRATION PROCEDURE.

6.1 The Contractor shall prepare all calibration samples as shown below.

6.2 Obtain aggregate material and asphalt for the HMA mixture as shown on the DMF/JMF.

6.3 Determine the weight required for the calibration samples. The samples shall not be more than 500 g greater than the minimum recommended sample size indicated in the following table:

Mixture Designation Size	Minimum Recommended Sample Weight, g
4.75 mm	1200
9.5 mm	1200
12.5 mm	1500
19.0 mm, OG 19.0	2000
25.0 mm, OG 25.0	3000

6.4 Prepare all replicate calibration samples of the HMA mixture in accordance with the mix design.

6.5 Butter the mixing bowl with the first sample for each mixture and discard the mixture after mixing.

6.6 Determine and record the weight required for each aggregate fraction and asphalt based on the percentages in the DMF/JMF.

6.7 Heat the asphalt to the temperature recommended by the manufacturer. Combine and mix the aggregate fractions until a uniform blend is obtained. Stir in the asphalt until the aggregate is uniformly coated.

6.8 Select 1000°F or 900 °F for the calibration test. If dolomite is used in the mix, 800°F may be used for the calibration test.

6.9 Submit four calibration samples and the information in 6.6 and 6.8 to the District

6.10 Determine the calibration factor for a specific oven for a specific HMA mixture as follows:

6.10.1 Test at least two of the calibration samples in accordance with 8.0. If dolomite is used in the mixture in accordance with 6.8, test all four of the calibration samples.

6.10.2 Record the calibrated asphalt content to the nearest 0.01 percent for each calibration sample.

6.10.3 Calculate the sample calibration factor as the difference between the calibrated asphalt content and the design asphalt content for each sample.

6.10.4 If dolomite is used in the mix in accordance with 6.8, follow 6.10.4c otherwise, follow 6.10.4a and 6.10.4b.

a) If the difference between the two sample calibration factors is less than 0.15 percent, then the mean of the two sample calibration factors may be determined and reported as the mix calibration factor.

b) If the difference between the two calibration factors is more than 0.15 percent, two additional calibration samples will be tested. Discard the highest and lowest sample calibration factors from the four values, then determine and report the mean of the remaining two sample calibration factors as the mix calibration factor.

c) Determine and report the mean of the four sample calibration factors as the mix calibration factor.

7.0 SAMPLING PROCEDURE. Sampling shall conform to the requirements of ITM 580.

8.0 ASPHALT CONTENT PROCEDURE.

8.1 Set the stability threshold value of the ignition oven to 0.01 percent weight loss for three minutes.

8.2 Program the oven to provide a ticket. Check the printer and ensure paper is installed.

8.3 Preheat the ignition oven to the test temperature.

8.4 Record the mix calibration factor in percent for the mixture at the specified temperature

8.5 Weigh the sample and determine if the sample meets the size requirements specified at 6.3

8.6 If required, reduce the sample to the correct size in accordance with ITM 587

8.7 Dry the specimen to constant weight in an oven at 221 ± 9°F. Constant weight is defined as the weight at which further drying does not alter the weight by more than 0.05 percent over 15 minute intervals.

8.8 Measure and record the weight of the ignition oven basket assembly using the external balance

8.9 Place the bottom basket inside the catch pan on top of the scale and tare out the scale

8.10 Place the first half of the sample in the bottom basket. Spread the sample evenly over the bottom of the basket ensuring the material is not in contact with the sides of the basket.

8.11 Place the top basket on the bottom basket and tare out the scale.

8.12 Place the second half of the sample in the top basket. Spread the sample evenly over the bottom of the basket ensuring the material is not in contact with the sides of the basket.

8.13 Repeat 8.12 and 8.13 for additional baskets as required

8.14 Complete the ignition oven basket assembly by attaching the lid and guards

8.15 Measure and record the weight of the ignition oven basket assembly with the dry sample using the external balance

8.16 Calculate the weight in grams of the dry sample using the following formula.

$$W_1 = W_2 - W_3$$

where:

W_1 = weight of the dry HMA sample, g
W_2 = weight of ignition oven basket assembly with dry HMA sample, g
W_3 = weight of ignition oven basket assembly, g

8.17 Enter the mix calibration factor and the weight in grams of the dry sample into the ignition oven computer in accordance with the Ignition Oven Operations Manual.

8.18 Place the ignition oven basket assembly and dry sample in the ignition oven in accordance with the Ignition Oven Operation Manual.

8.19 Verify that the weight of the sample baskets displayed on the oven scale is within ± 5g of the weight on the external balance. (Differences > 5g or failure of the oven scale to stabilize may indicate that the sample baskets are contacting the oven wall)

8.20 Burn the dry sample in the ignition oven until the oven shuts off automatically.

8.21 Remove the ignition oven basket assembly and burned sample from the ignition oven. Place the assembly on a firm heat resistant surface. Cover the assembly with a protective cage and allow the sample to cool to about room temperature.

8.22 Remove the ignition oven ticket from the ignition oven console. Record the calibrated asphalt content from the ticket to the nearest 0.01%.

8.23 Cool the ignition oven basket assembly to room temperature.

8.24 Determine and record the weight of the ignition oven basket assembly and burned aggregate.

8.25 In cases when an ignition oven ticket is unavailable or there was an error in the ticket, calculate the asphalt content of the sample by the following formula:

$$AC,\ \% = \left(\frac{W_1 - W_2}{W_1}\right) \text{ x } 100 - C_1$$

where:

AC % = the measured (corrected) asphalt content
W_1 = weight of the HMA sample prior to ignition, g
W_2 = weight of the burned HMA sample, g
C_1 = calibration factor, percent by weight of HMA sample

9.0 AGGREGATE GRADATION PROCEDURE.

9.1 The starting weight of the aggregate for AASHTO T 30 is determined by 9.2 or 9.3, depending on the decant procedure used.

9.2 Decant in Ignition Oven Sample Basket.

9.2.1 Determine and record the weight of the ignition oven basket assembly and the aggregate using the external scale. Calculate the starting weight of the aggregate for decanting by the following formula:

$$W_1 = W_2 - W_3$$

where:

W_1 = weight of aggregate, g
W_2 = weight of ignition oven basket assembly and aggregate, g
W_3 = weight of ignition oven basket assembly, g

9.3 Decant in Container.

9.3.1 Determine and record the weight of the container.

9.3.2 Carefully dump the aggregate into the container. Clean the baskets with a brush to collect all loose material.

9.3.3 Determine and record the weight of the new container and aggregate.

9.3.4 Calculate the starting weight of the aggregate for the decant by the following formula:

$$W_1 = W_2 - W_3$$

where:

W_1 = weight of burned aggregate, g
W_2 = weight of new container and burned aggregate, g
W_3 = weight of new container, g

9.4 Determine the gradation of the aggregate in accordance with AASHTO T 30

10.0 REPORT.

10.1 Report the test temperature, mix calibration factor, and the absorption factor for mix calibration tests.

10.2 Report the calibrated asphalt content, test temperature, the mix calibration factor, the temperature correction factor and the oven number for the mix acceptance tests. Attach the ignition oven ticket to the report.

10.3 Report the weight retained on each sieve and the percent passing on each sieve, for aggregate gradation tests.

IGNITION OVEN - LIFT TEST
LOG SHEET

DATE	OVEN I.D.	READING		DATE	OVEN I.D.	READING

Refer to the Ignition Oven Operations Manual for the allowable range of lift values

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

REDUCING HMA SAMPLES TO TESTING SIZE
ITM No. 587-21

1.0 SCOPE.

1.1 This test method covers the procedures for reducing HMA samples to the appropriate size for testing.

1.2 This procedure may involve hazardous materials, operations and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

R 47 Standard Practice for Reducing Samples of Asphalt Mixtures to Testing Size

2.2 ITM Standards.

580 Sampling HMA

3.0 SIGNIFICANCE AND USE. This ITM is used to reduce HMA samples for testing purposes. Minimum size samples, sample sizes that are within a weight (mass) range, and sample sizes that meet a known target weight are required, depending on the type of test conducted.

4.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

5.0 APPARATUS.

5.1 Splitting Board. The splitting board shall be any flat surface free from contaminants such as HMA, aggregate, liquid asphalt, dirt, grease, excess solvents, etc., and may be preheated with heat lamps.

5.2 Trowel or drywall taping knife

The splitting board and tools can be made nonstick by the application of PAM® Original cooking spray or an approved anti-adhesive material that is diluted and used per the manufacturer's recommendations. The material shall not contain any solvents or petroleum-based products that could affect asphalt binder properties.

6.0 PROCEDURE – MINIMUM WEIGHT

6.1 Place the sample on a clean splitting board

6.2 Thoroughly mix the sample by turning the entire sample over a minimum of four times with a trowel or drywall taping knife. Create a conical pile and carefully flatten to a uniform thickness and diameter by pressing down the apex with the trowel or drywall taping knifes. Make a visual observation to ensure that the material is homogeneous. Quarter the sample into four approximately equal portions.

6.3 Recombine two diagonally opposite portions

6.4 Weigh the sample. If the sample does not meet the minimum weight (mass) required for the appropriate test method, set aside the sample, and repeat 6.2 and 6.3 for the remaining two portions.

6.5 Add the additional diagonally opposite portions to the original sample. Repeat this procedure until the minimum weight required is obtained.

6.6 If the sample obtained in 6.4 is excessively large, the sample may be discarded. Repeat 6.2 to 6.5 for the remaining two portions until the required weight is obtained.

7.0 PROCEDURE - WEIGHT RANGE.

7.1 Place the sample on a clean splitting board

7.2 Thoroughly mix the sample by turning the entire sample over a minimum of four times with a trowel or drywall taping knife. Create a conical pile and carefully flatten to a uniform thickness and diameter by pressing down the apex with the trowel or drywall taping knifes. Make a visual observation to ensure that the material is homogeneous. Quarter the sample into four approximately equal portions.

7.3 Recombine two diagonally opposite portions

7.4 Weigh the sample. If the sample does not meet the minimum weight required for the appropriate test method, set aside the sample, and repeat 7.2 and 7.3 for the remaining two portions.

7.5 Weigh the additional diagonally opposite portions. If the weight of the additional portion plus the original sample is less than the minimum required weight, repeat

7.2 and 7.3 and add the portions to the sample. Repeat this procedure until the weight is within the weight range. If the weight of the additional portion plus the original sample is greater than the maximum allowable weight, discard the additional mixture and repeat 7.2 to 7.5 until the weight is within the weight range.

7.6 If the sample obtained in 7.4 exceeds the maximum allowable weight, discard the sample, and repeat 7.2 to 7.5 until the weight is within the weight range.

8.0 PROCEDURE - TARGET WEIGHT

8.1 Place the sample on a clean splitting board

8.2 Thoroughly mix the sample by turning the entire sample over a minimum of four times with a trowel or drywall taping knife. Create a conical pile and carefully flatten to a uniform thickness and diameter by pressing down the apex with the trowel or drywall taping knifes. Make a visual observation to ensure that the material is homogeneous. Quarter the sample into four approximately equal portions.

8.3 Combine two diagonally opposite portions and weigh the sample (Note 1). This sample will initially be used to prepare Specimen A.

Note 1: The sample will generally exceed the target weight by more than 300 g after the first split. Weighing the sample is not required when the sample obviously exceeds the target weight. Set aside the remaining portions from the initial split for later use in Specimen B.

8.4 If the sample is greater than the target weight and not within 300 g of the target, repeat 8.2 and 8.3 on the sample. Proceed to 8.5 when the sample becomes less than the target weight by more than 300 g or proceed to 8.6 or 8.7 if the sample is within $\pm$ 300 g of the target weight.

8.5 If the sample is less than the target weight and not within 300 g of the target, set the sample aside and repeat 8.2 and 8.3 on the remaining portions. Add diagonally opposite portions to the previously weighed sample until the sample is within $\pm$ 300 g of the target weight (Note 2). Proceed to 8.6 or 8.7.

Note 2: Avoid exceeding the target weight by more than 300 g. If in doubt, the diagonally opposite portions should be weighed prior to adding to the previously weighed sample to avoid exceeding the target weight. Start over if the target weight has been exceeded by 300 g.

8.6 For samples less than and within 300 g of the target weight, mix the remaining quarters into a miniature stockpile. Carefully add to the sample an amount required for achieving the target weight by sampling with a trowel at a location approximately one-third the stockpile height, measured from the base of the stockpile.

8.7 For samples more than and within 300 g of the target weight, mix the sample into a miniature stockpile. Carefully remove from the sample an amount required for achieving the target weight by sampling with a trowel at a location approximately one-third the stockpile height, measured from the base of the stockpile.

8.8 The target weight is considered obtained when the weight is within $\pm$ 10 g of the DMF/JMF target weight value.

8.9 Discard the remnant material from Specimen A and repeat these procedures on material saved from the initial split for use in Specimen B.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

PERCENT WITHIN LIMITS (PWL)
ITM 588-08P

1.0 SCOPE.

1.1 This test method covers the procedure to determine the Percent Within Limits (PWL) for HMA.

1.2 Rounding of values will be in accordance with 109.01(a).

2.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

3.0 SIGNIFICANCE AND USE. This procedure is used to determine the PWL of a lot of HMA. Pay Factors for HMA are determined using PWL values.

4.0 PROCEDURE .

4.1 Mixture

4.1.1 Determine the average of the lot mixture properties for binder content, air voids at $N_{des,}$ and VMA at N_{des} as follows:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where:

$\overline{x}$ = average of the lot mixture property values
x_i = sublot mixture property value
n = number of mixture sublot samples in the lot

4.1.2 Determine the standard deviation of the lot mixture property as follows:

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n-1}}$$

where:

s = standard deviation of the lot mixture property
x_i = sublot mixture property value
$\overline{x}$ = average of the lot mixture property values
n = number of mixture sublot samples in the lot

4.1.3 Calculate the Upper Quality Index for each mixture property by subtracting the lot average of each mixture property from the Upper Specification Limit and dividing the result by the standard deviation of the lot mixture property as follows:

$$Q_U = \frac{USL - \bar{x}}{s}$$

where:

Q_u = Upper Quality Index
USL = Upper Specification Limit
$\bar{x}$ = average of the lot mixture property values
s = standard deviation of the lot mixture property

4.1.4 Calculate the Lower Quality Index for each mixture property by subtracting the Lower Specification Limit from the lot average of each mixture property and dividing the result by the standard deviation of the lot mixture property as follows:

$$Q_L = \frac{\bar{x} - LSL}{s}$$

where:

Q_L = Lower Quality Index
LSL = Lower Specification Limit
$\bar{x}$ = average of the lot mixture property values
s = standard deviation of the lot mixture property

4.1.5 Determine the percentage of material that will fall within the Upper and Lower Specification Limits by entering the table of Quality Index Values (Appendix A) with Q_U or Q_L using the column appropriate to the total number of measurements, n.

4.1.6 Determine the percent of material that will fall within the limits for each mixture property by adding the percent within the Upper Specification Limit (PWL_U) to the percent within the Lower Specification Limit (PWL_L), and subtracting 100 from the total as follows:

Total PWL = $(PWL_U + PWL_L) - 100$

4.2 Density

4.2.1 Determine the average of the lot density values as follows:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where:

$\overline{x}$ = average of the lot density values
x_i = core density value
n = number of cores in the lot

4.2.2 Determine the standard deviation of the lot density as follows:

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n-1}}$$

where:

s = standard deviation of the density of the lot
$\overline{x}$ = average of the lot density values
x_i = core density value
n = number of cores in the lot

4.2.3 Calculate the Lower Quality Index for in-place density (% G_{mm}) by subtracting the Lower Specification Limit from the average of the density of the lot and dividing the result by the standard deviation of the density of the lot as follows:

$$Q_L = \frac{\overline{x} - LSL}{s}$$

where:

Q_L = Lower Quality Index
LSL = Lower Specification Limit
$\overline{x}$ = average of the lot density values
s = standard deviation of the density of the lot

4.2.4 Determine the PWL for density by entering the table of Quality Index Values (Appendix A) using the column appropriate to the total number of measurements, n.

4.2.5 Determine the percent within the lower specification limit (PWL_L) for density as follows:

Total PWL = PWL_L

5.0 REPORT.

5.1 Binder content, air voids, VMA, and in-place density ($\%G_{mm}$) lot average values will be reported to the nearest 0.01%.

5.2 The standard deviation values for binder content, air voids, VMA, and in-place density ($\%G_{mm}$) will be reported to the nearest 0.01.

5.3 Binder content, air voids, and VMA Q_U and Q_L values will be reported to the nearest 0.01.

5.4 In-place density ($\%G_{mm}$) Q_L values will be reported to the nearest 0.01.

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
2.30	100	100	100	100	100	100	100	100	100	100	100	100
2.29	100	100	100	100	100	100	100	100	100	100	100	99
2.28	100	100	100	100	100	100	100	100	100	100	100	99
2.27	100	100	100	100	100	100	100	100	100	100	99	99
2.26	100	100	100	100	100	100	100	100	100	100	99	99
2.25	100	100	100	100	100	100	100	100	100	100	99	99
2.24	100	100	100	100	100	100	100	100	100	99	99	99
2.23	100	100	100	100	100	100	100	100	100	99	99	99
2.22	100	100	100	100	100	100	100	100	100	99	99	99
2.21	100	100	100	100	100	100	100	100	99	99	99	99
2.20	100	100	100	100	100	100	100	100	99	99	99	99
2.19	100	100	100	100	100	100	100	100	99	99	99	99
2.18	100	100	100	100	100	100	100	100	99	99	99	99
2.17	100	100	100	100	100	100	100	99	99	99	99	99
2.16	100	100	100	100	100	100	100	99	99	99	99	99
2.15	100	100	100	100	100	100	100	99	99	99	99	99
2.14	100	100	100	100	100	100	100	99	99	99	99	99
2.13	100	100	100	100	100	100	100	99	99	99	99	99
2.12	100	100	100	100	100	100	99	99	99	99	99	99
2.11	100	100	100	100	100	100	99	99	99	99	99	99
2.10	100	100	100	100	100	100	99	99	99	99	99	99
2.09	100	100	100	100	100	100	99	99	99	99	99	99
2.08	100	100	100	100	100	100	99	99	99	99	99	99
2.07	100	100	100	100	100	100	99	99	99	99	99	99
2.06	100	100	100	100	100	99	99	99	99	99	99	99
2.05	100	100	100	100	100	99	99	99	99	99	99	99
2.04	100	100	100	100	100	99	99	99	99	99	99	99
2.03	100	100	100	100	100	99	99	99	99	99	99	99
2.02	100	100	100	100	100	99	99	99	99	99	99	99
2.01	100	100	100	100	100	99	99	99	99	99	99	98
2.00	100	100	100	100	100	99	99	99	99	99	99	98
1.99	100	100	100	100	100	99	99	99	99	99	98	98
1.98	100	100	100	100	99	99	99	99	99	98	98	98
1.97	100	100	100	100	99	99	99	99	99	98	98	98
1.96	100	100	100	100	99	99	99	99	98	98	98	98
1.95	100	100	100	100	99	99	99	99	98	98	98	98
1.94	100	100	100	100	99	99	99	99	98	98	98	98
1.93	100	100	100	100	99	99	99	98	98	98	98	98
1.92	100	100	100	100	99	99	99	98	98	98	98	98
1.91	100	100	100	100	99	99	99	98	98	98	98	98
1.90	100	100	100	100	99	99	98	98	98	98	98	98

Quality Index (QI) Values PWL for a given sample size (n)												
QI	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**	**n=11**	**n=12**	**n=13**	**n=14**
1.89	100	100	100	100	99	99	98	98	98	98	98	98
1.88	100	100	100	100	99	99	98	98	98	98	98	98
1.87	100	100	100	99	99	98	98	98	98	98	98	98
1.86	100	100	100	99	99	98	98	98	98	98	98	98
1.85	100	100	100	99	99	98	98	98	98	98	98	98
1.84	100	100	100	99	99	98	98	98	98	98	97	97
1.83	100	100	100	99	99	98	98	98	98	98	97	97
1.82	100	100	100	99	99	98	98	98	98	97	97	97
1.81	100	100	100	99	98	98	98	98	97	97	97	97
1.80	100	100	100	99	98	98	98	98	97	97	97	97
1.79	100	100	100	99	98	98	98	97	97	97	97	97
1.78	100	100	100	99	98	98	98	97	97	97	97	97
1.77	100	100	100	99	98	98	97	97	97	97	97	97
1.76	100	100	100	99	98	98	97	97	97	97	97	97
1.75	100	100	100	99	98	98	97	97	97	97	97	97
1.74	100	100	100	98	98	97	97	97	97	97	97	97
1.73	100	100	100	98	98	97	97	97	97	97	97	97
1.72	100	100	100	98	98	97	97	97	97	97	96	96
1.71	100	100	99	98	97	97	97	97	97	96	96	96
1.70	100	100	99	98	97	97	97	97	96	96	96	96
1.69	100	100	99	98	97	97	97	96	96	96	96	96
1.68	100	100	99	98	97	97	97	96	96	96	96	96
1.67	100	100	99	98	97	97	96	96	96	96	96	96
1.66	100	100	99	98	97	97	96	96	96	96	96	96
1.65	100	100	99	97	97	96	96	96	96	96	96	96
1.64	100	100	99	97	97	96	96	96	96	96	96	96
1.63	100	100	98	97	97	96	96	96	96	96	96	95
1.62	100	100	98	97	96	96	96	96	96	95	95	95
1.61	100	100	98	97	96	96	96	96	95	95	95	95
1.60	100	100	98	97	96	96	96	95	95	95	95	95
1.59	100	100	98	97	96	96	95	95	95	95	95	95
1.58	100	100	98	96	96	96	95	95	95	95	95	95
1.57	100	100	97	96	96	95	95	95	95	95	95	95
1.56	100	100	97	96	96	95	95	95	95	95	95	95
1.55	100	100	97	96	95	95	95	95	95	95	95	95
1.54	100	100	97	96	95	95	95	95	95	94	94	94
1.53	100	100	97	96	95	95	95	95	94	94	94	94
1.52	100	100	97	96	95	95	95	94	94	94	94	94
1.51	100	100	96	95	95	95	94	94	94	94	94	94
1.50	100	100	96	95	95	94	94	94	94	94	94	94
1.49	100	100	96	95	95	94	94	94	94	94	94	94

Quality Index (QI) Values PWL for a given sample size (n)												
QI	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**	**n=11**	**n=12**	**n=13**	**n=14**
1.48	100	99	96	95	94	94	94	94	94	94	94	94
1.47	100	99	96	95	94	94	94	94	94	94	93	93
1.46	100	99	95	94	94	94	94	94	93	93	93	93
1.45	100	98	95	94	94	94	93	93	93	93	93	93
1.44	100	98	95	94	94	93	93	93	93	93	93	93
1.43	100	98	95	94	94	93	93	93	93	93	93	93
1.42	100	97	95	94	93	93	93	93	93	93	93	93
1.41	100	97	94	94	93	93	93	93	93	93	93	93
1.40	100	97	94	93	93	93	93	93	92	92	92	92
1.39	100	96	94	93	93	93	92	92	92	92	92	92
1.38	100	96	94	93	93	92	92	92	92	92	92	92
1.37	100	96	93	93	92	92	92	92	92	92	92	92
1.36	100	95	93	93	92	92	92	92	92	92	92	92
1.35	100	95	93	92	92	92	92	92	92	92	92	92
1.34	100	95	93	92	92	92	92	92	91	91	91	91
1.33	100	94	93	92	92	92	91	91	91	91	91	91
1.32	100	94	92	92	91	91	91	91	91	91	91	91
1.31	100	94	92	92	91	91	91	91	91	91	91	91
1.30	100	93	92	91	91	91	91	91	91	91	91	91
1.29	100	93	92	91	91	91	91	91	91	90	90	90
1.28	100	93	91	91	91	91	90	90	90	90	90	90
1.27	100	92	91	91	90	90	90	90	90	90	90	90
1.26	100	92	91	90	90	90	90	90	90	90	90	90
1.25	100	92	91	90	90	90	90	90	90	90	90	90
1.24	100	91	90	90	90	90	90	90	90	90	90	89
1.23	100	91	90	90	90	89	89	89	89	89	89	89
1.22	100	91	90	89	89	89	89	89	89	89	89	89
1.21	100	90	90	89	89	89	89	89	89	89	89	89
1.20	100	90	89	89	89	89	89	89	89	89	89	89
1.19	100	90	89	89	89	89	89	89	89	88	88	88
1.18	100	89	89	89	88	88	88	88	88	88	88	88
1.17	100	89	88	88	88	88	88	88	88	88	88	88
1.16	100	89	88	88	88	88	88	88	88	88	88	88
1.15	97	88	88	88	88	88	88	88	88	88	88	88
1.14	95	88	88	88	87	87	87	87	87	87	87	87
1.13	93	88	87	87	87	87	87	87	87	87	87	87
1.12	92	87	87	87	87	87	87	87	87	87	87	87
1.11	91	87	87	87	87	87	87	87	87	87	87	87
1.10	90	87	87	87	87	87	87	87	87	87	86	86
1.09	89	86	86	86	86	86	86	86	86	86	86	86
1.08	88	86	86	86	86	86	86	86	86	86	86	86
1.07	88	86	86	86	86	86	86	86	86	86	86	86

Quality Index (QI) Values PWL for a given sample size (n)												
QI	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**	**n=11**	**n=12**	**n=13**	**n=14**
1.06	87	85	85	85	85	86	86	86	86	86	86	86
1.05	86	85	85	85	85	85	85	85	85	85	85	85
1.04	86	85	85	85	85	85	85	85	85	85	85	85
1.03	85	84	85	85	85	85	85	85	85	85	85	85
1.02	84	84	84	84	84	84	85	85	85	85	85	85
1.01	84	84	84	84	84	84	84	84	84	84	84	84
1.00	83	83	84	84	84	84	84	84	84	84	84	84
0.99	83	83	83	84	84	84	84	84	84	84	84	84
0.98	82	83	83	83	83	83	83	84	84	84	84	84
0.97	82	82	83	83	83	83	83	83	83	83	83	83
0.96	81	82	82	83	83	83	83	83	83	83	83	83
0.95	81	82	82	82	83	83	83	83	83	83	83	83
0.94	80	81	82	82	82	82	82	82	82	82	83	83
0.93	80	81	82	82	82	82	82	82	82	82	82	82
0.92	79	81	81	82	82	82	82	82	82	82	82	82
0.91	79	80	81	81	81	81	82	82	82	82	82	82
0.90	78	80	81	81	81	81	81	81	81	81	81	81
0.89	78	80	80	81	81	81	81	81	81	81	81	81
0.88	78	79	80	80	81	81	81	81	81	81	81	81
0.87	77	79	80	80	80	80	80	80	81	81	81	81
0.86	77	79	79	80	80	80	80	80	80	80	80	80
0.85	76	78	79	79	80	80	80	80	80	80	80	80
0.84	76	78	79	79	79	79	80	80	80	80	80	80
0.83	76	78	78	79	79	79	79	79	79	79	79	79
0.82	75	77	78	79	79	79	79	79	79	79	79	79
0.81	75	77	78	78	78	79	79	79	79	79	79	79
0.80	74	77	77	78	78	78	78	78	78	79	79	79
0.79	74	76	77	78	78	78	78	78	78	78	78	78
0.78	74	76	77	77	77	78	78	78	78	78	78	78
0.77	73	76	77	77	77	77	77	78	78	78	78	78
0.76	73	75	76	77	77	77	77	77	77	77	77	77
0.75	73	75	76	76	77	77	77	77	77	77	77	77
0.74	72	75	76	76	76	76	77	77	77	77	77	77
0.73	72	74	75	76	76	76	76	76	76	76	76	76
0.72	71	74	75	75	76	76	76	76	76	76	76	76
0.71	71	74	75	75	75	75	76	76	76	76	76	76
0.70	71	73	74	75	75	75	75	75	75	75	75	76
0.69	70	73	74	74	75	75	75	75	75	75	75	75
0.68	70	73	74	74	74	74	75	75	75	75	75	75
0.67	70	72	73	74	74	74	74	74	74	74	75	75
0.66	69	72	73	73	74	74	74	74	74	74	74	74

Quality Index (QI) Values PWL for a given sample size (n)												
QI	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**	**n=11**	**n=12**	**n=13**	**n=14**
0.65	69	72	73	73	73	74	74	74	74	74	74	74
0.64	69	71	72	73	73	73	73	73	73	74	74	74
0.63	68	71	72	72	73	73	73	73	73	73	73	73
0.62	68	71	72	72	72	73	73	73	73	73	73	73
0.61	68	70	71	72	72	72	72	72	72	73	73	73
0.60	67	70	71	71	72	72	72	72	72	72	72	72
0.59	67	70	71	71	71	72	72	72	72	72	72	72
0.58	67	69	70	71	71	71	71	71	71	72	72	72
0.57	66	69	70	70	71	71	71	71	71	71	71	71
0.56	66	69	70	70	70	71	71	71	71	71	71	71
0.55	66	68	69	70	70	70	70	70	70	70	71	71
0.54	65	68	69	69	70	70	70	70	70	70	70	70
0.53	65	68	69	69	69	69	70	70	70	70	70	70
0.52	65	67	68	69	69	69	69	69	69	69	69	70
0.51	65	67	68	68	69	69	69	69	69	69	69	69
0.50	64	67	68	68	68	68	69	69	69	69	69	69
0.49	64	66	67	68	68	68	68	68	68	68	68	68
0.48	64	66	67	67	68	68	68	68	68	68	68	68
0.47	63	66	67	67	67	67	67	68	68	68	68	68
0.46	63	65	66	67	67	67	67	67	67	67	67	67
0.45	63	65	66	66	67	67	67	67	67	67	67	67
0.44	62	65	65	66	66	66	66	67	67	67	67	67
0.43	62	64	65	66	66	66	66	66	66	66	66	66
0.42	62	64	65	65	65	66	66	66	66	66	66	66
0.41	62	64	64	65	65	65	65	65	65	66	66	66
0.40	61	63	64	65	65	65	65	65	65	65	65	65
0.39	61	63	64	64	64	65	65	65	65	65	65	65
0.38	61	63	63	64	64	64	64	64	64	64	64	65
0.37	60	62	63	63	64	64	64	64	64	64	64	64
0.36	60	62	63	63	63	63	64	64	64	64	64	64
0.35	60	62	62	63	63	63	63	63	63	63	63	63
0.34	60	61	62	62	63	63	63	63	63	63	63	63
0.33	59	61	62	62	62	62	62	63	63	63	63	63
0.32	59	61	61	62	62	62	62	62	62	62	62	62
0.31	59	60	61	61	61	62	62	62	62	62	62	62
0.30	58	60	61	61	61	61	61	61	61	61	62	62
0.29	58	60	60	61	61	61	61	61	61	61	61	61
0.28	58	59	60	60	60	61	61	61	61	61	61	61
0.27	58	59	60	60	60	60	60	60	60	60	60	60
0.26	57	59	59	60	60	60	60	60	60	60	60	60
0.25	57	58	59	59	59	59	59	60	60	60	60	60

Quality Index (QI) Values PWL for a given sample size (n)												
QI	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10	n=11	n=12	n=13	n=14
0.24	57	58	59	59	59	59	59	59	59	59	59	59
0.23	56	58	58	58	59	59	59	59	59	59	59	59
0.22	56	57	58	58	58	58	58	58	58	58	58	59
0.21	56	57	57	58	58	58	58	58	58	58	58	58
0.20	56	57	57	57	57	58	58	58	58	58	58	58
0.19	55	56	57	57	57	57	57	57	57	57	57	57
0.18	55	56	56	57	57	57	57	57	57	57	57	57
0.17	55	56	56	56	56	56	56	57	57	57	57	57
0.16	54	55	56	56	56	56	56	56	56	56	56	56
0.15	54	55	55	56	56	56	56	56	56	56	56	56
0.14	54	55	55	55	55	55	55	55	55	55	55	55
0.13	54	54	55	55	55	55	55	55	55	55	55	55
0.12	53	54	54	54	54	55	55	55	55	55	55	55
0.11	53	54	54	54	54	54	54	54	54	54	54	54
0.10	53	53	54	54	54	54	54	54	54	54	54	54
0.09	52	53	53	53	53	53	53	53	53	53	53	54
0.08	52	53	53	53	53	53	53	53	53	53	53	53
0.07	52	52	52	53	53	53	53	53	53	53	53	53
0.06	52	52	52	52	52	52	52	52	52	52	52	52
0.05	51	52	52	52	52	52	52	52	52	52	52	52
0.04	51	51	51	51	51	52	52	52	52	52	52	52
0.03	51	51	51	51	51	51	51	51	51	51	51	51
0.02	51	51	51	51	51	51	51	51	51	51	51	51
0.01	50	50	50	50	50	50	50	50	50	50	50	50
0.00	50	50	50	50	50	50	50	50	50	50	50	50
-0.01	50	50	50	50	50	50	50	50	50	50	50	50
-0.02	49	49	49	49	49	49	49	49	49	49	49	49
-0.03	49	49	49	49	49	49	49	49	49	49	49	49
-0.04	49	49	49	49	49	48	48	48	48	48	48	48
-0.05	49	48	48	48	48	48	48	48	48	48	48	48
-0.06	48	48	48	48	48	48	48	48	48	48	48	48
-0.07	48	48	48	47	47	47	47	47	47	47	47	47
-0.08	48	47	47	47	47	47	47	47	47	47	47	47
-0.09	48	47	47	47	47	47	47	47	47	47	47	46
-0.10	47	47	46	46	46	46	46	46	46	46	46	46
-0.11	47	46	46	46	46	46	46	46	46	46	46	46
-0.12	47	46	46	46	46	45	45	45	45	45	45	45
-0.13	46	46	45	45	45	45	45	45	45	45	45	45
-0.14	46	45	45	45	45	45	45	45	45	45	45	45
-0.15	46	45	45	44	44	44	44	44	44	44	44	44
-0.16	46	45	44	44	44	44	44	44	44	44	44	44

Quality Index (QI) Values PWL for a given sample size (n)												
QI	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=9**	**n=10**	**n=11**	**n=12**	**n=13**	**n=14**
-0.17	45	44	44	44	44	44	44	43	43	43	43	43
-0.18	45	44	44	43	43	43	43	43	43	43	43	43
-0.19	45	44	43	43	43	43	43	43	43	43	43	43
-0.20	44	43	43	43	43	42	42	42	42	42	42	42
-0.21	44	43	43	42	42	42	42	42	42	42	42	42
-0.22	44	43	42	42	42	42	42	42	42	42	42	
-0.23	44	42	42	42								
-0.24	43	42										
-0.25	43	42										
-0.26	43											
-0.27	42											
-0.28	42											
-0.29	42											
-0.30	42											

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

TOTAL AGGREGATE BULK SPECIFIC GRAVITY DETERMINATION FROM EXTRACTED HMA OR SMA MIXTURE ITM No. 590-18

1.0 SCOPE.

1.1 This test method covers the procedure to determine the total aggregate bulk specific gravity value from extracted HMA mixture.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCED DOCUMENTS.

2.1 AASHTO Standards.

R 76 Reducing Samples of Aggregate to Testing Size
T 30 Mechanical Analysis of Extracted Aggregate
T 84 Specific Gravity and Absorption of Fine Aggregate
T 85 Specific Gravity and Absorption of Coarse Aggregate
T 164 Quantitative Extraction of Bitumen from Bituminous Paving Mixtures

2.2 ITM Standards.

571 Quantitative Extraction of Asphalt and Gradation of Extracted Aggregate from HMA Mixtures
580 Sampling HMA
587 Reducing HMA Samples to Testing Size

2.3 Other References.

Design Mix Formula Cover Sheet

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This test method covers the procedure to determine the total aggregate bulk specific gravity value from extracted HMA mixture.

5.0 APPARATUS. The apparatus shall be as stated in the referenced test methods.

6.0 SAMPLING. Sampling shall be as stated in the referenced test methods.

7.0 PROCEDURE.

7.1 Determine the minimum mass of coarse aggregate required based on the mixture designation as follows:

Mixture Designation, mm	Minimum mass of coarse aggregate, g
12.5 or less	2000*
19.0	3000
25.0	4000

**The minimum mass of coarse aggregate will be waived if at least two extractions are performed and if the HMA sample size in each extraction is between 2800g and 3000g.*

7.2 Reduce the HMA sample in accordance with ITM 587, section 7.0, to the mass of HMA needed to adequately fill the centrifuge bowl.

7.3 Extract the HMA sample in accordance with ITM 571, Method A.

Note 1: Multiple extractions may be necessary to achieve the minimum mass of coarse aggregate required in 7.1. ITM 571 specifies minimum HMA sample sizes. The HMA sample size may be increased to the capacity of the centrifuge bowl.

7.4 Perform a gradation in accordance with AASHTO T 30.

7.4.1 Combine all coarse aggregate material retained on the 4.75 mm sieve and above.

7.4.2 Combine all fine aggregate material passing the 4.75 mm sieve

7.5 Determine the bulk specific gravity, $(Gsb)_{CA}$, of the coarse aggregate sample in accordance with AASHTO T 85 except as follows:

7.5.1 The in-water mass shall be determined following the 15 h soaking period prior to determining the SSD mass.

7.6 Reduce the fine aggregate material in accordance with AASHTO R 76, Method A, to a minimum 1200g sample size.

Determine the bulk specific gravity, $(Gsb)_{FA}$, of two fine aggregate samples in accordance with AASHTO T 84 except as follows:

7.6.1 Prior to the 15 hr soaking period, the immersed sample shall be manually stirred to ensure the water will adequately permeate and saturate the aggregate.

7.6.2 Excess water shall be poured over a No. 200 sieve and fines retained on the sieve should be washed back into the sample.

7.7 Determine the $(Gsb)_{FA}$ by averaging the two fine aggregate sample results.

7.8 Combine the $(Gsb)_{CA}$ determined in 7.5 and the $(Gsb)_{FA}$ determined in 7.7 to achieve the $(Gsb)_{TOTAL}$ of the aggregate blend as follows:

7.8.1 $$(Gsb)_{TOTAL} = \frac{100}{\left[\frac{(100 - A)}{(Gsb)_{CA}}\right] + \left[\frac{(A)}{(Gsb)_{FA}}\right]}$$

Where:

A = % passing the 4.75 mm sieve as determined in 7.5.

8.0 REPORT. The $(Gsb)_{TOTAL}$ is reported to the nearest 0.001.

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

DELTA Pb (ΔPb) DETERMINATION FOR DENSE GRADED HMA OR SMA MIXTURES

ITM No. 591-20

1.0 SCOPE.

1.1 This test method covers the procedure to determine the delta Pb, (ΔPb), which is the difference between the estimated total binder content of the mixture, $(Pb)_{EST}$, and the total binder content as reported on the DMF, $(Pb)_{DMF}$.

The $(Pb)_{EST}$ is derived from the effective binder content of the mixture, Pbe, and an estimate of asphalt binder absorption, $(Pba)_{EST}$.

1.2 The ΔPb determination begins by obtaining the aggregate bulk specific gravity list and instructions as well as any applicable addendums. The mixture type, the aggregate and recycled materials blend percentages, the total binder content and the mixture bulk specific gravity value must also be obtained from the DMF mix-design cover sheet.

1.3 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCED DOCUMENTS.

2.1 AASHTO Standards.

R 35 Superpave Volumetric Design for Hot Mix Asphalt
R 46 Designing Stone Matrix Asphalt (SMA)

2.2 ITM Standards.

584 Bulk Specific Gravity of Aggregate Blends with Recycled Aggregate

2.3 Other References.

SP-2 Superpave Mix Design by Asphalt Institute
Design Mix Formula Cover Sheet

3.0 TERMINOLOGY.

TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This test method covers the procedure to determine the ΔPb which is the difference between the $(Pb)_{EST}$ and $(Pb)_{DMF}$.

5.0 APPARATUS. The apparatus shall be as stated in the referenced test methods.

6.0 SAMPLING. Sampling shall be as stated in the referenced test methods.

7.0 PROCEDURE.

7.1 Determine the water absorption of the combined aggregates blend as follows:

$$(ABS)_{TOTAL} = (ABS_1)(P_1) + (ABS_2)(P_2) + \ldots + (ABS_N)(P_N) + (1.00)[(P_{RAP}) + (P_{RAS}) + (P_{BH}) + (P_{MF})]$$

Where:

- $(ABS)_{TOTAL}$ = water absorption of the combined aggregates blend
- P_1, $P_2 \ldots P_N$ = percentages by weight of aggregates 1, 2…N as shown on the DMF cover sheet
- ABS_1, $ABS_2 \ldots ABS_N$ = water absorption of aggregates 1, 2…N
- P_{RAP}, P_{RAS}, P_{BH}, P_{MF} = percentages by weight of RAP, RAS, Baghouse Fines and Mineral Filler as shown on the DMF cover sheet
- $P_1 + P_2 + \ldots + P_N + P_{RAP} + P_{RAS} + P_{BH} + P_{MF} = 100.0\%$

7.2 Determine the estimated total binder content as follows:

$$(Pb)_{EST} = \frac{(\mathrm{Pbe}) + (Pba)_{EST}}{1 + \left(\frac{(Pba)_{EST}}{100}\right)}$$

Where:

$$(\mathrm{Pbe}) = \frac{(\mathrm{VMA} - \mathrm{AV})}{\left(\frac{\mathrm{Gmb}}{1.03}\right)}$$

VMA = specification minimum VMA value
AV = specification design target air voids
$(Pba)_{EST} = (0.50) \times (ABS)_{TOTAL}$ when $(ABS)_{TOTAL} < 1.25\%$
$(Pba)_{EST} = (0.65) \times (ABS)_{TOTAL}$ when $1.25\% \leq (ABS)_{TOTAL} \leq 2.50\%$
$(Pba)_{EST} = (0.80) \times (ABS)_{TOTAL}$ when $(ABS)_{TOTAL} > 2.50\%$

7.3 Determine the ΔPb as follows:

$$\Delta Pb = (Pb)_{EST} - (Pb)_{DMF}$$

8.0 REPORT. The ΔPb value is reported to the nearest 0.01.

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

RANDOM SAMPLING
ITM No. 802-21

1.0 SCOPE.

1.1 This procedure is used to determine the random unit, random quantity, or random location for sampling of construction materials. Use of this method is intended to minimize any bias on the part of the person taking the sample.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and to determining the applicability of regulatory limitations prior to use.

2.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101 and ASTM D16.

3.0 SIGNIFICANCE AND USE. This ITM is used to determine the unit, quantity, or location of the material to be sampled for acceptance in accordance with the Standard Specifications.

4.0 RANDOM NUMBERS.

4.1 The Random Number Tables consist of a list of numbers in blocks which may be used in the random selection process. Random numbers generated by software may be used in place of the Random Number Tables.

4.2 To use a Random Number Table select one block in the table without looking.

4.3 After selecting the block, the top left number in the block is the first random number used. If a pair of random numbers is needed, the adjacent number within the block is used.

4.4 Proceed down the vertical column for additional numbers and proceed to the top of the adjacent column to the right, if available, when the bottom of the column is reached. When the bottom of the last column on the right is reached, proceed to the top of the column of the first column on the left in the table.

If a pair of numbers is needed, proceed down the vertical column by pairs for additional numbers, and proceed to the adjacent top block to the right, if available. When the bottom pair of numbers on the right is reached, proceed to the top block on the left in the table.

4.5 If each number or pair of numbers in the table is used for the random selection process, select a new starting block in accordance with 3.3 and repeat the procedure.

4.6 If the random location results in a location that a sample is not allowed, then the random number shall be discarded and the next random number in sequence will be used, unless otherwise indicated.

5.0 PROCEDURE.

5.1 Random Unit.

5.1.1 Identify the number of units from which a random unit is required and label these units numerically beginning with 1 and increasing until all the units have a different number.

5.1.2 Select a random number in accordance with 4.0.

5.1.3 Multiply the number of units by the random number.

5.1.4 Round up the resulting number to the next whole number to determine the random unit.

Example**:**

Number of Samples = 4
Random Number = 0.698
Random Sample = 4 x 0.698 = 2.792 (Round up to 3)

5.2 Random Quantity.

5.2.1 Identify the quantity from which a random quantity is required.

5.2.2 Select a random number in accordance with 4.0.

5.2.3 Multiply the quantity by the random number.

5.2.4 The resulting number is the random quantity to be sampled.

5.2.5 The sample is obtained from the truck containing the random quantity.

Example:
Sublot Size = 380 t of HMA
Random Number = 0.871
Random Quantity = 380 x 0.871 = 331 t
Sample HMA from the truck containing ton number 331

5.3 Random Location per Length.

5.3.1 Identify the length from which a random location is required.

5.3.2 Select a random number in accordance with 4.0

5.3.3 Multiply the length by the random number.

5.3.4 The resulting number is the random distance.

5.3.5 Add the random distance to the beginning of the length to determine the random location.

5.4 Random Location per Area.

5.4.1 Identify the area from which a random location is required.

5.4.2 Select a pair of random numbers in accordance with 4.0. Use the first number for the longitudinal location and the second number for the transverse location.

5.4.3 Determine the longitudinal length in accordance with 4.3

5.4.4 Multiply the transverse width by the random number.

5.4.5 The resulting numbers represent the random location.

HMA -- Plate Samples.

The random location of a plate sample is determined from a random quantity, random longitudinal distance, and transverse distance as follows:

1. A random quantity is determined in accordance with 5.2.

2. The random longitudinal distance is determined from the length the mixture is placed by the truck containing the random quantity. The starting station for the longitudinal distance is the location of the paver where the truck begins to unload the mixture into the paver or material transfer device. Computations are made to the nearest 1 ft.
3. The random transverse distance is determined using the width of the course being placed. Computations are made to the nearest 1 ft. The distance is measured from the right edge of the course determined by looking in the direction of increasing station numbers. If the width of the course is 4 ft or less, the sample plate will be placed in the center of the course.

Plate samples will not be taken at the following locations and contract requirements:

1. Less than 1 ft from the edge of the course

2. A course thickness less than 2.0 times the maximum particle size except 4.75 mm mixtures shall be at least 1.5 times but not more than 3 times the maximum particle size

3. Original pay item quantities less than 300 t (Does not apply to SMA)

4. Areas specifically exempted per 401.09:

   a. Mixture placed on an approach, taper, gore area, or crossover that is not placed simultaneously with the mainline.
   b. Mixture placed on a shoulder less than 8 feet wide that is not placed simultaneously with the mainline
   c. Within 25 feet of a transverse construction joint
   d. Areas placed with wideners, or specialty equipment approved by the Engineer.

   If the random location falls within these areas another randomly selected location is determined. If the entire sublot falls within these areas, the previous sublot is used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

When additional plate samples are required for gyratory specimens and backup samples, the following procedure is used:

1. The first plate location is determined using the procedure for HMA plate samples. This sample is used for the MSG and binder content determination. This plate sample will be designated A1.

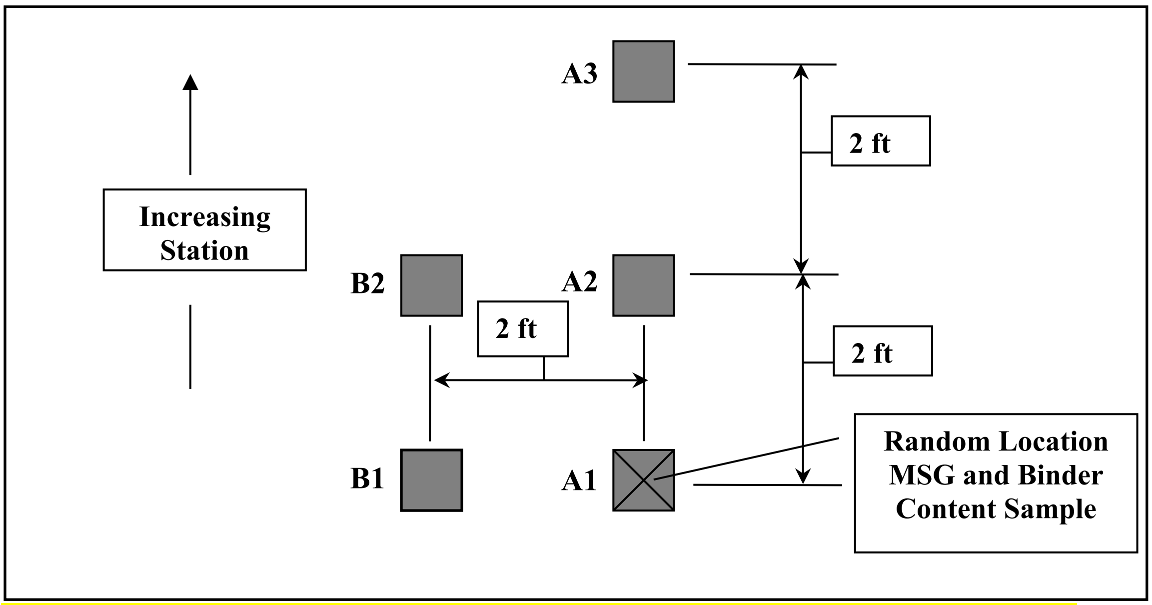
2. The second plate is placed longitudinally 2 ft ahead station from the first plate at the same transverse offset. This sample is used for the gyratory specimens. This plate sample will be designated A2.

3. The third plate is placed longitudinally 2 ft ahead station from the second plate at the same transverse offset. This sample is used to determine the aggregate bulk specific gravity within the mixture. This plate sample will be designated A3.

4. The backup sample plate for the MSG and binder content is placed transversely 2 ft from the first plate towards the center of the mat. If the width of the course is 4 ft or less, the sample plate will be placed 2 ft back station from the first plate in the center of the course. This plate sample will be designated B1.

5. The backup sample plate for the gyratory specimens is placed transversely 2 ft from the second plate toward the center of the mat.

The following diagram shows an example of the arrangement of the plate samples when additional samples are required and backup samples are taken transversely from the first and second sample locations:



Typical sample requirements: SMA: A1 and B1. HMA and OG: A1, A2, A3, B1 and B2.

Example No. 1:

A 25.0 mm base mixture is being placed at 250 lb/yd² for a width of 12 ft. The truck contains 20 t of mixture. The station of the paver when the truck begins unloading is 105+00.

Sublot Size = 1000 t
Random Number = 0.613
Random Quantity = 1000 x 0.613 = 613

$$\text{Length of Load} = \frac{\text{Load Weight, t}}{\text{Avg. Planned Quantity, lb/yd}^2 \text{ x Width, ft}} \text{ x } 18000$$

$$= \frac{20}{250 \text{ x } 12} \text{ x } 18000 = 120 \text{ ft}$$

Random Numbers = 0.428, 0.417
Longitudinal Distance = 120 x 0.428 = 51 ft
Random Location = 105+00 + 51 = 105+51
Transverse Distance = 12 x 0.417 = 5 ft

If additional samples are required, the following locations are determined:

Gyratory Specimen Sample:
Random Location = 105+51 + 02 = 105+53 (nearest foot)
Transverse Distance = 5 ft

Aggregate Bulk Specific Gravity Sample:
Random Location = 105+53 + 02 = 105+55 (nearest foot)
Transverse Distance = 5 ft

Backup Sample for MSG and Binder Content:
Random Location = 105+51
Transverse Distance = 5 + 2= 7 ft

Backup Sample for Gyratory Specimen:
Random Location = 105 + 51 + 02 = 105+53 (nearest foot)
Transverse Distance` = 5 + 2 =7 ft

HMA -- Density Using Cores.

The station at which a core is taken is determined using the length of pavement needed for a sublot of HMA. The transverse distance is determined using the width of the course being placed and is measured from the right edge of the course determined by looking in the direction of increasing station numbers. Computations for the longitudinal distance are made to the nearest 1 ft and computations for the transverse distance are made to the nearest 0.1 ft. Cores will not be taken at the following locations and contract requirements:

1. Less than 3 in. from a confined edge of the course being placed

2. Less than 6 in. from a non-confined edge of the course being placed

3. A course thickness less than 2.0 times the maximum particle size

4. Areas specifically exempted per 401.16:

    a. Mixture placed on an approach, taper, gore area, or crossover that is not placed simultaneously with the mainline
    b. Mixture placed on a shoulder less than 8 feet wide that is not placed simultaneously with the mainline
    c. Within 25 feet of a transverse construction joint
    d. Within 25 feet of an acceptance plate sample
    e. Areas placed with wideners, or specialty equipment approved by the Engineer.

    If the random location falls within these areas, another randomly selected location is determined. If the entire sublot falls within these areas, the previous sublot is used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

5. Original pay item quantities less than 300 t

Example:

A 19.0 mm intermediate mixture is being placed at 165 lb/yd² for a width of 12 ft. The starting station of the sublot is 158+00. The sublot size is 1000 t.

$$\text{Length of Sublot} = \frac{\text{Sublot Size, t}}{\text{Avg. Planned Quantity, lb/yd}^2 \ \text{ x } \ \text{Width, ft}} \ \text{ x } \ 18000$$

$$= \frac{1000}{165 \text{ x } 12} \ \text{ x } \ 18000 = 9090 \text{ ft}$$

Random Numbers = 0.256, 0.561
Longitudinal Distance = 9090 x 0.256 = 2327 ft
Random Station = (158+00) + (23+27) = 181+27
Transverse Distance = 12 x 0.561 = 6.7 ft (Say 7 ft)

PCCP -- Core Thickness.

The station at which a core is taken is determined using the length of pavement needed for the sublot of PCCP. The transverse distance is determined using the width of pavement being placed, and is measured from the right edge of the lane determined by looking in the direction of increasing station numbers. Computations for the longitudinal distance are made to the nearest 1 ft and computations for the transverse distance are made to the nearest 1 ft. Cores will not be taken at the following locations:

1. Less than 2 ft from a D-1 contraction joint;

2. Less than 3 in. from the longitudinal joint; or

3. Less than 5 ft from a transverse construction joint.

4. Less than 6 in. from edge of pavement

If a core location is less than 2 ft from a D-1 contraction joint, a new location will be determined by subtracting or adding 2 feet from the random station. If a core location is less than 3 in. from a longitudinal joint, a new location will be determined by subtracting or adding 3 inches from the random transverse distance. If a core location is less than 5 ft from a transverse construction joint, a new location will be determined by subtracting or adding 5 ft from the random station. If a core location is less than 6 in. from the edge of pavement, a new location will be determined by subtracting or adding 6 in. from the random transverse distance. If a core location is over a dowel bar, a new location will be determined by subtracting or adding 3 ft from the random station.

Example:

A PCCP is being placed at a width of 12 ft and the starting station of the sublot is 75+00. The sublot size is 2400 yd².

$$\text{Length of Sublot} = \frac{\text{Sublot Size, yd}^2}{\text{Width, nearest ft}} \ \text{x} \ \frac{9\ \text{ft}^2}{1\ \text{yd}^2}$$

$$= \frac{2400}{12} \ \text{x} \ 9 = 1800\ \text{ft}$$

Random Numbers = 0.935, 0.114
Longitudinal Distance = 1800 x 0.935 = 1683 ft
Random Station = (75+00) + (16+83) = 91+83
Transverse Distance = 12 x 0.114 = 1.4 ft (Say 1 ft)
(Too close to edge of pavement)
= 1 + 2 = 3 ft

Retroreflective Pavement Markings

The random location to measure the retro-reflectivity of a pavement marking on a longitudinal line is determined by selecting a random sampling zone within the segment as follows:

Random Segment

1. The section is the number of miles to the nearest 0.1 mi of each color of pavement marking application completed in a single day.

2. Divide the section by three to determine the length of the segments to the nearest 0.1 mi.

Random Sampling Zone

1. Select three random numbers in accordance with 4.0.

2. For the first segment, multiply the first random number by the length of the segment and round to the nearest 0.1 mi. Add this length to the Reference Post (RP) at the beginning of the segment. This number is the beginning of the sampling zone. Repeat this procedure for the second and third segments using the second and third random numbers respectively.

3. The first measurement is taken at the beginning of the sampling zone and all subsequent measurements are taken at approximately 15 ft intervals.

Example:

The total length of one color of pavement markings on a longitudinal line placed in one day is 30 mi.

Segment Locations

Section Size = 30 mi
Segment Size = 30/3= 10 mi
Segment Locations 0 – 10 mi, 10 – 20 mi, 20 – 30 mi

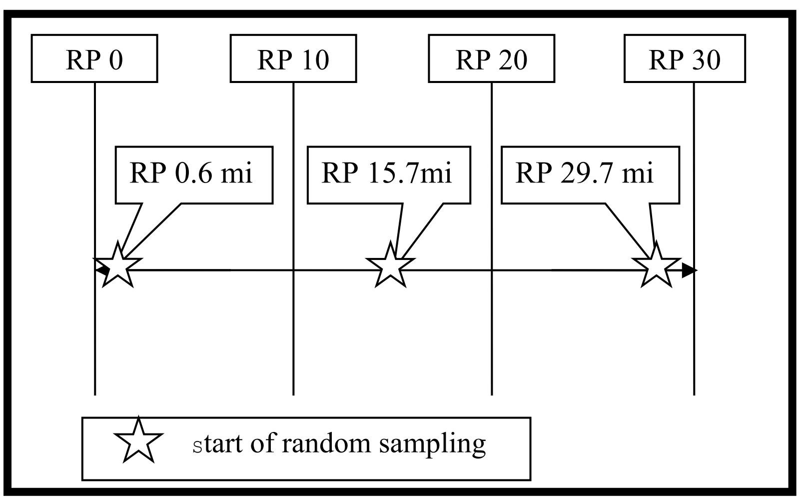
Random Sampling Zone

Random Numbers 0.063, 0.566, 0.968
Segment No. 1 0 – 10 mi): 10 mi x 0.063 = 0.6
0 + 4 0.6 = 0.6 mi (starting location for the first sampling zone is RP 0.6)

Segment No. 2 (10– 20 mi): 10 mi x 0.566 = 5.7
10 + 5.7 = 15.7 mi (starting location for the second sampling zone is RP 15.7)

Segment No. 3 (20 - 30 mi): 10 mi x 0.968 = 9.7
20 + 9.7 = 29.7 mi (starting location for the third sampling zone is RP 29.7)

The following diagram indicates the start of the random sampling zones:



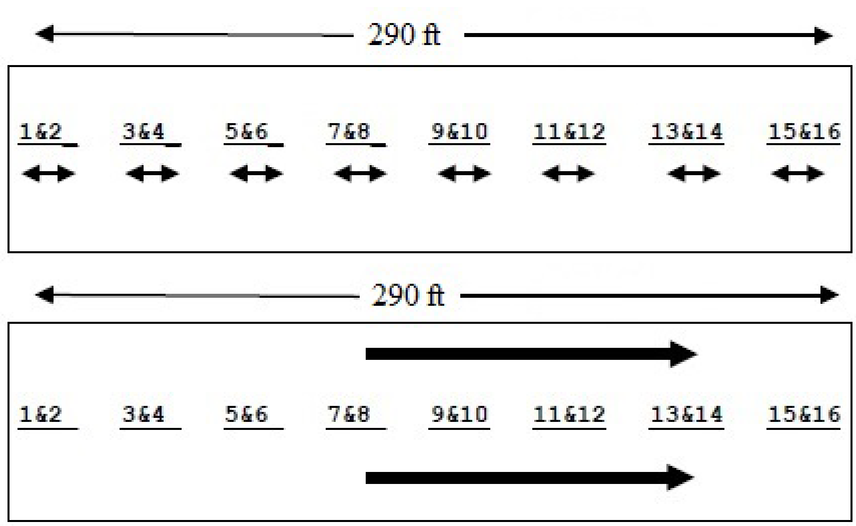
Additional requirements for the sampling locations are as follows:

1. The length required for measurements of skip lines and the combination of skip and solid lines is 290 ft, which is obtained from 10 ft line segments and 30 ft gaps between skip lines. The 105 ft length for double solid lines is obtained by taking 8 measurements on the line spaced at 15 ft intervals. If there is insufficient length in the sampling zone within the segment to obtain the required number of sampling locations, the additional sampling locations will be obtained backward from the beginning of the sampling zone. All retro-reflectivity measurements are made in the direction of the traffic flow, except for only skip lines with two-way traffic.

2. If any portion of the sampling zone is unsafe for taking measurements, the beginning of the sampling zone is moved forward to the first point which may be inspected safely. Sampling zones are not moved for convenience.

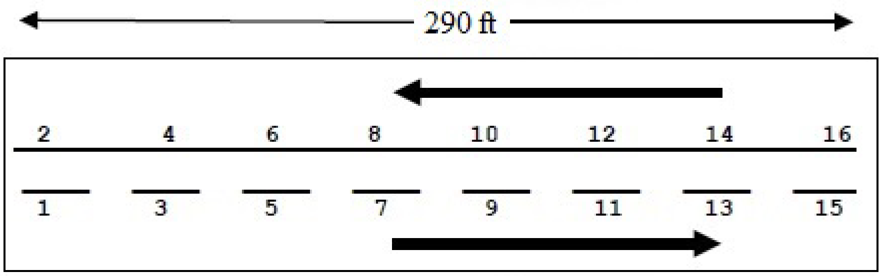
3. If a valid measurement is not attainable at a location within the sampling zone due to a pothole, grass, obvious tracking, etc., the sampling location is moved forward in the sampling zone to the first available location for a valid measurement. Subsequent measurements are obtained at the calculated random locations.

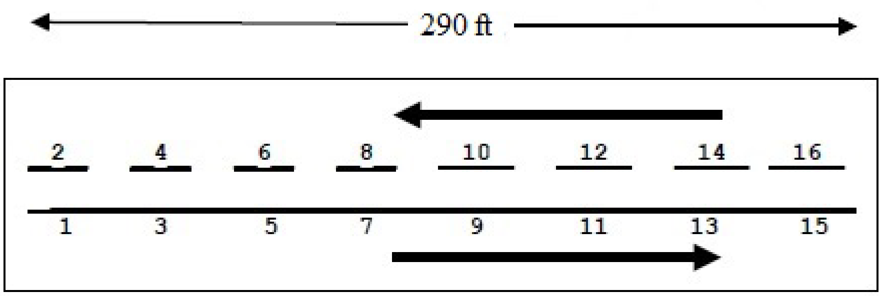
4. When a sampling zone contains only skip lines, each skip line is measured at two evenly spaced locations on the line. For two-way traffic, one measurement on each line is taken in one direction and the other measurement on the same line is taken in the opposite direction. This procedure is continued until 16 measurements are obtained as indicated in the following diagram:



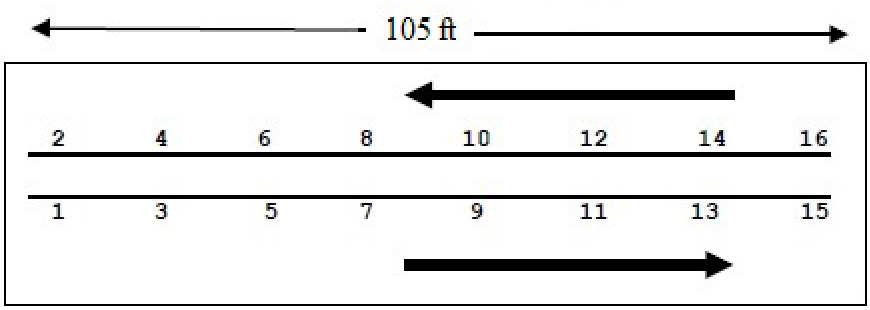
5. When a sampling zone contains a skip line and a solid line, each skip line is measured once and the measurement on the solid line is obtained at the same station. Measurements are taken in the direction of the traffic flow for each line.

This procedure is continued until 16 measurements are obtained as indicated in the following diagrams:

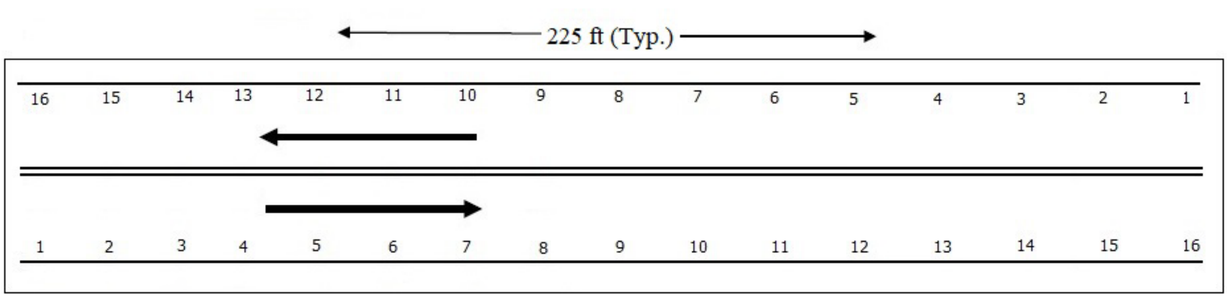




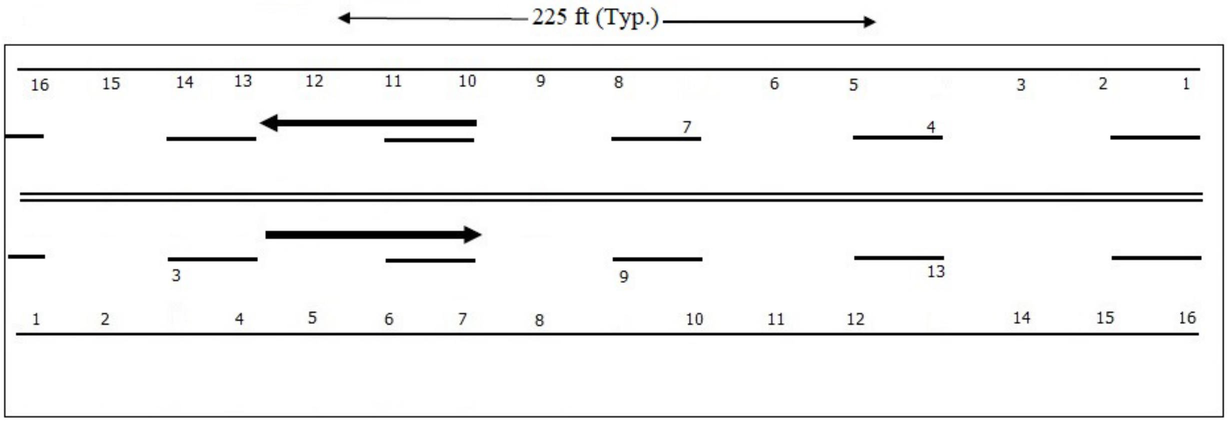
6. When a sampling zone contains two solid lines, measurements are taken alternately on each solid line at the same station and at 15 ft intervals in the direction of the traffic flow for each line. This procedure is continued until 16 measurements are obtained as indicated in the following diagram:



7. For two lane highways, measurements are taken separately for each edge line as indicated in the following diagram:



8. For multilane highways, divided or undivided, the lane line and white edge line measurements may be combined to reach 16 measurements for each direction of traffic, provided the markings were applied on the same day, as indicated in the following diagram:



Soil Embankment – DCP/LWD Measurements

The testing frequency for Light Weight Deflectometer (LWD) or Dynamic Cone Penetrometer (DCP) testing is based on the volume of material placed. The volume of material for a given lift thickness is converted to an area and the area is converted to a length and width based on the geometry of the lift to be tested. The station at which a LWD or DCP test is taken is determined using the length of embankment construction area.

Three LWD tests will be taken at the random station at 2 ft from each edge of the construction area and at 1/2 of the width of the construction area. One DCP test will be obtained at the random station. The transverse distance for the DCP test is determined using the width of the embankment being placed and is measured from the right edge of the construction area determined by looking in the direction of increasing station numbers. Computations for the longitudinal distance and transverse distance are made to the nearest 1 ft.

DCP Example:

The construction area for a soil embankment 6 in. lift is determined to start at station 10+00 and the width of the construction area is 38 ft. The frequency of testing is one test for each 1400 yd^3.

Convert 1400 yd^3 to the length of embankment placed:

$$1400\ yd^3 \times \frac{27\ ft^3}{1\ yd^3} \times \frac{1}{38\ ft} \times \frac{1}{6\ in.} \times \frac{12\ in.}{1\ ft} = 1989\ ft$$

Random Numbers	= 0.420, 0.607
Longitudinal Distance	= 1989 x 0.420 = 835 4 ft (Say 835 ft)
Random Station	= (10+00) + (8+35) = 18+35
Transverse Distance	= 38 x 0.607 = 23.1 ft (Say 23 ft)

5.5 Random Target Area.

5.5.1 Determine the area from which a random location is required to the nearest 1 yd^2

5.5.2 Divide the area by 100 and round down to the nearest whole number. The resulting number will be the number of segments within the area that are available for sampling.

5.5.3 Divide the area by the number of sample segments to determine the sample segment size to the nearest 1 yd^2

5.5.4 Select a random number in accordance with 4.0

5.5.5 Multiply the number of sample segments by the random number and round down to the nearest whole number. The resulting number represents the random target area. The sample will be taken from material placed within the random target area.

5.5.6 Divide the sample segment size by the width of the area and round to the nearest 0.1 ft length. The resulting number is the length of the random target area.

5.5.7 Multiply the random target area by the length of the random target area and round to the nearest whole foot. The resulting number will be the distance to the beginning of the random target area as measured from the start of the area to be sampled.

Portland Cement Concrete Pavement (PCCP) -- Plastic Concrete Samples.

The location of the random target area is determined for each sublot. The PCCP sample is taken from material placed within the random target area.

Example No. 1:

A PCCP is being placed at a width of 12 ft and the starting station of the sublot is 102+50.
The sublot size is 2400 yd^2.

$$\text{Number of Sample Segments} = \frac{2400}{100} = 24$$

$$\text{Sample Segment Size} = \frac{2400}{24} = 100 \text{ yd}^2$$

Random Number = 0.830
Random Target Area = 24 x 0.830 = 19.9 (round down to 19)

$$\text{Length of Random Target Area} = \frac{\text{Sample Segment Size, yd}^2}{\text{Width, nearest 0.1 ft}} \text{ x } \frac{9 \text{ ft}^2}{1 \text{ yd}^2}$$

$$= \frac{100}{12} \text{ x } 9 = 75 \text{ ft}$$

Distance to the beginning of the Random Target Area = 19 x 75 = 1425 ft

Example No. 2:

A PCCP is being placed at a width of 24 ft and the starting station of the sublot is 165+00. The sublot size is 550 yd^2.

$$\text{Number of Sample Segments} = \frac{550}{100} = 5.5 \text{ (round down to 5)}$$

$$\text{Sample Segment Size} = \frac{550}{5} = 110 \text{ yd}^2$$ Random Number = 0.361

Random Target Area = 5 x 0.361 = 1.8 (round down to 1)

$$\text{Length of Random Target Area} = \frac{\text{Sample Segment Size, yd}^2}{\text{Width, nearest 0.1 ft}} \text{ x } \frac{9 \text{ ft}^2}{1 \text{ yd}^2}$$

$$= \frac{110}{24} \text{ x } 9 = 41.2 \text{ ft}$$

Station of Random Target Area = 165+00 to (165+00 + 41) = 165+00 to 165+41

RANDOM NUMBER TABLE

0.576	0.730	0.430	0.754	0.271	0.870	0.732	0.721	0.998	0.239
0.892	0.948	0.858	0.025	0.935	0.114	0.153	0.508	0.749	0.291
0.669	0.726	0.501	0.402	0.231	0.505	0.009	0.420	0.517	0.858
0.609	0.482	0.809	0.140	0.396	0.025	0.937	0.310	0.253	0.761
0.971	0.824	0.902	0.470	0.997	0.392	0.892	0.957	0.040	0.463
0.053	0.899	0.554	0.627	0.427	0.760	0.470	0.040	0.904	0.993
0.810	0.159	0.225	0.163	0.549	0.405	0.285	0.542	0.231	0.919
0.081	0.277	0.035	0.039	0.860	0.507	0.081	0.538	0.986	0.501
0.982	0.468	0.334	0.921	0.690	0.806	0.879	0.414	0.106	0.031
0.095	0.801	0.576	0.417	0.251	0.884	0.522	0.235	0.389	0.222
0.509	0.025	0.794	0.850	0.917	0.887	0.751	0.608	0.698	0.683
0.371	0.059	0.164	0.838	0.289	0.169	0.569	0.977	0.796	0.996
0.165	0.996	0.356	0.375	0.654	0.979	0.815	0.592	0.348	0.743
0.477	0.535	0.137	0.155	0.767	0.187	0.579	0.787	0.358	0.595
0.788	0.101	0.434	0.638	0.021	0.894	0.324	0.871	0.698	0.539
0.566	0.815	0.622	0.548	0.947	0.169	0.817	0.472	0.864	0.466
0.901	0.342	0.873	0.964	0.942	0.985	0.123	0.086	0.335	0.212
0.470	0.682	0.412	0.064	0.150	0.962	0.925	0.355	0.909	0.019
0.068	0.242	0.777	0.356	0.195	0.313	0.396	0.460	0.740	0.247
0.874	0.420	0.127	0.284	0.448	0.215	0.833	0.652	0.701	0.326
0.897	0.877	0.209	0.862	0.428	0.117	0.100	0.259	0.425	0.284
0.876	0.969	0.109	0.843	0.759	0.239	0.890	0.317	0.428	0.802
0.190	0.696	0.757	0.283	0.777	0.491	0.523	0.665	0.919	0.246
0.341	0.688	0.587	0.908	0.865	0.333	0.928	0.404	0.892	0.696
0.846	0.355	0.831	0.218	0.945	0.364	0.673	0.305	0.195	0.887
0.882	0.227	0.552	0.077	0.454	0.731	0.716	0.265	0.058	0.075
0.464	0.658	0.629	0.269	0.069	0.998	0.917	0.217	0.220	0.659
0.123	0.791	0.503	0.447	0.659	0.463	0.994	0.307	0.631	0.422
0.116	0.120	0.721	0.137	0.263	0.176	0.798	0.879	0.432	0.391
0.836	0.206	0.914	0.574	0.870	0.390	0.104	0.755	0.082	0.939
0.636	0.195	0.614	0.486	0.629	0.663	0.619	0.007	0.296	0.456
0.630	0.673	0.665	0.666	0.399	0.592	0.441	0.649	0.270	0.612
0.804	0.112	0.331	0.606	0.551	0.928	0.830	0.841	0.702	0.183
0.360	0.193	0.181	0.399	0.564	0.772	0.890	0.062	0.919	0.875
0.183	0.651	0.157	0.150	0.800	0.875	0.205	0.446	0.648	0.685

RANDOM NUMBER TABLE

0.206	0.455	0.609	0.131	0.382	0.576	0.589	0.985	0.587	0.410
0.352	0.463	0.735	0.539	0.683	0.419	0.464	0.190	0.014	0.197
0.807	0.721	0.889	0.228	0.889	0.553	0.475	0.104	0.308	0.814
0.992	0.265	0.134	0.914	0.978	0.144	0.330	0.818	0.538	0.519
0.615	0.852	0.291	0.196	0.478	0.271	0.567	0.091	0.052	0.533
0.691	0.944	0.451	0.873	0.945	0.843	0.901	0.743	0.193	0.563
0.456	0.796	0.900	0.222	0.706	0.350	0.466	0.903	0.007	0.409
0.342	0.380	0.314	0.455	0.403	0.818	0.916	0.803	0.370	0.153
0.305	0.745	0.720	0.213	0.804	0.362	0.793	0.685	0.443	0.003
0.125	0.399	0.675	0.403	0.269	0.942	0.800	0.565	0.210	0.095
0.750	0.644	0.178	0.912	0.102	0.378	0.715	0.707	0.060	0.811
0.495	0.674	0.223	0.372	0.790	0.496	0.934	0.762	0.941	0.553
0.749	0.925	0.008	0.386	0.170	0.266	0.869	0.463	0.308	0.044
0.557	0.768	0.417	0.902	0.230	0.775	0.556	0.129	0.602	0.023
0.265	0.158	0.168	0.200	0.650	0.302	0.460	0.811	0.449	0.783
0.461	0.833	0.513	0.754	0.450	0.553	0.154	0.741	0.111	0.693
0.092	0.901	0.948	0.296	0.937	0.401	0.637	0.356	0.108	0.993
0.233	0.487	0.084	0.363	0.719	0.451	0.299	0.063	0.971	0.779
0.178	0.680	0.528	0.814	0.437	0.484	0.265	0.107	0.754	0.234
0.642	0.302	0.860	0.126	0.350	0.477	0.018	0.083	0.648	0.737
0.936	0.847	0.548	0.735	0.843	0.653	0.507	0.678	0.201	0.722
0.886	0.138	0.957	0.002	0.709	0.746	0.112	0.723	0.639	0.381
0.823	0.960	0.512	0.860	0.380	0.903	0.334	0.709	0.734	0.241
0.496	0.030	0.730	0.645	0.605	0.585	0.459	0.856	0.506	0.388
0.624	0.021	0.751	0.172	0.520	0.123	0.616	0.943	0.757	0.946
0.625	0.408	0.690	0.402	0.039	0.189	0.675	0.564	0.244	0.777
0.283	0.915	0.720	0.007	0.406	0.356	0.771	0.975	0.576	0.760
0.296	0.996	0.678	0.920	0.872	0.720	0.426	0.388	0.682	0.142
0.735	0.002	0.388	0.170	0.238	0.711	0.880	0.716	0.728	0.961
0.222	0.103	0.616	0.330	0.512	0.018	0.108	0.558	0.996	0.969
0.632	0.796	0.235	0.924	0.340	0.330	0.644	0.646	0.637	0.825
0.551	0.679	0.022	0.454	0.455	0.858	0.324	0.176	0.965	0.477
0.161	0.282	0.057	0.409	0.417	0.157	0.703	0.636	0.579	0.819
0.600	0.985	0.309	0.414	0.116	0.426	0.577	0.072	0.784	0.143
0.248	0.654	0.277	0.986	0.395	0.607	0.886	0.042	0.577	0.173

RANDOM NUMBER TABLE

0.779	0.284	0.210	0.877	0.351	0.611	0.544	0.091	0.483	0.778
0.438	0.495	0.264	0.694	0.005	0.970	0.594	0.757	0.710	0.912
0.071	0.491	0.689	0.601	0.408	0.360	0.483	0.766	0.541	0.674
0.691	0.646	0.759	0.965	0.337	0.494	0.054	0.846	0.485	0.772
0.075	0.270	0.325	0.371	0.381	0.590	0.868	0.643	0.597	0.233
0.888	0.375	0.489	0.450	0.263	0.842	0.586	0.862	0.153	0.228
0.613	0.838	0.358	0.725	0.958	0.146	0.424	0.601	0.363	0.895
0.639	0.967	0.636	0.724	0.495	0.357	0.132	0.797	0.098	0.665
0.272	0.257	0.765	0.217	0.339	0.928	0.241	0.464	0.608	0.348
0.041	0.365	0.358	0.628	0.208	0.297	0.028	0.062	0.326	0.765
0.795	0.849	0.984	0.550	0.453	0.592	0.216	0.100	0.179	0.257
0.961	0.325	0.114	0.732	0.829	0.637	0.706	0.950	0.977	0.265
0.840	0.934	0.012	0.949	0.269	0.581	0.872	0.310	0.763	0.893
0.738	0.848	0.613	0.699	0.129	0.781	0.263	0.397	0.688	0.198
0.594	0.960	0.898	0.519	0.034	0.853	0.070	0.136	0.151	0.829
0.569	0.905	0.347	0.957	0.034	0.302	0.594	0.708	0.529	0.219
0.358	0.828	0.920	0.887	0.349	0.491	0.616	0.785	0.460	0.572
0.458	0.763	0.207	0.483	0.203	0.996	0.186	0.076	0.647	0.883
0.060	0.145	0.114	0.934	0.733	0.786	0.961	0.241	0.172	0.995
0.401	0.248	0.516	0.911	0.669	0.991	0.999	0.617	0.547	0.969
0.964	0.458	0.356	0.414	0.953	0.176	0.987	0.381	0.256	0.309
0.118	0.918	0.142	0.540	0.448	0.889	0.555	0.205	0.879	0.362
0.254	0.600	0.806	0.126	0.299	0.754	0.373	0.779	0.594	0.301
0.254	0.838	0.398	0.389	0.970	0.018	0.132	0.512	0.569	0.608
0.427	0.410	0.434	0.847	0.787	0.001	0.524	0.828	0.448	0.087
0.342	0.746	0.382	0.662	0.670	0.065	0.133	0.067	0.958	0.630
0.112	0.129	0.663	0.666	0.018	0.522	0.454	0.813	0.405	0.698
0.767	0.879	0.390	0.279	0.994	0.474	0.004	0.831	0.323	0.414
0.940	0.989	0.854	0.835	0.957	0.154	0.493	0.642	0.637	0.578
0.271	0.337	0.728	0.173	0.840	0.814	0.777	0.877	0.028	0.794
0.078	0.590	0.712	0.705	0.336	0.603	0.992	0.214	0.934	0.800
0.799	0.519	0.235	0.113	0.936	0.059	0.793	0.504	0.065	0.526
0.033	0.873	0.130	0.921	0.485	0.146	0.330	0.633	0.835	0.172
0.423	0.958	0.967	0.605	0.632	0.710	0.217	0.613	0.259	0.699
0.273	0.945	0.329	0.895	0.813	0.154	0.149	0.425	0.881	0.029

RANDOM NUMBER TABLE

0.731	0.731	0.423	0.958	0.950	0.212	0.700	0.267	0.448	0.975
0.799	0.629	0.160	0.292	0.932	0.083	0.068	0.763	0.794	0.785
0.061	0.225	0.782	0.150	0.006	0.645	0.422	0.666	0.818	0.182
0.272	0.685	0.643	0.687	0.945	0.205	0.461	0.399	0.588	0.677
0.941	0.170	0.982	0.792	0.435	0.142	0.244	0.140	0.395	0.295
0.428	0.330	0.534	0.376	0.903	0.036	0.165	0.725	0.200	0.736
0.618	0.542	0.219	0.787	0.114	0.594	0.833	0.070	0.114	0.450
0.080	0.806	0.777	0.185	0.473	0.341	0.810	0.462	0.811	0.736
0.190	0.444	0.671	0.642	0.726	0.451	0.955	0.952	0.859	0.929
0.343	0.766	0.809	0.365	0.646	0.768	0.717	0.848	0.053	0.545
0.281	0.633	0.189	0.261	0.950	0.549	0.906	0.164	0.921	.791
0.974	0.666	0.600	0.834	0.832	0.205	0.163	0.668	0.096	0.350
0.819	0.495	0.392	0.968	0.755	0.917	0.266	0.452	0.341	0.095
0.131	0.253	0.777	0.120	0.753	0.008	0.205	0.626	0.826	0.778
0.522	0.878	0.990	0.159	0.278	0.643	0.024	0.287	0.707	0.373
0.510	0.132	0.722	0.906	0.800	0.932	0.009	0.383	0.677	0.289
0.094	0.058	0.483	0.285	0.264	0.546	0.047	0.761	0.085	0.786
0.186	0.546	0.975	0.715	0.628	0.525	0.231	0.444	0.077	0.066
0.797	0.784	0.884	0.604	0.954	0.992	0.175	0.129	0.224	0.984
0.485	0.263	0.597	0.268	0.498	0.722	0.184	0.686	0.536	0.089
0.573	0.755	0.217	0.463	0.776	0.492	0.420	0.107	0.164	0.940
0.266	0.433	0.175	0.403	0.519	0.730	0.091	0.385	0.984	0.578
0.880	0.037	0.157	0.535	0.466	0.215	0.818	0.636	0.215	0.276
0.396	0.158	0.227	0.636	0.823	0.238	0.172	0.522	0.805	0.109
0.436	0.091	0.271	0.032	0.644	0.475	0.372	0.399	0.481	0.605
0.850	0.863	0.748	0.453	0.925	0.418	0.018	0.570	0.834	0.079
0.839	0.866	0.943	0.093	0.493	0.530	0.995	0.282	0.544	0.532
0.103	0.528	0.632	0.643	0.780	0.752	0.974	0.850	0.997	0.303
0.218	0.786	0.065	0.149	0.903	0.049	0.223	0.487	0.242	0.559
0.693	0.355	0.412	0.535	0.878	0.121	0.031	0.919	0.710	0.069
0.339	0.521	0.001	0.297	0.190	0.802	0.682	0.836	0.694	0.242
0.515	0.885	0.494	0.739	0.373	0.058	0.026	0.386	0.658	0.455
0.076	0.471	0.334	0.422	0.136	0.871	0.818	0.790	0.365	0.276
0.367	0.901	0.023	0.530	0.992	0.758	0.821	0.399	0.926	0.974
0.795	0.218	0.884	0.070	0.291	0.436	0.905	0.271	0.181	0.881

RANDOM NUMBER TABLE

0.344	0.569	0.290	0.243	0.451	0.836	0.596	0.159	0.878	0.107
0.409	0.991	0.666	0.609	0.026	0.620	0.772	0.318	0.987	0.197
0.375	0.596	0.892	0.472	0.916	0.252	0.988	0.470	0.980	0.566
0.547	0.253	0.020	0.474	0.462	0.096	0.515	0.729	0.251	0.676
0.350	0.802	0.627	0.825	0.866	0.765	0.999	0.268	0.058	0.968
0.885	0.786	0.077	0.805	0.089	0.953	0.055	0.825	0.436	0.330
0.389	0.889	0.169	0.491	0.804	0.132	0.862	0.703	0.558	0.808
0.839	0.142	0.211	0.099	0.662	0.627	0.919	0.012	0.104	0.378
0.100	0.781	0.332	0.776	0.546	0.370	0.524	0.470	0.919	0.796
0.510	0.331	0.467	0.221	0.364	0.434	0.386	0.642	0.077	0.456
0.481	0.599	0.085	0.647	0.500	0.120	0.592	0.103	0.702	0.999
0.213	0.195	0.999	0.470	0.268	0.215	0.220	0.043	0.360	0.024
0.431	0.730	0.905	0.420	0.210	0.805	0.723	0.137	0.156	0.031
0.029	0.832	0.713	0.435	0.520	0.503	0.452	0.981	0.633	0.118
0.240	0.329	0.015	0.550	0.088	0.086	0.325	0.397	0.061	0.806
0.906	0.743	0.882	0.924	0.310	0.456	0.396	0.784	0.686	0.184
0.559	0.408	0.245	0.212	0.802	0.017	0.841	0.598	0.142	0.228
0.161	0.678	0.660	0.388	0.964	0.169	0.184	0.237	0.222	0.328
0.068	0.035	0.547	0.227	0.818	0.008	0.467	0.353	0.615	0.264
0.459	0.348	0.664	0.718	0.920	0.382	0.824	0.039	0.462	0.235
0.541	0.776	0.752	0.366	0.016	0.827	0.608	0.923	0.601	0.087
0.517	0.859	0.217	0.074	0.766	0.689	0.650	0.404	0.729	0.980
0.669	0.598	0.372	0.594	0.043	0.378	0.416	0.857	0.039	0.905
0.274	0.385	0.352	0.367	0.149	0.327	0.160	0.283	0.840	0.708
0.235	0.165	0.658	0.567	0.982	0.094	0.690	0.319	0.605	0.706
0.881	0.556	0.066	0.062	0.614	0.018	0.030	0.035	0.728	0.859
0.326	0.663	0.566	0.470	0.421	0.477	0.066	0.018	0.825	0.434
0.683	0.304	0.968	0.239	0.663	0.236	0.277	0.317	0.214	0.478
0.618	0.944	0.985	0.105	0.540	0.183	0.748	0.009	0.353	0.963
0.925	0.226	0.388	0.513	0.526	0.718	0.539	0.924	0.442	0.197
0.685	0.943	0.431	0.317	0.476	0.228	0.414	0.064	0.955	0.340
0.658	0.412	0.512	0.885	0.685	0.636	0.851	0.584	0.048	0.951
0.869	0.495	0.608	0.567	0.035	0.493	0.500	0.229	0.826	0.337
0.125	0.157	0.056	0.436	0.657	0.602	0.823	0.453	0.823	0.099
0.569	0.998	0.733	0.097	0.268	0.640	0.272	0.718	0.153	0.644

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

VERIFYING OVENS
ITM No. 903-15T

1.0 SCOPE.

1.1 This test method covers the procedures for verifying the temperature indicator settings on general purpose ovens.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and to determining the applicability of regulatory limitations prior to use.

2.0 APPARATUS.

2.1 Liquid-in-Glass Thermometer, verified by a Certified National Institute of Standards and Technology (NIST) traceable thermometer, graduated in 2.0°F increments, and having a range which includes the drying temperature of the material indicated in the appropriate test method

2.2 Digital Thermometer, verified by a NIST traceable thermometer, graduated in 0.1°F increments, and having a range which includes the drying temperature of the material indicated in the appropriate test method

2.3 Thermometer well, brass or aluminum

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM is used by laboratory personnel to verify the temperature indicator settings on general purpose ovens.

5.0 PROCEDURE.

5.1 Record the identification number, manufacturer, and model number of the oven.

5.2 Record the identification of the certified thermometer.

5.3 Place the liquid-in-glass thermometer or digital thermometer probe inside the thermometer well. Position the thermometer or probe and thermometer well as close to the three dimensional center of the oven as possible.

5.4 Set and record the oven temperature at the operating temperature of the material indicated in the appropriate test method.

5.5 Record an initial reading 1 h after closing the oven.

5.6 Adjust the temperature indicator of the oven if an observed reading is outside the tolerance specified in the appropriate test method. Allow at least 1/2 h for the temperature to stabilize between each adjustment.

5.7 Continue until three consecutive readings, at 1/2 h intervals, meet the required tolerance.

5.8 If there is a temperature offset required, visibly note the offset on the outside of the oven.

6.0 TOLERANCE. Ovens shall be capable of maintaining a constant temperature range listed in the appropriate test method.

OVEN TEMPERATURE VERIFICATION
ITM 903

Oven Identification: ______________________________

Manufacturer: ______________________________

Model No.: ______________________________

Thermometer used: ASTM No. ________________ Ser. No.: ______________________________

Operating Temperature: ______________________

Time	Initial Reading
1 h	
1-1/2 h	
2 h	
2-1/2 h	
3 h	

Remarks: ______________________________

____

____

Verified by: ______________________________

Date: ________________ Next Due Date: ______________________

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

VERIFYING VACUUM CHAMBERS
ITM No. 905-21

1.0 SCOPE.

1.1 This test method covers the procedure for verifying the vacuum chambers used in AASHTO T 331 and ITM 572. It also provides a procedure for verifying the digital gauge used in AASHTO T 209 with either a mercury manometer or National Institute of Standards and Technology (NIST) traceable digital gauge as the measurement standard.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

T 209 Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

T 331 Bulk Specific Gravity and Density of Compacted asphalt Mixtures Using Automatic Sealing Method

2.2 ASTM Standards.

D7227 Rapid Drying of Compacted Asphalt Specimens Using Vacuum Drying Apparatus

2.3 ITM Standards.

572 Drying HMA Mixtures

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM is used by laboratory personnel to standardize the vacuum chambers used in AASHTO T 331 and ITM 572. It can also be utilized to verify the digital vacuum gauge used in AASHTO T 209 using a mercury manometer or a NIST traceable calibrated digital gauge the measurement standard.

5.0 APPARATUS.

5.1 Mercury absolute pressure manometer (note: mercury manometers do not have to be calibrated).

5.2 Digital gauge capable of measuring vacuum down to 25 mm Hg. The gauge shall be NIST traceable, and the measurement standard calibrated annually. See Note 1.

5.3 Vacuum Gauge capable of being placed inside the vacuum chamber and has a minimum range of 10 to 0 mm Hg that is readable to a minimum of 1 mm Hg. The gauge shall be NIST traceable, and the measurement standard calibrated annually. See Note 1.

Note 1—Measurement Standard is defined as a device infrequently used only for the standardization of other devices and not used in the day to day operations of the laboratory.

6.0 PROCEDURES.

6.1 Vacuum Chamber AASHTO T 209, T 331, and ITM 572.

6.1.1 Record the identification number and date of calibration of the measurement standard vacuum gauge.

6.1.2 Record the identification number of the device being standardized.

6.1.3 Place the vacuum gauge inside the vacuum chamber.

6.1.4 Start the apparatus and allow the vacuum to remove the air from the vacuum chamber.

6.1.5 Record the reading on the vacuum gauge at the maximum vacuum level achieved.

6.2 Verifying a Digital Gauge using a Mercury Manometer or a Measurement Standard Digital Gauge AASHTO T 209

6.2.1 If a mercury manometer is used inspect it for mercury separation.

6.2.2 Record the identification on both devices.

6.2.3 Plumb the vacuum system with a two way splitter off of the pycnometer lid with one line going to the digital gauge being verified and the other line going to the mercury manometer or measurement standard digital gauge.

6.2.4 Place the lid on the pycnometer and start the vacuum system. Stabilize the mercury manometer or measurement standard gauge and verify that the reading is between 27 mm and 28 mm Hg.

6.2.5 Record the reading from both devices. The readings are recorded to the nearest 1/2 mm when using the mercury manometer.

7.0 TOLERANCE.

7.1 The reading of the vacuum gauge used for AASHTO T 331 shall be 10 mm Hg or less.

7.2 The reading of the vacuum gauge used for ITM 572 shall be 6 mm Hg or less.

7.3 A maximum of ± 2 mm Hg offset for the digital vacuum gage used in T 209 may be applied and is required to be clearly indicated at the test method point of use.

VACUUM CHAMBER VERIFICATION
ITM 905

Vacuum Chamber (AASHTO T 331 / CoreLok)

EQUIPMENT:

Measurement Standard Identification: ____________________

Measurement Standard calibration date: ____________________

Device being verified: ______________________

VERIFICATION:

Reading on measurement standard _________________ (less than 10 torr)

Remarks: ____

____

____

Verified by: ____Date: _________________

VACUUM CHAMBER VERIFICATION
ITM 905

Vacuum Chamber (ITM 572 / CoreDry)

EQUIPMENT:

Measurement Standard Identification: ______________________

Measurement Standard calibration date: ______________________

Device being verified: ________________________

VERIFICATION:

Reading on measurement standard ___________________ (less than 6 torr)

Remarks: ____

____

____

Verified by: ____________________________________ Date: ___________________

VACUUM GAUGE VERIFICATION
ITM 905/AASHTO T209

EQUIPMENT:

Digital Gauge Identification: ________________________

Mercury Manometer or Measurement Standard Identification: ___________________

Date of calibration if Measurement Standard gauge if used ________________

VERIFICATION:

Vacuum reading of Measurement Standard: ___________ (between 27-28, to the nearest ½ mm)

Vacuum reading of Digital Gauge: ___________________

Difference between Mercury Manometer/Measurement Standard and Digital Gauge being verified: ___________ (not to exceed 2 mm)

If necessary, offset (+/-) clearly displayed where the digital gauge is used: ____________
(Yes/NA)

Remarks: ____

____

____

Verified By: _________________________________ Date: _________________

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

VERIFYING MECHANICAL SHAKERS
ITM No. 906-17T

1.0 SCOPE.

1.1 This test method covers the procedure for verifying the sieving sufficiency of mechanical shakers and the accuracy of timers used in the sieve analysis of aggregates.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and to determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 ITM Standards.

902 Verifying Sieves

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 SIGNIFICANCE AND USE. This ITM is used by laboratory personnel to verify the sieving sufficiency of mechanical shakers and the accuracy of timers used in the sieve analysis of aggregates.

5.0 APPARATUS.

5.1 Balance, readable to 0.1 g

5.2 Stopwatch, readable to 1 s

5.3 Sieves, verified in accordance with ITM 902

5.4 Sieve pan and lid

6.0 PROCEDURE.

6.1 Timer.

6.1.1 Operate the mechanical shaker with the timer set at 5 min, and measure the time using the stopwatch.

6.1.2 Repeat 5.1.1 with the timer set at 10 min and 15 min.

6.1.3 If the timer is not within the allowable tolerance of 8.1, the manufacturers markings shall not be used, and accurate settings on the shaker shall be established by trial and error determination.

6.2 Shakers using 8 in. and 12 in. diameter sieves.

6.2.1 Determine and record an initial sample weight.

6.2.2 Insert sieves No. 4 through No. 200 for fine aggregates or 1 in. through No. 200 for coarse or dense graded aggregates into the shaker.

6.2.3 Shake sample mechanically for 15 min for sands or 10 min for blended aggregates.

6.2.4 Place the first sieve retaining material on a pan, and cover the sieve with the lid.

6.2.5 Hand shake the first sieve for 1 min by holding the sieve in a slightly inclined position in one hand and striking the side of the sieve sharply and with an upward motion against the heel of the other hand at approximately 150 times per min. The sieve should be turned about 1/6 of a revolution at intervals of about 25 strokes. For sieves larger than the No. 4 sieve, the material on the sieve should be limited to a single layer of particles.

6.2.6 Weigh the material passing the sieve and retained in the pan.

6.2.7 Weigh the material retained on the sieve.

6.2.8 Add the weight retained on the sieve and weight passing the sieve, and verify the sieve was not overloaded in accordance with Table 1. If the sieve was overloaded, verification is void, and a new sample shall be obtained.

Screen Size	Standard 15 in. x 23 in.	Standard 14 in. x 14 in.	12 in. Diameter	8 in. Diameter
3 in.	40.5 kg	23.0 kg	12.6 kg	--------
2 in.	27.0 kg	15.3 kg	8.4 kg	3.6 kg
1 1/2 in.	20.2 kg	11.5 kg	6.3 kg	2.7 kg
1 in.	13.5 kg	7.7 kg	4.2 kg	1.8 kg
3/4 in.	10.2 kg	5.8 kg	3.2 kg	1.4 kg
1/2 in.	6.7 kg	3.8 kg	2.1 kg	890 g
3/8 in.	5.1 kg	2.9 kg	1.6 kg	670 g
No. 4	2.6 kg	1.5 kg	800 g	330 g
8 in. diameter sieves: No. 8 to No. 200 shall not exceed 200 g/sieve				
12 in. diameter sieves: No. 8 to No. 200 shall not exceed 469 g/sieve				

APPROXIMATED SIEVE OVERLOAD
TABLE 1

6.2.9 Repeat 6.2.5 through 6.2.8 on all remaining sieves.

6.2.10 If a sieve does not meet the allowable tolerance of 8.2, the shaking time shall be increased to determining an adequate time.

6.3 Shakers using 15 in. x 23 in., 14 in. x 14 in., or other size sieves.

6.3.1 Determine and record an initial sample weight of an aggregate having a nominal maximum aggregate size of 1 in.

6.3.2 Insert sieves 1 in. through No. 8 into the shaker.

6.3.3 Shake sample mechanically for 5 min.

6.3.4 Remove the first sieve retaining material, determine the weight of material retained, and verify that the sieve was not overloaded in accordance with Table 1. If the sieve was overloaded, verification is void, and a new sample shall be obtained.

6.3.5 Place the material on a 8 in. or 12 in. diameter sieve of equivalent opening size in increments that will not overload the sieve in accordance with Table 1. Place the sieve on a pan and cover the sieve with the lid.

6.3.6 Handshake for one min as described in 6.2.5. Continue until all material has been introduced onto the 8 in. or 12 in. sieve.

6.3.7 Weigh the accumulated material passing the sieve and retained in the pan.

6.3.8 Repeat 6.3.4 through 6.3.7 for all remaining sieves.

6.3.9 If a sieve does not meet the allowable tolerance of 8.2, the shaking time shall be increased to determine an adequate time.

7.0 CALCULATIONS. The percent passing a sieve by hand shaking after mechanical shaking is calculated by the following formula:

$$\%\ \text{Passing} = \frac{W_1}{W_2} \text{ x } 100$$

where:

W_1 = weight (mass) of sample passing a sieve by hand shaking, g
W_2 = initial sample weight (mass), g

8.0 TOLERANCE.

8.1 The timer of the mechanical shaker shall be within ± 5 s at 5 min, ± 10 s at 10 min, and ± 15 s at 15 min of the stopwatch reading.

8.2 After mechanical shaking, no more than 0.5 percent by weight of the total sample shall pass any sieve after 1 min of hand sieving.

9.0 REPORT. The timing and sieving sufficiency verification shall be reported on the form in Appendix A.

MECHANICAL SHAKER AND TIMER VERIFICATION ITM 906

SHAKER IDENTIFICATION
Manufacturer: ____________________

Model. No.: ____________________ Serial No.: ____________________

VERIFICATION EQUIPMENT USED
Balance: ____________________ Have sieves been verified using ITM 902? ________

TIMER VERIFICATION

Setting on Shaker Timer	Timing Device Reading	Corrective Adjustment Made
5		
10		
15		

SIEVING SUFFICIENCY VERIFICATION
Frame Dimensions: ____________________ Mechanical Sieving Time: ____________

Total Sample Weight: ____________________

Sieve Size	Weight Retained by Mechanical Sieving	Weight Passing After Hand Sieving	% Passing After Hand Sieving
1 in.			
3/4 in.			
1/2 in.			
3/8 in.			
No. 4			
No. 8			
No. 16			
No. 30			
No. 50			
No. 100			
No. 200			

Remarks: ____________________

Verified by: ____________________

Date: ____________________ Next Due Date: ____________________

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

VERIFYING CALIBRATION SETTINGS FOR SUPERPAVE GYRATORY COMPACTORS
ITM No. 908-22

1.0 SCOPE.

1.1 This test method covers the procedures for verifying calibration settings on an approved SUPERPAVE Gyratory Compactor (SGC).

1.2 This ITM may involve hazardous materials, operations, equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

3.0 SIGNIFICANCE AND USE. This ITM is used by laboratory personnel to verify the calibration settings on an approved SGC.

4.0 APPARATUS.

4.1 Digital Stopwatch, readable to 1 s

4.2 Dynamometer or load cell, National Institute of Standards and Technology (NIST) traceable in accordance with ASTM E74 and calibrated every 24 months

4.3 Precision gauge blocks, NIST traceable and calibrated every 24 months

4.4 Device for verifying the external angle of gyration

5.0 PROCEDURES.

5.1 General.

5.1.1 Use the manufacturer's calibration equipment and procedures for verification of the speed of gyration, ram pressure, ram position, and external angle of gyration[1].

[1] *AFG2AS gyratory devices manufactured by Pine Test Equipment, Inc. will have the external angle of gyration verified by the manufacturer as part of the annual verification process.*

5.1.2 Turn on the SGC and allow the SGC to warm up for approximately 15 minutes or the manufacturer's recommended time prior to verifying the calibration settings.

5.1.3 If any of the calibration settings are outside the specified tolerances of 6.0, a new calibration shall be performed for all of the parameters.

5.2 Speed of Gyration.

5.2.1 Set the SGC for 30 revolutions and start the machine

5.2.2 Record the time for the 30 gyrations using the stopwatch

5.3 Ram Pressure.

5.3.1 Center the dynamometer or load cell under the ram

5.3.2 If the dynamometer is used, flex the device to the maximum load required during calibration

5.3.3 Apply a force with the SGC. The SGC shall load the ram to a minimum of two forces spanning the full capacity of the SGC.

5.3.4 Record the force indicated on the load cell. If the dynamometer is used, record the deflection and determine the force from the conversion chart of the dynamometer.

5.4 Ram Position.

5.4.1 Insert the gauge blocks under the ram so that the height of the blocks is 6 in.

5.4.2 Apply a force with the SGC

5.4.3 Record the height indicated on the control panel

5.5 Angle of Gyration.

5.5.1 Attach the appropriate indicator for determination of the external angle of gyration

5.5.2 Verify that the measurement indicates that the allowable tolerance of the external angle is within ± 0.02°

6.0 TOLERANCES.

6.1 The speed of gyration shall be 30 gyrations in 60 ± 1 s.

6.2 The ram pressure shall be within ± 3 percent of the pressure indicated on the SGC.

6.3 The ram position shall be within ± 0.004 in. of the height of the gauge blocks.

6.4 The external angle shall be ± 0.02° from the established external angle. The dial indicator value shall be within the verification range.

< < The remainder of this page is intentionally blank > >

SUPERPAVE Gyratory Compactor Verification
ITM 908

SGC Model: _______________ Serial No: ______________ Machine Hours:_____________

Dynamometer/Load Cell Serial No.: ___________________ Calibration Date: ____________

Gauge Block Serial Nos.: ____________________________ Calibration Date: ____________

Speed of Gyration	Ram Pressure				
30 gyrations in 60 ± 1s	Applied Load – Load Cell		Applied Load - Dynamometer		
	Displayed	Actual	Deflection	Force	Actual

Ram Position		External Angle	
Height		Dial Indicator Value (Second - First = Value)	Verification Range
Displayed	Actual		
		Second: ___________ First: ___________ Value: ___________	
		Second: ___________ First: ___________ Value: ___________	

Remarks: ____

____

Verified by: ____

Date: ______________________________ Next Due Date: __________________________

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

VERIFYING THERMOMETERS
ITM No. 909-15T

1.0 SCOPE.

1.1 This test method covers the procedure for a verification of scale accuracy of liquid-in-glass total and partial immersion thermometers, dial type thermometers, handheld digital thermometers, infrared digital thermometers.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 ASTM Standards.

E 1 Specification for ASTM Thermometers

3.0 TERMINOLOGY. Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101.

4.0 APPARATUS.

4.1 Certified thermometer, National Institute of Standards and Technology (NIST) traceable, and of equal or better precision than the thermometer being verified.

4.2 Water/oil bath, capable of maintaining a constant temperature for the time sufficient for verification.

5.0 SIGNIFICANCE AND USE. This ITM is used by laboratory personnel to verify the scale accuracy of liquid-in-glass total and partial immersion thermometers, dial type thermometers, and handheld digital thermometers.

6.0 PROCEDURE.

6.1 Liquid-in-Glass Total and Partial Immersion Thermometers.

6.1.1 Record the manufacturer, serial number, type, model number, graduation, and date of calibration for the certified thermometer

6.1.2 Record the manufacturer, serial number, type, model number, and graduation of the thermometer being verified

6.1.3 Visually inspect the shaft of the thermometer being verified for air bubbles, separation of the liquid, foreign matter, glass faults, or any other apparent defects

6.1.4 Immerse the thermometer being verified into a water/oil bath to the indicated immersion line for partial immersion thermometers or to the point being verified for total immersion thermometers. A water bath is used for verifications less than 200°F, and an oil bath is used for verifications equal to or greater than 200°F.

6.1.5 Immerse the certified thermometer into the bath as specified in 6.1.4

6.1.6 Allow the readings on both thermometers to stabilize, and record the temperatures of the thermometers

6.2 Dial Type Thermometers.

6.2.1 Record the manufacturer, serial number, type, model number, graduation, and date of calibration for the certified thermometer

6.2.2 Record the manufacturer, serial number, type, model number, and graduation of the thermometer being verified

6.2.3 Immerse the dial thermometer into a container of boiling water to a depth of approximately one-half of the depth of the container

6.2.4 Immerse the certified thermometer into the container as specified in 6.2.3

6.2.5 Allow the readings on both thermometers to stabilize and record the temperatures of the thermometers

6.3 Handheld Digital Thermometer.

6.3.1 Record the manufacturer, serial number, type, model number, graduation, and date of calibration for the certified thermometer

6.3.2 Record the manufacturer, serial number, type, model number, and graduation of the thermometer being verified

6.3.3 Immerse the thermocouple assembly into a container of boiling water to a depth of approximately one-half of the depth of the container

6.3.4 Immerse the certified thermometer into the container as specified in 6.3.3

6.3.5 Allow the readings on both thermometers to stabilize and record the temperature of the thermometers

6.4 Infrared Digital Thermometer

6.4.1 Record the manufacturer, serial number, type, model number, graduation, and date of calibration for the certified thermometer

6.4.2 Record the manufacturer, serial number, type, model number, and graduation of the thermometer being verified

6.4.3 Immerse the certified thermometer into a 1000 mL glass beaker of boiling water to a depth of approximately one-half of the depth of the container and allow the thermometer to stabilize. Record the temperature of the thermometer.

6.4.4 Hold the infrared digital thermometer approximately 3 in. from the top of the boiling water and point the thermometer to the center of the beaker. Record the temperature of the thermometer.

6.4.5 Repeat 6.4.4 to obtain nine additional temperature readings. After each reading, allow the infrared digital thermometer to recycle to an off setting before obtaining the next reading.

6.4.6 Calculate the average of the 10 temperature readings and record the average.

7.0 TOLERANCES.

7.1 Thermometers not indicating the same reading as the certified thermometer may be used if the difference in the readings is within the tolerances of 7.2, 7.3, 7.4, and 7.5 for the type of thermometer verified. The difference in readings shall be visibly noted on the thermometer and the difference applied during use is visibly noted and the offset is applied during use. Thermometers not within the tolerances of 7.2, 7.3, 7.4, and 7.5 shall not be used.

7.2 Liquid-in-glass thermometers shall agree with the certified thermometer to within the scale error max of Table 1.

7.3 Dial type thermometers shall be within 5.0°F.

7.4 Handheld digital thermometers shall be within 2°F.

7.5 Infrared digital thermometers shall be within 4°F.

8.0 REPORT. The verification of scale accuracy is reported on the form in Appendix A.

Celsius Range	Scale Error max	Fahrenheit Range	Scale Error max	Celsius Range	Scale Error max	Fahrenheit Range	Scale Error max
Graduated in 0.01 ^{0}C				Graduated in 0.1 ^{0}C		Graduated in 0.2 ^{0}F	
18.9 to 25.1	0.1			0 to 30	0.1		
23.9 to 30.1	0.1			19 to 27	0.1	66 to 80	0.2
Graduated in 0.02 ^{0}C		Graduated in 0.05 ^{0}F		20 to 50	0.1		
4 to 6	0.04			25 to 50	0.1	77 to 131	0.2
19 to 35	0.10	66 to 95	0.20	34 to 42	0.1	94 to 108	0.2
Graduated in 0.05 ^{0}C		Graduated in 0.1 ^{0}F		38 to 82	0.1	100 to 180	0.2
-55.4 to -52.6	0.1	-67.5 to 62.5	0.2	40 to 70	0.1		
-41.4 to 38.6	0.1	-42.5 to 37.5	0.2	49 to 57	0.1	120 to 134	0.2
-27.4 to 24.6	0.1	-17.5 to -12.5	0.2	50 to 80	0.1	122 to 176	0.2
-21.4 to 18.6	0.1			57 to 65	0.1	134 to 148	0.2
-19.4 to 16.6	0.1	-2.5 to +2.5	0.2	60 to 90	0.1		
-1.4 to +1.4	0.1	29.5 to 34.5	0.2	75 to 105	0.1	167 to 221	0.2
		54 to 101	0.2	79 to 87	0.1	174 to 188	0.2
18.6 to 21.4	0.1	66.5 to 71.5	0.2	80 to 110	0.1		
	0.1	69 to 116	0.2	95 to 103	0.1	204 to 218	0.2
23.6 to 26.4	0.1	74.5 to 79.5	0.2	100 to 130	0.2		
28.6 to 31.4	0.1	83.5 to 88.5	0.2	120 to 150	0.2		
36.6 To 39.4	0.1	97.5 to 102.5	0.2	130 to 140	0.2		
38.5 to 41.5	0.1			Graduated in 0.2 ^{0}C		Graduated in 0.5 ^{0}F	
48.6 to 51.4	0.1	119.5 to 124.5	0.2			-65 to +5	1
52.6 to 55.4	0.1	127.5 to 132.5	0.2	-50 to +5	0.2	-55 to +40	0.4
58.6 to 61.4	0.1	137.5 to 142.5	0.2	-38 to +42	0.2	-36.5 to +107.5	0.5
80.6 to 83.4	0.1	177.5 to 182.5	0.2			-35 to +35	0.5
91.6 to 94.4	0.1	197.5 to 202.5	0.2	0.2-20 to +102	0.1	-5 to +215	0.25
		207.5 to 212.5	0.2	-2 to +52	0.2		
98.6 to 101.4	0.1			-2 to +68	0.2		
133.6 to 136.4	0.15	272.5 to 277.5	0.3	-2 to +80	0.2	30 to 180	0.4
				18 to 28	0.1		
Graduated in 0.1 ^{0}C		Graduated in 0.2 ^{0}F		20 to 70	0.2		
-51.6 to -34	0.1	-61 to -29	0.2	20 to 100.6	0.2	68 to 213	0.5
-45 to -35	0.4			24 to 78	0.2		
-38.3 to -30	0.2	-37 to -22	0.4	25 to 105	0.2	77 to 221	0.5
-38 to +2	0.1	-36 to +35	0.2	32 to 127	0.2	90 to 260	0.5
-35 to -25	0.4			39 to 54	0.1		
-25 to -15	0.2			48 to 102	0.2		
-15 to -5	0.2			72 to 126	0.2		
-20 to +10	0.1			90 to 170	0.4	194 to 338	1
-10 to +5	0.1			95 to 105	0.1		
				98 to 152	0.3		
-8 to +32	0.1	18 to 89		95 to 155	0.2	203 to 311	0.5

TABLE 1

Celsius Range	Scale Error max	Fahrenheit Range	Scale Error max
Graduated in 0.2 ^{0}C		Graduated in 0.5 ^{0}F	
[redacted]	[redacted]	245 to 265	0.5
123 to 177	0.3	[redacted]	[redacted]
[redacted]	[redacted]	270 to 290	0.5
[redacted]	[redacted]	295 to 315	0.5
145 to 205	0.2	293 to 401	0.5
145 to 205	0.4	[redacted]	[redacted]
148 to 202	0.4	[redacted]	[redacted]
[redacted]	[redacted]	320 to 340	0.5
170 to 250	A	[redacted]	[redacted]
173 to 227	0.4	[redacted]	[redacted]
[redacted]	[redacted]	345 to 365	0.5
198 to 252	0.6	[redacted]	[redacted]
[redacted]	[redacted]	395 to 415	0.5
[redacted]	[redacted]	445 to 465	0.5
223 to 277	0.8	[redacted]	[redacted]
248 to 302	1	[redacted]	[redacted]
Graduated in 0.5 ^{0}C		Graduated in 1 ^{0}F	
-80 to +20	1	[redacted]	[redacted]
-37 to +21	0.2	-35 to +70	0.5
-34 to +49	0.5	-30 to +120	0.5
-20 to +50	0.5	-4 to +122	1
-18 to +49	0.5	0 to 120	0.5
-18 to +82	0.5	0 to 180	0.5
-7 to 105	0.5	20 to 220	1
-5 to +110	0.5	20 to 230	1
-1 to 175	0.5	30 to 350	1
[redacted]	[redacted]	60 to 160	2
16 to 82	0.5	60 to 180	0.5
[redacted]	[redacted]	75 to 175	2
30 to 200	0.3	85 to 392	0.5
95 to 255	1	[redacted]	[redacted]
147 to 182	0.5	[redacted]	[redacted]
155 to 170	0.5	[redacted]	[redacted]
[redacted]	[redacted]	300 to 400	2
195 to 305	0.5	383 to 581	1
195 to 305	1	[redacted]	[redacted]
295 to 405	0.5	563 to 761	1

Celsius Range	Scale Error max	Fahrenheit Range	Scale Error max
Graduated in 1 ^{0}C		Graduated in 2 ^{0}F	
-80 to +20	B	-112 to +70	C
-38 to +50	0.5	-36 to +120	1
-15 to +105	1	0 to 220	2
-20 to +150	0.5	0 to 302	1
-5 to +300	1	20 to 580	2
-5 to 400	D	20 to 760	E
-2 to +300	F	30 to 580	G
-2 to +400	H	30 to 760	I
10 to 200	1	50 to 392	2
15 to 70	1	[redacted]	[redacted]
25 to 80	1	[redacted]	[redacted]
40 to 150	1	100 to 300	2
77 to 260	1	170 to 500	1
95 to 175	1	200 to 350	2
150 to 205	1	[redacted]	[redacted]
Graduated in 2 ^{0}C		Graduated in 5 ^{0}F	
-6 to +400	J	20 to 760	K
90 to 370	L	200 to 700	M

A 0.4 ^{0}C to 225 ^{0}C; 0.6 ^{0}C above 225 ^{0}C
B 1^{0}C to -33 ^{0}C; 2 ^{0}C below -33 ^{0}C
C 2 ^{0}F to -28 ^{0}F; 4 ^{0}F below -28 ^{0}F
D 1 ^{0}C to 301 ^{0}C; 1.5 ^{0}C to 301 ^{0}C
E 2 ^{0}F to 574 ^{0}F; 3 ^{0}F above 574 ^{0}F
F 0.5 ^{0}C to 150 ^{0}C; 1 ^{0}C above 150 ^{0}C
G 1 ^{0}F to 300 ^{0}F; 2 ^{0}F above 300 ^{0}F
H 1 ^{0}C to 300 ^{0}C; 1.5 ^{0}C above 300 ^{0}C
I 2 ^{0}F to 570 ^{0}F; 3 ^{0}F above 570 ^{0}F
J 2 ^{0}C to 260 ^{0}C; 4 ^{0}C above 260 ^{0}C
K 5 ^{0}F to 500 ^{0}F; 7 ^{0}F above 500 ^{0}F
L 1 ^{0}C to 260 ^{0}C; 2 ^{0}C above 260 ^{0}C
M 2.5 ^{0}F to 500 ^{0}F; 3.5 ^{0}F above 500 ^{0}F

TABLE 1 (cont.)

THERMOMETER VERIFICATION
ITM 909

CERTIFIED THERMOMETER IDENTIFICATION

Manufacturer: ____ Model No.: ______________

Type: _______________________________________ Serial No.: ______________________

Date of Calibration: _______________________ Graduations: __________________________

VERIFICATION OF THERMOMETER

Manufacturer: ____ Model No.: ______________

Type: _______________________________________ Serial No.: ______________________

Graduations: _________________________________

Is thermometer free of any apparent defects? (Yes or No) ____________

Certified Thermometer Reading	Thermometer Being Verified Reading	Correction Applied

Remarks: ____

____

____

Verified by: ____

Date: _________________________ Next Due Date: ________________________

INDIANA DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS

VERIFYING BALANCES
ITM No. 910-22

1.0 SCOPE.

1.1 This test method covers the procedures for verifying the accuracy and off-center error of balances.

1.2 This ITM may involve hazardous materials, operations, equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 AASHTO Standards.

M 231 Weighing Devices Used in the Testing of Materials

3.0 TERMINOLOGY.

3.0 TERMINOLOGY. Definitions for terms and abbreviations will be in accordance with the Department's Standard Specifications, Section 101 and the following:

3.1 Accuracy. The degree of conformity of a measurement with the true value of the quantity measured.

3.2 Off-Center Errors. The differences in indicated weight when a sample weight is shifted to various positions on the weighing area of the sample pan.

3.3 National Institute of Standards and Technology (NIST). A federal technology agency that develops and applies technology, measurements, and standards.

4.0 APPARATUS.

4.1 Balance, a Class G2, G5, or G20 in accordance with AASHTO M 231.

Class	Readability and Sensitivity	Accuracy [a]
G2	0.1 g	0.2 g or 0.1 %
G5	1 g	2 g or 0.1 %
G20	5 g	5 g or 0.1 %

[a] Accuracy equal to the mass stated or 0.1 % of the test load, whichever is greater, throughout the range of use

4.2 A set of weights, up to the capacity of the balance, with sufficient subdivisions of weight so that increments of approximately 10 percent of the capacity of the balance is measured. The weights shall be a minimum ASTM Class 3 for use on Class G2 or G5 balances and a minimum of NIST Class F for use on Class G20 balances. The Class 3 or Class F weights shall have a calibration report indicating traceability to NIST. The weights shall be calibrated at a minimum frequency of once each 12 months.

4.3 Thermometer, room temperature, with a resolution of at least 1°C (2°F).

5.0 SIGNIFICANCE AND USE. This ITM is used by laboratory personnel to verify the accuracy and off-center error of balances.

6.0 PROCEDURE.

6.1 General. Use the balance in the manner recommended by the manufacturer for each step of the verification procedures.

6.2 Accuracy.

6.2.1 Clean the balance and standard weights with a lint free dry cloth.

6.2.2 Place the standard weights near the instrument.

6.2.3 Allow the balance and the weights to stabilize to the ambient working temperature.

6.2.4 Place the thermometer on the bench near the balance and record the temperature.

6.2.5 Place the standard weight(s) in the center of the balance pan in increasing increments of approximately 10 percent of the capacity and record the indications. If possible, the weights should be carefully stacked upon each other.

6.3 Off-Center Error.

(Note 1: Off-Center Error verification may be waived for balances when the weights cannot be placed directly on the pan of the balance. Example: Ignition ovens.)

6.3.1 Place the standard weight(s) equal to approximately 50 percent of the capacity of the balance on the center of the sample pan and record the indication.

6.3.2 Place the same standard weight(s) on each corner of the sample pan and record the indication. For balances with circular pans place the weight(s) toward the edge at 12, 3, 6, and 9 o'clock.

6.3.3 Calculate the off center percent error using difference from the weight obtained in 6.3.1 as long as the reading obtained at the center is within the accuracy tolerance.

7.0 TOLERANCES.

7.1 G2 Balance.

7.1.1 Within any interval equal to approximately 10 percent of the capacity of the balance, the accuracy shall be equal to 0.2 g or 0.1 percent of the test load, whichever is greater.

7.1.2 The maximum off-center error shall be equal to or less than 0.2 g or 0.1 percent of the test load, whichever is greater.

7.2 G5 Balance.

7.2.1 Within any interval equal to approximately 10 percent of the capacity of the balance, the accuracy shall be equal to 2 g or 0.1 percent of the test load, whichever is greater.

7.2.2 The maximum off-center error shall be equal to or less than 2 g or 0.1 percent of the test load, whichever is greater.

7.3 G20 Balance.

7.3.1 Within any interval equal to approximately 10 percent of the capacity of the balance, the accuracy shall be equal to 5 g or 0.1 percent of the test load, whichever is greater.

7.3.2 The maximum off-center error shall be equal to or less than 5 g or 0.1 percent of the test load, whichever is greater.

8.0 REPORT. The accuracy and off-center error are reported on the form in Appendix A.

< < The remainder of this page is intentionally blank > >

BALANCE VERIFICATION
ITM 910

Customer Name & Address: ______________________________

Balance	**Standard Weights**
Comm. #: ______________	Comm. #: ______________
Class: ______________	Class: ______________
Model #: ______________	Date Calibrated: ______________

Temperature: ______________

Weight Applied (A)	Indication on Balance (B)	Percent of Error [(A - B) / A] x 100

Location	Weight Applied	Indication on Balance	Percent Error from Center [(A - B) / A] x 100
Center		A	
Off Center 1		B	
Off Center 2		B	
Off Center 3		B	
Off Center 4		B	

Remarks: ______________________________

Verified by: ______________________________ Date: ______________

Next Due Date: ______________

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

VERIFICATION OF CALIPERS
ITM No. 916-20

1.0 SCOPE.

1.1 This test method covers the procedures for verifying the accuracy of calipers used for measuring the critical dimension of various testing equipment.

1.2 This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 TERMINOLOGY.

2.1 Accuracy. The degree of conformity of a measurement with the true value of the quantity measured.

2.2 National Institute of Standards and Technology (NIST). A federal technology agency that develops and applies technology, measurements, and standards.

3.0 APPARATUS.

3.1 Set of gauge blocks including the 1.000”, 3.000”, 6.000” and 12.000” (if applicable) having NIST traceability documentation which includes parallelism verification and certified within the last 24 months.

3.2 Calipers readable to the nearest 0.001 in.

3.3 Rubber band

3.4 Thermometer having a range of at least 68°F-77°F.

3.5 Record all measurements on Appendix A

4.0 SIGNIFICANCE AND USE.

This ITM is used by laboratory personnel to determine the accuracy of calipers. Verification should be performed in an environment that the ambient temperature will be between 68°F-77°F.

5.0 PROCEDURES.

5.1 Allow the gauge blocks and calipers to stabilize to the ambient working temperature (68°F-77°F) overnight. Place a thermometer next to the blocks/calipers, measure and record the temperature.

5.2 Visually inspect the caliper blades for nicks, burrs, scratches, wear or other signs of mishandling that may affect accuracy of instrument

5.2.1 For the blades used to measure outside dimensions, close the calipers and hold up to a light source to check for illuminated gaps between the blades. Light will not be seen if jaws are parallel.

5.2.2 For the blades used to measure inside dimensions, close the calipers and hold up to a light source. Adjust the calipers until light is apparent between the outside dimensional measurement blades. Using the illuminating light as a reference, visually determine that the blades are parallel with no apparent wear (Figure 1).

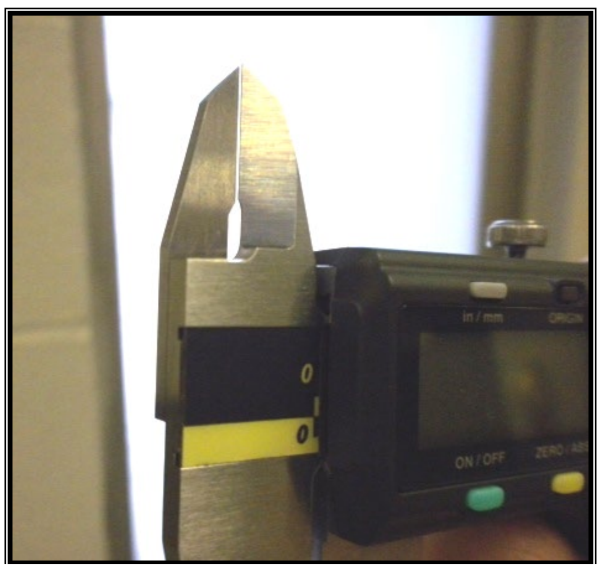


Figure 1

5.3 Using the calipers record the outside measurement width at 1 in. and 3 in. of the smallest gauge block (Figure 2).

5.4 Using the calipers record the outside measurement of the 6 in. gauge block (Figure 3).

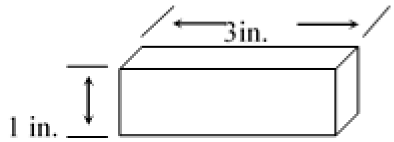


Figure 2

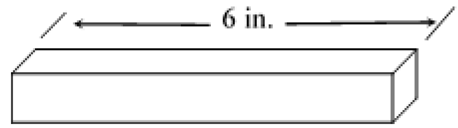


Figure 3

Using the calipers record the outside measurement of the 12 in gauge block (Figure 4)

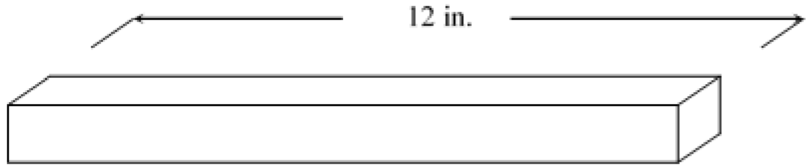


Figure 4

5.5 Arrange the blocks in accordance with (Figure 5) to verify the jaws for internal measurements at 1 in., 3 in.,6 in and 12 in. Wrap a rubber band around the blocks to prevent the end blocks from moving. Measure and record the internal measurement at 1 in., 3 in., 6 in and 12 in. (Figure 6).

Note 1: Care should be taken to ensure parallelism with the center block(s).
Note 2: Measurements are required to be taken on the sharpened blade of the calipers during verification and in regular use.

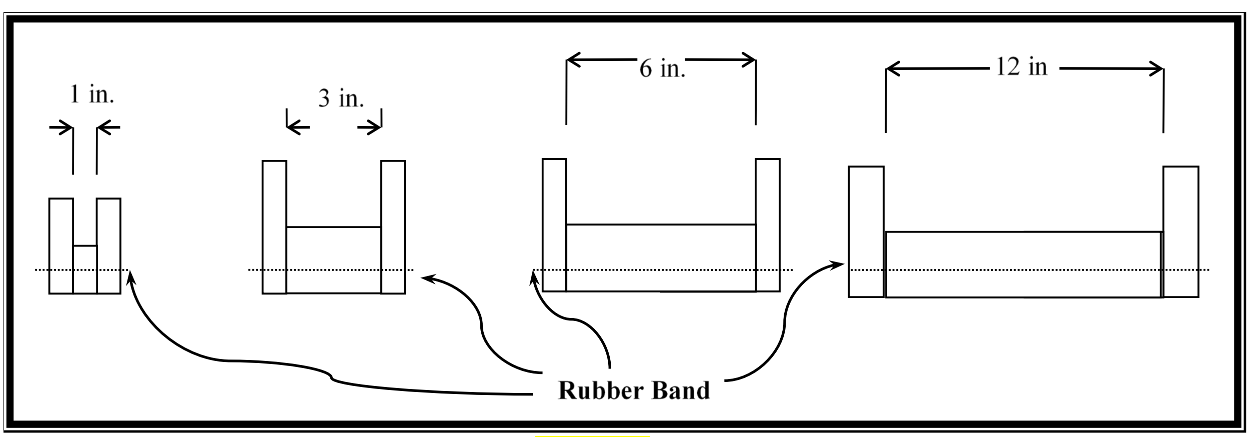


Figure 5

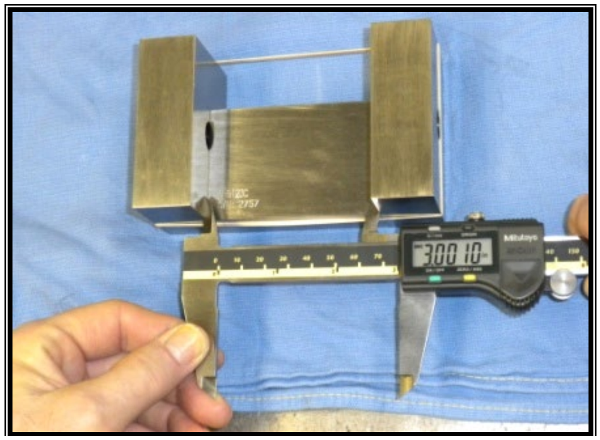


Figure 6

5.6 Place the gauge blocks on end, using the depth part of the calipers, measure and record the depth measurement at 1 in., 3 in., 6 in. and 12 in., if applicable. (Figure 7)

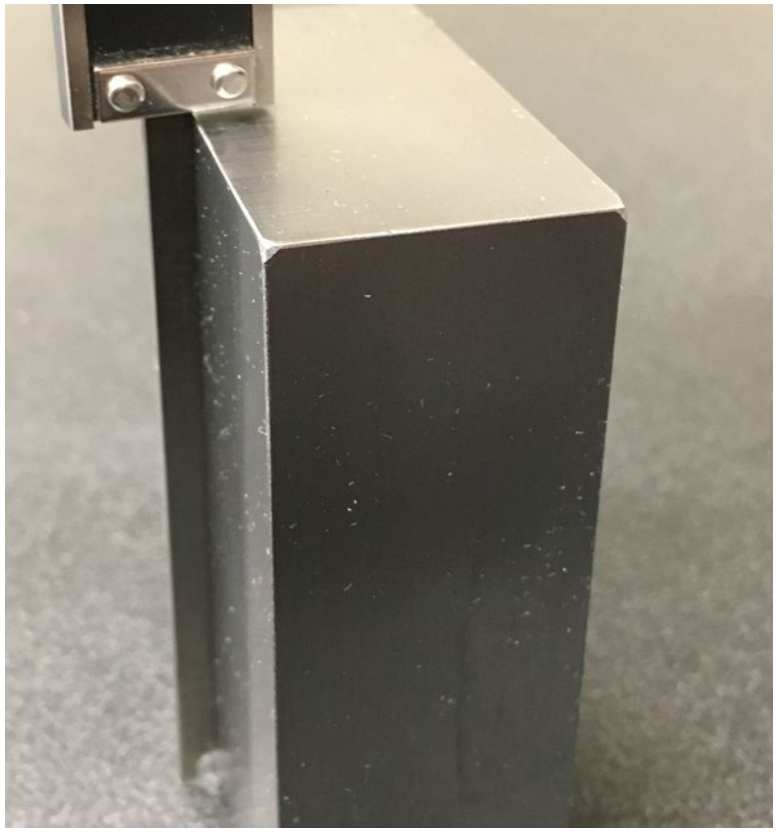


Figure 7 (3 inch block)

6.0 REPORT. The measurements and error shall be reported on the form in Appendix A

<table>
<tr><th colspan="10">CALIPER VERIFICATION FORM
ITM 916</th></tr>
<tr><td colspan="3">Description:</td><td colspan="4">Tolerance: ± 0.002”</td><td colspan="3">Comm #:</td></tr>
<tr><td colspan="3">Location:</td><td colspan="2" rowspan="2">Calibration Interval:
12 months</td><td colspan="2" rowspan="2">Calibration Procedure:
ITM 916</td><td colspan="3" rowspan="2">Serial #:</td></tr>
<tr><td colspan="3">Lab:</td></tr>
<tr><td colspan="3">Ambient Temperature (°F):</td><td colspan="7"></td></tr>
<tr><td rowspan="2">Calibration Date:</td><td rowspan="2">Calibrated By:</td><td rowspan="2">Visual Inspection</td><td colspan="2">Outside Jaw</td><td colspan="2">Inside Jaw</td><td colspan="2">Depth</td><td rowspan="2">In Specs.</td></tr>
<tr><td>Standard Value</td><td>Measured Value</td><td>Standard Value</td><td>Measured Value</td><td>Standard Value</td><td>Measured Value</td></tr>
<tr><td></td><td></td><td rowspan="7">Pass □
Fail □</td><td>1.000 in.</td><td></td><td>1.000 in.</td><td></td><td>1.000 in.</td><td></td><td>Yes □ No □</td></tr>
<tr><td></td><td></td><td>3.000 in.</td><td></td><td>3.000 in.</td><td></td><td>3.000 in.</td><td></td><td>Yes □ No □</td></tr>
<tr><td></td><td></td><td>6.000 in.</td><td></td><td>6.000 in.</td><td></td><td>6.000 in.</td><td></td><td>Yes □ No □</td></tr>
<tr><td></td><td></td><td>*12.000 in.</td><td></td><td>*12.000 in.</td><td></td><td>*12.000 in.</td><td></td><td>Yes □ No □</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Yes □ No □</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Yes □ No □</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Yes □ No □</td></tr>
<tr><td colspan="5">Comments:</td><td colspan="2">Previous Calibration Date:</td><td colspan="3">Next Calibration Date:</td></tr>
</table>

*If applicable

INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT

PLATE SAMPLE PREPARATION AND SUPERPAVE GYRATORY COMPACTOR (SGC) SPECIMEN FABRICATION
Directive No. 303

Roadway plate samples are taken from behind the paver in accordance with ITM 580 and placed in approved cardboard transport containers for delivery to a Production Laboratory. The samples require being conditioned for 2 hours, sample reduction to specimen quantity, heating to compaction temperature, compaction in accordance with AASHTO T 312 and removal and cooling prior to subsequent testing for volumetric properties. The SGC specimen fabrication will be completed in a continuous sequence upon initiating sample heating. A checklist for the lubrication and maintenance schedules of the gyratory compactor is included in Appendix A. The procedures will be as follows:

Plate Sample Conditioning

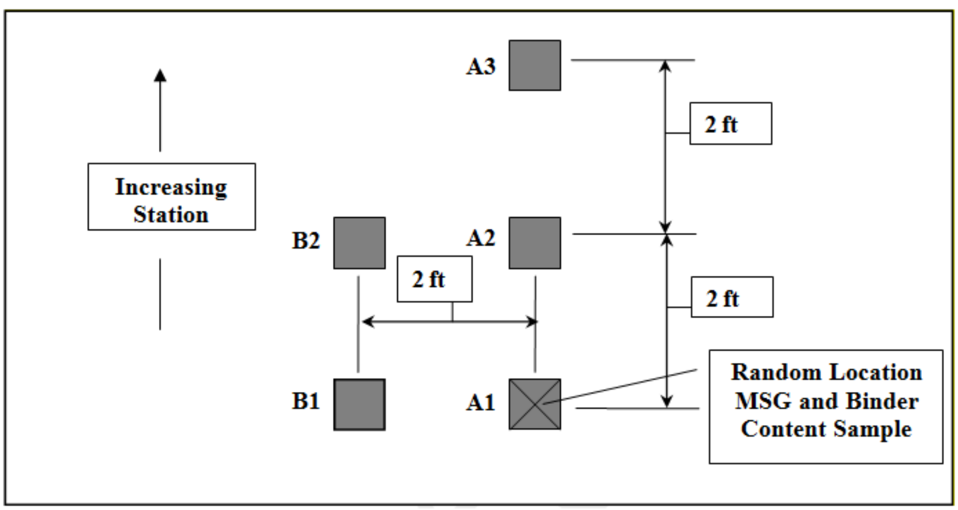


Plate samples A1, A2, and A3 (and corresponding back up samples, B1 and B2) shall be conditioned, from ambient temperature, for a minimum of 2 hours prior to any sample reduction or testing. Conditioning more than 2 hours is acceptable as aging of the binder does not affect the maximum specific gravity, binder content, gyratory pill height, bulk specific gravity, or aggregate properties.

The cardboard sample transport container shall be closed, placed in a 300 ± 9°F (dense-graded HMA and SMA) or 260 ± 9°F (open-graded HMA) oven and conditioned from ambient temperature for 2 hours. If overnight timers are applied and samples preloaded, the 2 hour conditioning time starts once the oven reaches temperature (300 ± 9°F or 260 ± 9°F).

Gyratory Compactor Maintenance and Calibration/Verification Procedures

The procedures for the maintenance of the Pine SGC Model #AFG1A and #AFG2A gyratory compactor and the calibration/verification procedures are required prior to compaction of any gyratory specimens. These procedures include:

1. The SGC Operations Manual recommended maintenance schedule is completed in accordance with the established checklist.
2. Verification of calibration settings for the gyratory compactor is in accordance with ITM 908 on a one month schedule.
3. Verification of the dimensions of the gyratory molds, top plates, and base plates is in accordance with AASHTO T 312 on a 12 month schedule.
4. Verification of the internal angle of the gyratory compactor is in accordance with AASHTO T 344 simulated loading on a 12 month schedule.
5. All SGC surfaces, rollers, plates, and molds are kept as clean as possible.
6. The molds and top and bottom plate surfaces are cleaned with WD 40 and wiped dry after each use.

Gyratory Sample Reduction

The procedures for reducing the sample to the quantity required for the gyratory specimen are as follows:

NOTE: If the cardboard transport container has been exposed to water, grease, solvents, oils, etc., the container contents will be transferred to a rectangular sample pan and covered before placement in the oven.

1. After conditioning, the mixture from the cardboard transport container is placed on the splitting board and reduced in accordance with ITM 587, section 7.0, to the target weight listed on the DMF form.
   - A reasonable effort shall be made to remove any significant amount of remaining material that does not fall from the container. It shall be thoroughly mixed back into the sample.
   - The splitting board and tools can be made nonstick by the application of PAM® Original cooking spray or an approved anti-adhesive material that is diluted and used per the manufacturer's recommendations. The material shall not contain any solvents or petroleum-based products that could affect asphalt binder properties.
   - The splitting board will be any flat surface free from contaminants such as HMA, aggregate, liquid asphalt, dirt, grease, excess solvents, etc., and may be preheated with heat lamps.

2. The split samples are placed in a silicone laminate paperboard carton. The carton lid and end flap are then closed.

Sample Heating and Temperature Measurements

The sample is heated to the required compaction temperature as follows:

1. The cartons are placed in a 300 ± 9°F (dense-graded HMA and SMA) or 260 ± 9°F (open-graded HMA) oven.
2. A thermometer is inserted into the carton and left for continuous reading of the mixture temperature by external digital display.
3. The mold and bottom plate are placed separately in the compaction oven or oven of the same temperature.
4. The mold and bottom plate are kept in the oven for 90 minutes or until the bottom plate temperature, as verified by a dial contact surface thermometer, is 300 ± 9°F for dense-graded HMA and SMA or 260 ± 9°F for open-graded HMA.
5. Once the mixture temperature has been achieved, the mold will be assembled and charged.

Sample Mold Charging

The sample is charged into the gyratory mold as follows:

1. The sample, mold and bottom plate are removed from the compaction oven.
2. The bottom plate is assembled in the bottom of the mold.
3. A gyratory paper disk is placed on top of the bottom plate inside the heated mold assembly so that the specimen will be in contact with the non-print side. Pine gyratory paper disks are to be used.
4. The carton lid will remain closed while the end flap is released prior to sample transfer.
5. The carton is placed into the mold and the sample is deposited with one quick motion.
6. A paper disk is placed on top of the sample with the non-print side in contact with the specimen.
7. The mold with sample is placed into the SGC and compacted to the specified design gyrations listed on the DMF form.

Sample Extraction and Cooling

Dense-Graded and SMA

1. The specimen is raised level to the top of the mold and the paper disk is removed.
2. The specimen and base plate are extruded from the mold, lifted with specimen lift handles, and placed on a flat surface.
3. The specimen is left on the base plate in front of a fan for a minimum of 5 minutes.
4. The specimen is lifted from the base plate and inverted on a flat surface.
5. The paper disk is removed.
6. The specimen is cooled overnight or until the surface temperature measured with a non-contact digital infrared thermometer is 77 ± 9°F.

Open-Graded

1. The specimen is raised level to the top of the mold.
2. The specimen is initially cooled in the mold for 10 minutes by directing a fan towards the top of the mold in the compactor.
3. The paper disk is removed.
4. The specimen is extruded approximately 1.25 inches and the specimen is cooled with a fan for five minutes.
5. The specimen is extruded an additional 1.25 inches (2.50 inches total) and cooled with a fan for five minutes.
6. The specimen is extruded an additional 1.25 inches (3.75 inches total) and cooled with a fan for five minutes.
7. The specimen and base plate are extruded from the mold and placed on a flat surface.
8. The specimen is lifted from the base plate and inverted on a flat surface.
9. The paper disk is removed.
10. The specimen is cooled overnight or until the surface temperature measured with a non-contact digital infrared thermometer is 77 ± 9°F.

Specimen Requirements

Two specimens are prepared from one roadway plate sample and the Bulk Specific Gravity (G_{mb}) is determined for each sample in accordance with AASHTO T 166. The two G_{mb} results are averaged to obtain one G_{mb} value. The gyratory specimens are checked for the following requirements:

1. The compacted height of each specimen is required to be 115 ± 5mm. If the height of a specimen is not within these tolerances, the specimen is discarded.
2. Two specimens prepared by the same operator should have G_{mb} values within 0.020 of each other. If the specimens are not within these limits, the G_{mb} values may be used for subsequent determination of the volumetric properties of the mixture; however, the procedures contained within this Directive should be reviewed prior to compaction of additional specimens.

FABRICATION OF HOT MIX ASPHALT SPECIMENS BY MEANS OF THE SUPERPAVE GYRATORY COMPACTOR

APPARATUS

[ ] Superpave Gyratory Compactor
  - [ ] Maintenance schedule in accordance with recommended frequency
  - [ ] ITM 908, Verifying Calibration Settings for SGC, done monthly
  - [ ] AASHTO T 312, Verifying SGC molds, top plates and bottom plates, done
  - [ ] AASHTO T 344, Evaluation of SGC Internal Angle of Gyration using Simulated Loading, done annually
  - [ ] All SGC surfaces, rollers, plates and molds are clean
  - [ ] Molds and plates wiped clean after each use with WD40

[ ] Oven themostatically controlled to ± 5°F
[ ] Digital infrared thermometer
[ ] External digital thermometer
[ ] Dial contact surface thermometer

PROCEDURE – SAMPLE REDUCTION

[ ] Transport container closed or sample covered and placed in oven
  - [ ] 300 ± 9°F for dense-graded HMA or SMA
  - [ ] 260 ± 9°F for open-graded HMA

[ ] Sample conditioned from ambient temperature for 2 hrs
[ ] Mixture placed on contaminant free splitting board or flat surface
[ ] Mixture reduced by ITM 587, section 7.0, to target weight from DMF
[ ] Split samples placed in silicone laminate paperboard carton
[ ] Carton lid and end flap closed

PROCEDURE – HEATING AND TEMPERATURE MEASUREMENTS

[ ] Carton placed in oven
  - [ ] 300 ± 9°F for dense-graded HMA or SMA
  - [ ] 260 ± 9°F for open-graded HMA

[ ] Thermometer placed in carton and mixture temperature determined by external digital display
[ ] Mold and bottom plate placed separately in compaction oven or oven of same temperature for 90 minutes or until the bottom plate temperature is verified by a dial contact thermometer
  - [ ] 300 ± 9°F for dense-graded HMA or SMA
  - [ ] 260 ± 9°F for open-graded HMA

[ ] Mixture temperature verified
  - [ ] 300 ± 9°F for dense-graded HMA or SMA
  - [ ] 260 ± 9°F for open-graded HMA

PROCEDURE – MOLD CHARGING

[ ] Sample, mold and bottom plate removed from oven
[ ] Mold assembled
[ ] Pine paper disk placed inside mold with non-print side in contact with mixture
[ ] Carton lid closed and end flap released
[ ] Carton placed into mold and sample deposited in one quick motion
[ ] Paper disk placed on top of sample with non-print side touching mixture
[ ] Mold placed in SGC and compacted to specified gyrations per DMF within two hours of reaching compaction temperature

PROCEDURE – COOLING (Dense Graded and SMA)

[ ] Specimen raised level to top of the mold and paper disk removed
[ ] Specimen and base plate removed from mold, lifted with specimen lift handles, and placed on flat surface
[ ] Specimen and base plate cooled in front of fan for 5 minutes
[ ] Specimen lifted from base plate and inverted
[ ] Paper disk removed
[ ] Specimen cooled overnight or until surface temperature measured with non-contact digital infrared thermometer is 77 ± 9°F

PROCEDURE – COOLING (Open Graded)

[ ] Specimen raised level to top of the mold
  [ ] Fan directed toward top of mold in compactor
  [ ] Specimen and mold cooled by fan for 10 min
  [ ] Paper disk removed
[ ] Specimen extruded approximately 1.25 in. and cooled with a fan for 5 min
[ ] Specimen extruded a total of approximately 2.50 in. and cooled with a fan for 5 min
[ ] Specimen extruded a total of approximately 3.75 in. and cooled with a fan for 5 min
[ ] Specimen and base plate extruded from mold and placed on flat surface
[ ] Specimen lifted from base plate and inverted on flat surface
[ ] Paper removed
[ ] Specimen cooled overnight or until surface temperature measured with non-contact digital infrared thermometer is 77 ± 9°F

NA - Not Applicable
X - Requires Corrective Action
√ - Satisfactory

____
Acceptance Technician

______________________________ ______________
INDOT Date

Comments______________________________

SUPERPAVE GYRATORY LUBRICATION/MAINTENANCE SCHEDULE

LUBRICATION SCHEDULE

Component	Daily	Initial 5 Hours	Every 25 Hours
Ram Foot	B		
Ball Screw Bearings		A	A
Ball Screw		A	A
Actuator Bearings		A	A
Mold Clamp Pivot			B
Mold Top Clamps			B

Type of Lubrication: A -- Grease (NLGI Grade 2 Lithium Soap)
B -- Anti-Seize Lubricant

Component	Hours on SGC at Time of Lubrication					
Ball Screw Bearings						
Ball Screw						
Actuator Bearings						
Mold Clamp Pivot						
Mold Top Clamps						

MAINTENANCE SCHEDULE

Component	Daily	Initial 5 Hours	Every 25 Hours
Clean Compaction Chamber	X		
Clean Mold Top	X		
Inspect Ram Key			X
Check Mold Base Clamps		X	X
Timing Belt Tension		X	X
Inspect Mold Clamps		X	X
Inspect Ram Foot for Wear			X

Component	Hours on SGC at Time of Maintenance					
Inspect Ram Key						
Check Mold Base Clamps						
Timing Belt Tension						
Inspect Mold Clamps						
Inspect Ram Foot for Wear						

Remarks: ______________________________

Verified by: ______________________________

Date:____________________ Next Date Due: ____________________

CERTIFIED
HOT MIX ASPHALT PRODUCER PROGRAM
FULL AUDIT CHECKLIST (YEARLY)

Date ______________ Page 1 of ___

Plant No. __________

Producer ____

Plant Location ____

INDOT Audit Team Members

	Name	Position
1.	____________________	District Testing Engineer
2.	____________________	Area Supervisor
3.	____________________	Technician
4.	____________________	____________________
5.	____________________	____________________
6.	____________________	____________________

Producer Members

	Name	Position
1.	____________________	Management Representative
2.	____________________	Level 1 or Certified Asphalt Technician
3.	____________________	____________________
4.	____________________	____________________

1. GENERAL INSTRUCTIONS

Audit Team Members

Tasks to be **completed before arriving** at the Producer's site:

- Review the QCP
- Review previous audits, especially the most recent one and note all corrective actions
- Coordinate with Independent Assurance Technician for comparison testing schedule
- Bring copies of the following:
    - Approved DMF and Contract Record worksheets for the current calendar year. These can be found at https://itap.indot.in.gov/
    - Qualified Products Lists and Qualified Source Lists
        - Performance-Graded Asphalt Binder Suppliers
        - Anti-Adhesive materials
    - Indiana Certified Asphalt Technicians (ICAT) List
    - Current copy of ITM 583

<u>Terminology:</u>

QC/QA HMA	Std. Spec. Section 401 (QC/QA Hot Mix Asphalt)
HMA	Std. Spec. Section 402 (Hot Mix Asphalt)
QCP	Quality Control Plan
DMF	Design Mix Formula
PGABS	Performance-Graded Asphalt Binder Suppliers
RAP	Reclaimed Asphalt Pavement
RAS	Reclaimed Asphalt Shingles
SMA	Std. Spec. Section 410 (Stone Matrix Asphalt)

Brackets must be filled in as follows:

[✓] Satisfactory
[X] Unsatisfactory or deficient; a **Corrective Action** Sheet must be prepared
[NA] Not applicable to the audit or Producer

* Item is only applicable in some cases; fill in 'NA' if not applicable

All unsatisfactory or deficient items resolved during the audit shall be noted on corrective action sheets with indication that item has been corrected.

2. PRODUCER GENERAL INFORMATION

ITM 583 Reference
5.0, 12.2

Audit Team Member: ______________________

2.1 [ ] Review the complete QCPs of INDOT and the Producer and verify they are identical and have the same authentication page:
DTE signature date: _____________
2.2 [ ] QCP is in accordance with ITM 583 (no updates needed)
2.3 [ ] Plant location and address in QCP is correct
2.4 [ ] Plant telephone numbers in QCP are correct
2.5 [ ] Management Representative ______________________________
2.6 [ ] Management Representative e-mail address in QCP is correct
2.7 [ ] Level 1 or Certified Asphalt Technician at audit _______________________
2.8 [ ]* All other Level 1 or Certified Technicians in QCP are current

For information only (ensure the QCP includes the following, if applicable):
2.9 [ ] Is this plant equipped with a water injection foaming device?
2.10 [ ] Is this plant equipped to produce latex modified asphalt by in-line blending?

3. DOCUMENTS

ITM 583 Reference
2.0

Audit Team Member: ______________________

Determine whether the following current documents are maintained at the Producer's lab or Plant, either by hard copies or electronically.

3.1 [ ] INDOT Standard Specifications (Including any applicable Supplemental Specifications and Special Provisions)
3.2 [ ] Indiana Certified Asphalt Technician (ICAT) Manual

Documents (continued)

3.3 [ ] The ITM, AASHTO, and ASTM Test Methods ***referenced in QCP***. ITM revision dates are on the ITM webpage. The AASHTO and ASTM documents have the current revision date listed next to the test method. If the documents are accessible on the computer or internet, hard copies are not needed.

ITM			**908**		Yes / No	T305-22 Date _______
[ ] ITMs on Computer			**909**		Yes / No	T312-22 Date _______
ITM	Date (if printed)	Current?	**910**		Yes / No	T331-22 Date _______
207		Yes / No	**916**		Yes / No	T344-22 Date _______
220		Yes / No	**AASHTO**			**ASTM**
571		Yes / No	[ ] AASHTOs on Computer			[ ] ASTMs on Computer
572		Yes / No	R30-22	Date _______		**D5821**-13 Date _______
580		Yes / No	R35-22	Date _______		
581		Yes / No	R46-22	Date _______		
583		Yes / No	R66-16	Date _______		
584		Yes / No	R76-16	Date _______		
586		Yes / No	R90-18	Date _______		**OTHER TEST METHODS**
587		Yes / No	T11-22	Date _______		**REFERENCED IN QCP**
588		Yes / No	T27-22	Date _______		Test Method Date
590		Yes / No	T30-21	Date _______		
591		Yes / No	T166-22	Date _______		
902		Yes / No	T209-22	Date _______		
903		Yes / No	T255-22	Date _______		
905		Yes / No	T269-14	Date _______		
906		Yes / No	T275-22	Date _______		

3.4 [ ] All assigned DMFs for current calendar year

Number of approved DMFs on ITAP:___________

Number of SMA DMF's:

INDOT__________ Producer__________

3.5 [ ]* Does plant use a Vacuum Extractor? If no skip to 3.6

[ ]* Fines correction data for each DMF

[ ]* Fines correction data for each RAP

3.6 [ ]* Does plant do in-line-blending with SBR polymer latex? If no skip to 3.7

[ ]* PG 70-22 binder test reports from an AASHTO accredited laboratory whenever PG 64-22 is in-line blended with SBR polymer latex

[ ]* Type A certifications for the SBR polymer latex

[ ]* Flow meter calibration reports and flow computer printouts whenever in-line blending with SBR polymer latex

3.7 [ ]* Does plant use Fibers in SMA? If no skip to section 4

[ ]* Fibers certifications from manufacturer for SMA

[ ]* Instructions from manufacturer regarding storage and handling of fibers for SMA

4. CONTROL LIMITS - QC/QA HMA and SMA

ITM 583 Reference
10.0

Audit Team Member: ______________________

Select one QC/QA HMA PWL contract if applicable or one the larger contracts available. Otherwise select an SMA mixture from one current or recently completed contract for review of all test results for all stated properties. Verify the test results are within the control limits of the target value from the DMF or are within the control limits of the target value identified by Producer.

Target Values (see appendix to record any values outside of control limits)

Contract __________ Mixture Selected __________ DMF __________

4.1 Air Void Target Value from DMF __________

[ ] Air Void Test Results ± 1.0 from Target Value (Dense Graded)
-or-
± 3.0 from Target Value (Open Graded)

4.2 Mixture Binder Content Target Value from DMF __________

[ ] Mixture Binder Content Test Results ± 0.7% from DMF Target Value

4.3 VMA Target Value from DMF __________

[ ] VMA Test Results ± 1.0% from DMF Target Value
-or-
min. 16% (12.5 SMA) or min. 17% (9.5 SMA)

4.4 Dust/Calculated Effective Binder Ratio from DMF___________

[ ] Dust/Calculated Effective Binder Ratio between 0.6 to 1.4
(1.0 to 2.0 for 4.75mm)

4.5 Volume of Effective Binder ____________

[ ] Vbe above spec design min. and less than + 2.0 from spec design min.

	4.75mm	9.5mm	12.5mm	19.0mm	25.0mm	9.5 SMA	12.5 SMA	19.0 SMA
Spec design min.	13.0	11.0	10.0	9.0	8.0	13.0	12.0	11.0

Control Limits (continued)

4.6 [ ]* Aggregate Stockpile testing:
Aggregate Size __________ (select a stockpile)
Critical sieve identified is __________
Target Value identified by Producer is __________

Gradation Test Results for the critical sieve are within the following from Target Value:

3/4 in. -- ± 10.0	No. 8 -- ± 10.0	No. 50 -- ± 6.0
1/2 in. -- ± 10.0	No. 16 -- ± 8.0	No. 100 -- ± 6.0
No. 4 -- ± 10.0	No. 30 -- ± 6.0	No. 200 -- ± 2

4.7 Blended Aggregate – Mixture size __________

[ ]* Belt sample -or- [ ]* HMA sample used for gradation

[ ]* Gradation Test Results are within the following from Target Value. (The Producer may establish values that are more restrictive).

Sieve Sizes		Base and Intermediate Mixtures	Surface Mixture	Target from DMF	Test Result	Test Results within target value? (✓ or x)
19.0 mm	3/4 in.	± 10.0	---			☐
12.5 mm	1/2 in.	± 10.0	± 10.0			☐
4.75 mm	No. 4	± 10.0	± 10.0			☐
2.36 mm	No. 8	± 10.0	± 8.0			☐
1.18 mm	No. 16	± 8.0	± 8.0			☐
600 µm	No. 30	± 6.0	± 4.0			☐
300 µm	No. 50	± 6.0	± 4.0			☐
150 µm	No. 100	± 6.0	± 3.0			☐
75 µm	No. 200	± 2.0	± 2.0			☐

4.8 Recycled Materials – RAP Size/Name __________
Binder Content Target Value from DMF for RAP _______and RAS _______
[ ]* RAP coarse aggregate gradation is 100% passing the mixture maximum particle size sieve
[ ]* Fine RAP gradation is 100% passing the 3/8 in. (9.5 mm) sieve and 95 to 100% passing the No. 4 (4.75 mm) sieve when used in ESAL Category 3 and 4 surface mixtures
[ ]* RAS gradation is 100% passing the 3/8 in. (9.5 mm) sieve
[ ]* RAP Binder Content Test Results ± 0.7% from DMF Target Value
[ ]* RAS Binder Content Test Results ± 3.0% from DMF Target Value

5. DIARY

ITM 583 Reference
8.0, 11.0

Audit Team Member: ______________________

Select at random one production month for review of the diary. The month chosen can be any month within the current year or past three complete calendar years. The diary should be in accordance with the following requirements and information.

Month/Year ____________________

5.1 [ ] Diary on file for 3 years
5.2 [ ] Open book format or readily accessible electronic format
5.3 [ ] One or more pages for each day of production
5.4 [ ] Type of Mixture (QC/QA HMA, HMA, SMA) produced and quantity
5.5 [ ] DMF number
5.6 [ ] Contract or purchase order number the mixture was sent to
5.7 [ ] Time sample obtained and tests completed (samples are required to be tested within two working days of the time the sample was taken. If all samples are tested the same day, a statement indicating that this occurred is acceptable)
5.8 [ ]* Significant events or problems
5.9 [ ] Signature of Level 1 or Certified Technician or Management Representative

Review the month of test data for nonconforming tests. If some are found, review the diary on the date of each test for notations regarding action taken.

5.10 [ ] Nonconforming test(s) are noted in diary

- Control limits are exceeded for Binder Content, Vbe, VMA, Air Voids, aggregate gradation.
- Control limits are exceeded for 2.36mm sieve (9.5mm surface only)
- 2.36 mm sieve %passing greater than 47% for 9.5 mm surface mix
- Aggregate degradation value for SMA mix is greater than 3.0%
- Dust/Pbe ratio is less than 0.6 or greater than 1.4 (or 1.0 to 2.0 for 4.75 mm mixtures)
- Vbe is determined to be less than design minimum or more than design maximum
- Moisture content of surface mixture exceeds 0.30% at the plant or 0.10% behind paver

5.11 [ ] Corrective action was taken or documented.

6. SAMPLING AND TESTING

ITM 583 Reference
9.1, 9.2

Audit Team Member: ______________________

Obtain the diary for one **QC/QA HMA or SMA** mixture produced for a selected contract within the current year or past three complete calendar years. Perform calculations as needed and compare the quantities produced from the diary against the number of tests, thereby determining the frequency of testing.

Contract__________ DMF__________ Mixture ___________ Quantity __________

Recycled Materials

6.1 [ ]* Sampling and testing of Recycled Materials for actual binder content, moisture content, gradation, coarse aggregate angularity, and bulk specific gravity is in accordance with QCP

Note: For assistance, see example calculation page in appendix

Percent by mass from DMF ___________ Total RAP and/or RAS used ___________

-- or --

Total RAP and/or RAS processed ____________

	QCP Frequency	Tests Required	Tests Completed
Actual Binder Content	_____________	_____________	_____________
Moisture	_____________	_____________	_____________
Gradation	_____________	_____________	_____________
CAA	_____________	_____________	_____________
Bulk Spec. Gravity of Agg	_____________	_____________	_____________

Aggregates

6.2 [ ] Sampling and testing of Blended Aggregate is in accordance with QCP

QCP Frequency	Tests Required	Tests Completed
_____________	_____________	_____________

6.3 [ ] Sampling and testing of Aggregate Stockpiles is in accordance with QCP

PG Binder

6.4 [ ] Sampling of PG Binder is in accordance with QCP

Mixture

Plant/Truck Samples	**QCP Frequency**	**Tests Required**	**Tests Completed**
Actual Binder Content	______	______	______
Gradation	______	______	______
Moisture	______	______	______
Temperature	______	____N/A_____	(Y or N)
Draindown (OG & SMA)	______	______	______
Agg. Degredation (SMA, 1 per lot)	______	______	______

6.5 [ ] Sampling and testing of Mixture at the Plant for actual binder content, gradation, draindown (open graded and SMA mixtures only), moisture content, and temperature is in accordance with QCP

Pavement/Plate Samples	**QCP Frequency**	**Tests Required**	**Tests Completed**
Air Voids	______	______	______
VMA	______	______	______
Actual Binder Content	______	______	______
Gradation	______	______	______
Dust/Pbe ratio	______	______	______
Volume Eff. Binder (Vbe)	______	______	______
Moisture (surface only)	______	______	______

6.6 [ ] Sampling and testing of Mixture from the pavement for properties listed above is in accordance with QCP

SAMPLING AND TESTING (continued)

ITM 583 Reference
9.1, 9.2

Obtain the diary for one **HMA** (402) mixture produced for a selected DMF within the current year or past three complete calendar years. Perform calculations as needed and compare the quantities produced from the diary against the number of tests, thereby determining the frequency of testing. The frequency of sampling and testing shall be in accordance with the QCP, but not less than:

1. The first 250 t and each subsequent 1000 t of each DMF for base and intermediate mixtures. If a DMF does not reach 250 t, a minimum of one sample is required for certification.

2. The first 250 t and each subsequent 600 t of each DMF for surface mixtures. If a DMF does not reach 250 t, a minimum of one sample is required for certification.

Mixture_________ QCP Frequency _____________ Quantity____________

Tests Required ___________ Tests Completed __________

Certifications Required __________ Certifications sent to Jobsite __________

6.7 [ ] Sampling and Testing of Mixture for binder content, coarse aggregate angularity, gradation, and air voids is in accordance with QCP.

6.8 [ ] Test results are within requirements as follows:
Air Voids -- ± 2% from DMF
Binder Content -- ± 0.7% from DMF

6.9 [ ] Type D certifications were sent to jobsite as required and are on file

6.10 [ ] Test results shown on Type D certifications match test reports

SAMPLING AND TESTING (continued)

ITM 583 Reference
9.1, 9.2

Select at random one test report for any one **QC/QA HMA or SMA** mixture and check the calculations performed for the Blended Aggregate, RAP, and Mixture. If only **HMA** mixture is produced, check the calculations for that mixture only.

Blended Aggregate Mixture _______________ Date ___________

6.11 [ ]* Gradation of aggregate from mixture sample is calculated correctly
6.12 [ ]* Gradation of aggregate from cold feed belt or belt discharge is calculated correctly (Drum Plants)
6.13 [ ]* Gradation of aggregate from each hot bin is calculated correctly and blend calculations are correct (Batch Plants)
6.14 [ ]* Moisture content of aggregate is calculated correctly

* Recycled Materials RAP size/Name _______________ Date ___________

6.15 [ ] Actual binder content calculated correctly (fines correction, if required, is used in calculation)
6.16 [ ] Gradation of aggregate calculated correctly
6.17 [ ]* Moisture content calculated correctly
6.18 [ ]* Coarse Aggregate Angularity for RAP calculated correctly
6.19 [ ] Gsb of recycled aggregate calculated correctly

Hot Mix Asphalt Mixture _______________ Date ___________

6.20 [ ] Determination of Air Voids and VMA calculated correctly
6.21 [ ] Actual binder content calculated correctly (fines correction, if required, is used in calculation)
6.22 [ ] Gradation from mixture sample calculated correctly
6.23 [ ] Dust/calculated effective binder ratio calculated correctly
6.24 [ ]* Moisture content calculated correctly
6.25 [ ] Bulk Specific Gravity calculated correctly
6.26 [ ]* Aggregate degradation value (SMA only)
6.27 [ ] Maximum Specific Gravity calculated correctly
6.28 [ ] Volume of Effective Binder calculated correctly
6.29 [ ]* If ignition oven is utilized, correct calibration factors are used

7. HMA PLANT　　　　ITM 583 Reference 2.5, 12.2

Audit Team Member: ______________________

Determine if the following documents are on file. Typically, the documents will be on file at the HMA Plant rather than the Laboratory.

7.1 [ ] Bill of ladings for most current day's production indicating material from ASC Supplier
7.2 [ ] Instructions from the PGABS Supplier concerning storage and handling of the PG binders
7.3 [ ] Plant calibrations/blend sheets for each DMF (Calibrations on Plant computer are acceptable)
7.4 [ ] Annual calibrations for plant scales and verification of meters
7.5 [ ]* Legitimate Use Approval letter from IDEM for post-consumer shingles
7.6 [ ] Weigh tickets adhere to requirements of section 109.01(b) of INDOT Standard Specifications

Net weight, ticket serial #, date, contract number, source of material, material designation (size or type), DMF #, truck #, time weighed, gross weight/tare weight (if applicable)

7.7 [ ] Type A Certifications for all binders

Inspect the site and observe the operation of the Plant to verify that the production process is in accordance with the QCP and the Plant site layout diagram is correct.

Plant Site Layout

7.8 [ ] Binder tanks are located correctly
7.9 [ ] Fuel tank is located correctly
7.10 [ ]* Fibers supply is located correctly
7.11 [ ] Anti-adhesive supply is located correctly
7.12 [ ]* Field laboratory is located correctly
7.13 [ ] Visitor parking area is located correctly
7.14 [ ] Mixing Plant major components are located correctly

Aggregates (material stockpiles)

7.15 [ ] Stockpile map is current and located as indicated in QCP
7.16 [ ]* All stockpiles have signs as indicated in QCP
7.17 [ ]* Stockpiling procedure is in accordance with QCP
7.18 [ ] Stockpiles are adequately spaced and not contaminated
7.19 [ ]* Cold bin loading procedure is in accordance with QCP

HMA PLANT (continued)

ITM 583 Reference
2.5, 12.2

Binder Tanks

7.20 [ ] Binder tanks are labeled

Fibers

7.21 [ ]* Procedure for addition of fibers is in accordance with QCP

Anti-Adhesive Agent

7.22 [ ]* Procedure for application of anti-adhesive agent is in accordance with QCP
7.23 [ ] Anti-adhesive agent supply is labeled
Name: ___________________________
7.24 [ ] Anti-Adhesive is on approved list. Approval # : _______________

Truck Loading

7.25 [ ]* Procedure for loading trucks is in accordance with QCP

Other Process Control Techniques

7.26 [ ]* Procedures are in accordance with QCP

8. LABORATORY

ITM 583 Reference
6.0, 7.0

Audit Team Member: _______________________

The laboratory will be inspected for compliance with the QCP.

8.1 Lab location: [ ] Plant -or- [ ] Offsite
8.2 [ ] Facility acceptable for testing materials
8.3 [ ] All equipment listed in QCP at laboratory
8.4 [ ] All equipment apparently in good working order
8.5 [ ]* Procedure for transportation of mixture to laboratory not located at plant is in accordance with QCP
8.6 [ ] Calibration or verification documentation on file for minimum of 3 years

Check the calibration or verification records to verify that the frequency meets the minimum requirements and the documentation includes the following:

- Description of equipment including Model or Serial Number
- Name of person performing calibration or verification
- Identification of calibration equipment
- Date of calibration or verification and next due date
- Reference of procedure used
- Calibration or verification results

LABORATORY (continued)

ITM 583 Reference
6.0, 7.0

	Equipment	Requirement	Minimum Frequency	Procedure	Date Calibrated/ Verified
8.7	Balances	Standardize	12 mo.	ITM 910	
8.8	Gyratory Compactor	Verify Ram Pressure, Angle of Gyration, Frequency of Gyration, LVDT	1 mo.	ITM 908	
8.9	Gyratory Compactor Internal Angle	Verification	12 mo.	AASHTO T 344	
8.10	Gyratory Mold and Plate Dimensions	Verification	12 mo.	AASHTO T 312	
8.11	Ignition Oven	Conduct Lift Test	Weekly	Operators Manual	
8.12	Ignition Oven Balance	Standardize	12 mo.	ITM 910	
8.13	Mechanical Shakers	Verify Sieving Thoroughness	12 mo.	ITM 906	
8.14	Ovens	Verify Temperature Settings	12 mo.	ITM 903	
8.15	Sieves	Verify Physical Condition	12 mo.	ITM 902	
8.16	Thermometers	Verification	12 mo.	ITM 909	
8.17	Vacuum Chamber	Verification	3 mo.	ITM 905	
8.18	Calipers	Verification	12 mo.	ITM 916	

	Calibration Equipment	Testing Equipment	Minimum Frequency	Date Calibrated/ Verified
8.19	Master ring used with the Bore Gauge	Gyratory Compactor Molds – AASHTO T 312	36 mo.	
8.20	Dynamometer Load Cell with Height Billet[1]	Gyratory Compactor – AASHTO T 312	24 mo.	
8.21	Proving Ring with Height Gage Blocks	Gyratory Compactor – AASHTO T 312	24 mo.	
8.22	Vacuum Gage	Vacuum Systems – ITM 905	12 mo.	
8.23	Weights, Min. Class 3	Balances – ITM 910	12 mo.	

NOTE 1: Troxler equipment only

9. COMPARISON TESTING

Audit Team Member: ______________________

Testing procedures required by the QCP will be observed to verify that they comply with the Sampling, Sample Reduction, and Testing Procedures checklist. IA comparison testing that occurs every 2 years will be adequate.

9.1 [ ] Independent Assurance Technician has completed
Date Comparison Testing Completed: ____________________

9.2 [ ] Independent Assurance Technician will complete
Estimated Comparison Testing Date: ____________________

9.3 [ ] Will be completed as part of this audit (Provide results to IA).

If comparison testing will be performed as part of this audit, the Producer's Certified Technician shall obtain a sample of the mixture, the blended aggregate, and the RAP (if applicable). A separate blended aggregate sample is only required if specified by QCP. The samples obtained shall be split by the Producer's Certified Technician and the Department's portion given to the INDOT audit team member. Samples shall be tested by both the Producer and INDOT.

9.4 [ ] Sampling procedures are correct
9.5 [ ] Sample Reduction procedures are correct

The following test results will be determined. A copy of all test reports from both the INDOT audit team member and the Producer's Certified Technician will be attached to the audit checklist. The variation of test results will be shown in the remarks section of the INDOT audit team member's report for each material sampled and tested. The allowable variation will be as follows:

Sieves	Deviation (± %)
*1 in.	5
*3/4 in	5
*1/2 in.	5
No. 8	3
No. 30	3
No. 200	3

Binder Content	Deviation (± %)
*RAP	0.5
Mixture	0.5

9.6 [ ] Gradation is within limits
9.7 [ ]* Binder content of RAP is within limits
9.8 [ ] Binder content of Mixture is within limits

10. AUDIT CLOSE-OUT

DTE or Area Supervisor

A meeting with the Producer will be conducted at the completion of the audit. The results of the audit will be discussed, and all outstanding matters will be completely resolved or solutions with deadlines will be established. An Audit Close-Out meeting with the Producer will be scheduled for two weeks after the Audit, or if circumstances require, at a time deemed appropriate by the DTE. Any addenda required by items listed on the Addenda Summary Sheet, QCP Annex, or Corrective Action Sheets shall be submitted at this time.

When all items indicated on Corrective Action Sheets have been addressed, and all testing results (if applicable) have been reviewed, the DTE and/or Area Supervisor will verify the audit package is prepared properly and completely. Upon completion of the Audit Close-Out meeting, all documents will be sent to the Asphalt Engineer, Office of Materials Management.

Corrective Action Sheets requiring longer than two weeks must be addressed by the DTE.

____

____

____

________________________	________________
DTE/Area Supervisor	Date

CORRECTIVE ACTION SHEET

PLANT # ___ ___ ___ ___

DATE _____________

ITEM _____________

Problem Explanation:____

____

____

____

____

Corrective Action To Be Taken Is:

[ ] **Not Applicable; Observation**. This item occurred in the past and cannot be corrected.
[ ] **Not Applicable; Corrected**. This item was resolved at the audit.

____

____

____

____

____

Deadline Date Is: ____________________

Follow-up **Date** ______________________

Finding:____

____

____

____

Corrective Action Sheets requiring longer than two weeks must be addressed by the DTE.

CALCULATIONS

BINDER CONTENT (ITM 571)

$$\% \text{ Binder} = \frac{\text{Wt. of Sample} - (\text{Wt. of Extracted Aggregate} + \text{Wt. of Fines})}{\text{Wt. of Sample}} \text{ x } 100$$

HMA or RAP MOISTURE CONTENT (ITM 572)

$$\% \text{ Moisture} = \frac{\text{Wt. of Original Sample - Wt. of Dried Sample}}{\text{Wt. of Dried Sample}} \text{ x } 100$$

VOIDS in the MINERAL AGGREGATE (AASHTO R 35)

G_{sb} = Bulk Specific Gravity of Aggregate (obtained from DMF)
P_s = Aggregate, percent by total weight of HMA

$$\% \text{ VMA} = 100 - \frac{G_{mb} \times P_s}{G_{sb}}$$

AGGREGATE GRADATION (AASHTO T 27)

$$\% \text{ Passing} = \frac{\text{Wt. Passing Each Sieve}}{\text{Original Dry Sample Wt.}} \text{ x } 100$$

HMA or RAP EXTRACTED AGGREGATE GRADATION (AASHTO T 30)

$$\% \text{ Passing} = \frac{\text{Wt. Passing Each Sieve}}{\text{Original Dry Wt. of Aggregate + Wt. of Fines*}} \text{ x } 100$$

*Not required for ignition oven

BULK SPECIFIC GRAVITY (Dense Graded and SMA) -- G_{mb} (AASHTO T 166)

$$G_{mb} = \frac{\text{Wt. of Specimen in Air}}{(\text{Wt. of Surface-Dry Specimen in Air}) - (\text{Wt. of Specimen in Water})}$$

$$\% \text{ Absorption} = \frac{(\text{Wt. of Surface-Dry Specimen in Air}) - (\text{Wt. of Specimen in Air})}{(\text{Wt. of Surface-Dry Specimen in Air}) - (\text{Wt. of Specimen in Water})}$$

CALCULATIONS (continued)

MAXIMUM SPECIFIC GRAVITY -- G_{mm} (AASHTO T 209)

A = weight of oven dry sample in air
A_1 = weight of surface dry sample
B = weight of container in water, g
C = weight of container and sample in water, g
D = weight of container filled with water at 77°F
E = weight of container filled with sample and water at 77°F

<u>Weighing in Air</u>

$$G_{mm} = \frac{A}{A + D - E}$$

<u>Weighing in Water</u>

$$G_{mm} = \frac{A}{A - (C - B)}$$

<u>Supplemental Procedure</u>

$$G_{mm} = \frac{A}{A_1 + D - E}$$

AGGREGATE MOISTURE CONTENT (AASHTO T 255)

$$\%\ \text{Moisture} = \frac{\text{Wt. of Original Sample - Wt. of Dried Sample}}{\text{Wt. of Dried Sample}} \times 100$$

AIR VOIDS (AASHTO T 269)

$$\%\ \text{Air Voids} = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100$$

DRAINDOWN (Open Graded and SMA) -- (AASHTO T 305)

$$\%\ \text{Draindown} = \frac{A - B}{C} \times 100$$

A = final weight of plate or container, g
B = initial weight of plate or container, g
C = initial total sample weight, g

AGGREGATE DEGRADATION LOSS VALUE (SMA only) – (ITM 220)

Aggregate Degradation Loss, % = A - B

A = average % passing the No. 8 sieve from the gyratory specimens
B = % passing the No. 8 sieve from the uncompacted mixture sample

CALCULATIONS (continued)

BULK SPECIFIC GRAVITY (Open Graded) -- G_{mb} (AASHTO T331)

A = weight of dry specimen in air, g
B = weight of dry, sealed specimen, g
E = weight of sealed specimen in water, g
F_t = apparent specific gravity of plastic sealing material at 77°F

$$G_{mb} = \frac{A}{B - E - \frac{B - A}{F_t}}$$

COARSE AGGREGATE ANGULARITY (ASTM D 5821)

$$\%\ CAA = \frac{\text{Wt. of Crushed Particles}}{\text{Wt. of Crushed Particles} + \text{Wt. of Uncrushed Particles}} \times 100$$

VOLUME OF EFFECTIVE BINDER

Vbe = VMA - AV

VMA = VMA of the mixture
AV = Air voids of the mixture

DUST TO CALCULATED EFFECTIVE BINDER RATIO

$$\text{Dust/Pbe} = \left(\frac{P200}{Pbe}\right)$$

P200 = aggregate passing the No. 200 sieve
Pbe = Percent of effective binder

$$Pbe = \left(\frac{Vbe}{Gmb/1.03}\right)$$

CALCULATIONS (continued)

Example Calculation for Recycled Materials Sampling and Testing

Contract __R-38721_ DMF_120460J__ Mixture _19.0 mm Int._ Quantity __17,500 tons_

Recycled Materials

$$Total\ RAP\ used = Total\ mix\ quantity * \frac{Percent\ RAP\ by\ Mass}{100}$$

	Binder % RAS	Binder Replacement %	Virgin Binder %
	0.0%	24.7%	2.9%
			%

10.0% + 9.0%
= 19.0% RAP
by mass

Fine RAP/ Coarse RAP/ RAS in mixture, %	10.0%	9.0%	
Fine RAP/ Coarse RAP/ RAS binder, extracted, %	5.7%	4.1%	
Ignition oven test temp (°F)		1000	

$$Total\ RAP\ used = 17{,}500\ tons\ mix * \frac{19.0\ \%}{100}$$

$$Total\ RAP\ used = 3{,}325\ tons\ RAP$$

Percent by mass from DMF ___19.0____ Total used (in tons) _3,325_tons_

-- or --

Total Processed _3,325_tons_

	QCP Frequency	Tests Required	Tests Completed
Actual Binder Content	_1/1000 t RAP_	______3_____	______5______
Moisture	_1/1000 t RAP_	______3_____	______5______
Gradation	_1/1000 t RAP_	______3_____	______5______
CAA	_1/1000 t RAP_	______3_____	______5______

6.4 [✓]* Sampling and testing of Recycled Materials for actual binder content, moisture content, gradation and coarse aggregate angularity is in accordance with QCP

APPENDIX
Testing Results Outside of Control Limits

Record the date and the result for any value outside of the control limit for the following properties

Air Voids	Target Value:
Date/Air Voids Value:	

Binder Content	Target Value:
Date/Binder Content Value:	

VMA	Target Value:
Date/VMA Value:	

Dust/Effective Binder Ratio	Target Value:
Date/Dust/Pbe Value:	

Vbe	Target Value:
Date/Vbe Value:	

CERTIFIED
HOT MIX ASPHALT PRODUCER PROGRAM
AUDIT CHECKLIST (NO INDOT PRODUCTION)

Date _______________ Page 1 of ___

Plant No. ___________

Producer ____

Plant Location ____

INDOT Audit Team Members

	Name	Position
1.	______________________________	District Testing Engineer
2.	______________________________	Area Supervisor
3.	______________________________	Technician
4.	______________________________	________________________
5.	______________________________	________________________
6.	______________________________	________________________

Producer Members

	Name	Position
1.	______________________________	Management Representative
2.	______________________________	Level 1 or Certified Asphalt Technician
3.	______________________________	________________________
4.	______________________________	________________________

1. GENERAL INSTRUCTIONS

Audit Team Members

A No Production Audit should only be conducted when no mixture was produced for INDOT in that calendar year or after the audit in the previous year.

Tasks to be **completed before arriving** at the Producer's site:

- Review the QCP
- Review previous audits, especially the most recent one and note all corrective actions
- Coordinate with Independent Assurance Technician for comparison testing schedule
- Bring copies of the following:
  - Approved DMF and Contract Record worksheets for the current calendar year. These can be found at https://itap.indot.in.gov/
  - Qualified Products Lists and Qualified Source Lists
    - Performance-Graded Asphalt Binder Suppliers
    - Anti-Adhesive materials
  - Indiana Certified Asphalt Technicians (ICAT) List
  - Current copy of ITM 583

Terminology:

QC/QA HMA	Std. Spec. Section 401 (QC/QA Hot Mix Asphalt)
HMA	Std. Spec. Section 402 (Hot Mix Asphalt)
QCP	Quality Control Plan
DMF	Design Mix Formula
PGABS	Performance-Graded Asphalt Binder Suppliers
RAP	Reclaimed Asphalt Pavement
RAS	Reclaimed Asphalt Shingles
SMA	Stone Matrix Asphalt

Brackets must be filled in as follows:

[✓] Satisfactory
[X] Unsatisfactory or deficient; a **Corrective Action** Sheet must be prepared
[NA] Not applicable to the audit or Producer

* Item is only applicable in some cases; fill in 'NA' if not applicable

All unsatisfactory or deficient items resolved during the audit shall be noted on corrective action sheets with indication that item has been corrected.

2. PRODUCER GENERAL INFORMATION

ITM 583 Reference
5.0, 12.2

Audit Team Member: ______________________

2.1 [ ] Review the complete QCPs of INDOT and the Producer and verify they are identical and have the same authentication page:
DTE signature date: ____________
2.2 [ ] QCP is in accordance with ITM 583 (no updates needed)
2.3 [ ] Plant location and address in QCP is correct
2.4 [ ] Plant telephone numbers in QCP are correct
2.5 [ ] Management Representative ____________________________
2.6 [ ] Management Representative e-mail address in QCP is correct
2.7 [ ] Level 1 or Certified Asphalt Technician at audit ______________________
2.8 [ ]* All other Level 1 or Certified Technicians in QCP are current

For information only (ensure the QCP includes the following, if applicable):
2.9 [ ] Is this plant equipped with a water injection foaming device?
2.10 [ ] Is this plant equipped to produce latex modified asphalt by in-line blending?

3. DOCUMENTS

ITM 583 Reference
2.0

Audit Team Member: ______________________

Determine whether the following current documents are maintained at the Producer's lab or Plant, either by hard copies or electronically.

3.1 [ ] INDOT Standard Specifications (Including any applicable Supplemental Specifications and Special Provisions)
3.2 [ ] Indiana Certified Asphalt Technician (ICAT) Manual

Documents (continued)

3.3 [ ] The ITM, AASHTO, and ASTM Test Methods **referenced in QCP**. ITM revision dates are on the ITM webpage. The AASHTO and ASTM documents have the current revision date listed next to the test method. If the documents are accessible on the computer or internet, hard copies are not needed.

ITM			**910**		Yes / No	T331-22 Date ______
[ ] ITMs on Computer			**916**		Yes / No	T344-22 Date ______
ITM	Date on printed	Current?				
207		Yes / No				
220		Yes / No	**AASHTO**			**ASTM**
571		Yes / No	[ ] AASHTOs on Computer			[ ] ASTMs on Computer
572		Yes / No	R30-22	Date ______		**D5821**-13 Date ______
580		Yes / No	R35-22	Date ______		
581		Yes / No	R46-22	Date ______		
583		Yes / No	R66-16	Date ______		
584		Yes / No	R76-16	Date ______		
586		Yes / No	R90-18	Date ______		**OTHER TEST METHODS**
587		Yes / No	T11-22	Date ______		**REFERENCED IN QCP**
588		Yes / No	T27-22	Date ______		Test Method Date
590		Yes / No	T30-21	Date ______		
591		Yes / No	T166-22	Date ______		
902		Yes / No	T209-22	Date ______		
903		Yes / No	T255-22	Date ______		
905		Yes / No	T269-14	Date ______		
906		Yes / No	T275-22	Date ______		
908		Yes / No	T305-22	Date ______		
909		Yes / No	T312-22	Date ______		

4. HMA PLANT ITM 583 Reference
2.5, 12.2

Audit Team Member: ______________________

Determine if the following documents are on file. Typically, the documents will be on file at the HMA Plant rather than the Laboratory.

4.1 [ ] Instructions from the PGABS Supplier concerning storage and handling of the PG binders
4.2 [ ] Annual calibrations for plant scales and verification of meters

Inspect the site and observe the operation of the Plant to verify that the production process is in accordance with the QCP and the Plant site layout diagram is correct.

Plant Site Layout

4.3 [ ] Binder tanks are located correctly
4.4 [ ] Fuel tank is located correctly
4.5 [ ]* Fibers supply is located correctly
4.6 [ ] Anti-adhesive supply is located correctly
4.7 [ ]* Field laboratory is located correctly
4.8 [ ] Visitor parking area is located correctly
4.9 [ ] Mixing Plant major components are located correctly

Aggregates (material stockpiles)

4.10 [ ] Stockpile map is current and located as indicated in QCP
4.11 [ ]* All stockpiles have signs as indicated in QCP
4.12 [ ]* Stockpiling procedure is in accordance with QCP
4.13 [ ] Stockpiles are adequately spaced and not contaminated
4.14 [ ]* Cold bin loading procedure is in accordance with QCP

HMA PLANT (continued)

ITM 583 Reference
2.5, 12.2

Binder Tanks

4.15 [ ] Binder tanks are labeled

Fibers

4.16 [ ]* Procedure for addition of fibers is in accordance with QCP

Anti-Adhesive Agent

4.17 [ ]* Procedure for application of anti-adhesive agent is in accordance with QCP
4.18 [ ] Anti-adhesive agent supply is labeled
Name: ___________________________
4.19 [ ] Anti-adhesive is on approved list. Approval # : _______________

Truck Loading

4.20 [ ]* Procedure for loading trucks is in accordance with QCP

Other Process Control Techniques

4.21 [ ]* Procedures are in accordance with QCP

5. LABORATORY

ITM 583 Reference
6.0, 7.0

Audit Team Member: ______________________

The laboratory will be inspected for compliance with the QCP.

5.1 Lab location: [ ] Plant -or- [ ] Offsite
5.2 [ ] Facility acceptable for testing materials
5.3 [ ] All equipment listed in QCP at laboratory
5.4 [ ] All equipment apparently in good working order
5.5 [ ]* Procedure for transportation of mixture to laboratory not located at plant is in accordance with QCP
5.6 [ ] Calibration or verification documentation on file for minimum of 3 years

Check the calibration or verification records to verify that the frequency meets the minimum requirements and the documentation includes the following:

- Description of equipment including Model or Serial Number
- Name of person performing calibration or verification
- Identification of calibration equipment
- Date of calibration or verification and next due date
- Reference of procedure used
- Calibration or verification results

LABORATORY (continued)

ITM 583 Reference
6.0, 7.0

	Equipment	Requirement	Minimum Frequency	Procedure	Date Calibrated/ Verified
5.7	Balances	Standardize	12 mo.	ITM 910	
5.8	Gyratory Compactor	Verify Ram Pressure, Angle of Gyration, Frequency of Gyration, LVDT	1 mo.	ITM 908	
5.9	Gyratory Compactor Internal Angle	Verification	12 mo.	AASHTO T 344	
5.10	Gyratory Mold and Plate Dimensions	Verification	12 mo.	AASHTO T 312	
5.11	Ignition Oven	Conduct Lift Test	Weekly	Operators Manual	
5.12	Ignition Oven Balance	Standardize	12 mo.	ITM 910	
5.13	Mechanical Shakers	Verify Sieving Thoroughness	12 mo.	ITM 906	
5.14	Ovens	Verify Temperature Settings	12 mo.	ITM 903	
5.15	Sieves	Verify Physical Condition	12 mo.	ITM 902	
5.16	Thermometers	Verification	12 mo.	ITM 909	
5.17	Vacuum Chamber	Verification	3 mo.	ITM 905	
5.18	Calipers	Verification	12 mo.	ITM 916	

	Calibration Equipment	Testing Equipment	Minimum Frequency	Date Calibrated/ Verified
5.19	Master ring used with the Bore Gauge	Gyratory Compactor Molds – AASHTO T 312	36 mo.	
5.20	Dynamometer Load Cell with Height Billet[1]	Gyratory Compactor – AASHTO T 312	24 mo.	
5.21	Proving Ring with Height Gage Blocks	Gyratory Compactor – AASHTO T 312	24 mo.	
5.22	Vacuum Gage	Vacuum Systems – ITM 905	12 mo.	
5.23	Weights, Min. Class 3	Balances – ITM 910	12 mo.	

NOTE 1: Troxler equipment only

6. AUDIT CLOSE-OUT

DTE or Area Supervisor

A meeting with the Producer will be conducted at the completion of the audit. The results of the audit will be discussed, and all outstanding matters will be completely resolved or solutions with deadlines will be established. An Audit Close-Out meeting with the Producer will be scheduled for two weeks after the Audit, or if circumstances require, at a time deemed appropriate by the DTE. Any addenda required by items listed on the Addenda Summary Sheet, QCP Annex, or Corrective Action Sheets shall be submitted at this time.

When all items indicated on Corrective Action Sheets have been addressed, the DTE and/or Area Supervisor will verify the audit package is prepared properly and completely. Upon completion of the Audit Close-Out meeting, all documents will be sent to the Asphalt Engineer, Office of Materials Management.

Corrective Action Sheets requiring longer than two weeks must be addressed by the DTE.

____

____

____

__________________________	________________
DTE/Area Supervisor	Date

CORRECTIVE ACTION SHEET

PLANT # ___ ___ ___ ___

DATE _____________

ITEM _____________

Problem Explanation:____

____

____

____

____

Corrective Action To Be Taken Is:

[ ] **Not Applicable; Observation**. This item occurred in the past and cannot be corrected.
[ ] **Not Applicable; Corrected**. This item was resolved at the audit.

____

____

____

____

____

Deadline Date Is: ____________________

<u>Follow-up</u> **Date** ______________________

Finding:____

____

____

____

Corrective Action Sheets requiring longer than two weeks must be addressed by the DTE

CERTIFIED
HOT MIX ASPHALT PRODUCER PROGRAM
PARTIAL AUDIT CHECKLIST (EXTRA/INTERIM)

Date _______________ Page 1 of ___

Plant No. ___________

Producer ____

Plant Location ____

INDOT Audit Team Members

	Name	Position
1.	______________________________	District Testing Engineer
2.	______________________________	Area Supervisor
3.	______________________________	Technician
4.	______________________________	______________________
5.	______________________________	______________________
6.	______________________________	______________________

Producer Members

	Name	Position
1.	______________________________	Management Representative
2.	______________________________	Level 1 or Certified Asphalt Technician
3.	______________________________	______________________
4.	______________________________	______________________

1. GENERAL INSTRUCTIONS

Audit Team Members

A Partial Audit should be conducted only when a Full Audit has already been conducted or will be conducted in the same calendar year.

Tasks to be **completed before arriving** at the Producer's site:
- Review the QCP
- Review previous audits, especially the most recent one and note all corrective actions
- Coordinate with Independent Assurance Technician for comparison testing schedule
- Bring copies of the following:
  - Approved DMF and Contract Record worksheets for the current calendar year. These can be found at https://itap.indot.in.gov/
  - Qualified Products Lists and Qualified Source Lists
    - Performance-Graded Asphalt Binder Suppliers
    - Anti-Adhesive materials
  - Indiana Certified Asphalt Technicians (ICAT) List
  - Current copy of ITM 583

Terminology:

QC/QA HMA	Std. Spec. Section 401 (QC/QA Hot Mix Asphalt)
HMA	Std. Spec. Section 402 (Hot Mix Asphalt)
QCP	Quality Control Plan
PGABS	Performance-Graded Asphalt Binder Suppliers
DMF	Design Mix Formula
RAP	Reclaimed Asphalt Pavement
RAS	Reclaimed Asphalt Shingles
SMA	Stone Matrix Asphalt

Brackets must be filled in as follows:

[✓] Satisfactory
[X] Unsatisfactory or deficient; a **Corrective Action** Sheet must be prepared
[NA] Not applicable to the audit or Producer

* Item is only applicable in some cases; fill in 'NA' if not applicable

All unsatisfactory or deficient items resolved during the audit shall be noted on corrective action sheets with indication that item has been corrected.

2. DOCUMENTS

ITM 583 Reference
2.0

Audit Team Member: ______________________

Determine whether the following current documents are maintained at the Producer's lab or Plant, either by hard copies or electronically.

2.1 [ ] Bill of ladings for most current days production indicating material from an ASC producer
2.2 [ ] Weigh tickets adhere to requirements of section 109.01(b) of INDOT specs
2.2 [ ] Type A Certifications for all binders

3. DIARY

ITM 583 Reference
8.0, 11.0

Audit Team Member: ______________________

Select at random one production week for review of the diary. The diary should be in accordance with the following requirements and information.

Week/Month/Year ______________________

3.1 [ ] Diary on file for 3 years
3.2 [ ] Open book format or readily accessible electronic format
3.3 [ ] One or more pages for each day of production
3.4 [ ] Type of Mixture (QC/QA HMA, HMA, SMA) produced and quantity
3.5 [ ] DMF number
3.6 [ ] Contract or purchase order number the mixture was sent to
5.7 [ ] Time sample obtained and tests completed (samples are required to be tested within two working days of the time the sample was taken. If all samples are tested the same day, a statement indicating that this occurred is acceptable)
3.8 [ ]* Significant events or problems
3.9 [ ] Signature of Level 1 or Certified Technician or Management Representative

Plant # ___ ___ ___ ___ Page 4 of ___

DIARY (continued)

Review the month test data for nonconforming tests. If some are found, review the diary on the date of each test for notations regarding action taken.

3.10 [ ] Nonconforming test(s) are noted in diary

- Control limits are exceeded for Binder Content, Vbe, VMA, Air Voids, aggregate gradation.
- Control limits are exceeded for 2.36mm sieve (9.5mm surface only)
- 2.36 mm sieve %passing greater than 47% for 9.5 mm surface mix
- Aggregate degradation value for SMA mix is greater than 3.0%
- Dust/Vbe ratio is less than 0.6 or greater than 1.4 (or 1.0 to 2.0 for 4.75 mm mixtures)
- Vbe is determined to be less than design minimum or more than design maximum
- Moisture content of surface mixture exceeds 0.30% at the plant or 0.10% behind paver

3.11 [ ] Corrective action was taken or documented.

4. SAMPLING AND TESTING

ITM 583 Reference
9.1, 9.2

Audit Team Member: ______________________

For the week being reviewed, perform calculations as needed for a **QC/QA HMA or SMA** mixture and compare the quantities produced from the diary against the number of tests, thereby determining the frequency of testing. The previous or subsequent week in the diary may need to be obtained to verify the frequency of tests.

Contract__________ DMF__________ Mixture ___________ Quantity __________

Recycled Materials

4.1 [ ]* Sampling and testing of Recycled Materials for actual binder content, moisture content, gradation, coarse aggregate angularity, and bulk specific gravity is in accordance with QCP

Note: For assistance, see example calculation page in appendix

Percent by mass from DMF ___________ Total RAP and/or RAS used ___________

--or—

Total RAP and/or RAS processed ____________

	QCP Frequency	Tests Required	Tests Completed
Actual Binder Content	_____________	____________	_____________
Moisture	_____________	____________	_____________
Gradation	_____________	____________	_____________
CAA	_____________	____________	_____________
Bulk Spec. Gravity of Agg	_____________	____________	_____________

Aggregates

4.2 [ ] Sampling and testing of Blended Aggregate is in accordance with QCP

QCP Frequency	Tests Required	Tests Completed
_____________	____________	_____________

4.3 [ ] Sampling and testing of Aggregate Stockpiles is in accordance with QCP

PG Binder

4.4 [ ] Sampling of PG Binder is in accordance with QCP

Plant # ___ ___ ___ ___ Page <u>6</u> of ___

<u>Mixture</u>

Plant/Truck Samples	**QCP Frequency**	**Tests Required**	**Tests Completed**
Actual Binder Content	______	______	______
Gradation	______	______	______
Moisture	______	______	______
Temperature	______	N/A	(Y or N)
Draindown (OG & SMA)	______	______	______
Agg. Degredation (SMA, 1 per lot)	______	______	______

4.5 [ ] Sampling and testing of Mixture at the Plant for actual binder content, gradation, draindown (open graded and SMA mixtures only), moisture content, and temperature is in accordance with QCP

Pavement/Plate Samples	**QCP Frequency**	**Tests Required**	**Tests Completed**
Air Voids	______	______	______
VMA	______	______	______
Actual Binder Content	______	______	______
Gradation	______	______	______
Dust/Pbe ratio	______	______	______
Volume Eff. Binder (Vbe)	______	______	______
Moisture (surface only)	______	______	______

4.6 [ ] Sampling and testing of Mixture from the pavement for properties listed above is in accordance with QCP

SAMPLING AND TESTING (continued)

ITM 583 Reference
9.1, 9.2

Obtain the diary for one **HMA** (402) mixture produced during one a one week period. Perform calculations as needed and compare the quantities produced from the diary against the number of tests, thereby determining the frequency of testing. The previous of subsequent week in the diary may need to be obtained to verify the frequency of tests. The frequency of sampling and testing shall be in accordance with the QCP, but not less than:

1. The first 250 t and each subsequent 1000 t of each DMF for base and intermediate mixtures. If a DMF does not reach 250 t, a minimum of one sample is required for certification.

2. The first 250 t and each subsequent 600 t of each DMF for surface mixtures. If a DMF does not reach 250 t, a minimum of one sample is required for certification.

Mixture_________ QCP Frequency _____________ Quantity____________

Tests Required ___________ Tests Completed __________

Certifications Required __________ Certifications sent to Jobsite __________

4.7 [ ] Sampling and Testing of Mixture for binder content, coarse aggregate angularity, gradation, and air voids is in accordance with QCP.
4.8 [ ] Test results are within requirements as follows:
Air Voids -- ± 2% from DMF
Binder Content -- ± 0.7% from DMF
4.9 [ ] Type D certifications were sent to jobsite as required and are on file
4.10 [ ] Test results shown on Type D certifications match test reports

SAMPLING AND TESTING (continued) ITM 583 Reference
9.1, 9.2

Select at random one test report for any one **QC/QA HMA or SMA** mixture and check the calculations performed for the Blended Aggregate, RAP, and Mixture. If only **HMA** mixture is produced, check the calculations for that mixture only.

Blended Aggregate Mixture ________________ Date ____________

4.11 [ ]* Gradation of aggregate from mixture sample is calculated correctly
4.12 [ ]* Gradation of aggregate from cold feed belt or belt discharge is calculated correctly (Drum Plants)
4.13 [ ]* Gradation of aggregate from each hot bin is calculated correctly and blend calculations are correct (Batch Plants)
4.14 [ ]* Moisture content of aggregate is calculated correctly

* Recycled Materials RAP size/Name ________________ Date ____________

4.15 [ ] Actual binder content calculated correctly (fines correction, if required, is used in calculation)
4.16 [ ] Gradation of aggregate calculated correctly
4.17 [ ]* Moisture content calculated correctly
4.18 [ ]* Coarse Aggregate Angularity for RAP calculated correctly
4.19 [ ] Gsb of recycled aggregate calculated correctly

Hot Mix Asphalt Mixture ________________ Date ____________

4.20 [ ] Determination of Air Voids and VMA calculated correctly
4.21 [ ] Actual binder content calculated correctly (fines correction, if required, is used in calculation)
4.22 [ ] Gradation from mixture sample calculated correctly
4.23 [ ] Dust/calculated effective binder ratio calculated correctly
4.24 [ ]* Moisture content calculated correctly
4.25 [ ] Bulk Specific Gravity calculated correctly
4.26 [ ]* Aggregate degradation value (SMA only)
4.27 [ ] Maximum Specific Gravity calculated correctly
4.28 [ ] Volume of Effective Binder calculated correctly
4.29 [ ]* If ignition oven is utilized, correct calibration factors are used

5. HMA PLANT

ITM 583 Reference
2.5, 12.2

Audit Team Member: ______________________

Inspect the site and observe the operation of the Plant to verify that the production process is in accordance with the QCP and the Plant site layout diagram is correct.

Aggregates (material stockpiles)

5.1 [ ]* Stockpiling procedure is in accordance with QCP
5.2 [ ] Stockpiles are adequately spaced and not contaminated
5.3 [ ]* Cold bin loading procedure is in accordance with QCP

Binder Tanks

5.4 [ ] Binder tanks are labeled

Anti-Adhesive Agent

5.5 [ ]* Procedure for application of anti-adhesive agent is in accordance with QCP
5.6 [ ] Anti-adhesive agent supply is labeled
Name: ____________________
5.7 [ ] Anti-adhesive is on approved list. Approval # : ________________

Truck Loading

5.8 [ ]* Procedure for loading trucks is in accordance with QCP

Other Process Control Techniques

5.9 [ ]* Procedures are in accordance with QCP

6. COMPARISON TESTING

Audit Team Member: ______________________

Testing procedures required by the QCP will be observed to verify that they comply with the Sampling, Sample Reduction, and Testing Procedures checklist. IA comparison testing that occurs every 2 years will be adequate.

6.1 [ ] Independent Assurance Technician has completed
Date Comparison Testing Completed: ____________________

6.2 [ ] Independent Assurance Technician will complete
Estimated Comparison Testing Date: ____________________

6.3 [ ] Will be completed as part of this audit (Provide results to IA)

If comparison testing will be performed as part of this audit, the Producer's Certified Technician shall obtain a sample of the mixture, the blended aggregate, and the RAP (if applicable). A separate blended aggregate sample is only required if specified by QCP. The samples obtained shall be split by the Producer's Certified Technician and the Department's portion given to the INDOT audit team member. Samples shall be tested by both the Producer and INDOT.

6.4 [ ] Sampling procedures are correct
6.5 [ ] Sample Reduction procedures are correct

The following test results will be determined. A copy of all test reports from both the INDOT audit team member and the Producer's Certified Technician will be attached to the audit checklist. The variation of test results will be shown in the remarks section of the INDOT audit team member's report for each material sampled and tested. The allowable variation will be as follows:

Sieves	Deviation (± %)
*1 in.	5
*3/4 in	5
*1/2 in.	5
No. 8	3
No. 30	3
No. 200	3

Binder Content	Deviation (± %)
*RAP	0.5
Mixture	0.5

6.6 [ ] Gradation is within limits
6.7 [ ]* Binder content of RAP is within limits
6.8 [ ] Binder content of Mixture is within limits

7. AUDIT CLOSE-OUT

DTE or Area Supervisor

A meeting with the Producer will be conducted at the completion of the audit. The results of the audit will be discussed, and all outstanding matters will be completely resolved or solutions with deadlines will be established. An Audit Close-Out meeting with the Producer will be scheduled for two weeks after the Audit, or if circumstances require, at a time deemed appropriate by the DTE.

When all items indicated on Corrective Action Sheets have been addressed, and all testing results (if applicable) have been reviewed, the DTE and/or Area Supervisor will verify the audit package is prepared properly and completely. Upon completion of the Audit Close-Out meeting, all documents will be sent to the Asphalt Engineer, Office of Materials Management.

Corrective Action Sheets requiring longer than two weeks must be addressed by the DTE.

____

____

____

______________________________ ____________________

DTE/Area Supervisor Date

CORRECTIVE ACTION SHEET

PLANT # ___ ___ ___ ___

DATE _____________

ITEM _____________

Problem Explanation:____

____

____

____

____

Corrective Action To Be Taken Is:

[ ] **Not Applicable; Observation**. This item occurred in the past and cannot be corrected.
[ ] **Not Applicable; Corrected**. This item was resolved at the audit.

____

____

____

____

____

Deadline Date Is: ____________________

Follow-up **Date** ______________________

Finding:____

____

____

____

Corrective Action Sheets requiring longer than two weeks must be addressed by the DTE

CALCULATIONS

BINDER CONTENT (ITM 571)

$$\% \text{ Binder} = \frac{\text{Wt. of Sample} - (\text{Wt. of Extracted Aggregate} + \text{Wt. of Fines})}{\text{Wt. of Sample}} \text{ x } 100$$

HMA or RAP MOISTURE CONTENT (ITM 572)

$$\% \text{ Moisture} = \frac{\text{Wt. of Original Sample - Wt. of Dried Sample}}{\text{Wt. of Dried Sample}} \text{ x } 100$$

VOIDS in the MINERAL AGGREGATE (AASHTO R 35)

G_{sb} = Bulk Specific Gravity of Aggregate (obtained from DMF)
P_s = Aggregate, percent by total weight of HMA

$$\% \text{ VMA} = 100 - \frac{G_{mb} \times P_s}{G_{sb}}$$

AGGREGATE GRADATION (AASHTO T 27)

$$\% \text{ Passing} = \frac{\text{Wt. Passing Each Sieve}}{\text{Original Dry Sample Wt.}} \text{ x } 100$$

HMA or RAP EXTRACTED AGGREGATE GRADATION (AASHTO T 30)

$$\% \text{ Passing} = \frac{\text{Wt. Passing Each Sieve}}{\text{Original Dry Wt. of Aggregate + Wt. of Fines*}} \text{ x } 100$$

*Not required for ignition oven

BULK SPECIFIC GRAVITY (Dense Graded and SMA) -- G_{mb} (AASHTO T 166)

$$G_{mb} = \frac{\text{Wt. of Specimen in Air}}{(\text{Wt. of Surface-Dry Specimen in Air}) - (\text{Wt. of Specimen in Water})}$$

$$\% \text{ Absorption} = \frac{(\text{Wt. of Surface-Dry Specimen in Air}) - (\text{Wt. of Specimen in Air})}{(\text{Wt. of Surface-Dry Specimen in Air}) - (\text{Wt. of Specimen in Water})}$$

CALCULATIONS (continued)

MAXIMUM SPECIFIC GRAVITY -- G_{mm} (AASHTO T 209)

A = weight of oven dry sample in air
A_1 = weight of surface dry sample
B = weight of container in water, g
C = weight of container and sample in water, g
D = weight of container filled with water at 77°F
E = weight of container filled with sample and water at 77°F

<u>Weighing in Air</u>

$$G_{mm} = \frac{A}{A + D - E}$$

<u>Weighing in Water</u>

$$G_{mm} = \frac{A}{A - (C - B)}$$

<u>Supplemental Procedure</u>

$$G_{mm} = \frac{A}{A_1 + D - E}$$

AGGREGATE MOISTURE CONTENT (AASHTO T 255)

$$\%\ \text{Moisture} = \frac{\text{Wt. of Original Sample - Wt. of Dried Sample}}{\text{Wt. of Dried Sample}} \times 100$$

AIR VOIDS (AASHTO T 269)

$$\%\ \text{Air Voids} = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100$$

DRAINDOWN (Open Graded and SMA) -- (AASHTO T 305)

$$\%\ \text{Draindown} = \frac{A - B}{C} \times 100$$

A = final weight of plate or container, g
B = initial weight of plate or container, g
C = initial total sample weight, g

AGGREGATE DEGRADATION LOSS VALUE (SMA only) – (ITM 220)

Aggregate Degradation Loss, % = A - B

A = average % passing the No. 8 sieve from the gyratory specimens
B = % passing the No. 8 sieve from the uncompacted mixture sample

CALCULATIONS (continued)

BULK SPECIFIC GRAVITY (Open Graded) -- G_{mb} (AASHTO T331)

A = weight of dry specimen in air, g
B = weight of dry, sealed specimen, g
E = weight of sealed specimen in water, g
F_t = apparent specific gravity of plastic sealing material at 77°F

$$G_{mb} = \frac{A}{B - E - \frac{B - A}{F_t}}$$

COARSE AGGREGATE ANGULARITY (ASTM D 5821)

$$\% \text{ CAA} = \frac{\text{Wt. of Crushed Particles}}{\text{Wt. of Crushed Particles} + \text{Wt. of Uncrushed Particles}} \times 100$$

VOLUME OF EFFECTIVE BINDER

Vbe = VMA - AV

VMA = VMA of the mixture
AV = Air voids of the mixture

DUST TO CALCULATED EFFECTIVE BINDER RATIO

$$\text{Dust/Pbe} = \left(\frac{P200}{Pbe}\right)$$

P200 = aggregate passing the No. 200 sieve
Pbe = Percent of effective binder

$$Pbe = \left(\frac{Vbe}{Gmb/1.03}\right)$$

CALCULATIONS (continued)

Example Calculation for Recycled Materials Sampling and Testing

Contract__R-38721_ DMF_120460J__ Mixture _19.0 mm Int._ Quantity __17,500 tons_

Recycled Materials

$$Total\ RAP\ used = Total\ mix\ quantity * \frac{Percent\ RAP\ by\ Mass}{100}$$

	Binder % RAS	Binder Replacement %	Virgin Binder %
	0.0%	24.7%	2.9%
			%

10.0% + 9.0%
= 19.0% RAP
by mass

Fine RAP/ Coarse RAP/ RAS in mixture, %	10.0%	9.0%	
Fine RAP/ Coarse RAP/ RAS binder, extracted, %	5.7%	4.1%	
Ignition oven test temp (°F)	1000		

$$Total\ RAP\ used = 17{,}500\ tons\ mix * \frac{19.0\ \%}{100}$$

$$Total\ RAP\ used = 3{,}325\ tons\ RAP$$

Percent by mass from DMF ___19.0____ Total used (in tons) _3,325_tons_

-- or --

Total Processed _3,325_tons_

	QCP Frequency	Tests Required	Tests Completed
Actual Binder Content	1/1000 t RAP	3	5
Moisture	1/1000 t RAP	3	5
Gradation	1/1000 t RAP	3	5
CAA	1/1000 t RAP	3	5

6.4 [✓]* Sampling and testing of Recycled Materials for actual binder content, moisture content, gradation and coarse aggregate angularity is in accordance with QCP

CERTIFIED HOT MIX ASPHALT PRODUCER
QUALITY CONTROL PLAN CHECKLIST

DATE ____________________

PLANT NO. _______________

PRODUCER ____

PLANT LOCATION ____

[ ] County
[ ] Nearest Identifiable Point

ORGANIZATIONAL STRUCTURE

Management Representative

[ ] Name
[ ] Employer
[ ] Duties
[ ] Telephone Number
[ ]* Fax Number
[ ] Email Address

Certified or Level 1 Technician(s)

[ ] Name
[ ] Employer
[ ] Duties
[ ] Telephone Number
[ ]* Fax Number
[ ] Email Address

* Qualified Technician(s)

[ ] Name
[ ] Employer
[ ] Duties
[ ] Telephone Number
[ ]* Fax Number
[ ] Email Address

* Only If Applicable

* <u>Other Personnel</u>
[ ] Duties

LABORATORY

[ ] List of Equipment Calibrated or Verified
[ ] Test Methods and Frequency of Calibration/Verification
[ ] Statement of Lab accessibility to Department personnel
[ ]* Location of Lab (if not same location as Plant)
[ ]* Transportation of Mixture to Lab

MIXING PLANT

<u>Site Layout</u>

[ ] Binder Tanks
[ ]* Fuel Tank
[ ]* Stabilizing Additive Supply
[ ]* Anti-Adhesive Supply
[ ]* Field Laboratory
[ ] Visitor Parking Area
[ ] Mixing Plant Components

<u>Material Stockpiles Control Plan</u>

[ ] Aggregate and Recycled Material Stockpile Area
[ ] Identification of Stockpiles
[ ] Stockpiling Procedure for Aggregates
[ ]* Stockpiling Procedure for Recycled Materials
[ ] Cold Bin Loading Procedures to prevent overflow of material from one bin into another

<u>Mixture Calibrations</u>

[ ] Procedure

<u>Binder</u>

[ ] Plan for Identification of Grade of Binder in each Tank
[ ]* Plan for Change in Binder Grades
[ ] Sampling Location Indicated

<u>Baghouse Fines</u>

[ ]* Procedure for Return of Fines

* Only If Applicable

Stabilizing Additives

[ ]* Procedure for Addition of Stabilizing Additive

Anti-Adhesive Agent

[ ]* Procedure for Application
[ ]* Statement that Agent is on Approved List

Surge Bins

[ ]* Procedure for Sealing
[ ] Method to prevent discharge when mixture falls below top of cone

Trucks

[ ] Procedure for Loading Trucks

MATERIALS SAMPLING AND TESTING – QC/QA HMA and SMA

Aggregate Stockpiles

[ ] Sampling Procedure
[ ] Sample Reduction Procedure
[ ] Size of Sample
[ ] Gradation Test Method
[ ] Testing Frequency for each Aggregate is stated

Blended Aggregate (Hot Bin, Cold Feed Belt, or Belt Discharge)

[ ] Location of Sample
[ ] Sampling Procedure
[ ] Sample Reduction Procedure
[ ] Size of Sample
[ ] Gradation Test Method
[ ] Testing Frequency for each Mixture is stated

* Recycled Materials

[ ] Location of Sample
[ ] Sampling Procedure
[ ] Sample Reduction Procedure
[ ] Size of Sample
[ ] Binder Content Test Method

[ ]*	Fines Correction Procedure

* Only If Applicable

MATERIALS SAMPLING AND TESTING – QC/QA HMA and SMA (continued)

[ ]	Moisture Content Test Method
[ ]	Coarse Aggregate Angularity Test Method
[ ]	Bulk Specific Gravity of Recycled Aggregate
[ ]	Testing Frequency is stated

<u>Hot Mix Asphalt – Plant</u>

[ ]	Sample
	[ ]	Sampling Procedure
	[ ]	Sample Reduction Procedure
[ ]	Binder Content
	[ ]	Size of Sample
	[ ]	Test Method
	[ ]*	Fines Correction Procedure
	[ ]	Testing Frequency for each Mixture is stated
[ ]	Gradation Test Method
[ ]	Moisture Content Test Method
[ ]	Temperature Procedure
[ ]	Aggregate Degradation value (SMA Mixture Only) Test Method
[ ]	Draindown (Open Graded and SMA Mixture Only) Test Method

<u>Hot Mix Asphalt – Pavement</u>

[ ]	Sample
	[ ]	Sampling Procedure
	[ ]	Sample Reduction Procedure
[ ]	Bulk Specific Gravity
	[ ]	Size of Sample
	[ ]	Test Method
	[ ]	Testing Frequency for each Mixture is stated
[ ]	Maximum Specific Gravity
	[ ]	Size of Sample
	[ ]	Test Method
	[ ]	Testing Frequency for each Mixture is stated
[ ]	Binder Content
	[ ]	Size of Sample
	[ ]	Test Method
	[ ]*	Fines Correction Procedure
	[ ]	Testing Frequency for each Mixture is stated
[ ]	Air Voids
[ ]	VMA

* Only if Applicable

MATERIALS SAMPLING AND TESTING – QC/QA HMA and SMA (continued)

[ ] Gradation Test Method
[ ] Dust/Calculated Effective Binder ratio
[ ] Moisture Content (Surface Mixture Only) Test Method
[ ] Volume of Effective Binder, Vbe

MATERIALS SAMPLING AND TESTING – HMA

<u>Hot Mix Asphalt</u>

[ ] Sample
- [ ] Location
- [ ] Sampling Procedure
- [ ] Sample Reduction Procedure

[ ] Binder Content
- [ ] Size of Sample
- [ ] Test Method
- [ ] Testing Frequency for each Mixture (Min. – First 250 t and each subsequent 1000 t for base and intermediate mixtures and first 250 t and each subsequent 600 t for surface mixtures

[ ] Gradation Test Method
[ ]* Coarse Aggregate Angularity (mix containing gravel) Test Method
[ ] Bulk Specific Gravity
- [ ] Size of Sample
- [ ] Test Method
- [ ] Testing Frequency for each Mixture (Min.- First 250 t and each subsequent 1000 t for base and intermediate mixtures and first 250 t and each subsequent 600 t for surface mixtures)

[ ] Maximum Specific Gravity
- [ ] Size of Sample
- [ ] Test Method
- [ ] Testing Frequency for each Mixture (Min.- First 250 t and each subsequent 1000 t for base and intermediate mixtures and first 250 t and each subsequent 600 t for surface mixtures)

OTHER PROCESS CONTROL TECHNIQUES

[ ]* Different Types or Greater Frequencies of Testing
[ ]* Visual Checks and Monitoring of Plant Production

ADDENDA

[ ] Means of Handling Addenda - Includes Time Schedule for Submittal
[ ] Statement Concerning Plant Number, Date of Revision, and Means of Identifying Revision

* Only if Applicable

DOCUMENTATION

[ ]* Control Charts (QC/QA HMA and SMA Only)
[ ] Test Data
[ ] Diary
[ ] List of Documents on File at Plant or Lab

AUTHENTICATION

[ ] Last Page
[ ] QCP Signed and Dated
[ ] Corporate Title of Management Representative indicated

* Only If Applicable

DIVISION 400 – ASPHALT PAVEMENTS

SECTION 401 – QC/QA HMA PAVEMENT

401.01 Description

This work shall consist of one or more courses of QC/QA HMA base, intermediate, or surface mixtures constructed on prepared foundations in accordance with 105.03.

401.02 Quality Control

The HMA shall be produced from a certified HMA plant in accordance with ITM 583, Certified Hot Mix Asphalt Producer Program.

The HMA shall be transported and placed according to a QCP prepared and submitted by the Contractor in accordance with ITM 803, Contractor Quality Control Plans for Hot Mix Asphalt Pavements. The QCP shall be submitted to the Engineer at least 15 days prior to commencing HMA paving operations.

When a safety edge is required for a project, the QCP shall identify the devices in accordance with 409.03(c) to be used for constructing the safety edge.

MATERIALS

401.03 Materials

Materials shall be in accordance with the following:

Asphalt Materials
    PG Binder..902.01(a)
Coarse Aggregates 904.03
    Base Mixtures – Class D or Higher
    Intermediate Mixtures – Class C or Higher
    Surface Mixtures* – Class B or Higher
Fine Aggregates 904.02
Stabilizing Additives.....................................AASHTO M 325
    * Surface aggregate requirements are listed in 904.03(d).

401.04 Design Mix Formula

A DMF shall be prepared in accordance with 401.05 and submitted in a format acceptable to the Engineer one week prior to use. The DMF shall be based on the ESAL category identified in the pay item and shall state the mixture designation and maximum particle size in the mixture. No mixture shall be used until the DMF has been assigned a mixture number by the DTE.

The DMF shall state the binder content, the ΔPb as determined in accordance with ITM 591, and the MAF. The DMF shall state the source, type, and dosage rate of any stabilizing additives.

The ESAL category identified in the pay item correlates to the following ESAL ranges.

ESAL Category	ESAL
2*	< 3,000,000
3	3,000,000 to < 10,000,000
4*	≥ 10,000,000
* A category 2 mixture shall replace a category 1 mixture and a category 4 mixture shall replace a category 5 mixture.	

The plant discharge temperature for any mixture shall not be more than 315°F whenever PG 64-22 or PG 70-22 binders are used or not more than 325°F whenever PG 76-22 binder is used. QC/QA HMA may be produced using a water-injection foaming device. The DMF shall list the minimum and maximum plant discharge temperatures as applicable to the mixture.

401.05 Volumetric Mix Design

The DMF shall be determined for each mixture from a volumetric mix design by a design laboratory selected from the Department's list of Qualified Mix Design Laboratories. A volumetric mixture shall be designed in accordance with AASHTO R 35 and the respective AASHTO reference as listed below.

All loose mixtures shall be conditioned for 4 h in accordance with AASHTO R 30 prior to testing. Steel furnace slag coarse aggregate, when used in an intermediate or base mixture application, shall have a deleterious content less than 4.0% as determined in accordance with ITM 219.

Bulk Specific Gravity and Density of
Compacted Asphalt Mixtures using
Automatic Vacuum Sealing ....AASHTO T 331

The single percentage of aggregate passing each required sieve shall be within the limits of the following gradation tables:

Sieve Size	Dense Graded, Mixture Designation – Control Point (Percent Passing)				
	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm**
2 in. (50.0 mm)					
1 1/2 in. (37.5 mm)	100.0				
1 in. (25.0 mm)	90.0 - 100.0	100.0			
3/4 in. (19.0 mm)	< 90.0	90.0 - 100.0	100.0		
1/2 in. (12.5 mm)		< 90.0	90.0 - 100.0	100.0	100.0
3/8 in. (9.5 mm)			< 90.0	90.0 - 100.0	95.0 - 100.0
No. 4 (4.75 mm)				< 90.0	90.0 - 100.0
No. 8 (2.36 mm)	19.0 - 45.0	23.0 - 49.0	28.0 - 58.0	32.0 - 67.0*	
No. 16 (1.18 mm)					30.0 - 55.0
No. 30 (600 µm)					
No. 50 (300 µm)					
No. 200 (75 µm)	1.0 - 7.0	2.0 - 8.0	2.0 - 10.0	2.0 - 10.0	3.0 - 8.0

* The mix design gradation shall be less than or equal to 58.0% passing the No. 8 (2.36 mm) sieve for all 9.5 mm surface mixtures. The mix design gradation can be greater than 58.0% passing the No. 8 (2.36 mm) sieve when used on non-Department maintained facilities.

** The total blended aggregate gradation for the 4.75 mm mixture shall have a fineness modulus greater than or equal to 3.30 as determined in accordance with AASHTO T 27.

Primary Control Sieve, PCS, Control Point for Mixture Designation (Percent Passing)					
Mixture Designation	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm
PCS	4.75 mm	4.75 mm	2.36 mm	2.36 mm	n/a
PCS Control Point	40	47	39	47	n/a

Sieve Size	Open Graded, Mixture Designation – Control Point (Percent Passing)		
	OG9.5 mm	OG19.0 mm	OG25.0 mm
1 1/2 in. (37.5 mm)			100.0
1 in. (25.0 mm)		100.0	70.0 – 98.0
3/4 in. (19.0 mm)		70.0 – 98.0	50.0 – 85.0
1/2 in. (12.5 mm)	100.0	40.0 – 68.0	28.0 – 62.0
3/8 in. (9.5 mm)	75.0 – 100.0	20.0 – 52.0	15.0 – 50.0
No. 4 (4.75 mm)	10.0 – 35.0	10.0 – 30.0	6.0 – 30.0
No. 8 (2.36 mm)	0.0 – 20.0	7.0 – 23.0	7.0 – 23.0
No. 16 (1.18 mm)		2.0 – 18.0	2.0 – 18.0
No. 30 (600 µm)		1.0 – 13.0	1.0 – 13.0
No. 50 (300 µm)		0.0 – 10.0	0.0 – 10.0
No. 100 (150 µm)		0.0 – 9.0	0.0 – 9.0
No. 200 (75 µm)	0 – 6.0	0.0 – 8.0	0.0 – 8.0
% Binder	> 3.0	> 3.0	> 3.0

Dust/Calculated Effective Binder Ratio shall be 0.6 to 1.4. The Dust/Calculated Effective Binder Ratio for 4.75 mm mixtures shall be 1.0 to 2.0.

The optimum binder content shall produce a ΔPb ≤ 0.20 as determined in accordance with ITM 591 and the following air voids at N_{des}:

Air Voids at Optimum Binder Content							
	Dense Graded					Open Graded	
Mixture Designation	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	25.0 mm	19.0 mm	9.5 mm
Air Voids	5.0%	5.0%	5.0%	5.0%	5.0%	15.0% - 20.0%	12.0% - 17.0%

The design for dense graded mixtures shall have at least four points, including a minimum of two points above and one point below the optimum. A one point design may be used for open graded mixtures. The MSG shall be mass determined in water in accordance with AASHTO T 209. The BSG of the gyratory specimens shall be determined in accordance with AASHTO T 166, Method A or AASHTO T 331, if required, for dense graded and open graded mixtures.

The percent draindown of open graded mixtures shall not exceed 0.30% in accordance with AASHTO T 305. Open graded mixtures may incorporate recycled materials and fibers. The recycled materials shall be in accordance with 401.06. The fiber type and minimum dosage rate shall be in accordance with AASHTO M 325. The binder for open graded mixtures may have the upper temperature classification reduced by 6°C from the specified binder grade if fibers are incorporated into the mixture or if 3.0% reclaimed asphalt shingles by weight of the total mixture is used.

The percent draindown of dense graded mixtures shall not exceed 0.30% in accordance with AASHTO T 305. Dense graded mixture shall be tested for moisture susceptibility in accordance with AASHTO T 283, except that the loose mixture curing shall be replaced by mixture conditioning for 4 h in accordance with AASHTO R 30. The minimum TSR shall be 80%. The 6 in. mixture specimens shall be compacted in accordance with AASHTO T 312. If anti-stripping additives are added to the mixture to be in accordance with the minimum TSR requirements, the dosage rate shall be submitted with the DMF.

A PG binder grade or source change will not require a new mix design. If the upper temperature classification of the PG binder is lower than the original PG grade, a new TSR value is required.

The MAF equals the Gmm from the mixture design divided by the following:

(a) 2.465 for 9.5 mm mixtures
(b) 2.500 for 12.5 mm, 19.0 mm, and 25.0 mm mixtures.

If the MAF calculation results in a value where 0.980 ≤ MAF ≤ 1.020, then the MAF shall be considered to be 1.000. If the MAF is greater than 1.020, the calculated MAF value shall have 0.020 subtracted from the value. If the MAF is less than 0.980, the calculated MAF value shall have 0.020 added to the value. The MAF does not apply to OG mixtures.

Changes in the source or types of aggregates shall require a new DMF.

The mixture design compaction temperature for the specimens shall be 300 ±9°F for dense graded mixtures and 260°F for open graded mixtures.

Design criteria for each mixture shall be based on the ESAL shown in the contract documents and shall be as follows:

Gyratory Compaction Effort					
ESAL	N_{ini}*	N_{des}*	N_{max}*	Max. %Gmm @ N_{ini}	Max. %Gmm @ N_{max}
Dense Graded 4.75 mm					
< 3,000,000	7	75	115	90.5	98.0
3,000,000 to < 10,000,000	8	100	160	89.0	98.0
≥ 10,000,000	8	100	160	89.0	98.0
Dense Graded 9.5 mm, 12.5 mm, 19.0 mm, and 25.0 mm					
< 3,000,000	5	30	40	91.5	97.0
3,000,000 to < 10,000,000	6	50	75	91.5	97.0
≥ 10,000,000	6	50	75	91.5	97.0
Open Graded					
All ESAL	n/a	20	n/a	n/a	n/a
* N_{ini}, N_{des}, N_{max} - definitions are included in AASHTO R 35.					

Voids in Mineral Aggregate, VMA, Criteria @ N_{des}	
Mixture Designation	Minimum VMA, %

4.75 mm	17.0
9.5 mm	16.0
12.5 mm	15.0
19.0 mm	14.0
25.0 mm	13.0
OG	n/a

Volume of Effective Binder, Vbe, Criteria @ N_{des}	
Mixture Designation	Minimum Vbe, %
4.75 mm	12.0
9.5 mm	11.0
12.5 mm	10.0
19.0 mm	9.0
25.0 mm	8.0
OG	n/a

Voids Filled with Asphalt, VFA, Criteria @ N_{des}	
ESAL	VFA, %
< 3,000,000	60 – 73
3,000,000 to < 10,000,000	60 – 70
≥ 10,000,000	60 – 70

Notes:
1. For 4.75 mm mixtures, the specified VFA range shall be 67% to 79%.
2. For 9.5 mm mixtures, the specified VFA range shall be 69% to 72% for design traffic levels ≥ 3,000,000 ESALs.
3. For 25.0 mm mixtures, the specified lower limit of the VFA shall be 62% for design traffic levels < 300,000 ESALs.
4. For OG mixtures, VFA is not applicable.

401.06 Recycled Materials

Recycled materials may consist of RAP or RAS or a blend of both. RAP shall be the product resulting from the cold milling or crushing of an existing HMA pavement. Before entering the plant, RAP shall be processed so that 100% will pass the 2 in. (50 mm) sieve. Before entering the plant, RAS shall be processed so that 100% will pass the 3/8 in. (9.5 mm) sieve. The RAP coarse aggregate shall pass the maximum size sieve for the mixture being produced.

RAP for the ESAL category 3 and 4 surface mixtures shall be a fine RAP with 100% passing the 3/8 in. (9.5 mm) sieve and 95 to 100% passing the No. 4 (4.75 mm) sieve. The Contractor may request the use of coarse RAP in a category 4 surface mixture up to a maximum 20.0% by volume of material retained on the No. 4 (4.75 mm) sieve. The election to use coarse RAP in a category 4 surface mixture will void the allowed use of crushed stone and gravel coarse aggregate materials in accordance with 904.03(d). SMA RAP as defined in 410.06 shall not be used in any HMA mixture.

Recycled materials may be used as a substitute for a portion of the new materials required to produce HMA mixtures. The amount of total binder replaced by binder in the recycled material shall be computed as follows:

$$\text{Binder Replacement, \%} = \frac{(A \text{ x } B)+(C \text{ x } D)}{E}$$

where:

A = RAP, % Binder Content by Mass of RAP
B = RAP, % by Total Mass of Mixture
C = RAS, % Binder Content by Mass of RAS
D = RAS, % by Total Mass of Mixture
E = Total, % Binder Content by Total Mass of Mixture.

RAS may be obtained from either pre-consumer or post-consumer asphalt shingles. The two RAS types shall not be blended together for use in HMA mixtures.

Post-consumer asphalt shingles shall be in accordance with the following:

(a) post-consumer asphalt shingles shall be essentially nail-free,

(b) extraneous metallic materials retained on or above the No. 4 (4.75 mm) sieve shall not exceed 0.5% by mass,

(c) extraneous non-metallic materials such as glass, rubber, soil, brick, paper, wood, and plastic retained on or above the No. 4 (4.75 mm) sieve shall not exceed 1.5% by mass, and

(d) post-consumer shingles shall be prepared by a processing company with an IDEM Legitimate Use Approval letter. The approval letter shall be submitted with the DMF to the Engineer.

The recycled material percentages shall be as specified on the DMF. HMA mixtures utilizing recycled materials shall be limited to the binder replacement percentages in the following table:

HMA mixtures utilizing RAP or RAS or a blend of RAP and RAS

Maximum Binder Replacement, %										
Mixture Category	Base and Intermediate							Surface		
	Dense Graded				Open Graded			Dense Graded		
	25.0 mm	19.0 mm	12.5 mm	9.5 mm	25.0 mm	19.0 mm	9.5 mm	12.5 mm	9.5 mm	4.75 mm
2	25.0*				25.0*			25.0*		
3	25.0*				25.0*			25.0*		

4	25.0*	25.0*	25.0*
* The contribution of RAS to any HMA mixture shall be ≤ 3.0% by total mass of mixture and ≤ 15.0% binder replacement.			

The combined aggregate properties shall be in accordance with 904. The combined aggregate bulk specific gravity shall be determined in accordance with ITM 584 and the combined aggregate gradation shall be in accordance with 401.05 for the HMA mixture specified.

401.07 Lots and Sublots

Lots will be defined as 5,000 t of base or intermediate mixtures or 3,000 t of surface mixture. Lots will be further sub-divided into sublots not to exceed 1,000 t of base or intermediate mixtures or 600 t of surface mixture. Partial sublots of 100 t or less will be added to the previous sublot. Partial sublots greater than 100 t constitute a full sublot. Partial lots of four sublots or less will be added to the previous lot to create an extended lot.

401.08 Blank

401.09 Acceptance of Mixtures

Acceptance of mixtures for Vbe at N_{des}, and air voids at N_{des} for each lot will be based on tests performed by the Engineer for dense graded 9.5 mm, 12.5 mm, 19.0 mm and 25.0 mm mixtures with original contract pay item quantities greater than or equal to 300 t.

Acceptance of mixtures for binder content and air voids at N_{des} will be based on a type D certification in accordance with 402.09 for dense graded mixtures with original contract pay item quantities less than 300 t. Acceptance of mixtures for binder content and air voids at N_{des} for each lot will be based on a type D certification in accordance with 402.09 for dense graded 4.75 mm mixtures.

Acceptance of mixtures for binder content and air voids at N_{des} for each lot will be based on tests performed by the Engineer for open graded mixtures with original contract pay item quantities greater than or equal to 300 t. Acceptance of mixtures for binder content and air voids at N_{des} will be based on a type D certification in accordance with 402.09 for open graded mixtures with original pay item quantities less than 300 t, except the air voids tolerance shall be ±3.5% from the DMF.

The Engineer will randomly select the location within each sublot for sampling in accordance with ITM 802. The first 300 t of the first sublot of the first lot for each mixture pay item will not be sampled. An acceptance sample will consist of plate samples obtained in accordance with ITM 802 and ITM 580. The Engineer will take immediate possession of the samples.

Acceptance samples will be reduced to the appropriate size for testing in accordance with ITM 587. The binder content and gradation will be determined in accordance with ITM 571. The maximum specific gravity will be mass determined in water in accordance with AASHTO T 209.

The effective specific gravity, Gse, of the mixture will be determined in each sublot and reported from the acceptance sample testing.

The total aggregate bulk specific gravity, Gsb, value will be determined in accordance with ITM 597.

The air voids will be determined in accordance with AASHTO R 35 based on the average bulk specific gravity from two gyratory specimens and the MSG for the sublot. The VMA will be determined in accordance with AASHTO R 35 based on the average bulk specific gravity from two gyratory specimens, the percent aggregate in the mixture from the sublot, and the BSG of the aggregate blend from the DMF as applicable. The gyratory specimens will be prepared in accordance with AASHTO T 312.

The dust/calculated effective binder ratio and the volume of effective binder in the mixture will be determined and reported from the acceptance sample testing conducted in each sublot. The volume of effective binder will be the difference between VMA and air voids. The Contractor shall take action in accordance with ITM 583 to address a dust/calculated effective binder ratio not in accordance with 401.05, a volume of effective binder in the mixture below design minimums, or a volume of effective binder in the mixture greater than 2.0% above design minimums.

The bulk specific gravity of gyratory specimens for dense graded mixtures will be determined in accordance with AASHTO T 166, Method A or AASHTO T 331, if required, except samples are not required to be dried overnight. The bulk specific gravity of gyratory specimens for open graded mixtures will be determined in accordance with AASHTO T 331.

A binder draindown test in accordance with AASHTO T 305 for open graded mixtures shall be completed once per lot in accordance with 401.07 and shall not exceed 0.50%.

The Contractor shall make available the sublot quality control results within seven calendar days from the date the acceptance sample was taken.

The Engineer will make available the sublot acceptance test results after receiving the sublot quality control results from the Contractor.

Air voids, binder content and Vbe values will be reported to the nearest 0.01%. Draindown test results will be rounded to the nearest 0.01%. Rounding will be in accordance with 109.01(a).

Pay factors for dense graded mixtures with original contract pay item quantities greater than or equal to one lot will be determined in accordance with 401.19(a). Partial lots of four sublots or less will have pay factors determined in accordance with 401.19(b) if the previous lot is not available.

Pay factors for dense graded mixtures with original contract pay item quantities greater than or equal to 300 t and less than one lot and open graded mixtures will be determined in accordance with 401.19(b).

The Contractor may request an appeal of the Engineer's test results in accordance with 401.20.

A type C certification in accordance with 916 shall be provided for the stabilizing additives for each shipment. Stabilizing additives from different manufacturers and different types of stabilizing additives shall not be intermixed.

In the event that an acceptance sample is not available to represent a sublot, all test results of the previous sublot will be used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

Samples shall not be obtained from the following areas:

(a) Mixture placed on an approach, taper, gore area, crossover that is not placed simultaneously with the mainline.

(b) Mixture placed on a shoulder less than 8 ft in width that is not placed simultaneously with the mainline.

(c) Within 25 ft of a transverse construction joint.

(d) Areas placed with paving equipment in accordance with 409.03(c)2 or 409.03(c)3.

If a random location falls within this area, the Engineer will randomly select another location within the sublot for sampling. If an entire sublot falls within this area, test results from the previous sublot will be used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance. If previous or subsequent sublot results for a mixture accepted by 401.19(a) will be replicated for an entire lot, each sublot in that lot will be accepted by 401.19(b).

CONSTRUCTION REQUIREMENTS

401.10 General

Equipment for HMA operations shall be in accordance with 409. The Contractor shall submit to the Engineer written documentation that includes the manufacturer's make, model, serial number, manufactured year, and the manufacturer's literature with pictures. The documentation shall be submitted prior to use and shall certify that the paving equipment proposed for the project is new and includes the modifications or has been modified in accordance with the following.

The paver shall be equipped with means of preventing the segregation of the coarse aggregate particles when moving the mixture from the paver hopper to the paver augers. The means and methods used shall be in accordance with the paver manufacturer's instructions and may consist of chain curtains, deflector plates, or other such devices, or any combination of these.

The following specific requirements shall also apply to identified HMA pavers:

1. Blaw-Knox HMA pavers shall be equipped with the Blaw-Knox Materials Management Kit, MMK.

2. Cedarapids HMA pavers shall be those that were manufactured in 1989 or later.

3. Barber-Green/Caterpillar HMA pavers shall be equipped with deflector plates as identified in the December, 2000 Service Magazine entitled “New Asphalt Deflector Kit {6630-DFL, 6631-DFL, or 6640-DFL}”.

The Contractor shall demonstrate to the Engineer, prior to use, that the modifications to the paving equipment have been implemented on all pavers to be used on the project.

Fuel oil, kerosene, or solvents shall not be transported in open containers on equipment. Cleaning of equipment and small tools shall not be performed on the pavement or shoulder areas.

HMA mixtures shall not exhibit segregation, flushing, or bleeding. Corrective action shall immediately be taken to prevent continuation of these conditions. Segregated, flushed, or bleeding HMA mixtures will be referred to the Department’s Division of Materials and Tests for adjudication as a failed material in accordance with 105.03.

All mixtures that become loose and broken, mixed with dirt, or are defective in any way shall be removed and replaced in accordance with 105.03.

401.11 Preparation of Surfaces to be Overlaid

The subgrade, or subbase shall be shaped to the required grade and sections, free from all ruts, corrugations, or other irregularities, and uniformly compacted and approved in accordance with 207 and 302. Milling of an existing pavement surface shall be in accordance with 306. Surfaces on which a mixture is placed shall be free from objectionable or foreign materials at the time of placement.

Rubblized concrete pavements shall be primed in accordance with 405. PCCP, milled asphalt surfaces, and new and existing asphalt surfaces shall be tacked in accordance with 406. Contact surfaces of curbing, gutters, manholes, and other structures shall be tacked in accordance with 406.

All partially completed sections of roadway that are 8 in. or less in thickness shall be proofrolled prior to the placement of additional materials unless otherwise directed by the Engineer. Proofrolling shall be accomplished in accordance with 203.26. The contact pressure shall be 70 to 80 psi. Soft yielding areas shall be removed and replaced.

401.12 Process Control

The Engineer and Contractor will jointly review the operations to ensure compliance with the QCP. Continuous violations of compliance with the QCP will result in suspension of paving operations.

401.13 Weather Limitations

HMA courses of less than 138 lb/sq yd shall be placed when the ambient temperature and the temperature of the surface on which it is to be placed is 45°F or above. No mixture shall be placed on a frozen subgrade.

401.14 Spreading and Finishing

The mixture shall be placed upon an approved surface by means of laydown equipment in accordance with 409.03(c). Prior to paving, both the planned quantity and lay rate shall be adjusted by multiplying by the MAF. When mixture is produced from more than one DMF for a given pay item, the MAF will be applied to the applicable portion of the mixture for each. The temperature of each mixture at the time of spreading shall be less than 315°F whenever PG 64-22 or PG 70-22 binders are used or not more than 325°F whenever PG 76-22 binder is used. No mixture shall be placed on a previously paved course that has not cooled to below 175°F. For mixtures compacted in accordance with 402.15, the temperature of each mixture at the time of spreading shall not be less than 245°F.

Planned HMA courses greater than 220 lb/sq yd placed under traffic, shall be brought up even with each adjacent lane at the end of each work day. Planned HMA courses less than or equal to 220 lb/sq yd shall be brought forward concurrently, within practical limits, limiting the work in one lane to not more than one work day of production before moving back to bring forward the adjacent lane. Traffic shall not be allowed on open graded mixtures.

Hydraulic extensions on the paver will not be allowed for continuous paving operations. Fixed extensions or extendable screeds shall be used on courses greater than the nominal width of the paver except in areas where the paving width varies. Hydraulic extensions may be used in tapers and added lanes less than 250 ft in length.

Automatic slope and grade controls shall be used as outlined in the QCP.

HMA mainline and HMA shoulders which are 8 ft or more in width shall be placed with paving equipment in accordance with 409.03(c)1.

When laying mixtures with density not controlled by cores, the speed of the paver shall not exceed 50 ft per minute. Rollers shall be operated to avoid shoving of the HMA and at speeds not to exceed 3 mph. However, vibratory rollers will be limited to 2.5 mph.

The finished thickness of any course shall be at least two times but not more than five times the maximum particle size as shown on the DMF, except 4.75 mm mixtures shall be at least 1.5 times but not more than 3 times the maximum particle size shown on the DMF.

A safety edge shall be constructed at locations where a dense graded intermediate mixture or a surface mixture is constructed adjacent to an aggregate or earth shoulder.

Vibratory rollers in accordance with 409.03(d)4 shall not be operated in the vibratory mode at locations indicated on the plans. Oscillatory rollers in accordance with 409.03(d)5 will be allowed for use but the vertical impact force capability shall not be used. Density acceptance shall be in accordance with 401.16.

401.15 Joints

Longitudinal joints in the surface shall be at the lane lines of the pavement. Longitudinal joints below the surface shall be offset from previously constructed joints by approximately 6 in. and be located within 12 in. of the lane line.

Hot poured joint adhesive in accordance with 906 shall be applied to longitudinal joints constructed between two adjacent HMA courses in the top course of dense graded intermediate mixtures and all 4.75 mm, 9.5 mm, and 12.5 mm surface mixture courses. This includes joints within the traveled way as well as between any of the following:

(a) traveled way and an auxiliary lane
(b) traveled way and a paved shoulder
(c) auxiliary lane and a paved shoulder.

The material shall be heated in a jacketed, double boiler melting kettle. The kettle shall have an attached pressure feed wand system with applicator shoe.

The joint adhesive shall be applied to the face of the previously constructed edge at the joint using a wand applicator. Prior to application of the joint adhesive, the joint face shall be dry and free of loose material and foreign objects. The adhesive shall be applied on the joint face 1/8 in. thick at the temperature recommended by the manufacturer. Excess joint adhesive shall not be allowed to pool on the top of the previously constructed pavement course or the pavement to be overlaid. The application of the adhesive shall be made within the same day, but at least 30 minutes prior to construction of the longitudinal joint.

All 9.5 mm and 12.5 mm surface mixture longitudinal joints that have the joint adhesive applied shall be sealed using SS-1h, RPE, or AE-NT asphalt emulsion in accordance with 902.01(b). The sealing operation shall not begin until all density cores in accordance with 401.16 and 401.20 have been obtained and the installation of pavement corrugations, when specified in accordance with 606, has been completed.

The liquid asphalt sealant shall be a minimum width of 24 in., centered on the joint line, and shall be extended, when necessary, to provide coverage beyond the edge of the pavement corrugation. The sealant shall be applied onto a dry surface, free of any foreign or loose material, using a distributor in accordance with 409.03(a). The sealant temperature at the time of application shall be at least 135°F and shall not exceed 180°F. The ambient air and pavement temperatures at the time of application shall be greater than 32°F.

The application rate of the sealant shall be as follows:

Asphalt Emulsion	*Application Rate* (gal./sq yd)*
SS-1h or AE-NT	*0.03 ±0.01***
RPE	*0.15 ±0.01****
** The asphalt material shall not be diluted. ** Areas receiving greater than 0.04 gal./sq yd shall be lightly broomed to reduce the effects of excess sealant on the pavement surface. *** The application rate shall be reduced when sealing milled corrugations in accordance with 606. The application rate shall be 0.11 ±0.01 gal./sq yd.*	

Temporary pavement markings in accordance with 801.12 shall be offset a sufficient distance from the longitudinal joint so as not to obstruct the installation of the pavement corrugations or the application of the liquid asphalt sealant.

The SS-1h or AE-NT sealant shall be cured a minimum of five days prior to applying the permanent pavement traffic markings in accordance with 808. The RPE sealant shall be cured a minimum of 48 h prior to applying the permanent pavement traffic markings in accordance with 808. Where pavement markings are to be grooved in accordance with 808.07(b)1, the minimum cure for the sealant shall not apply.

Transverse joints shall be constructed by exposing a near vertical full depth face of the previous course. For areas inaccessible to rollers, other mechanical devices shall be used to achieve the required density.

If constructed under traffic, temporary transverse joints shall be feathered to provide a smooth transition to the driving surface.

401.16 Density

Acceptance will be based on lots and sublots in accordance with 401.07.

Density of the compacted dense graded mixture will be determined from cores except where:

(a) the total planned lay rate to be placed over a shoulder existing prior to the contract award is less than 385 lb/sq yd; or

(b) the first lift of material placed at less than 385 lb/sq yd over a shoulder existing prior to the contract award.

Density of any random core location in these areas will be assigned a value of 94.0% MSG and compaction shall be in accordance with 402.15.

Open graded mixtures shall be compacted with six passes of a static tandem roller and will be assigned a value of 84.0% MSG. Vibratory rollers shall not be used on open graded mixtures.

Compaction of 4.75 mm mixtures shall be in accordance with 402.15, except vibratory rollers shall be operated in static mode and the vertical impact force capability of oscillatory rollers shall not be used.

Compaction of mixtures with original contract pay item quantities less than 300 t shall be in accordance with 402.15.

Density acceptance by cores will be based on samples obtained from two random locations selected by the Engineer within each sublot in accordance with ITM 802. One core shall be cut at each random location in accordance with ITM 580. The transverse core location will be located so that the edge of the core will be no closer than 3 in. from a confined edge or 6 in. from a non-confined edge of the course being placed. The maximum specific gravity will be determined from the samples obtained in 401.09.

The Contractor shall obtain cores in the presence of the Engineer with a device that shall produce a uniform 6.00 ±0.25 in. diameter pavement sample. Coring shall be completed prior to the random location being covered by the next course.

All core locations will be marked and shall be cored within two work days of placement. A damaged core shall be discarded and replaced with a core from a location selected by adding 1 ft to the longitudinal location of the damaged core using the same transverse offset.

The Contractor and the Engineer shall mark the core to define the course to be tested. If the core indicates a course thickness of less than two times the maximum particle size, the core will be discarded and a core from a new random location will be selected for testing.

Cores shall not be obtained from the following areas:

(a) Mixture placed on an approach, taper, gore area, crossover that is not placed simultaneously with the mainline.

(b) Mixture placed on a shoulder less than 8 ft in width that is not placed simultaneously with the mainline.

(c) Within 25 ft of a transverse construction joint.

(d) Within 25 ft of an acceptance sample taken in accordance with 401.09.

(e) Areas placed with paving equipment in accordance with 409.03(c)2 or 409.03(c)3.

If a random location falls within this area, the Engineer will randomly select another location within the sublot for coring. If an entire sublot falls within this area, test results from the previous sublot will be used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

The Engineer will take immediate possession of the cores. If the Engineer's cores are subsequently damaged, additional coring will be the responsibility of the Department. Subsequent core locations will be determined by subtracting 1 ft from the random location using the same transverse offset.

The density for the mixture will be expressed as:

$$Density, \% = \frac{BSG}{MSG} \; x \; 100$$

where:

BSG = average bulk specific gravity
MSG = maximum specific gravity

Samples for the bulk specific gravity and maximum specific gravity will be dried in accordance with ITM 572. The Engineer will determine the bulk specific gravity of the cores in accordance with AASHTO T 166, Method A or AASHTO T 331, if required. The maximum specific gravity will be mass determined in water in accordance with AASHTO T 209.

Within one work day of coring operations, the Contractor shall clean, dry, and refill the core holes with HMA of similar or smaller size particles.

The Engineer's acceptance test results for each sublot will be available when the sublot testing is complete. Acceptance of the pavement for density, %MSG, will be reported to the nearest 0.01%. Rounding will be in accordance with 109.01(a).

401.17 Pavement Corrugations

Pavement corrugations shall be in accordance with 606.

401.18 Pavement Smoothness

Pavement smoothness will be accepted by means of an inertial profiler, a 16 ft straightedge, or a 10 ft straightedge as described below.

(a) Inertial Profiler with Smoothness Pay Adjustments

When a pay item for Inertial Profiler, HMA is included in the contract, the Contractor shall furnish, calibrate, and operate an approved inertial profiler in accordance with ITM 917 for the acceptance of longitudinal smoothness on the mainline traveled way, including adjacent acceleration or deceleration lanes, where all of the following conditions are met:

1. The posted speed is greater than 45 mph.

2. The traveled way width and slope are constant and is at least 0.5 mi in length.

3. The HMA is placed on a milled surface and the planned lay rate for a single lift is 165 lb/sq yd or greater, or the total combined planned lay rate of surface, intermediate, and base courses is 385 lb/sq yd or greater.

The profiles and International Roughness Index, IRI, results including areas of localized roughness shall become the property of the Department. The inertial profiler shall remain the property of the Contractor.

The project area will be divided into individual smoothness sections measuring 0.1 mi in length for each lane. The paving exceptions and areas exempt from inertial profiler operation will be in accordance with ITM 917.

If the posted speed limit for an entire smoothness section is less than or equal to 45 mph, the section will be exempt from Inertial Profiler operation and the smoothness within the section will be accepted in accordance with 401.18(b).

If the posted speed limit is greater than 45 mph for a portion of a smoothness section and is less than or equal to 45 mph for the remainder, the section smoothness acceptance will be as follows:

1. By inertial profiler for the portion of the section with a posted speed limit greater than 45 mph.

2. In accordance with 401.18(b) for the portion of the section with a posted speed limit less than or equal to 45 mph.

At locations where the inertial profiler is required, it shall be used on the surface course and on any dense graded intermediate course immediately below the surface course.

(b) 16 ft Straightedge

The Contractor shall furnish and operate a 16 ft straightedge in accordance with 306.03(d) and as described below. The 16 ft straightedge shall be used to measure smoothness along the direction of mainline traffic.

Locations on the pavement surface scraped by the straightedge shall be marked. The pavement shall be corrected in accordance with 401.18(e) to meet the required tolerance. For existing utility and manhole castings that required no grade adjustment, the tolerance may be adjusted after being reviewed and approved by the Engineer.

For contracts which include the Inertial Profiler, HMA pay item, the 16 ft straightedge or the Inertial Profiler simulating the 16 ft straightedge shall be used to measure longitudinal smoothness on surface courses at the following locations:

1. All mainline traveled way lanes shorter than 0.5 mi.

2. All mainline traveled way lanes at locations exempted from inertial profiler operation in accordance with ITM 917.

3. All mainline traveled way lanes within smoothness sections with posted speed limits less than or equal to 45 mph throughout the entire section length.

4. All tapers.

5. All ramps.

6. All turn lanes, including bi-directional left turn lanes shorter than 0.5 mi.

7. All acceleration and deceleration lanes associated with ramps with posted speeds of 45 mph or less.

8. All shoulders.

9. All intersections with significant change in cross slope.

For contracts where the inertial profiler is not used for smoothness acceptance, the 16 ft straightedge shall be used to measure longitudinal smoothness on all surface courses, and on any dense graded intermediate course immediately below the surface course. Measurement with the 16 ft straightedge shall include the above locations, all mainline traveled way lanes and ramps with posted speeds greater than 45 mph, and on ramp acceleration or deceleration lanes.

(c) 10 ft Straightedge

The 10 ft straightedge will be in accordance with 306.03(d). The 10 ft straightedge will be used to check transverse slopes, across travel lanes and shoulders, approaches, and crossovers. When the 10 ft straightedge is used, the pavement variations shall be corrected to 1/8 in. or less.

(d) Areas of Localized Roughness, ALR

At locations where the inertial profiler is being used on an intermediate course, all areas having a localized roughness in excess of 160 in./mi utilizing continuous IRI with a 25 ft window shall be corrected subject to approval by the Engineer.

At locations where the inertial profiler is being used on a surface course, all areas under category Type A, as defined in 401.19(c), having a localized roughness in excess of 160 in./mile or category Type B in excess of 170 in./mile utilizing continuous IRI with a 25 ft window shall be corrected subject to approval by the Engineer. After ALR's have been identified, a grinding simulation shall be performed to estimate whether the ALR can be corrected to an IRI value of less than 160 in./mi with no more than a 1/4 in. max grind depth at any spot. If such correction is not possible, then an ALR with an IRI value of less than 190 in./mi can remain uncorrected if approved by the Engineer, and an ALR with an IRI value greater than 190 in./mi shall require full depth removal and replacement of the surface course of sufficient area to meet specifications.

In addition, if there is only one ALR in any two lane mile section, then no smoothness correction will be required if the ALR does not exceed 190 in./mi and the overall smoothness in accordance with 401.18(d) of the two lane mile section does not require any corrective action. A two lane mile section will start one mile before the ALR and end one mile after the ALR in order that all two lane mile sections will have, at most, one ALR each.

(e) Smoothness Section Correction

The width of the corrected area may be partial or full lane width, depending on the respective wheel path profiles. Underlying courses that are exposed by corrective action shall be milled to a depth of 1 1/2 in. and replaced with surface course. After the corrective action is taken on a surface course, the inertial profiler shall be operated throughout the entire affected smoothness section to verify the adequacy of the corrective action.

At locations where the 16 ft straightedge is used, the pavement variations shall be corrected to 1/4 in. or less.

If grinding of an intermediate course is used for pavement smoothness corrections, the grinding shall not precede the surface placement by more than 30 calendar days if open to traffic.

401.19 Pay Factors

(a) Dense Graded Mixture ≥ One Lot

Pay factors, PF, are calculated for the air voids at N_{des}, Vbe at N_{des} and in-place density, %Gmm. The Percent Within Limits, PWL, for each lot will be determined in accordance with ITM 588.

The appropriate pay factor for each property is calculated as follows:

Estimated PWL greater than 90:

$$PF = ((0.50 \times PWL) + 55.00)/100$$

Estimated PWL greater than 70 and equal to or less than 90:

$$PF = ((0.40 \times PWL) + 64.00)/100$$

Estimated PWL greater than or equal to 50 and equal to or less than 70:

$$PF = ((0.85 \times PWL) + 32.5)/100$$

If the Lot PWL for any one of the properties is less than 50, a sublot has an air void content less than 1.0% or greater than 8.0%, or a sublot has a volume of effective binder greater than 3.0% above design minimums, the lot will be referred to the Department's Division of Materials and Tests for adjudication as a failed material in accordance with normal Department practice as listed in 105.03.

Air voids, Vbe, and in-place density, %Gmm, PF values will be reported to the nearest 0.01. Rounding will be in accordance with 109.01(a).

A composite pay factor for each lot based on test results for mixture properties and density is determined by a weighted formula as follows:

$$\text{Lot PF} = 0.30(PF_{VOIDS}) + 0.35(PF_{Vbe}) + 0.35(PF_{DENSITY})$$

where:

Lot PF =	Lot Composite Pay Factor for Mixture and Density
PF_{VOIDS} =	Lot Pay Factor for Air Voids at N_{des}
PF_{Vbe} =	Lot Pay Factor for Vbe at N_{des}
$PF_{DENSITY}$ =	Lot Pay Factor for In-Place Density, % Gmm

The lot quality assurance adjustment for mixture properties and density is calculated as follows:

$$q = L \times U \times (\text{Lot PF} - 1.00)/MAF$$

where:

q = quality assurance adjustment for mixture properties and density of the lot
L = Lot quantity
U = Unit price for the material, \$/ton
Lot PF = Lot Pay Factor

Lot test results for the air voids at N_{des}, Vbe at N_{des}, and density will be used to determine the Lot Pay Factors.

The specification limits for the air voids at N_{des}, Vbe at N_{des}, and density will be as follows:

Specification Limits		
Mixture		
	LSL*	USL**
Air Voids at N_{des}, %	3.60	6.40
Volume of Effective Binder at N_{des}, %	Spec	Spec +2.50
Density		
	LSL*	USL**
Roadway Core Density (%Gmm), %	93.00	n/a
* LSL, Lower Specification Limit ** USL, Upper Specification Limit		

(b) Dense Graded Mixture < One Lot and Open Graded Mixture

A composite pay factor for each sublot based on test results for mixture properties and density is determined in a weighted formula as follows:

Dense Graded Mixture:

$$SCPF = 0.30(PF_{VOIDS}) + 0.35(PF_{Vbe}) + 0.35(PF_{DENSITY})$$

Open Graded Mixture:

$$SCPF = 0.20(PF_{BINDER}) + 0.35(PF_{VOIDS}) + 0.45$$

where:

SCPF = Sublot Composite Pay Factor for Mixture and Density
PF_{BINDER} = Sublot Pay Factor for Binder Content
PF_{VOIDS} = Sublot Pay Factor for Air Voids at N_{des}
PF_{Vbe} = Sublot Pay Factor for Vbe at N_{des}
$PF_{DENSITY}$ = Sublot Pay Factor for Density

If the SCPF for an open graded sublot is less than 0.85 or the volume of effective binder is greater than 3.0% above design minimums, the sublot will be referred to the Division of Materials and Tests for adjudication as a failed material in accordance with 105.03.

The sublot quality assurance adjustment for mixture properties and density is calculated as follows:

$$q = L \times U \times (SCPF - 1.00)/MAF$$

where:

q = quality assurance adjustment for the sublot
L = sublot quantity
U = unit price for the material $/ton
SCPF = sublot composite pay factor

Sublot test results for mixture properties will be assigned pay factors in accordance with the following:

Binder Content	
Open Graded Deviation from DMF (±%)	Pay Factor
≤ 0.2	1.05
0.3	1.04
0.4	1.02
0.5	1.00
0.6	0.90
0.7	0.80
0.8	0.60
0.9	0.30
1.0	0.00
>1.0	Submitted to the Division of Materials and Tests*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.	

Volume of Effective Binder, Vbe	
Dense Graded	Pay Factors
Deviation from Spec Minimum	
> +3.0	Submitted to the Division of Materials and Tests*

≥ +2.5 and ≤ +3.0	1.00 - 0.05 for each 0.1% above +2.5%
≥ +2.0 and < +2.5	1.05 - 0.01 for each 0.1% above +2.0%
> +0.5 and < +2.0	1.05
≥ 0.0 and ≤ +0.5	1.05 - 0.01 for each 0.1% below +0.5%
≥ -0.5 and < 0.0	1.00 - 0.02 for each 0.1% below 0.0%
≥ -2.0 and < -0.5	0.90 - 0.06 for each 0.1% below -0.5%
< -2.0	Submitted to the Division of Materials and Tests*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.	

Air Voids		
Dense Graded	Open Graded	Pay Factor
Deviation from Spec (±%)	Deviation** (±%)	
≤ 0.5	≤ 3.0	1.05
> 0.5 and ≤ 1.7	> 3.0 and ≤ 4.0	1.00
	4.1	0.98
1.8	4.2	0.96
	4.3	0.94
	4.4	0.92
1.9	4.5	0.90
2.0	4.6	0.84
	4.7	0.78
	4.8	0.72
	4.9	0.66
	5.0	0.60
> 2.0	> 5.0	Submitted to the Division of Materials and Tests*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03. ** Deviation shall be from 17.5% for OG25.0 mm and OG19.0 mm mixtures and shall be from 14.5% for OG9.5 mm mixtures.		

For mixtures produced during a plant's adjustment period, pay factors based on the DMF with the above tolerances will be used to compute quality assurance adjustments.

Sublot test results for density will be assigned pay factors in accordance with the following:

Density

Percentages are based on %MSG Dense Graded	Pay Factors, %
≥ 98.0	Submitted to the Division of Materials and Tests*
97.0 - 97.9	1.00
96.6 - 96.9	1.05 - 0.01 for each 0.1% above 96.5
95.0 - 96.5	1.05
94.1 - 94.9	1.00 + 0.005 for each 0.1% above 94.0
93.0 - 94.0	1.00
92.0 - 92.9	1.00 - 0.005 for each 0.1% below 93.0
91.0 - 91.9	0.95 - 0.010 for each 0.1% below 92.0
90.0 - 90.9	0.85 - 0.030 for each 0.1% below 91.0
≤ 89.9	Submitted to the Division of Materials and Tests*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.	

The pay factors will be rounded to the nearest 0.01.

(c) Smoothness Smoothness pay adjustments will only be applied when the smoothness is measured by an inertial profiler in accordance with 401.18(a).

The Mean Roughness Index, MRI, will be determined utilizing a fixed interval for each lane for each 0.1 mile section of paving. The MRI for a 0.1 mile section will be the average of the IRI of the two wheel paths. Categorized segments shall be as follows:

1. *Type A. Pavement on a non-interstate with more than a single opportunity to achieve a smooth ride or asphalt pavement on an interstate with a single opportunity or more. The following operations, if performed on the contract, will be considered opportunities.*

    a. *A layer of HMA base, intermediate, and surface; each layer is an opportunity. Wedge and level will not be considered an opportunity.*

    b. *Profile milling to correct cross slope is considered an opportunity prior to placing base, intermediate, or surface HMA.*

2. *Type B. Pavement that is not included in the description above under Type A.*

At locations where an inertial profiler is used to accept smoothness, a quality assurance adjustment will be determined for each lane. This adjustment will be applied to all QC/QA HMA pay items within the pavement section. The adjustment will be calculated using the following formula:

$$q_s = (PF_s - 1.00) \sum_{i=1}^{n} \left(A \times \frac{S}{T} \times U \right)$$

where:

q_s = *quality assurance adjustment for smoothness for one section*
PF_s = *pay factor for smoothness*
n = *number of layers*
A = *area of the section, sq yd*
S = *planned spread rate for material, lb/sq yd*
T = *conversion factor: 2,000 lb/ton*
U = *unit price for the material, \$/ton.*

The quality assurance adjustment for smoothness, Q_s, for the contract will be the total of the quality assurance adjustments for smoothness, q_s, on each section by the following formula:

$$Q_s = \sum q_s$$

When smoothness is measured by an inertial profiler, payment adjustments will be made for any 0.1 mile section based on initial MRI generated on the surface course only and in accordance with the following table. Smoothness correction, if required, shall be in accordance with 401.18(e). The MRI pay factors for smoothness will be determined prior to any required smoothness correction.

PAY FACTORS FOR SMOOTHNESS Posted Speed greater than 45 mph	
MRI, in./mi.	*Pay Factor, PF*
over 0 to 35	*1.06*
over 35 to 40	*1.05*
over 40 to 45	*1.04*
over 45 to 50	*1.03*
over 50 to 55	*1.02*
over 55 to 60	*1.01*
over 60 to 70	*1.00*
over 70 to 75	*0.99*
over 75 to 80	*0.98*
over 80 to 85	*0.96*
over 85 to 90	*0.95*
over 90	*For Type A, PFs will be 0.95 and the section shall be corrected to 70 or less.*
over 90 to 110	*For Type B, PFs will be 0.95 and the section does not require correction.*

over 110	*For Type B, PFs will be 0.95 and the section shall be corrected to 90 or less.*

401.20 Appeals

(a) Dense Graded Mixtures and Open Graded Mixtures

If the QC test results do not agree with the acceptance test results in a sublot, a request, along with a comparison of the QC and acceptance test results, may be made in writing for additional testing of that sublot. The appeal sample will be analyzed in a lab different than the lab that analyzed the original sample at the discretion of the Engineer.

The Contractor may appeal an individual sublot for the binder content, the MSG, the BSG of the gyratory specimens, or the BSG of the density cores when the QC results are greater than one standard deviation from the acceptance test results as follows: 0.25 for binder content, 0.010 for the MSG and BSG of the gyratory specimens, and 0.020 for the BSG of the density cores.

Upon request from the Contractor, the BSG of the density core may be exempted from the individual sublot appeal if both the QC and QA results show a %MSG for the density greater than or equal to 93.0%.

A $500.00 credit adjustment will be included in a quality adjustment pay item in accordance with 109.05.1(d) for each appealed sublot that did not result in an improvement to the SCPF or Lot PF.

A written request for an appeal shall be submitted within seven calendar days of receipt of the Department's written results for the lot accepted under 401.19(a) or the sublot accepted under 401.19(b). The conditions for an extended lot appeal are as follows:

1. one appeal will be allowed for the entire extended lot if the Contractor informs the Department of the anticipated extended lot condition within seven calendar days of receipt of the lot results, or

2. one appeal will be allowed only for the extended sublots if the Contractor did not inform the Department of the anticipated extended lot condition within seven calendar days of receipt of the lot results.

The backup sample will be tested in accordance with the applicable test method for the sublot requested for all tests exceeding the sublot standard deviation criteria.

1. MSG

The backup MSG will be dried in accordance with ITM 572 and mass determined in water in accordance with AASHTO T 209.

2. BSG of the Gyratory Specimen

New gyratory specimens will be prepared and tested in accordance with AASHTO T 312 from the backup sample.

3. Binder Content

The backup binder content sample will be prepared and tested in accordance with ITM 571.

4. BSG of the Density Core

Additional cores shall be taken within seven calendar days unless otherwise directed. Additional core locations will be determined by adding 1 ft longitudinally of the cores tested using the same transverse offset. The appeal density cores will be dried in accordance with ITM 572 and tested in accordance with AASHTO T 166, Method A or AASHTO T 331, if required.

The appeal results will replace all previous test result for acceptance of mixture in accordance with 401.09 and density in accordance with 401.16. The results will be furnished to the Contractor.

(b) Smoothness

The Department will perform annual Quality Assurance reviews of a portion of each Contractor's MRI results in accordance with ITM 917. The Contractor's results will be compared to the Department's. The Department will notify the Contractor of unacceptable results in a timely manner. The Department will allow an appeal period of 14 days during which time the Contractor must submit a written request and appeal results for Department review. If the Contractor's appeal results do not agree with the Department's results, the Contractor shall be required to perform a side-by-side evaluation. The Department's results will be utilized for smoothness payment in place of the Contractor's results unless the Contractor's appeal results are determined to be acceptable for payment. Sections where corrective action has taken place prior to the Department's data collection will utilize the Contractor's initial results prior to corrective action for payment.

401.21 Method of Measurement

HMA mixtures will be measured by the ton of the type specified, in accordance with 109.01(b). The measured quantity will be divided by the MAF to determine the pay quantity.

Milled shoulder corrugations will be measured in accordance with 606.02.

Joint adhesive will be measured by the linear foot in accordance with 109.01(a). Liquid asphalt sealant will be measured by the linear foot.

401.22 Basis of Payment

The accepted quantities for this work will be paid for at the contract unit price per ton for QC/QA-HMA, of the type specified, complete in place.

Payment for furnishing, calibrating, operating the *inertial profiler*, and furnishing IRI profile information will be made at the contract lump sum price for I*nertial Profiler*, HMA.

Furnishing and operating the 16 ft straightedge shall be included in the cost of other pay items within this section.

Adjustments to the contract payment with respect to mixture, density, and smoothness for the mixture produced will be included in a quality adjustment pay item in accordance with 109.05.1.

Milled shoulder corrugations will be paid for in accordance with 606.03.

Joint adhesive will be paid for at the contract unit price per linear foot, complete in place. Liquid asphalt sealant will be paid for at the contract unit price per linear foot.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Joint Adhesive, __________ (course type)	LFT
Liquid Asphalt Sealant	LFT
I*nertial Profiler*, HMA	LS
QC/QA-HMA, ______, ______, ______, ______mm (ESAL(1)) (PG(2)) (Course(3)) (Mix(4))	TON

(1) ESAL Category as defined in 401.04
(2) Number represents the high temperature binder grade. Low temperature grades are - 22
(3) Surface, Intermediate, or Base
(4) Mixture Designation

Preparation of surfaces to be overlaid shall be included in the cost of other pay items.

Coring and refilling of the core holes shall be included in the cost of other pay items within this section.

No payment will be made for additional anti-stripping additives, appeal coring, or traffic control expenditures related to coring operations.

The cost of removing and replacing soft and yielding areas shall be included in the cost of other pay items in this section.

Corrections for pavement smoothness shall be included in the cost of other pay items within this section.

The price for Inertial Profiler, HMA will be full compensation regardless of how often the inertial profiler is used or how *often the IRI is determined*.

If QC/QA-HMA 19.0 mm over QC/QA-HMA 25.0 mm mixtures are specified, QC/QA-HMA 19.0 mm mixture may be considered as a substitute for the QC/QA-HMA 19.0 mm and QC/QA-HMA 25.0 mm mixtures upon a written request by the Contractor. The request for the substitution shall be prepared in advance of the work. A computation will be made in order to obtain a unit price for the QC/QA-HMA 19.0 mm mixture. The quantity and amount for QC/QA-HMA 19.0 mm mixture shall equal the sum of the contract quantities and amounts shown for QC/QA-HMA 19.0 mm and QC/QA-HMA 25.0 mm mixtures. The unit price for QC/QA-HMA 19.0 mm mixture shall be equal to the sum of contract amounts divided by the sum of contract quantities. Payment for the QC/QA-HMA 19.0 mm mixture will be made at the unit price per ton for QC/QA-HMA 19.0 mm mixture. No payment will be made for additional work or costs which may result due to this change.

SECTION 402 – HMA PAVEMENT

402.01 Description

This work shall consist of one or more courses of miscellaneous mixtures constructed in accordance with 105.03.

402.02 Quality Control

The HMA shall be supplied from a certified HMA plant in accordance with ITM 583; Certified Hot Mix Asphalt Producer Program. The HMA shall be transported and placed according to a QCP prepared and submitted by the Contractor in accordance with ITM 803, Contractor Quality Control Plans for Hot Mix Asphalt Pavements. The QCP shall be submitted to the Engineer at least 15 days prior to commencing HMA paving operations.

When a safety edge is required for a project, the QCP shall identify the devices in accordance with 409.03(c) to be used for constructing the safety edge.

MATERIALS

402.03 Materials

Materials shall be in accordance with the following:

Asphalt Materials
    PG Binder..902.01(a)
Coarse Aggregates 904
    Base Mixtures – Class D or Higher
    Intermediate Mixtures – Class C or Higher
    Surface Mixtures* – Class B or Higher
Fine Aggregates 904
    * Surface aggregate requirements are listed in 904.03(d).

402.04 Design Mix Formula

A DMF shall be prepared in accordance with 401.04 and submitted in a format acceptable to the Engineer one week prior to use.

The DMF will be based on the ESAL and mixture designation as follows:

Mixture Type	Type B*	Type C	Type D
Design ESAL	< 3,000,000	3,000,000 to < 10,000,000	≥ 10,000,000
Surface	4.75 mm	4.75 mm	4.75 mm
	9.5 mm	9.5 mm	9.5 mm
	12.5 mm	12.5 mm	12.5 mm
Surface – PG Binder	64-22	70-22	70-22
Intermediate	9.5 mm	9.5 mm	9.5 mm
	12.5 mm	12.5 mm	12.5 mm
	19.0 mm	19.0 mm	19.0 mm
	25.0 mm	25.0 mm	25.0 mm
Intermediate – PG Binder	64-22	64-22	70-22
Base	19.0 mm	19.0 mm	19.0 mm
	25.0 mm	25.0 mm	25.0 mm
Base – PG Binder	64-22	64-22	64-22
*A type B mixture shall replace a type A mixture.			

A type C mixture may be used in lieu of a type B mixture. A type D mixture may be used in lieu of a type C or a type B mixture.

Surface 4.75 mm mixtures shall not be used when the required lay rate shown on the plans is greater than 100 lb/sq yd. Surface 12.5 mm mixtures shall not be used when the required lay rate shown on the plans is less than 195 lb/sq yd.

The plant discharge temperature for any mixture shall not be more than 315°F whenever PG 64-22 or PG 70-22 binders are used. HMA may be produced using a water-injection foaming device. The DMF shall list the minimum and maximum plant discharge temperatures as applicable to the mixture.

No mixture shall be used until the DMF has been assigned a mixture number by the DTE.

402.05 Volumetric Mix Design

The DMF shall be determined for each mixture from a volumetric mix design in accordance with 401.05.

A DMF developed for a QC/QA HMA mixture may be used and the source or grade of the binder may be changed. The high temperature grade shall meet the minimum requirements of 402.04.

The MAF equals the G_{mm} from the mixture design divided by the following:

(a) 2.465 for 9.5 mm mixtures
(b) 2.500 for 12.5 mm, 19.0 mm, and 25.0 mm mixtures.

If the MAF calculation results in a value where 0.980 ≤ MAF ≤ 1.020, then the MAF shall be considered to be 1.000. If the MAF is greater than 1.020, the calculated MAF value shall have 0.020 subtracted from the value. If the MAF is less than 0.980, the calculated MAF value shall have 0.020 added to the value.

402.06 Blank

402.07 Mix Criteria

(a) Composition Limits for HMA Transverse Rumble Strip Mixtures

Transverse rumble strip mixtures shall be type B surface in accordance with 402.04. An MAF in accordance with 402.05 will not apply. Aggregate requirements of 904.03(d) do not apply.

(b) Composition Limits for HMA Wedge and Leveling Mixtures

The mixture shall consist of surface or intermediate mixtures in accordance with 402.04. Aggregate requirements of 904.03(d) do not apply when the wedge and leveling mixture is covered by a surface or intermediate mixture.

(c) Composition Limits for Temporary HMA Mixtures

Temporary HMA mixtures shall be the type specified in accordance with 402.04. An MAF in accordance with 402.05 will not apply.

(d) Composition Limits for HMA Curbing Mixes

The mixture shall be HMA surface type B in accordance with 402, except 402.05 shall not apply and RAP shall not be used. The binder content shall be 7.0% and the gradations shall meet the following.

HMA Curbing Gradations	
Sieve Size	Percent Passing
1/2 in. (12.5 mm)	100.0
3/8 in. (9.5 mm)	80.0 - 100.0
No. 4 (4.75 mm)	73.0 ±5.0
No. 30 (600 µm)	20.0 - 50.0
No. 200 (75 µm)	6.0 - 12.0

A DMF shall be prepared in accordance with the above table and submitted in a format acceptable to the Engineer one week prior to use. The DMF shall state the binder content.

402.08 Recycled Materials

Recycled materials shall be in accordance with 401.06, except type B mixtures shall correspond to category 2 mixtures, type C mixtures shall correspond to category 3 mixtures, and type D mixtures shall correspond to category 4 mixtures.

402.09 Acceptance of Mixtures

A type D certification in accordance with 916 and the Frequency Manual shall be provided for the HMA pavement. The test results shown on the certification shall be the quality control tests representing the material supplied and include air voids and binder content. Air voids tolerance shall be ±2.0% and binder content tolerance shall be ±0.7% from DMF.

Single test values and averages will be reported to the nearest 0.1%. Rounding will be in accordance with 109.01(a).

Test results exceeding the tolerance limits will be considered as a failed material and adjudicated in accordance with 105.03.

CONSTRUCTION REQUIREMENTS

402.10 General

Equipment for HMA operations shall be in accordance with 409. The Contractor shall submit to the Engineer prior to use a written Certificate of Compliance that the proposed paving equipment has been modified in accordance with 401.10 or is new and includes the modifications.

Fuel oil, kerosene, or solvents shall not be transported in open containers on any equipment at any time. Cleaning of equipment and tools shall not be performed on the pavement or shoulder areas.

Segregation, flushing, or bleeding of HMA mixtures will not be allowed. Corrective action shall be taken to prevent continuation of these conditions. Areas of segregation, flushing, or bleeding shall be corrected, if directed. All areas showing an excess or deficiency of asphalt materials shall be removed and replaced.

All mixtures that become loose and broken, mixed with dirt, or defective in any way shall be removed and replaced.

Mixture shall not be dispatched from the plant that cannot be spread and compacted before sundown of that day, unless otherwise specified.

402.11 Preparation of Surfaces to be Overlaid

The subgrade, or subbase, shall be shaped to the required grade and sections, free from all ruts, corrugations, or other irregularities, and uniformly compacted and approved in accordance with 207 and 302. Milling of an existing surface shall be in accordance with 306. Surfaces on which a mixture is placed shall be free from objectionable or foreign materials at the time of placement.

Rubblized concrete pavements shall be primed in accordance with 405. PCCP, milled asphalt surfaces, and asphalt surfaces shall be tacked in accordance with 406. Contact surfaces of curbing, gutters, manholes, and other structures shall be tacked in accordance with 406.

402.12 Weather Limitations

HMA courses less than 110 lb/sq yd are to be placed when the ambient and surface temperatures are 60°F or above. HMA courses equal to or greater than 110 lb/sq yd but less than 220 lb/sq yd are to be placed when the ambient and surface temperatures are 45°F or above. HMA courses equal to or greater than 220 lb/sq yd and HMA curbing are to be placed when the ambient and surface temperatures are 32°F or above. Mixture shall not be placed on a frozen subgrade. However, HMA courses may be placed at lower temperatures, provided the density of the HMA course is in accordance with 402.16.

All partially completed sections of roadway that are 8 in. or less in thickness shall be proofrolled prior to the placement of additional materials unless otherwise directed by the Engineer. Proofrolling shall be accomplished in accordance with 203.26. The contact pressure shall be 70 to 80 psi. Soft yielding areas shall be removed and replaced.

402.13 Spreading and Finishing

The mixture shall be placed upon an approved surface by means of laydown equipment in accordance with 409.03(c). Prior to paving, both the planned quantity and lay rate shall be adjusted by multiplying by the MAF. When a mixture is produced from more than one DMF for a given pay item, the MAF will be applied to the applicable portion of the mixture for each. Mixtures in areas inaccessible to laydown equipment or mechanical devices may be placed by other methods.

The temperature of each mixture at the time of spreading shall be less than 315°F whenever PG 64-22 or PG 70-22 binders are used. The temperature of each mixture at the time of spreading shall not be less than 245°F. No mixture shall be placed on a previously paved course that has not cooled to less than 175°F.

Planned HMA courses greater than 220 lb/sq yd placed under traffic shall be brought up even with each adjacent lane at the end of each work day. Planned HMA courses less than or equal to 220 lb/sq yd shall be brought forward concurrently, within practical limits, limiting the work in one lane to not more than one work day of production before moving back to bring forward the adjacent lane. Traffic shall not be allowed on open graded mixtures.

Hydraulic extensions on the paver will not be allowed for continuous paving operations. Fixed extensions or extendable screeds shall be used on courses greater than the nominal width of the paver except in areas where the paving widths vary. Hydraulic extensions may be used on approaches, tapers, and added lanes less than 250 ft in length.

HMA shoulders which are 8 ft or more in width shall be placed with automatic paving equipment.

HMA mixtures in hauling equipment shall be protected by tarps from adverse weather conditions or foreign materials. Adverse weather conditions include, but will not be limited to, precipitation or temperatures below 45°F.

The speed of the paver shall not exceed 50 ft per minute when spreading mixtures.

Automatic slope and grade controls shall be required except when placing mixtures on roadway approaches which are less than 200 ft in length or on miscellaneous work. The use of automatic controls on other courses where use is impractical due to project conditions may be waived by the Engineer.

The finished thickness of each course shall be at least two times but not more than five times the maximum particle size as shown on the DMF. The finished thickness of wedge and level mixtures shall be at least 1 1/2 times but not more than six times the maximum particle size as shown on the DMF. Feathering may be less than the minimum thickness requirements.

Transverse rumble strips shall be placed to ensure uniformity of height, width, texture, and the required spacing between strips. A tack coat in accordance with 406 shall be applied on the pavement surface prior to placing the mixture. The tack coat may be applied with a paint brush or other approved methods.

A safety edge shall be constructed at locations where an intermediate mixture or a surface mixture is constructed adjacent to an aggregate or earth shoulder.

Vibratory rollers in accordance with 409.03(d)4 shall not be operated in vibratory mode at locations indicated on the plans. Oscillatory rollers in accordance with 409.03(d)5 will be allowed for use but the vertical impact force capability shall not be used. Density acceptance shall be in accordance with 402.15.

402.14 Joints

Longitudinal joints in the surface shall be at the lane lines of the pavement. Longitudinal joints below the surface shall be offset from previously constructed joints by approximately 6 in. and be located within 12 in. of the lane line.

Transverse joints shall be constructed by exposing a near vertical full depth face of the previous course.

If constructed under traffic, temporary transverse joints shall be feathered to provide a smooth transition to the driving surface.

402.15 Compaction

The HMA mixture shall be compacted with equipment in accordance with 409.03(d) immediately after the mixture has been spread and finished. Rollers shall not cause undue displacement, cracking, or shoving.

A roller application is defined as one pass of the roller over the entire mat. Compaction operations shall be completed in accordance with one of the following options.

Number of Roller Applications							
Rollers	Courses						
	≤ 440 lb/sq yd					> 440 lb/sq yd	
	Option 1	Option 2	Option 3	Option 4	Option 5	Option 1	Option 2
Three Wheel	2		4			4	
Pneumatic Tire	2	4				4	
Tandem	2	2	2			4	
Vibratory				6			8

Oscillatory					6	-	-

A reduced number of applications on a course may be approved if detrimental results are being observed.

Compaction equipment shall be operated with the drive roll or wheels nearest the paver and at speeds not to exceed 3 mph. However, vibratory rollers will be limited to 2.5 mph. Rolling shall be continued until applications are completed and all roller marks are eliminated.

Compaction operations shall begin at the low side and proceed to the high side of the mat. The heaviest roller wheel shall overlap its previous pass by a minimum of 6 in.

Longitudinal joints shall be compacted in accordance with the following:

(a) For confined edges, the first pass adjacent to the confined edge, the compaction equipment shall be entirely on the hot mat 6 in. from the confined edge.

(b) For unconfined edges, the compaction equipment shall extend 6 in. beyond the edge of the hot mat.

All displacement of the HMA mixture shall be corrected at once using lutes or the addition of fresh mixture as required. The line and grade of the edges of the HMA mixture shall not be displaced during rolling.

The wheels of the compaction equipment shall be kept properly moistened with water or water with detergent to prevent adhesion of the materials to the wheels.

Areas inaccessible to rollers shall be compacted thoroughly with hand tampers or other mechanical devices in accordance with 409.03(d)7 to achieve the required compaction. A trench roller, in accordance with 409.03(d)6, may be used to obtain compaction in depressed areas.

The final two roller applications shall be completed at the highest temperature where the mixture does not exhibit any tenderness.

Vehicular traffic will not be allowed on a course until the mixture has cooled sufficiently to prevent distortions.

Transverse rumble strips shall be compacted with vibratory compacting equipment in accordance with 409.03(d)7 unless otherwise stated.

402.16 Low Temperature Compaction Requirements

Compaction for mixtures placed below the temperatures listed in 402.12 shall be controlled by density determined from MSG of the plate samples and cores cut from the compacted pavement placed during a low temperature period. Samples shall be obtained in accordance with ITM 580. Acceptance will be based on a plate sample and two cores. The Engineer will randomly select the locations in accordance with ITM 802. The transverse core location will be located so that the edge of the core will be no closer than 3 in. from a confined edge or 6 in. from a non-confined edge of the course being placed.

For compaction of HMA during low temperature periods with quantities less than 100 t per day, acceptance may be visual.

The Contractor shall obtain cores in the presence of the Engineer with a device that shall produce a uniform 6.00 ±0.25 in. diameter pavement sample. Coring shall be completed prior to the random location being covered. The final HMA course shall be cored within one work day of placement. Damaged cores shall be discarded and replaced with a core from a location selected by adding 1 ft to the longitudinal location of the damaged core using the same transverse offset.

The Contractor and the Engineer shall mark the core to define the course to be tested. If the core indicates a course thickness of less than two times the maximum particle size, the core will be discarded and a core from a new random location will be selected for testing.

The Engineer will take immediate possession of the cores. If the Engineer's cores are subsequently damaged, additional coring within a specific section will be the responsibility of the Department. Subsequent core locations will be determined by subtracting 1 ft from the random location using the same transverse offset.

The density for the mixture shall be expressed as:

$$Density, \% = \frac{BSG}{MSG} \, x \, 100$$

where:

BSG = average bulk specific gravity
MSG = maximum specific gravity

The Engineer will determine the bulk specific gravity of the cores in accordance with AASHTO T 166, Method A or AASHTO T 331, if required. The maximum specific gravity will be mass determined in water in accordance with AASHTO T 209. Density shall not be less than 93.0%.

Within one work day of coring operations, the Contractor shall clean, dry, refill, and compact the core holes with suitable HMA of similar or smaller size particles.

402.17 Pavement Corrugations

Pavement corrugations shall be in accordance with 606.

402.18 Pavement Smoothness

Pavement smoothness will be in accordance with 401.18, except inertial profiler requirements will not apply.

402.19 Method of Measurement

HMA mixtures will be measured by the ton of the type specified in accordance with 109.01(b). The measured quantity will be divided by the MAF to determine the pay quantity.

HMA rumble strips will be measured by the linear foot of each transverse strip, complete in place.

Milled pavement corrugations will be measured in accordance with 606.02.

402.20 Basis of Payment

The accepted quantities for this work will be paid for at the contract unit price per ton for HMA, of the type specified, complete in place.

HMA transverse rumble strips will be paid for at the contract unit price per linear foot, complete in place.

Milled pavement corrugations will be paid for in accordance with 606.03.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
HMA Transverse Rumble Strips................................	LFT
HMA for Temporary Pavement, Type __*__............	TON
HMA Wedge and Level, Type __*__........................	TON
* Mixture type	

Preparation of surfaces to be overlaid shall be included in the cost of other pay items in this section.

No payment will be made for additional anti-stripping additives.

The cost of removing and replacing soft yielding areas shall be included in the cost of other pay items in this section.

No payment will be made for coring operations and related traffic control expenditures required in 402.16.

Corrections for pavement smoothness including removal and replacement of pavement, shall be included in the cost of other pay items in this section.

The cost of removal of HMA for temporary pavement including the subgrade and subbase materials shall be included in the cost of HMA for temporary pavement.

SECTION 403 – BLANK

404.01 Description

This work shall consist of one or more applications of asphalt material, each followed by an application of cover aggregate in accordance with 105.03.

404.02 Quality Control

Seal coat, SC, shall be constructed according to a QCP prepared and submitted by the Contractor in accordance with ITM 803; Contractor Quality Control Plan for Seal Coat.

The QCP shall be submitted to the Engineer at least 15 days prior to commencing seal coat operations.

MATERIALS

404.03 Asphalt Material

The type and grade of asphalt material shall be in accordance with the following:

Asphalt Emulsion, RS-2, AE-90,
AE-90S, or HFRS-2 ....902.01(b)

404.04 Cover Aggregate

Aggregate shall be in accordance with the following requirements. When slag is used as an alternate to natural aggregate, adjustments will be made in accordance with 904.01, to compensate for differences in specific gravity.

Coarse Aggregates*, Class B or Higher
Size No. 8, 9, 11, 12, SC 11, SC 12, or SC 16 ....904.03
Fine Aggregate, Size No. 23 or 24..904.02
* Coarse aggregate type required shall be in accordance with 904.03(d)1 for ESAL categories 2 or 3.

The types of seal coats shall be as follows:

Type (see Note 1)	Application	Cover Aggregate Size No. and Course	Rates of Application per sq yd	
			Aggregate, lb	Asphalt Material, Gal. at 60°F
1 or 1P (see Note 2)	Single	23, 24	12 - 15	0.12 - 0.16
2 or 2P	Single	12, SC 12	14 - 17	0.29 - 0.33
3 or 3P	Single	11, SC 11, SC 16	16 - 20	0.36 - 0.40
4 or 4P	Single	9	28 - 32	0.63 - 0.68
5 or 5P	Double	Top: 12, SC 12 Bottom: 11, SC 11, SC 16	16 - 19 16 - 20	0.41 - 0.46 0.28 - 0.31
6 or 6P	Double	Top: 11, SC 11, SC 16 Bottom: 9	18 - 22 28 - 32	0.62 - 0.68 0.42 - 0.46
7 or 7P	Double	Top: 11, SC 11, SC 16 Bottom: 8	18 - 22 28 - 32	0.62 - 0.68 0.42 - 0.46
Note 1 – AE-90S and SC aggregates shall be used for type P seal coats, except SC aggregate requirement will not apply to seal coat used on shoulders. Note 2 – HFRS-2 shall not be used with type 1 seal coat.				

SC aggregates shall be 85% one face and 80% two face crushed. The Flakiness Index in accordance with ITM 224 shall be a maximum of 25%. Non SC aggregates shall have a minimum crushed particle percentage of 70%. Determination of crushed particles shall be made from the mass weight of material retained on the No. 4 (4.75 mm) sieve in accordance with ASTM D5821.

CONSTRUCTION REQUIREMENTS

404.05 Weather Limitations

Asphalt material shall not be applied on a wet surface, or when other weather conditions would adversely affect the seal coat. Seal coat shall not be placed when the ambient or pavement temperature is below 60°F. Seal coat shall not be applied to travel lanes or auxiliary lanes before May 1 or after October 1, but may be applied to shoulders within the above temperature range.

404.06 Equipment

A distributor, rotary power broom, pneumatic tire roller, and aggregate spreader in accordance with 409.03 shall be used.

404.07 Preparation of Surface

Surfaces to be sealed shall be patched as shown on the plans or as directed, brought to proper section and grade, and compacted.

The surface shall be cleaned of all loose material prior to seal coat application. Sealing operations may not commence until the surface is approved.

All castings, detector housings, and snowplowable raised pavement markers shall be covered prior to applying the asphalt material to prevent coating with seal coat. These coverings shall be removed prior to opening to unrestricted traffic.

404.08 Applying Asphalt Material

Asphalt material shall be applied in a uniform continuous spread over the section to be treated. The quantity of asphalt material to be applied per square yard shall be in accordance with the QCP. During application, minor adjustments to the application rate shall be made in accordance with the QCP.

The asphalt material shall not be spread over a greater area than can be covered with the cover aggregate within the trucks at the site.

The spread of the asphalt material shall be no wider than the width covered by the cover aggregate from the spreading device. Operations shall allow asphalt materials to chill, set up, dry, or otherwise impair retention of the cover coat.

404.09 Application of Cover Aggregate

Within 1 minute of the application of the asphalt material, cover aggregate shall be spread in quantities as required. Spreading shall be accomplished such that the tires of the trucks or aggregate spreader do not contact the uncovered and newly applied asphalt material.

404.10 Rolling Operation

The aggregate shall be seated with at least three roller applications. A roller application is defined as one pass of the roller over the width sealed. The first roller application shall be completed within 2 minutes of aggregate application, with the final application completed within 30 minutes after the cover aggregate is applied. The rollers shall not be operated at speeds that will displace the cover aggregate from the asphalt material.

404.11 Sweeping Operation

Excess cover aggregate shall be removed from the pavement surface by brooming no later than the morning after placement of the seal coat. The brooming shall not displace the imbedded aggregate. A second brooming operation shall be performed prior to opening to unrestricted traffic in accordance with 101.35.

404.12 Protection of Surface

Traffic shall not be allowed on the freshly sealed surfaces until final rolling application is complete. The seal coat shall be protected by keeping traffic off the freshly sealed surface or by controlling traffic speed in accordance with the QCP. Traffic shall not displace the imbedded aggregate.

Any areas with minor bleeding will be covered with fine aggregate or other approved blotting material.

404.13 Method of Measurement
Seal coat will be measured by the square yard of the seal coated surface.

Patching will be measured in accordance with 304.06.

404.14 Basis of Payment
Seal coat will be paid for at the contract unit price per square yard complete in place.

Patching will be paid for in accordance with 304.07.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Seal Coat, ______ (type)	SYS
Seal Coat, ______ P (type)	SYS

The cost of determination of asphalt material and cover aggregate application rates, sweeping and rolling operations, blotting material, and other incidentals shall be included in the cost of the pay items.

The Contractor shall adjust application rates as directed by the Engineer within the limits set out herein. No additional payment will be made for additional materials necessary to meet the required application rates within the specified limits.

SECTION 405 – PRIME COAT

405.01 Description
This work shall consist of preparing and treating a rubblized PCCP with asphalt material in accordance with 105.03.

MATERIALS

405.02 Asphalt Materials
The type and grade of asphalt material shall be in accordance with the following:

Asphalt Emulsion, AE-PL ....902.01(b)

405.03 Cover Aggregate
Aggregate shall be in accordance with the following:

Coarse Aggregate, Class B or Higher, Size No. 12 ....904.03
Fine Aggregate, Size No. 23 or 24...904.02

CONSTRUCTION REQUIREMENTS

405.04 Weather Limitations

Asphalt material shall not be applied on a wet surface, when the ambient temperature is below 50°F, or when other unsuitable conditions exist, unless approved by the Engineer.

405.05 Equipment

A distributor and aggregate spreader in accordance with 409.03 shall be used.

405.06 Preparation of Surface

The existing surface to be treated shall be shaped to the required grade and section, free from all ruts, corrugations, or other irregularities, uniformly compacted, and approved.

405.07 Application of Asphalt Material

AE-PL shall be uniformly applied at the rate of 0.50 to 0.75 gal./sq yd placed in a single application. When placing material on a rubblized base, a carpet drag shall be utilized behind the distributor.

When traffic is to be maintained within the limits of the section, approximately one half of the width of the section shall be treated in one application. Complete coverage of the section shall be ensured. Treated areas shall not be opened to traffic until the asphalt material has been absorbed.

405.08 Cover Aggregate

If the asphalt material fails to penetrate and the primed surface must be used by traffic, cover aggregate shall be spread to provide a dry surface.

405.09 Method of Measurement

Asphalt for prime coat will be measured by the ton, or by the square yard. Cover aggregate will be measured by the ton.

405.10 Basis of Payment

The accepted quantities of prime coat will be paid for at the contract unit price per ton, or per square yard for asphalt for prime coat. The accepted quantities of cover aggregate will be paid for at the contract unit price per ton, complete in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Asphalt for Prime Coat	TON
	SYS
Cover Aggregate, Prime Coat	TON

SECTION 406 – TACK COAT

406.01 Description

This work shall consist of preparing and treating an existing pavement or concrete surface with asphalt material in accordance with 105.03.

MATERIALS

406.02 Materials
The type and grade of asphalt material shall be in accordance with the following:

Asphalt Emulsion, SS-1h, AE-NT ....902.01(b)
PG Asphalt Binder, PG 64-22........................902.01(a)

CONSTRUCTION REQUIREMENTS

406.03 Equipment
A distributor in accordance with 409.03(a) shall be used.

406.04 Preparation of Surface
The existing surface to be treated shall be free of foreign materials deemed detrimental by the Engineer. The surface where the asphalt material is applied shall be free of standing water and shall be cleaned of dust, debris and any substances that will prevent adherence.

406.05 Application of Asphalt Material
The asphalt material shall be uniformly applied across the entire width of pavement to be overlaid and shall cover a minimum of 95% of the surface. The asphalt material shall be given sufficient time to break and set to minimize tracking from hauling and laydown equipment. Areas of inadequate coverage that create streaking or areas of excessive coverage that create ponding shall be corrected to obtain an even distribution.

The asphalt material application rate shall be based on the existing surface type and shall be as follows:

Surface Type	Application Rate*(gal./sq yd)
New Asphalt	0.05 to 0.08
Existing Asphalt	0.06 to 0.11
Milled Asphalt	0.06 to 0.12
PCCP	0.05 to 0.08
* The asphalt material shall not be diluted.	

406.06 Method of Measurement
Asphalt for tack coat will be measured by the ton or by the square yard.

406.07 Basis of Payment
The accepted quantities of tack coat will be paid for at the contract unit price per ton or per square yard for asphalt for tack coat, complete in place.

Payment will be made under:

Pay Item **Pay Unit Symbol**

Asphalt for Tack Coat..TON
SYS

SECTION 407 – DUST PALLIATIVE

407.01 Description
This work shall consist of preparing and treating an existing aggregate surface with asphalt material in accordance with 105.03.

MATERIALS

407.02 Asphalt Material
The type and grade of asphalt material shall be in accordance with the following:

Asphalt Emulsion, AE-PL ....902.01(b)

CONSTRUCTION REQUIREMENTS

407.03 Weather Limitations
Asphalt material shall not be applied on a wet surface, when the ambient temperature is below 50°F, or when other unsuitable conditions exist, unless approved by the Engineer.

407.04 Equipment
A distributor in accordance with 409.03(a) shall be used.

407.05 Preparation of Surface
The surface to be treated shall be shaped to the required section and be free from all ruts, corrugations, or other irregularities.

407.06 Application of Asphalt Material
The asphalt material shall be uniformly applied at the rate of 0.25 to 1 gal./sq yd in a uniform continuous spread over the section to be treated or as directed.

When traffic is to be maintained within the limits of the section, approximately one half of the full section width shall be treated in one application. Complete coverage of the section shall be ensured.

Treated areas shall not be opened to traffic until the asphalt material has been absorbed.

407.07 Method of Measurement
Asphalt for dust palliative will be measured by the ton.

407.08 Basis of Payment
The accepted quantities of this work will be paid for at the contract unit price per ton for asphalt for dust palliative, complete in place.

Payment will be under:

Pay Item	Pay Unit Symbol
Asphalt for Dust Palliative..	TON

SECTION 408 – SEALING OR FILLING CRACKS AND JOINTS

408.01 Description

This work shall consist of sealing or filling longitudinal and transverse cracks and joints in existing asphalt pavement in accordance with 105.03.

Full lane width transverse cracks and longitudinal joints shall be routed and sealed. All other cracks shall be filled.

MATERIALS

408.02 Materials

Materials shall be in accordance with the following:

Asphalt Binder, PG 64-22*............................902.01(a)
Asphalt Emulsion for Crack Filling, AE-90S 902.01(b)
Fine Aggregates, No. 23 or 24.......................904.02
Joint Sealing Materials...................................906.02(a)2

* A PG 64-22 asphalt binder shall be used to fill cracks on a surface that is milled in accordance with 306, and polypropylene fibers shall be used only in conjunction with warranted micro-surfacing.

CONSTRUCTION REQUIREMENTS

408.03 Equipment

A distributor in accordance with 409.03 shall be used when crack filling with asphalt emulsion or an indirect-heat double boiler kettle with mechanical agitator shall be used when filling with hot poured material. An indirect-heat double boiler kettle with mechanical agitator shall be used when routing and sealing. Air compressors shall be capable of producing a minimum air pressure of 100 psi.

408.04 Weather Limitations

Sealing or filling operations shall not be conducted on a wet surface, when the ambient temperature is below 40°F, or when other unsuitable conditions exist, unless approved by the Engineer.

408.05 Routing and Sealing Cracks and Joints

Cracks and joints, 1/2 in. or less in width, shall be routed with a routing machine capable of cutting a uniform shape to form a reservoir not exceeding 3/4 in. wide with a minimum depth of 3/4 in. Cracks and joints shall be cleaned by blowing with compressed air or by other suitable means. The operation shall be coordinated such that routed materials do not encroach on pavement lanes carrying traffic and all routed materials are disposed of in accordance with 104.07. Cracks and joints shall be sealed with hot poured joint sealant to within 1/4 in. below the surface in accordance with the manufacturer's recommendations.

408.06 Filling Cracks

Cracks shall be cleaned by blowing with compressed air or by other suitable means. Asphalt material shall be placed utilizing a "V" shaped wand tip, to allow the penetration of the materials into the cracks. The cracks shall be completely filled or overbanded not to exceed 5 in., or as required. All excess asphalt material shall be removed from the pavement. The filled cracks shall be covered with sufficient fine aggregate or other suitable material to prevent tracking of the asphalt materials. All excess cover material shall be removed from the pavement within 24 h, when directed.

Application of asphalt materials shall be completed without covering existing pavement markings. When traffic is to be maintained within the limits of the section, temporary traffic control measures in accordance with 801 shall be used. Treated areas shall not be opened to traffic until the asphalt material has been absorbed.

408.07 Method of Measurement

Sealing and filling of cracks and joints in asphalt pavements will be measured by the ton of material used. Routing of cracks and joints will not be measured.

Temporary traffic control measures will be measured in accordance with 801.17.

408.08 Basis of Payment

Sealing and filling of cracks and joints in asphalt pavements will be paid for by the ton of material used for the type specified.

Temporary traffic control measures will be paid for in accordance with 801.18.

Payment will be made under:

Pay Item	Pay Unit Symbol
Cracks in Asphalt Pavement, Fill...	TON
Cracks and Joints in Asphalt Pavement, Rout and Seal.....................	TON

The cost of all materials, cover aggregate, cleaning, and all necessary incidentals shall be included in the cost of the pay items in this section.

SECTION 409 – EQUIPMENT

409.01 Production, Transportation, and Laydown of Asphalt Mixtures

For production of asphalt mixtures, the Contractor shall provide all equipment necessary for the production, transportation, and laydown operations.

409.02 Mixing Plant

The mixing plant shall be certified in accordance with ITM 583 and shall be capable of producing a uniform mixture.

409.03 HMA Laydown Operations

(a) Distributor

The distributor shall be equipped, maintained, and operated to provide uniform heating and application rates as specified. The distributor shall have a volume measuring device and a thermometer to monitor the asphalt material.

Distributors shall also be equipped with a power unit for the pump and a full circulation spray bar with vertical controls.

(b) Hauling Equipment

The mixtures shall be transported to the laydown operation in trucks that have tight, clean, and smooth beds.

Truck beds may be treated with anti-adhesive agents from the QPL. The truck beds shall be raised after application of non-foaming anti-adhesive agents to drain liquids from the bed prior to HMA being loaded into the truck. The Department will maintain a QPL of Anti-Adhesive Materials.

Hauling equipment shall be equipped with a watertight cover to protect the mixture.

(c) Laydown Equipment

1. Paver

The paver shall be self-propelled, and equipped with a material receiving system, and equipped with heated and vibrating screeds. The paver may also include automatic slope and grade controls, extendable screeds and extendable augers.

Automatic control devices shall be separated from the paver screeds, paver tracks or wheels and be capable of adjusting both sides of the screeds automatically to maintain a constant angle of attack in relation to the grade leveler device or grade line.

A grade leveling system may be used to activate the control devices on each HMA course, including matching lays. The leveling system shall be attached to the paver and operated parallel to the paver's line of travel.

Extendable screeds shall be rigid, heated, vibrating, and be capable of maintaining the cross slope and line and grade of the pavement to produce uniform placement of the materials.

Auger extensions shall be used when required to distribute the HMA uniformly in front of the screed.

When a dense graded intermediate or a surface mixture is placed adjacent to an aggregate or earth shoulder, the side of the paver adjacent to the aggregate or earth shoulder shall be equipped with a device capable of constructing a safety edge. The following devices are approved for this application:

(a) Advant-Edge™, Advant-Edge Paving Equipment LLC

(b) Safety Edge End Gate, Carlson Paving Products, Inc.
(c) TransTech Shoulder Wedge Maker™, TransTech Systems, Inc.
(d) SafeTSlope Edge Smoother™, Troxler Electronic Laboratories, Inc.

2. Widener

A device capable of receiving, transferring, spreading, and striking off materials to the proper grade and slope.

3. Other Mechanical Devices

Inaccessible or short sections of HMA may be placed with specialty equipment approved by the Engineer.

(d) Compaction Equipment

Compaction equipment shall be self-propelled, steel wheel or pneumatic tire types, in good condition, and capable of reversing direction without backlashing. All roller wheels shall be equipped with scrapers to keep the wheels clean, have water spraying devices on the wheels, and steering devices capable of accurately guiding the roller.

1. Tandem Roller

A roller having two axles and a minimum weight of 10 t.

2. Three Wheel Roller

A roller having three wheels with a minimum bearing of 300 lb/in. on the rear wheels. The crown of the wheels shall not exceed 2.5 in. in 18 ft.

A tandem roller which has a drive wheel bearing of no less than 300 lb/in. may be used in lieu of the three wheel roller.

3. Pneumatic Tire Roller

A pneumatic tire roller shall have a minimum rolling width of 5.5 ft. The roller shall be equipped with compaction tires, minimum size 7:50 by 15, exerting an average contact pressure from 50 to 90 psi uniformly over the pavement.

The wheels on at least one axle shall be fully oscillating vertically and mounted to prevent scuffing of the pavements during rolling or turning operations. Charts or tabulations showing the contact areas and pressures for the full range of tire inflation pressures and for the full range of tire loadings for each compactor shall be furnished to the Engineer.

4. Vibratory Roller

A vibratory roller shall have both drums equipped for vertical impact forces, a variable amplitude system, a speed control device, and have a minimum vibration frequency of 2,000 vibrations per minute. A reed tachometer shall be provided for verifying the frequency of vibrations.

5. Oscillatory Roller

An oscillatory roller shall have both drums equipped for horizontal and vertical shear forces or one drum equipped for horizontal and vertical shear force and the other drum equipped for a vertical impact force.

6. Trench Roller

A trench roller shall have a compaction wheel bearing of no less than 300 lb/in.

7. Specialty Roller/Compactor

Inaccessible or short sections of HMA may be compacted with specialty equipment approved by the Engineer.

(e) Miscellaneous Equipment

1. Aggregate Spreader

A spreader shall be a self-propelled, pneumatic tired, motorized unit with a front loading hopper and a transportation system for distributing the aggregates uniformly across the pavement.

2. Rotary Power Broom

A motorized, pneumatic tired unit with rotary bristle broom head.

(f) Smoothness Equipment

1. Inertial Profiler

The inertial profiler shall be in accordance with ITM 917.

SECTION 410 – QC/QA HMA – SMA PAVEMENT

410.01 Description

This work shall consist of one course of QC/QA HMA – SMA mixture constructed on prepared foundations in accordance with 105.03.

410.02 Quality Control

The SMA mixture shall be supplied from a certified HMA plant in accordance with ITM 583; Certified Hot Mix Asphalt Producer Program. The QCP shall be modified to include the requirements for the SMA mixtures. The SMA shall be transported and placed according to the QCP prepared and submitted by the Contractor in accordance with ITM 803; Contractor Quality Control Plans for Hot Mix Asphalt Pavements. The QCP shall be submitted to the Engineer at least 15 days prior to commencing SMA paving operations.

When a safety edge is required for a project, the QCP shall identify the device or devices in accordance with 409.03(c) to be used for constructing the safety edge.

MATERIALS

410.03 Materials

Materials shall be in accordance with the following:

Asphalt Materials
PG Binder, PG 76-22, PG 70-22.............902.01(a)
Coarse Aggregates, Class AS 904.03

Fine Aggregates (sand, mineral filler) 904.02
Stabilizing Additives...AASHTO M 325

410.04 Design Mix Formula

A DMF shall be prepared in accordance with 410.05 and submitted in a format acceptable to the Engineer one week prior to use. The DMF shall state the maximum particle size in the mixture. The DMF shall state the calibration factor, test temperature and absorption factors to be used for the determination of binder content using the ignition oven in accordance with ITM 586, the binder content by extraction in accordance with ITM 571, ΔPb, determined in accordance with ITM 591, the aggregate degradation loss value in accordance with ITM 220 and a Mixture Adjustment Factor, MAF. The DMF shall state the source, type dosage rate of any stabilizing additives. The DMF will be based on the ESAL and mixture designation. No mixture shall be used until the DMF has been assigned a mixture number by the DTE.

The ESAL category identified in the pay item correlates to the following ESAL ranges:

ESAL Category	ESAL
2*	< 3,000,000
3	3,000,000 to < 10,000,000
4*	$\geq$ 10,000,000
* A category 2 mixture shall replace a category 1 mixture and a category 4 mixture shall replace a category 5 mixture.	

The plant discharge temperature for any mixture shall not be more than 315°F whenever PG 70-22 binder is used or not more than 325°F whenever PG 76-22 binder is used. SMA may be produced using a water-injection foaming device. The DMF shall list the minimum and maximum plant discharge temperatures as applicable to the mixture.

410.05 SMA Mix Design

The DMF shall be determined for each mixture from a SMA mix design by a design laboratory selected from the Department's list of Qualified Mix Design Laboratories. A SMA mixture shall be designed in accordance with ITM 220, AASHTO M 325 and R 46 except the design gyrations shall be 75 for all ESAL categories. All loose mixture shall be conditioned for 4 h in accordance with AASHTO R 30 prior to testing. Steel furnace slag coarse aggregate, when used in an intermediate mixture application, shall have a deleterious content less than 4.0% as determined in accordance with ITM 219.

The single percentage of aggregate passing each required sieve shall be within the limits of the following gradation table.

SMA Gradation Control Limits						
	Mixture Designation					
	9.5 mm		12.5 mm		19.0 mm	
Sieve Size	Lower	Upper	Lower	Upper	Lower	Upper
1 1/2 in. (37.5 mm)					100.0	100.0
1 in. (25.0 mm)			100.0	100.0	99.0*	100.0
3/4 in. (19.0 mm)	100.0	100.0	99.0*	100.0	90.0	99.0
1/2 in. (12.5 mm)	99.0*	100.0	90.0	99.0	50.0	88.0
3/8 in. (9.5 mm)	70.0	95.0	50.0	80.0	25.0	60.0
No. 4 (4.75 mm)	30.0	50.0	20.0	35.0	20.0	28.0
No. 8 (2.36 mm)	20.0	30.0	16.0	24.0	16.0	24.0
No. 16 (1.18 mm)	---	21.0	---	---	---	---
No. 30 (600 µm)	---	18.0	---	---	---	---
No. 50 (300 µm)	---	15.0	---	---	---	---
No. 200 (75 µm)	8.0	12.0	8.0	11.0	8.0	11.0
* The lower % passing gradation may be 98.0% when SMA RAP material in accordance with 410.06 is used in the SMA mixture.						

The optimum binder and aggregate gradation content shall produce a $\Delta Pb \leq 0.20$ as determined in accordance with ITM 591 and 4.0% air voids. The maximum specific gravity shall be mass determined in water in accordance with AASHTO T 209. The percent draindown for SMA mixture shall not exceed 0.30% in accordance with AASHTO T 305.

The MAF equals the Gmm from the mixture design divided by the following:

(a) 2.465 for 9.5 mm mixtures
(b) 2.500 for 12.5 mm and 19.0 mm mixtures.

If the MAF calculation results in a value where $0.980 \leq MAF \leq 1.020$, then the MAF shall be considered to be 1.000. If the MAF is greater than 1.020, the calculated MAF value shall have 0.020 subtracted from the value. If the MAF is less than 0.980, the calculated MAF value shall have 0.020 added to the value. The MAF does not apply to OG mixtures.

The mixture shall be tested for moisture susceptibility in accordance with AASHTO T 283 except that the loose mixture curing shall be replaced by mixture conditioning for 4 h in accordance with AASHTO R 30. The minimum tensile strength ratio, TSR, shall be 70%. The 6 in. mixture specimens shall be compacted to 6.0 ±1.0% air voids in accordance with AASHTO T 312. Specimens shall be prepared using freeze-thaw preconditioning. If anti-stripping additives are added to the mixture to be in accordance with the minimum TSR requirements, the dosage rate shall be submitted with the DMF.

The fine aggregate portion of the aggregate blend shall be non-plastic as determined in accordance with AASHTO T 90.

A change in the source or types of aggregates or a change in source or type of stabilizing additives shall require a new DMF.

A PG binder grade or source change will not require a new mix design. If the upper temperature classification of the PG binder is lower than the original PG grade, a new TSR value is required.

The specific gravity of SF and the Gsb of the aggregate blend containing SF may be adjusted once per contract upon notification by the SF source and approval by the DTE. A new DMF is not required for this adjustment.

The mixture design compaction temperature for the specimens shall be 300 ±9°F.

Voids in Mineral Aggregate, VMA, Criteria	
Mixture Designation	Minimum VMA, %
19.0 mm	15.0
12.5 mm	16.0
9.5 mm	17.0

410.06 Recycled Materials

Recycled materials shall be in accordance with 401.06 for dense graded mixtures except non-SMA RAP material for use in the SMA mixture shall be 100% passing the 3/8 in. (9.5 mm) sieve and 95 to 100% passing the No. 4 (4.75 mm) sieve.

SMA RAP material shall be the product derived by exclusively milling an existing SMA mixture. The SMA RAP material shall pass the maximum size sieve for the mixture being produced as follows:

SMA RAP Gradation, %						
Sieve Size	Mixture Designation					
	9.5 mm		12.5 mm		19.0 mm	
	Lower	Upper	Lower	Upper	Lower	Upper
1 1/2 in. (37.5 mm)					100.0	100.0
1 in. (25.0 mm)			100.0	100.0	95.0	100.0
3/4 in. (19.0 mm)	100.0	100.0	95.0	100.0	---	---
1/2 in. (12.5 mm)	95.0	100.0	---	---	---	---

The Contractor may request the use of SMA RAP material in the SMA mixture provided the material is stockpiled separately at the plant and the material properties were determined in accordance with ITM 584 during stockpile construction. The request shall include all QC test results describing the stockpile composition. The Engineer will obtain a representative sample of the SMA RAP material in accordance with ITM 207 for testing in accordance with ITM 590 to verify the proposed design value.

410.07 Lots and Sublots

Lots will be defined as 4,000 t of SMA intermediate mixture or 2,400 t of SMA surface mixture. Lots will be further sub-divided into sublots not to exceed 1,000 t of SMA intermediate mixture or 600 t of SMA surface mixture. Partial sublots of 100 t or less will be added to the previous sublot. Partial sublots greater than 100 t constitute a full sublot.

410.08 Job Mix Formula

A JMF shall be developed by a certified HMA producer in accordance with ITM 583. A JMF used for SMA mixture in the current calendar year will be allowed.

The aggregate and recycled materials blend percentage and the amount passing all sieves on the DMF may be adjusted provided the gradation limits do not exceed the requirements of 410.05. Adjustments to the aggregate and recycled materials blend percentage, gradation and the new combined aggregate bulk specific gravity shall be included on the JMF.

The total binder content on the JMF may be determined by adjusting the DMF a maximum of ±0.3%. The recycled materials binder content may be adjusted as part of the total binder content provided the binder replacement percentage is in accordance with 410.06.

The mixture compaction temperature shall be 300 ±9°F. The JMF shall list the minimum and maximum plant discharge temperatures as applicable to the mixture. The JMF for each mixture shall be submitted to the Engineer.

410.09 Acceptance of Mixtures

Acceptance of mixtures for binder content and gradation for each lot will be based on tests performed by the Engineer. The Engineer will randomly select the location within each sublot for sampling in accordance with ITM 802. An acceptance sample will consist of one plate sample at the random location. A backup sample will consist of one plate sample located 2 ft towards the center of the mat from the acceptance sample.

Samples from each location shall be obtained from each sublot from the pavement in accordance with ITM 580. The Engineer will take immediate possession of the samples.

A maximum specific gravity sample and a binder content and gradation sample will be obtained from the plate sample in accordance with ITM 587. The binder content will be determined in accordance with ITM 586 or ITM 571 as directed by the Engineer and the gradation will be determined in accordance with AASHTO T 30. The maximum specific gravity will be mass determined in water in accordance with AASHTO T 209. The test results of the sublots will be averaged and shall meet the requirements for tolerances from the JMF for each sieve and binder content.

The Engineer will make the sublot acceptance test results available after receiving the sublot quality control results from the Contractor.

Acceptance Tolerance for Mixtures (Percent Mass)									
Mixture	Number of Tests	Sieve Size							
		*25.0 mm	*19.0 mm	*12.5 mm	*9.5 mm	*4.75 mm	2.36 mm	600 µm	75 µm
Surface	1	---	---	---	---	---	8.0	4.0	2.5
	2	---	---	---	---	---	5.7	2.8	2.1
	3	---	---	---	---	---	4.6	2.3	1.8
	4	---	---	---	---	---	4.0	2.0	1.5
Intermediate	1	---	---	---	---	---	10.0	6.0	2.0
	2	---	---	---	---	---	7.0	4.2	1.4
	3	---	---	---	---	---	5.8	3.5	1.2
	4	---	---	---	---	---	5.0	3.0	1.0
* The acceptance tolerance for this sieve shall be the applicable composition limits specified in 410.05.									

Acceptance Tolerance for Binder				
Binder Content	Number of Tests			
	1	2	3	4
%Binder	0.7	0.5	0.4	0.3

Acceptance of mixtures for range will be determined using the results of sublot tests performed by the Engineer from each lot. If the range is not in accordance with the requirements, adjustment points will be assessed in accordance with 410.19(a).

Acceptance Tolerance for Range (±Percent Mass)		
Sieve Size and Binder Content	Percentage Points	
	Surface	Intermediate
No. 8 (2.36 mm)	12.0	15.0
No. 30 (600 µm)	6.0	9.0
No. 200 (75 µm)	2.0	3.0
%Binder	1.0	1.0

Acceptance tolerances for binder content and gradation will be as set out above for the number of tests performed. The acceptance tolerance for range will be as set out above for lots of more than one sublot. The range of binder shall be the difference between the highest sublot binder content and the lowest sublot binder content in one lot. The range of gradation shall be the difference between the highest sublot percent passing and the lowest sublot percent passing each required sieve in one lot.

Single test values and averages will be reported to the nearest 0.1%. Rounding will be in accordance with 109.01(a).

Lot adjustment points will be assessed in accordance with 410.19(a) when the average or range for binder content or gradation are not met.

The Contractor may request an appeal of the Engineer's test results in accordance with 410.20.

A binder draindown test in accordance with AASHTO T 305 shall be completed once per lot in accordance with 410.07 and shall not exceed 0.30%.

A type C certification in accordance with 916 shall be provided for the stabilizing additives for each shipment. Stabilizing additives from different manufacturers and different types of additives shall not be intermixed.

In the event than an acceptance sample is not available to represent sublot, all test results of the previous sublot will be used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

Samples shall not be obtained from areas placed with paving equipment in accordance with 409.03(c)2 or 409.03(c)3. If a random location falls within this area, the Engineer will randomly select another location within the sublot for sampling. If an entire sublot falls within this area, test results from the previous sublot will be used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

CONSTRUCTION REQUIREMENTS

410.10 General

Equipment for SMA operations shall be in accordance with 409. The Contractor shall submit to the Engineer, prior to use, a written Certificate of Compliance that the proposed paving equipment has been modified in accordance with 401.10 or is new and includes the modifications.

Fuel oil, kerosene, or solvents shall not be transported in open containers on equipment. Cleaning of equipment and small tools shall not be performed on the pavement or shoulder areas.

SMA mixtures shall not exhibit segregation, flushing, or bleeding. Corrective action shall immediately be taken to prevent continuation of these conditions. Segregated, flushed, or bleeding of SMA mixtures will be referred to the Department's Division of Materials and Tests for adjudication as a failed material in accordance with 105.03.

All mixtures that become loose and broken, mixed with dirt, or are in any way defective shall be removed and replaced in accordance with 105.03.

410.11 Preparation of Surfaces to be Overlaid

Milling of an existing pavement surface shall be in accordance with 306. Surfaces on which a mixture is placed shall be free from objectionable or foreign materials at the time of placement.

Milled asphalt surfaces and asphalt surfaces shall be tacked in accordance with 406. Contact surfaces of curbing, gutters, manholes, and other structures shall be tacked in accordance with 406.

410.12 Process Control

The Engineer and Contractor will jointly review the operations to ensure compliance with the QCP. Continuous violations of compliance with the QCP will result in suspension of paving operations.

410.13 Weather Limitations

SMA courses shall be placed when the ambient temperature and the temperature of the surface on which it is to be placed is 45°F or above.

410.14 Spreading and Finishing

The mixture shall be placed upon an approved surface by means of a paver or other mechanical devices in accordance with 409.03. Mixtures in areas inaccessible to mechanical devices may be placed by other methods. The temperature of mixture at the time of spreading shall be no more than 315°F whenever PG 70-22 binder is used or no more than 325°F whenever PG 76-22 binder is used. The temperature of each mixture shall not be less than 245°F at the time of spreading when placed with paving equipment in accordance with 409.03(c)2 or 409.03(c)3. No mixture shall be placed on a previously paved course that has not cooled to less than 175°F.

Prior to paving, both the planned quantity and lay rate shall be adjusted by multiplying by the MAF. When mixture is produced from more than one DMF or JMF for a given pay item, the MAF will be applied to the applicable portion of the mixture for each.

Planned SMA courses greater than 220 lb/sq yd placed under traffic, shall be brought up even with each adjacent lane at the end of each work day. Planned SMA courses less than or equal to 220 lb/sq yd shall be brought forward concurrently, within practical limits, limiting the work in one lane to not more than one work day of production before moving back to bring forward the adjacent lane.

Hydraulic extensions on the paver will not be allowed for continuous paving operations. Fixed extensions or extendable screeds shall be used on courses greater than the nominal width of the paver except in areas where the paving widths vary. Hydraulic extensions may be used in tapers and added lanes less than 250 ft in length.

Automatic slope and grade controls will be required and shall be outlined in the QCP.

SMA mainline and SMA shoulders which are 8 ft or more in width shall be placed with automatic paving equipment.

The rollers shall be operated to avoid shoving of the SMA and at speeds not to exceed 3 mph. Rollers shall be in accordance with 409.03(d)1, 2, or 7. Vibratory rollers meeting the requirements of 409.03(d)4 may be used but shall not be operated in vibratory mode, except the vibratory mode may be used on the first pass to the paver. Oscillatory rollers in accordance with 409.03(d)5 will be allowed for use but the vertical impact force capability shall not be used, except the vertical impact force capability may be used on the first pass to the paver.

The finished thickness of any course shall be at least two times but not more than five times the maximum particle size as shown on the DMF.

A safety edge shall be constructed at locations where the surface mixture is constructed adjacent to an aggregate or earth shoulder.

410.15 Joints

Longitudinal joints in the surface shall be at the lane lines of the pavement.

Hot poured joint adhesive in accordance with 906 shall be applied to longitudinal joints constructed between two adjacent HMA courses in the top course of dense graded intermediate mixtures and all 9.5 mm and 12.5 mm SMA mixture courses. This includes joints within the traveled way as well as between any of the following: traveled way and an auxiliary lane; traveled way and a paved shoulder; and auxiliary lane and a paved shoulder.

The material shall be heated in a jacketed, double boiler melting kettle. The kettle shall have an attached pressure feed wand system with applicator shoe.

The joint adhesive shall be applied to the face of the previously constructed edge at the joint using a wand applicator. Prior to application of the joint adhesive, the joint face shall be dry and free of loose material and foreign objects. The adhesive shall be applied on the joint face 1/8 in. thick at the temperature recommended by the manufacturer. Excess joint adhesive shall not be allowed to pool on the top of the previously constructed pavement course or the pavement to be overlaid. The application of the adhesive shall be made within the same day, but at least 30 minutes prior to construction of the longitudinal joint.

Transverse joints shall be constructed by exposing a near vertical full depth face of the previous course. For areas inaccessible to rollers, other mechanical devices shall be used to achieve the required density.

If constructed under traffic, temporary transverse joints shall be feathered to provide a smooth transition to the driving surface.

410.16 Density

Acceptance will be based on lots and sublots in accordance with 410.07.

The Engineer’s acceptance test results for each sublot will be available after the sublot and testing are complete.

Sublot and lot density values will be reported to the nearest 0.1%. Rounding will be in accordance with 109.01(a).

Density acceptance for all SMA mixtures shall be based on cores cut from the compacted pavement and analysis of pavement samples obtained in accordance with ITM 580. Acceptance will be based on lots and sublots in accordance with 410.07. The Engineer will randomly select two locations in accordance with ITM 802, within each sublot for coring. The transverse core location will be located so that the edge of the core will be no closer than 3 in. from a confined edge or 6 in. from a non-confined edge of the course being placed. The maximum specific gravity will be determined from the sample obtained in 410.09.

The Contractor shall obtain cores in the presence of the Engineer with a device that shall produce a uniform 6.00 ±0.25 in. diameter pavement sample. Surface courses shall be cored within one work day of placement. Damaged core shall be discarded and replaced with a core from a location selected by adding 1 ft to the longitudinal location of the damaged core using the same transverse offset.

The Contractor and the Engineer shall mark the core to define the course to be tested. If the core indicates a course thickness of less than two times the maximum particle size, the core will be discarded and a core from a new random location will be selected for testing.

Cores shall not be obtained from areas placed with paving equipment in accordance with 409.03(c)2 or 409.03(c)3. If a random location falls within this area, the Engineer will randomly select another location within the sublot for coring. If an entire sublot falls within this area, test results from the previous sublot will be used for acceptance. If the previous sublot is not available, the subsequent sublot will be used for acceptance.

The Engineer will take immediate possession of the cores. If the Engineer's cores are subsequently damaged, additional coring within a specific sublot or sublots will be the responsibility of the Department. Subsequent core locations will be determined by subtracting 1 ft from the random location using the same transverse offset.

The density of the mixture will be expressed as:

$$Density, \% = \frac{BSG}{MSG} \, x \, 100$$

where:

BSG = average bulk specific gravity
MSG = maximum specific gravity

Samples for the bulk specific gravity and maximum specific gravity will be dried in accordance with ITM 572. The Engineer will determine the bulk specific gravity of the cores in accordance with AASHTO T 166, Method A or AASHTO T 331, if required. The maximum specific gravity will be mass determined in water in accordance with AASHTO T 209. The target value for density of SMA mixtures of each sublot shall be 93.0%.

The densities of the sublots will be averaged to determine the density of the lot.

Within one work day of coring operations, the Contractor shall clean, dry, and refill the core holes with SMA of similar or smaller size particles or other approved materials. The Contractor's plan for refilling core holes shall be outlined in the QCP.

410.17 Pavement Corrugations
Pavement corrugations shall be in accordance with 606.

410.18 Pavement Smoothness
The pavement smoothness will be evaluated and determined in accordance with 401.18.

410.19 Adjusted Points

When test results for mixture properties or density exceed the allowable tolerances, adjustment points will be assessed. The adjustment points will be used to calculate a quality assurance adjustment quantity, q, for the lot. Quality assurance adjustment points for smoothness will be in accordance with 401.19(c).

The adjustment for mixture properties and density are calculated as follows:

$$q = 1.00 \times (L \times U \times P/100)/MAF$$

where:

- q = quality assurance adjustment quantity
- L = lot quantity
- U = unit price for the material, $/ton
- P = total adjustment points

The total quality assurance adjustments is to be calculated as follows:

$$Q = Q_s + \sum (q_m + q_d)$$

where:

- Q = total quality assurance adjustment quantity
- Q_s = quality assurance adjustment for smoothness as calculated in 401.19(c)
- q_m = lot adjustments for mixtures
- q_d = lot adjustments for density

If the total adjustment points for a lot are greater than 15, the pavement will be evaluated by the Division of Materials and Tests. If the Contractor is not required to remove the mixture, quality assurance adjustments of the lot will be assessed or other corrective actions as determined by the Division of Materials and Tests.

(a) Mixture

When test results for the mixture furnished exceeded the allowable tolerances, adjustment points will be assessed as follows:

Adjustment Points for Gradation								
Adjustment Points	Sieve Size							
	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	600 µm	75 µm
For each 0.1% up to 1.0% out of tolerance	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3
For each 0.1% above 1.0% out of tolerance	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.6

Gradation adjustment points for the lot shall be the sum of points calculated for up to 1% out of tolerance and the points calculated for greater than 1% out of tolerance in accordance with 410.09.

Binder content adjustment points for the lot shall be two points for each 0.1% above the tolerance or four points for each 0.1% below the tolerance in accordance with 410.09.

When test results for the mixture furnished exceed the allowable range in accordance with 410.09, adjustment points will be assessed as follows:

Adjustment Points for Range	
Sieve Size and Binder Content	Adjustment Points (For each 0.1% out of range)
No. 8 (2.36 mm)	0.1
No. 30 (600 μm)	0.1
No. 200 (75 μm)	0.1
%Binder	1.0

For mixtures produced during a certified HMA plant's adjustment period, adjustment points will not be assessed if the mixture produced is in accordance with the following:

1. The gradation complies with 410.05 with the allowable tolerance limits shown in 410.09.

2. The range for the binder content and gradation do not exceed the limits shown in 410.09.

3. The binder content is within the tolerance requirements of 410.09.

If the mixture is not in accordance with these requirements, adjustment points will be assessed in accordance with 410.09 for variations exceeding the requirements shown above.

(b) Density

When the density of the lot is outside the allowable tolerances, adjustment points will be assessed as follows:

Density	
Percentages are based on %MSG	Pay Adjustments, %
> 97.0	Submitted to the Division of Materials and Tests*
93.0 – 97.0	0.00
92.0 – 92.9	0.20 points for each 0.10% below 93.0
91.0 – 91.9	2.00 + 0.40 points for each 0.10% below 92.0

89.0 – 90.9	6.00 + 1.00 points for each 0.10% below 91.0
≤ 89.0	Submitted to the Division of Materials and Tests*
* Test results will be considered and adjudicated as a failed material in accordance with normal Department practice as listed in 105.03.	

410.20 Appeals

If the QC test results do not agree with the acceptance test results, a request, along with the QC test results, may be made in writing for additional testing. Additional testing may be requested for one or more of the following tests: binder content, gradation, or MSG of the mixture samples, and bulk specific gravity of the density cores. The request for the appeal for MSG, BSG of the density cores or binder content and gradation shall be submitted within seven calendar days of receipt of the Department's written results for that sublot. The sublot and specific tests shall be specified at the time of the appeal request. Only one appeal request per sublot is allowed. Once the appeal request has been granted, the Engineer will perform additional testing.

The appeal results will replace all previous test results for acceptance of mixture in accordance with 410.09 and density in accordance with 410.16. The results will be furnished to the Contractor. The backup mixture samples or density cores will be tested in accordance with the following:

(a) MSG

The backup MSG will be dried in accordance with ITM 572 and mass determined in water in accordance with AASHTO T 209.

(b) Binder Content and Gradation

The backup binder content and gradation sample will be prepared and tested in accordance with the test methods that were used for acceptance.

(c) BSG of the Density Core

Cores shall be taken within seven calendar days unless otherwise directed. Additional core locations will be determined by adding 1 ft longitudinally of the cores tested using the same transverse offset. The cores will be dried in accordance with ITM 572 and tested in accordance with AASHTO T 166, Method A or AASHTO T 331, if required. The Contractor shall clean, dry, and refill the core holes with SMA or HMA surface materials within one work day of the coring operations.

410.21 Method of Measurement

SMA mixtures will be measured by the ton of the type specified, in accordance with 109.01(b). The measured quantity will be divided by the MAF to determine the pay quantity.

Joint adhesive will be measured by the linear foot in accordance with 109.01(a).

410.22 Basis of Payment

The accepted quantities for this work will be paid for at the contract unit price per ton for QC/QA-HMA, of the type specified, – SMA, complete in place.

Payment for furnishing, calibrating, operating the inertial profiler, and furnishing IRI profile information will be made in accordance with 401.18.

Furnishing and operating the 16 ft straightedge shall be included in the cost of other pay items within this section.

Joint adhesive will be paid for by the linear foot, complete in place.

Adjustments to the contract payment with respect to mixture, density, and smoothness for mixture produced will be included in a quality assurance adjustment pay item. The unit price for this pay item will be $1.00 and the quantity will be in units of dollars. The quantity is the total calculated in accordance with 410.19. A change order *will be prepared to reflect contract adjustments* in accordance with 109.05.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Joint Adhesive, ____________ .... (course type)	LFT
QC/QA-HMA, _____, _____, _____, ______ mm, - SMA (ESAL[(1)])(PG[(2)])(Course[(3)])(Mix[(4)])	TON
Quality Assurance Adjustment	DOL

(1) ESAL Category as defined in 410.04
(2) Number represents the high temperature binder grade. Low temperature grades are - 22
(3) Surface or Intermediate
(4) Mixture Designation

Preparation of surfaces to be overlaid shall be included in the cost of other pay items within this section.

Coring and refilling of the pavement holes shall be included in the cost of other pay items within this section.

No payment will be made for additional anti-stripping additives, appeal coring or related traffic control expenditures for coring operations.

Corrections for pavement smoothness shall be included in the cost of other pay items within this section.

The price for inertial profiler, HMA will be full compensation regardless of how often the inertial profiler is used or how many files are produced.

DIVISION 900 – MATERIALS DETAILS

SECTION 902 – ASPHALT MATERIALS

902.01 Asphalt

Asphalt is defined as a cementitious material obtained from petroleum processes. Asphalts shall be sampled and tested in accordance with the applicable requirements of 902.02.

(a) Performance Graded Asphalt Binders

Performance graded asphalt binders shall be supplied by a supplier on the QPL of Performance-Graded Asphalt Binder Suppliers. A binder will be considered for inclusion on the QPL by following ITM 581.

Performance graded, PG asphalt binders shall be in accordance with the following:

GRADE	58-28	64-22	64-28	70-22	70-28	76-22
ORIGINAL BINDER						
Flash Point, minimum, °C	230					
Viscosity, maximum, 3 Pa·s, Test Temp, °C	135					
DSR, G*/sin δ (delta), minimum, 1.00 kPa, Test Temp. @ 10 rad/s, °C	58	64	64	70	70	76
ROLLING THIN-FILM OVEN RESIDUE						
Mass Loss, maximum, %	1.00					
DSR, G*/sin δ (delta), minimum, 2.20 kPa, Test Temp. @ 10 rad/s, °C	58	64	64	70	70	76
PRESSURE AGING VESSEL (PAV) RESIDUE						
PAV Aging Temperature, °C	100 (Note 1)					
DSR, G*sin δ (delta), maximum, 5,000 kPa, Test Temp. @ 10 rad/s, °C (Note 3)	19	25	22	28	25	31
Physical Hardening	Report (Note 2)					
Creep Stiffness, S, maximum, 300 MPa, m-value, minimum, 0.300, Test Temp. @ 60 s, °C	-18	-12	-18	-12	-18	-12
Notes: 1. Oven temperature tolerance shall be ±0.5°C. 2. Physical Hardening is performed on a set of asphalt beams according to AASHTO T 313, Section 12.1, except the conditioning time is extended to 24 h ±10 minutes at 10°C above the minimum performance temperature. The 24 h stiffness and m-value are reported for information purposes only. 3. Binders that have a G*sin δ (delta) of 5,001 to 6,000 Kpa will be considered acceptable if the phase angle is 42 degrees or greater.						

A PG 58-28 or PG 64-22 binder may be modified by in-line blending with styrene butadiene rubber, SBR, polymer latex at the HMA plant in accordance with ITM 581. A PG 58-28 may be modified to a PG 64-28 and a PG 64-22 may be modified to a PG 70-22.

A type A certification in accordance with 916 shall be provided for SBR polymer latex. The results of the following shall be shown on the certification.

Property	Requirements
Total Polymer Solids, % by weight	60 – 72
Butadiene, % by weight, min.	68
Residual Styrene, % by weight, max.	0.1
Ash, % of total polymer solids by weight, max.	3.5
pH	9 – 11
Viscosity, Brookfield model RVF, Spindle No. 2 @ 20 rpm @ 25°C, max.	2,000

The minimum SBR polymer latex content shall be 2.5 %. The SBR polymer latex content may be reduced below the minimum content provided, if the following requirements are met:

1. An AASHTO accredited laboratory shall blend the PG binder and SBR polymer latex at the proposed SBR polymer latex content and test and grade the modified PG binder in accordance with AASHTO M 320.

2. The laboratory test results verifying the blend and compliance with 902.01(a) shall be submitted to the Engineer for approval.

3. The source of the PG Binder or SBR polymer latex shall not be changed.

1. Sampling

An acceptance sample and backup sample shall be taken from the asphalt delivery system at the HMA plant. A copy of a load ticket identifying the binder source shall be submitted with the samples. The Engineer will take immediate possession of the samples.

2. PG Binder Testing

The Department will perform complete testing in accordance with AASHTO M 320. Complete PG binder testing will consist of RTFO DSR and PAV BBR testing. Rotational viscosity and flashpoint tests are not required. If the material is not in accordance with the specifications, the material will represent one week of HMA production and be adjudicated as a failed material in accordance with 105.03.

3. Appeals

If the Contractor does not agree with the acceptance test results, a request may be made in writing for additional testing. The appeal shall be submitted within 15 calendar days of receipt of the Department's written results. The basis of the appeal shall include complete AASHTO M 320 test results.

(b) Asphalt Emulsions

Asphalt emulsions shall be from a supplier listed on the QPL of Asphalt Emulsion

Suppliers. An emulsion will be considered for inclusion on the QPL by following ITM 593. Asphalt emulsions may contain additives to improve handling and performance characteristics. Failure of an emulsion to perform satisfactorily in the field shall be cause for rejection, even though it passes laboratory tests. The grade used shall be in accordance with the table for asphalt emulsions as shown herein. A type A certification in accordance with 916 shall be provided for the asphalt emulsion. The results of the tests listed in ITM 804 shall be shown on the certification.

The requirements for asphalt emulsions are as follows:

RS-2, HFRS-2, and SS-1h shall be in accordance with AASHTO M 140 except the cement mixing test is waived.

CRS-2P and HFRS-2P shall be in accordance with AASHTO M 316. The distillation temperature shall be 350°F.

CSS-1h shall be in accordance with AASHTO M 208.

1. Asphalt Emulsion Warranted Micro-Surfacing

The polymer modified asphalt emulsion shall be a quick-set, CSS-1h emulsion in accordance with AASHTO M 208 except the cement-mixing test is waived. The polymer material shall be milled or blended into the asphalt or blended into the emulsifier solution prior to the emulsification process. The minimum polymer solids content will be 3.0% based on the residual of the emulsion. Mix set additives shall be added as required to provide control of the quick-set properties. Additional requirements shall be in accordance with the following:

Characteristics	Test Method	Requirements
Residue by Distillation, % (Note)	AASHTO T 59	62+
Softening Point, °F (°C)	AASHTO T 53	140+ (60+)
Viscosity @ 140°F (60°C)	AASHTO T 202	8000+
Elastic Recovery @ 25°C (77°F), %	AASHTO T 301	60+
Note: The distillation temperature for this test shall be 350°F (175°C).		

2. Asphalt Emulsion Ultrathin Bonded Wearing Course

Characteristics		Test Method	Min.	Max.
Viscosity, Saybolt Furol @ 77°F (25°C), s		AASHTO T 59	20	100
Storage Stability Test, 24 h, % (Note 1)		AASHTO T 59		1
Sieve Test, %		AASHTO T 59		0.05
Residue by Distillation, % (Note 2)		AASHTO T 59	63	
Oil Distillate by volume of emulsified asphalt, %		AASHTO T 59		2
Demulsibility, %	w/35 mL, 0.02 N CaCl2 or	AASHTO T 59	60	
	w/35 mL, 0.8% DSS	AASHTO T 59		
Tests on Residue from Distillation				
Penetration (0.1 mm) at 77°F (25°C), 100g, 5 s		AASHTO T 49	90	150

Elastic Recovery @ 39°F (4°C), %	AASHTO T 301	58	
Notes: 1. After 24 h, the emulsion shall be a homogeneous color. 2. Except maximum temperature of 400 ±10°F (205 ±5°C).			

3. Asphalt Emulsion Recycling

Characteristics (Note 1)	Test Method	Min.	Max.
Viscosity, Saybolt Furol, @ 77°F (25°C), SFS	AASHTO T 59	20	100
Sieve Test, No. 20, retained on sieve, %	AASHTO T 59		0.10
Storage Stability Test, 24 hr, %	AASHTO T 59		1
Residue by Distillation, % (Note 2)	AASHTO T 59	64	
Oil Distillate by volume of emulsified asphalt, %	AASHTO T 59		1
Penetration, 77°F (25°C), 100 g, 5 s, dmm	AASHTO T 49	50	200
Notes: 1. The asphalt emulsion shall be selected for the project by the asphalt emulsion supplier based on the Contractor's mixture design. The penetration of the supplied asphalt emulsion shall be within ±25 dmm of the penetration of the design asphalt emulsion. The asphalt emulsion shall be received on the job site at a temperature no greater than 120ºF (50°C). 2. Modified AASHTO T 59 – distillation temperature of 350 ±9°F (175 ±5°C) with a 20-minute hold.			

4. Rapid Penetrating Emulsion, RPE

The asphalt material comprising the rapid penetrating emulsion shall be in accordance with the following:

Characteristics	Test Requirement	Test Method
Test on Emulsion		
Viscosity, Saybolt Furol at 25°C, max.	50	AASHTO T 59
Sieve Test, %, max.	0.10	AASHTO T 59
Oil Distillate by Volume of Emulsified Asphalt, %, max.	1.0	AASHTO T 59
Identification Test, %, min.	60	ITM 599
Water Resistance Test, %, min.	60	ITM 598
Residue by Distillation*, %, min.	30	AASHTO T 59
Test on Residue		
Penetration (0.1 mm) at 25C, 100g, 5s, max.	150	AASHTO T 49
Ash Content, %, max.	1.0	AASHTO T 111
Note: * The minimum sample size shall be 300g.		

Characteristics[1]	Test Method	AE-90		AE-90S		AE-NT		AE-F		AE-150		AE-PL	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Test on Emulsion													
Viscosity, Saybolt Furol at 25°C (77°F), s or Viscosity, Rotational Paddle at 25°C (77°F), mPa*s	AASHTO T 59					15 30	100 200		100 200	50 100			115 230
Viscosity, Saybolt Furol at 50°C (122°F), s or Viscosity, Rotational Paddle at 50°C (122°F), mPa*s	AASHTO T 59	50 100		50 100						75 150	300 600		
Demulsibility w/35 mL, 0.02N CaC1$_2$, %	AASHTO T 59			30									
Demulsibility w/50 mL, 0.10N CaC1$_2$, %	AASHTO T 59	75											
Oil Distillate by Distillation, mL/100 g Emulsion[2]	AASHTO T 59		4.0		3.0		4.0		4.0		7.0		3.0
Residue by Distillation, %	AASHTO T 59	65		65[4]		50		27	35	65		30	
Sieve Test, sample retained, %	AASHTO T 59		0.10		0.10		0.30		0.10		0.10		0.10
Penetrating Ability, mm	902.02(u)											6.0	
Stone Coating Test, %	902.02(r)3a	90								90			
Settlement, % (5 days)	AASHTO T 59		5.0				5.0						
Storage Stability, %	AASHTO T 59				1.0								
Tests on Residue													
Penetration (0.1 mm) at 25°C (77°F), 100g, 5 s[3]	AASHTO T 49	100	200	90	150		40		90				
Penetration (0.1 mm) at 25°C (77°F), 50g, 5 s[3]	AASHTO T 49									100	300		
Ductility at 25°C (77°F), mm	AASHTO T 51	400											
Ash Content, %	AASHTO T 111		1.0		1.0		1.0		1.0		1.0		1.0
Float Test at 60°C (140°F), s[3]	AASHTO T 50	1200		1200						1200			
Force Ratio	AASHTO T 300			0.30									
Elongation Recovery, at 4°C (39°F)	AASHTO T 301			58									

Notes:
(1) Broken samples or samples more than 14 days old will not be tested.
(2) Oil distillate shall be in accordance with ASTM D396, table 1, grade No. 1.
(3) The Engineer may waive the test.
(4) Maximum temperature to be held for 15 minutes at 350 ±9°F (175 ±5°C).

(c) Blank

(d) Utility Asphalt

The asphalts shall be uniform in character and shall not foam when heated to 350°F. Utility asphalts shall be in accordance with the following:

Characteristics/Grades	UA-I	UA-II	UA-III
Softening Point (Ring & Ball), °C	46 - 63	63 - 85	79.5 - 96
Penetration of Original Samples(1) (0.1 mm)			
at 4°C, 200 g, 60 s, min……	10	10	10
at 25°C, 100 g, 5 s…………	50 - 100	25 - 45	15 - 35
at 46°C, 50 g, 5 s…………..	100 min.	130 max.	90 max.
Ductility @ 25°C, 50 mm/min, 10 mm, min.(1)	30	10	2.5
Solubility in Organic Solvents, % min.(1)	99.0	99.0	99.0
Flash Point (Cleveland Open Cup), °C, min.(1)	225	225	225
Penetration of Residue from Thin Film Oven Test, 25°C, 100 g, 5 s, (0.1 mm) min.(1)	30	15	10
(1) Test will be performed when complete physical characteristics are needed or desired.			

A type A certification in accordance with 916 shall be provided for utility asphalt. The results of the above shall be shown on the certification.

(e) Asphalt for Coating Corrugated Metal Pipe

Asphalt for coating corrugated metal pipe shall be in accordance with the following:

Physical Properties	Min.	Max.
Softening Point (Ring & Ball), °C	93	110
Penetration of Original Samples (0.1 mm)		
at 4°C, 200 g, 60 s……..	20	
at 25°C, 100 g, 5 s……..	35(1)	
Solubility in Organic Solvents, %	99.0	
Flash Point (Cleveland Open Cup), °C	232	
Flow Test, mm		6.4
Shock Test	3 of 4 specimens shall pass	
(1) May be 30 minimum provided all four shock test specimens pass.		

A type A certification in accordance with 916 shall be provided for asphalt coating to the pipe fabricator on corrugated metal pipe. The results of the above shall be shown on the certification.

902.02 Sampling and Testing Asphalt Materials

The tests and AASHTO references are as follows:

(a) Sampling Bituminous Materials..............AASHTO R 66

The following exceptions to AASHTO R 66 shall apply:

1. Samples may be obtained at any time before material is incorporated into the work.

2. Samples for all grades of asphalt emulsion shall be a minimum of 1/2 gal. The size of samples of other liquid material may be 1 qt.

3. Samples of liquid materials shall be obtained at one of the following:

   a. bulk storage tanks from sampling valves located in the tank or line and asphalt plant storage tanks from sampling valves located in the tank
   b. transports from sampling valves
   c. distributors from valves
   d. other storage or locations as approved
   e. sampling by other recognized devices may be approved
   f. sampling valves beyond the in-line blending location.

(b) Water in petroleum products, except the solvent or carrier may be toluene..........................ASTM D95

(c) Density, Specific Gravity, or API Gravity of Crude Petroleum and Liquid Products by Hydrometer Method................................ASTM D1298

(d) Specific Gravity of Semi-Solid Bituminous Materials...AASHTO T 228

(e) Specific Gravity of Solid Pitch and Asphalt ASTM D71

(f) Flash Point (Open Cup)

1. When the flash point is higher than 175°F, "Flash Point by Cleveland Open Cup"........................AASHTO T 48

2. When the flash point is 175°F, or lower, "Flash Point with Tag Open Cup"..AASHTO T 79

(g) Softening Point of Bituminous Materials, Ring and Ball...AASHTO T 53

(h) Penetration of Bituminous Materials ....AASHTO T 49

(i) Loss of Heating ....ASTM D6

(j) Solubility in Organic Solvents, except the solvent may be 1,1,1,-Trichloroethane.....AASHTO T 44

(k) Inorganic Matter or Ash ....AASHTO T 59

(l) Saybolt-Furol Viscosity ....AASHTO T 72

(m) Ductility of Binder Material, except that the conditioning period of the specimens may be shortened, and that only one normal test will be required. Shortened conditioning period: The specimen shall be allowed to cool in air for at least 30 minutes. It shall then be trimmed and placed in the water bath for a period of 60 to 90 minutes before testing. In case of failure or dispute, three normal tests will be required and specimens shall be conditioned as in AASHTO T 51.

(n) Float Test for Bituminous Materials ....AASHTO T 50

(o) Kinematic Viscosity of Asphalts.............AASHTO T 201

(p) Absolute Viscosity of Asphalts................AASHTO T 202

(q) Effect of Heat and Air on Asphalt Materials,
Thin-Film Oven Test................................AASHTO T 179

(r) Effect of Heat and Air on a Moving Film of
Asphalt, Rolling Thin Film Oven Test.....AASHTO T 240

(s) Testing Asphalt Emulsions ....AASHTO T 59

The following exceptions to AASHTO T 59 shall apply:

1. For the Residue by Distillation test, the specified aluminum alloy still shall be the referee still.

2. When tests on the residue are not required, the % of residue for emulsion grades RS-2 and AE-90 only, may be determined by the Residue by Evaporation test of AASHTO T 59. The % of residue shall be determined by the Residue of Distillation test in all cases of failure or dispute.

3. The stone coating test shall be performed as follows on a mixture of 465 ±1 g of reference stone and 35.0 ±0.1 g of asphalt emulsion:

   a. For AE-90 the mixture of stone and asphalt shall be mixed vigorously for 5 minutes. At the end of the mixing period, the mix shall be rinsed by running sufficient tap water at the side of the container to completely immerse the mix. The tap water shall then be poured off and the rinsing step repeated as necessary until the rinse water pours off essentially clear. The stone shall remain a minimum of 90% coated.

b. For AE-150 the mixture of stone and asphalt shall be mixed vigorously for 5 minutes and then allowed to stand for 3 h. At the end of this time, the mixture shall again be mixed vigorously for 5 minutes. At the end of the mixing period, the mix shall be rinsed by running sufficient tap water at the side of the container to completely immerse the mix. The tap water shall then be poured off and the rinsing step repeated as necessary until the rinse water pours off essentially clear. The stone shall remain a minimum of 90% coated.

4. For the Demulsibility test, normally only one test will be required. In case of failure or dispute, the specified procedure in AASHTO T 59 will be followed.

5. For oil portion from Residue by Distillation, report the number of milliliters of oil per 100 g of emulsion.

(t) Stripping tests for HMA mixtures using binder materials, with or without additives, shall be performed as follows:

1. **Test 1.** A sample of produced mixture, 500 g, minimum, shall be obtained for testing. The size of test specimen and the amount of distilled water shall be:

Approximate Size of Aggregate	Minimum Weight of Test Specimen	Amount of Distilled Water
Sand	100 g	400 mL
12	100 g	400 mL
11	150 g	600 mL
9	200 g	600 mL

Place the specimen in the boiling distilled water and stir with a glass rod at the rate of one revolution per second for 3 minutes. The aggregate shall retain a minimum of 90% of its asphalt film compared with the remainder of the sample, upon completion of this procedure.

2. **Test 2**. Approximately 500 g of produced mixture shall be heated to 250°F in a laboratory oven for 2 h; stirred and cooled to 200°F. Then a portion of the mix shall be placed in boiling distilled water, quantity of mix and quantity of boiling water shall be as specified in Test 1, and stirred with a glass rod at the rate of one revolution per second for 3 minutes. The aggregate shall retain a minimum of 90% of its asphalt film compared with the remainder of the sample, upon completion of this procedure.

Note: The purpose of these tests is to determine the relative compatibility of the aggregate and asphalt, and to detect tendency of

Asphalt Emulsions to re-emulsify. Test 2 may be performed as a method of determining whether compatibility can be achieved, Test 1 having given unsatisfactory results.

(u) Penetrating Ability of AE-PL.

1. Apparatus and Equipment:

   a. Sand mixture:

      (1) Dry Ottawa Sand (AASHTO T 106)...90 parts

      (2) Dry Reference Limestone Dust, portion passing No. 50 (300 mm) sieve only.
      Reference Limestone Dust used by the Department is Limestone Calcium Carbonate manufactured by France Stone Co. The Department will furnish approximately 5 lb of Reference Limestone Dust upon request. 10 parts

      (3) Water..3 parts

   b. Container, 6 oz ointment tin

   c. Ruler or other measuring device

   d. Timing device readable in seconds

   e. Compacting Device. Rimac Spring Tester or other device suitable for compacting sand by applying a 20 psi load. The compacting device shall include an adapter consisting of two metal discs slightly smaller in diameter than a 6 oz ointment tin separated by a spacer 1 to 2 in. The 2.54 in. diameter discs used in determining weight of coating in AASHTO T 65 or ASTM A90 are satisfactory.

   f. Small, square ended spatula or putty knife

2. Procedure:
   Thoroughly mix Standard Ottawa Sand, Reference Limestone Dust, and water. Weigh 190 ±1 g of sand mixture into a 6 oz ointment tin. Level surface of sand with a spatula. Place the compacting adapter on the sand surface and slowly, over a period of about 5 s, compact the sand until the 20 psi load is achieved, which is approximately 100 lb on the Rimac Spring Tester. Remove the compacting device, avoiding disturbance to the sand surface. Quickly pour 12 g of the emulsion from a height of about 4 in. onto top of sand mixture. Start timer at start of pour. Stop timer when all emulsion penetrates into sand mixture. Delay 2 minutes then remove sand and mixture from one side of ointment tin, about 1/2 of mixture. Measure to determine average depth of penetration into sand

mixture. Penetration time shall be 100 s or less; penetration depth shall be 6.0 mm or more.

(v) Flow Test for Asphalt for Coating Corrugated Metal Pipe .... AASHTO M 190

(w) Shock Test for Asphalt for Coating Corrugated Metal Pipe .... AASHTO M 190

(x) Viscosity Determinations of Asphalt Binder Using Rotational Viscometer .... AASHTO T 316

(y) Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer ... AASHTO T 315

(z) Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel.............................. AASHTO R 28

(aa) Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer .... AASHTO T 313

902.03 Application Temperatures

Binder materials for the several applications indicated in the specifications shall be applied at temperatures not to exceed those shown in the following:

Type and Grade of Material	Maximum Application Temperature, °F	
	Spray	Mix
MC-70, MCA-70	150	
MC-250, MCA-250	225	200
MC-800, MCA-800	250	225
MC-3000, MCA-3000	275	250
SC-70, SCA-70..	200	
SC-250, SCA-250..	225	225
SC-800-3000, SCA-800-3000	250	250
All Emulsions	160	180
All Penetration and Viscosity, Utility and Pipe Coating	350	325
PG Binders	(see Note)	(see Note)
Note: In accordance with manufacturer’s recommendations.		

SECTION 904 – AGGREGATES

904.01 Aggregates

Aggregates shall consist of natural or manufactured materials produced from but not limited to limestone, dolomite, gravels, sandstones, steel furnace slag, SF, air-cooled blast furnace slag, ACBF, granulated blast furnace, GBF, wet bottom boiler slag, or other geologic rock types approved by the Engineer.

A source will not be considered for acceptance of material until a preliminary investigation has been made. As part of this investigation, samples will be obtained and tests conducted to determine the quality and classification of the aggregates in accordance with ITM 203.

Two types of samples are required for the preliminary investigation: ledge samples for crushed stone sources and production samples for crushed stone, natural sand and gravel, and slag sources.

Ledge samples will be obtained from bedrock units as they naturally occur in the proposed working face of the quarry. Ledges will be identified, at a minimum, by their differences in color, texture, and geological formation.

Production samples will be obtained from stockpiles of finished materials.

Aggregates, except those used for precast concrete units or fine aggregates used for snow and ice abrasive, shall be supplied by a Certified Aggregate Producer in accordance with 917. Structure backfill may be obtained from a non-CAPP source in accordance with 211.02. SF for SMA mixtures shall also require the following.

(a) Specific gravity quality control tests shall be completed at a frequency of one test per 2,000 t produced.

(b) Target bulk specific gravity shall be established using the average of the first four tests.

(c) Subsequent individual tests shall be within 0.050 of the target bulk specific gravity.

(d) Moving average of four consecutive tests shall be within 0.040 of the target bulk specific gravity.

(e) Tests outside these ranges shall require the material to be isolated from the approved stockpile until action has been taken to eliminate the cause of the non-conformity. Any non-conforming test shall be followed immediately by a corrective action. Corrective actions shall include, but are not limited to, investigation for assignable cause, correction of known assignable cause, and retesting.

(f) If it is determined that a new target is necessary, a request shall be made in writing to the District Testing Engineer to establish the new target.

Dolomite aggregates are defined as carbonate rock containing at least 10.3% elemental magnesium when tested in accordance with ITM 205.

Polish resistant aggregates are defined as those aggregates in accordance with ITM 214. Aggregates meeting these requirements will be maintained on the QPL of Polish Resistant

Aggregate Sources.

Sandstone aggregates shall only be used in HMA surface or SMA surface mixtures. Sandstone aggregates are defined as a sedimentary rock composed of siliceous sandgrains containing quartz, chert, and quartzose rock fragments in a carbonate matrix or cemented with silica, calcite, or dolomite. The Department's Division of Materials and Tests will determine identification of sandstone.

Steel furnace slag, SF, may be used in aggregate shoulders, HMA surface or SMA surface mixtures, dumped riprap, and snow and ice abrasives. SF slag coarse aggregate may be used in HMA base and HMA intermediate mixtures if the deleterious content is less than 4.0% when tested in accordance with ITM 219. RAP with steel slag may be used in accordance with 401.06, 402.08, and 410.06.

Adjustments in weight shall be made to compensate for the difference in specific gravity of slag compared to natural aggregate when payment is on a weight basis. The following typical values for specific gravity will be used: natural aggregate both fine and coarse, 2.6; ACBF slag coarse aggregate, 2.3; ACBF slag fine aggregate, 2.6; GBF slag fine aggregate, 2.1; and SF slag both fine and coarse, 3.4. The contract quantity shall not be adjusted on any pay item less than 500 t.

When slag is furnished as an aggregate, the approximate quantity of tons to be supplied will be determined by multiplying the pay item quantity of tons by the specific gravity of slag divided by 2.6. The adjusted contract quantities will be determined by multiplying the accepted quantity of tons by 2.6 divided by the specific gravity of the slag.

At time of use, aggregates shall be free from lumps or crusts of hardened or frozen materials.

Composite stockpiling of natural sand fine aggregate from multiple sources into one stockpile will be allowed provided the fine aggregates are within a range of 0.030 for the bulk specific gravity (dry) and a range of 0.5% for the absorption. The range of bulk specific gravity (dry) and absorption values shall be the difference between the average values for each of the fine aggregate sources within the stockpile as determined by the Department's Division of Materials and Tests. A written request for the composite stockpiling shall be made to the Department's Division of Materials and Tests.

904.02 Fine Aggregates

Fine aggregates are defined as 100% passing the 3/8 in. (9.5 mm) sieve and a minimum of 80% passing the No. 4 (4.75 mm) sieve. Characteristics of fine aggregates are as follows:

Characteristic	PCC	HMA	SMA
Physical Organic Impurities, AASHTO T 21 lighter than or equal to, Color Standard (Note 1)…. Acid Insoluble, ITM 202…………………………	3	(Note 2)	
Soundness			

Freeze and Thaw, AASHTO T 103, Procedure A, % max. (Note 3)………………….	10.0 12.0	10.0 12.0	10.0 12.0
Brine Freeze and Thaw, ITM 209, % max. (Note 3)	10.0	10.0	10.0
Sodium Sulfate Soundness, AASHTO T 104, % max. (Note 3)…………………			

Notes:

1. When subjected to the colormetric test for organic impurities and a color darker than the standard is produced, it shall be tested for effect of organic impurities on strength of mortar in accordance with AASHTO T 71. If the relative strength at seven days is less than 95% it shall be rejected.

2. The fine aggregate, including blended fine aggregate, used in HMA Surface 4.75 mm mixtures shall have a minimum acid-insoluble content of 40%, except when using ACBF or GBF slag sands, the minimum acid-insoluble content shall be 25%. Acid-insoluble requirements shall not apply to crushed gravel, limestone, or dolomite sands.

3. AASHTO T 104 and ITM 209 may be run at the option of the Engineer, in-lieu of AASHTO T 103.

(a) For Portland Cement Concrete

Fine aggregate for use in PCCP or bridge decks shall be natural sand. Fine aggregate for other PCC shall be natural sand or crushed limestone, dolomite, gravel, or ACBF.

Natural sand which has been used as foundry sand when tested in accordance with ITM 215, and complying with IDEM Class III or Class IV in accordance with 329 IAC 10-7-4 may be used in precast concrete units or precast concrete pipe. When foundry sand is used, the precast concrete manufacturer shall maintain a copy of the Waste Classification issued by IDEM and an indemnification statement shall accompany the precast items to each contract.

(b) For HMA Mixtures

Fine aggregates for use in HMA shall be natural sand or crushed limestone, dolomite, gravel, sandstone, SF, or ACBF. SF sand may be used in HMA surface mixtures. SF sand may only be used in HMA base and HMA intermediate mixtures if SF in accordance with 904.01 is used to produce the SF sand. The amount of crushed limestone sand shall not exceed 20% by volume of the total aggregate used in HMA surface mixtures with ESAL equal to or greater than 3,000,000, except limestone sands manufactured from aggregates on the QPL of Polish Resistant Aggregate Sources will not be limited. If soundness testing cannot be conducted, the aggregate shall come from a Category I source in accordance with ITM 203.

The fine aggregate angularity value of the total blended aggregate material from the fine and coarse aggregates, and recycled materials shall meet or exceed the minimum values for the appropriate ESAL category and position within the pavement structure as follows:

Fine Aggregate Angularity		
Traffic ESAL	Depth from Surface	
	≤ 4 in.	> 4 in.
< 3,000,000	40*	40
3,000,000 to < 10,000,000	45	40
≥ 10,000,000	45	40
* For 4.75 mm mixtures, the fine aggregate angularity shall be 45 for < 3,000,000 ESAL.		

Fine Aggregate Angularity, Method A ....AASHTO T 304

The fine aggregate angularity value shall not apply to OG mixtures.

(c) For SMA Mixtures

Fine aggregate for SMA shall be limestone, dolomite, crushed gravel, SF, or ACBF. Crushed gravels shall have a minimum fine aggregate angularity of 45 in accordance with AASHTO T 304, Method A. Fine aggregates shall be non-plastic in accordance with AASHTO T 90.

(d) For Pneumatically Placed Mortar

Fine aggregate shall be natural sand suitable for use with a pneumatic cement gun. Fine aggregate shall be size No. 15, or size PP in accordance with 904.02(h), or an approved gradation from a CAPP source.

(e) Mortar Sand

Fine aggregate for mortar shall consist of uniformly graded natural sand in accordance with gradation requirements of 904.02(h) for size No. 15 or an approved gradation from a CAPP source.

(f) Mineral Filler for SMA

Mineral filler shall consist of dust produced by crushing stone, portland cement, or other inert mineral matter having similar characteristics. Mineral filler shall be in accordance with the gradation requirements of 904.02(h) for size No. 16 or as approved by the Engineer. Mineral filler shall be in accordance with ITM 203 or from an ACBF slag source. The sieve analysis of mineral filler shall be conducted in accordance with AASHTO T 37 except as noted in 904.07. Mineral filler shall be non-plastic in accordance with AASHTO T 90.

(g) Snow and Ice Abrasives

Snow and ice abrasives shall be fine aggregates or cinders in accordance with the gradation requirements of 904.02(h) for size S&I.

When steel slag is used for snow and ice abrasives, and payment is on a tonnage basis, the pay quantity shall be adjusted in accordance with 904.01.

(h) Sizes of Fine Aggregates

Sizes (Percent Passing)						
Sieve Sizes	23	24	15	16	PP	S&I
3/8 in. (9.5 mm)	100	100				100
No. 4 (4.75 mm)	95 - 100	95 - 100			100	
No. 6 (3.35 mm)			100			
No. 8 (2.36 mm)	80 - 100	70 - 100	90 - 100		85 - 95	
No. 16 (1.18 mm)	50 - 85	40 - 80				
No. 30 (600 µm)	25 - 60	20 - 60	50 - 75	100	50 - 65	
No. 50 (300 µm)	5 - 30	7 - 40	15 - 40		15 - 25	0 - 30
No. 80 (180 µm)				95 - 100		
No. 100 (150 µm)	0 - 10	1 - 20	0 - 10		0 - 10	
No. 200 (75 µm)	0 - 3	0 - 6	0 - 3	65 - 100		0 - 7

(i) Sampling and Testing

Sampling and testing shall be conducted in accordance with the following AASHTO and ITMs.

Acid Insoluble Content ....ITM 202
Amount of Material Finer than
No. 200 (75 µm) Sieve* ....AASHTO T 11
Brine Freeze and Thaw Soundness ....ITM 209
Control Procedures for Classification
of Aggregates ....ITM 203
Determining the Plastic Limit and
Plasticity Index of Soils ....AASHTO T 90
Mortar Strength..AASHTO T 71
Organic Impurities ....AASHTO T 21
Sampling Aggregates ....AASHTO T 2
Sampling Stockpiled Aggregates.........................ITM 207
Sieve Analysis of Aggregate*..............................AASHTO T 27
Sieve Analysis of Mineral Filler* ....AASHTO T 37
Soundness* ....AASHTO T 103,
AASHTO T 104
Specific Gravity and Absorption, Fine Aggregate AASHTO T 84
* Except as noted in 904.07.

904.03 Coarse Aggregates

Coarse aggregates are defined as having a minimum of 20% retained on the No. 4 (4.75 mm) sieve. Coarse aggregates shall not contain adherent fines that are detrimental to the end product as defined in ITM 211.

The coarse aggregate shall comply with the quality requirements and the additional requirements in accordance with 904.03(a). However, coarse aggregate may be rejected based on previous performance service records. Class AP is defined as the highest classification and Class F the lowest. Blending of material for compliance with gradation or crushed particle requirements may be approved when requested in writing. Blending of aggregate products to improve the quality classification of the finished product will not be allowed.

(a) Classification of Aggregates

Characteristic Classes	AP	AS	A	B	C	D	E	F
Quality Requirements:								
Freeze and Thaw Beam Expansion, % max. (Note 1)	.060							
Los Angeles Abrasion, % max. (Note 2)...........	40.0	30.0	40.0	40.0	45.0	45.0	50.0	
Freeze and Thaw, AASHTO T 103, Procedure A, % max. (Note 3)...	12.0	12.0	12.0	12.0	16.0	16.0	20.0	25.0
Sodium Sulfate Soundness, % max. (Note 3)....	12.0	12.0	12.0	12.0	16.0	16.0	20.0	25.0
Brine Freeze and Thaw Soundness, % max. (Note 3)	30	30	30	30	40	40	50	60
Absorption, % max. (Note 4)............................	5.0	5.0	5.0	5.0	5.0			
Additional Requirements:								
Deleterious, % max.								
Clay Lumps and Friable Particles.........	1.0	1.0	1.0	1.0	2.0	4.0		
Non-Durable (Note 5)...........................	4.0	2.0	4.0	4.0	6.0	8.0		
Coke...					(See Note 6)			
Iron...					(See Note 6)			
Chert (Note 7).......................................	3.0	3.0	3.0	5.0	8.0	10.0		
Weight per Cubic Foot for Slag, lb, min.	75.0		75.0	75.0	70.0	70.0	70.0	
Crushed Particles, % min. (Note 8)								
Compacted Aggregates....................................			20.0	20.0	20.0	20.0		

Notes:

1. Freeze and thaw beam expansion shall be tested and re-tested in accordance with ITM 210.
2. Los Angeles abrasion requirements shall not apply to BF.
3. Aggregates may, at the option of the Engineer, be accepted by the Sodium Sulfate Soundness or Brine Freeze and Thaw Soundness requirements.

4. Absorption requirements apply only to aggregates used in PCC and HMA mixtures except they shall not apply to BF. When crushed stone coarse aggregates from Category I sources consist of production from ledges whose absorptions differ by more than two percentage points, the absorption test will be performed every three months on each size of material proposed for use in PCC or HMA mixtures. Materials having absorption values between 5.0 and 6.0 that pass AP testing may be used in PCC. If variations in absorption preclude satisfactory production of PCC or HMA mixtures, independent stockpiles of materials will be sampled, tested, and approved prior to use.

5. Non-durable particles include soft particles as determined by ITM 206 and other particles which are structurally weak, such as soft sandstone, shale, limonite concretions, coal, weathered schist, cemented gravel, ocher, shells, wood, or other objectionable material. Determination of non-durable particles shall be made from the total weight (mass) of material retained on the 3/8 in. (9.5 mm) sieve. Scratch Hardness Test shall not apply to crushed stone coarse aggregate.

6. ACBF and SF coarse aggregate shall be free of objectionable amounts of coke, iron, and lime agglomerates.

7. The bulk specific gravity of chert shall be based on the saturated surface dry condition. The amount of chert less than 2.45 bulk specific gravity shall be determined on the total weight (mass) of material retained on the 3/8 in. (9.5 mm) sieve for sizes 2 through 8, 43, 53, and 73 and on the total weight (mass) of material retained on the No. 4 (4.75 mm) sieve for sizes 9, 11, 12, and 91.

8. Crushed particle requirements apply to gravel coarse aggregates used in compacted aggregates. Determination of crushed particles shall be made from the weight (mass) of material retained on the No. 4 (4.75 mm) sieve in accordance with ASTM D5821.

(b) Coarse Aggregate Angularity for HMA and SMA

The coarse aggregate angularity, CAA of the total blended aggregate, including recycled materials, shall meet or exceed the minimum values for the appropriate ESAL category and position within the pavement structure as follows.

Coarse Aggregate Angularity		
Traffic ESAL	Depth from Surface	
	≤ 4 in.	> 4 in.
< 3,000,000	75	50
3,000,000 to < 10,000,000	85/80*	60
≥ 10,000,000	95/90*	95/90*
* Denotes two faced crush requirements.		

For SMA mixtures, the total blended aggregate shall be 100% one face and 95% two face crushed.

Coarse Aggregate Angularity ....ASTM D5821

Coarse aggregate angularity requirements do not apply to 4.75 mm HMA mixture designation.

(c) Flat and Elongated

The coarse aggregate shall contain 10% or less flat and elongated particles. A flat and elongated piece is defined as a particle having a ratio of length to thickness greater than 5. Determination of flat and elongated particles shall be made from the weight (mass) of material retained on the 3/8 in. (9.5 mm) sieve and each sieve size greater than the 3/8 in. (9.5 mm) sieve.

Flat and Elongated ....ASTM D4791

Flat and elongated requirements do not apply to 4.75 mm HMA mixture designation.

(d) Surface Aggregate Requirements

The surface mixture aggregates selection shall be based on the ESAL category as follows.

1. HMA Coarse Aggregate

a. ESAL Category 2 and type B surface mixtures. All coarse aggregate types including ACBF slag, SF slag, sandstone, crushed dolomite, polish resistant aggregate, crushed stone and gravel may be used.

b. ESAL Category 3 and type C surface mixtures. ACBF slag, SF slag, sandstone, crushed dolomite, polish resistant aggregate or any combination thereof shall be used. Crushed stone or gravel shall not be used unless the aggregate is classified as a crushed dolomite or polish resistant aggregate.

c. ESAL Category 4 and type D surface mixtures. High friction aggregates including ACBF slag, SF slag, sandstone or aggregates in accordance with ITM 221 shall be used and at a minimum shall comprise 50% by volume of the coarse aggregate.

Crushed dolomite and polish resistant aggregates may be used up to a maximum 50% by volume of the coarse aggregate material retained on the No. 4 (4.75 mm) sieve when blended with a high friction aggregate.

Crushed stone and gravel may be used up to a maximum 20% by volume of the coarse aggregate material retained on the No. 4 (4.75 mm) sieve when blended with a high friction aggregate.

2. SMA Coarse Aggregate

SF slag, sandstone, crushed dolomite and polish resistant aggregates in accordance with 904.03(a) may be used in SMA mixtures provided the mixtures are designed in accordance with ITM 220.

(e) Sizes of Coarse Aggregates

Sieve Sizes	Coarse Aggregate Sizes (Percent Passing)											
	Coarse Graded										Dense Graded	
	2	5	8	9	11, SC 11[5]	12, SC 12[5]	SC 16[5]	43[1]	91	93PG[6]	53[1]	73[1]
4 in. (100 mm)												
3 1/2 in. (90 mm)												
2 1/2 in. (63 mm)	100											
2 in. (50 mm)	80 - 100											
1 1/2 in. (37.5 mm)		100						100			100	
1 in. (25 mm)	0 - 25	85 - 98	100					70 - 90	100		80 - 100	100
3/4 in. (19 mm)	0 - 10	60 - 85	75 - 95	100				50 - 70			70 - 90	90 - 100
1/2 in. (12.5 mm)	0 - 7	30 - 60	40 - 70	60 - 85	100	100	100	35 - 50		98 - 100	55 - 80	60 - 90
3/8 in. (9.5 mm)		15 - 45	20 - 50	30 - 60	75 - 95	95 - 100	94 - 100			75 - 100		
No. 4 (4.75 mm)		0 - 15	0 - 15	0 - 15	10 - 30	50 - 80	15 - 45	20 - 40		10 - 60	35 - 60	35 - 60
No. 8 (2.36 mm)		0 - 10	0 - 10	0 - 10	0 - 10	0 - 35		15 - 35		0 - 15	25 - 50	
No. 16 (1.18 mm)							0 - 4					
No. 30 (600 µm)						0 - 4		5 - 20		0 - 5	12 - 30	12 - 30
No. 200 (75 µm)[2]								0 - 6.0			5.0 - 13.0[4]	5.0 - 12.0
Decant (PCC)[3]		0 - 1.5	0 - 1.5	0 - 1.5	0 - 1.5	0 - 1.5			0 - 1.5			
Decant (Non-PCC)	0 - 2.5	0 - 2.5	0 - 3.0	0 - 2.5	0 - 2.5	0 - 2.0			0 - 2.5	0 -2.0		
Decant (SC)					0 - 1.5	0 - 1.5	0 - 1.5					

Notes: (1) The liquid limit shall not exceed 25 (35 if slag) and the plasticity index shall not exceed 5. The liquid limit shall be determined in accordance with AASHTO T 89 and the plasticity index in accordance with AASHTO T 90.

(2) Includes the total amount passing the No. 200 (75 µm) sieve as determined by AASHTO T 11 and AASHTO T 27.

(3) Decant may be 0 - 2.5 for stone and slag.

(4) When slag is used for separation layers as defined in 302.01, the total amount passing the No. 200 (75 µm) sieve shall be 10.0 to 12.0.

[5] Seal coat (SC) aggregates shall be 85% one face and 80% two face crushed. The Flakiness Index in accordance with ITM 224 shall be a maximum of 25%.

[6] Pea gravel shall be generally uncrushed gravel, with a maximum of 20% crushed particles, and shall meet the gradation requirements of 93PG. Determination of crushed particles shall be made from the weight (mass) of material retained on the No. 4 (4.75 mm) sieve in accordance with ASTM D5821.

(f) Sampling and Testing

Sampling and testing will be in accordance with the following AASHTO, ASTM, and ITMs.

Amount of Material finer than No. 200 (75 µm) Sieve*	AASHTO T 11
Brine Freeze and Thaw Soundness	ITM 209
Clay Lumps and Friable Particles	AASHTO T 112
Control Procedures for Classification of Aggregates	ITM 203
Crushed Particles	ASTM D5821
Dolomite Aggregates	ITM 205
Flat and Elongated Particles	ASTM D4791
Freeze and Thaw Beam Expansion	ITM 210
Lightweight Pieces in Aggregates*	AASHTO T 113
Los Angeles Abrasion	AASHTO T 96
Micro-Deval Abrasion	AASHTO T 327
Polished Resistant Aggregates	ITM 214
Sampling Aggregates*	AASHTO T 2
Sampling Stockpiled Aggregates	ITM 207
Scratch Hardness	ITM 206
Sieve Analysis*	AASHTO T 27
Soundness*	AASHTO T 103, AASHTO T 104
Specific Gravity and Absorption*	AASHTO T 85
Unit Weight and Voids in Aggregates	AASHTO T 19

*Except as noted in 904.07

904.04 Riprap

Riprap shall consist of SF for dumped riprap only, sound stone, stone masonry, or other approved material, free from structural defects and of approved quality. Stone containing shale, unsound sandstone, or other material that will disintegrate readily, shall not be used.

(a) Dumped Riprap

Dumped riprap shall be broken concrete, masonry, or stone removed from an old structure; broken pieces removed from concrete pavement, base, or monolithic brick pavement; or broken rock from class X, class Y, unclassified excavation, or solid rock excavation. Material provided from sources outside the right-of-way shall be coarse aggregate, Class F or higher.

(b) Grouted Riprap

Grouted riprap material shall be in accordance with dumped riprap or revetment riprap.

(c) Revetment, Class 1, and Class 2 Riprap

The material shall be coarse aggregate, Class F or higher. Gradation shall be in accordance with 904.04(f).

(d) Uniform Riprap

The material shall be coarse aggregate, Class F or higher in accordance with 904.03(a). Gradation shall be in accordance with 904.04(f). Either type A or type B may be utilized.

(e) Precast Concrete Riprap

Precast concrete riprap shall consist of unreinforced concrete units of the thickness specified and shall be in accordance with the details shown on the plans. The precast concrete units shall be in accordance with ASTM C139 except the fine aggregates shall be in accordance with 904.02(a) and the coarse aggregates, class A or higher, shall be in accordance with 904.03. The minimum compressive strength shall be 2,500 psi for an average of three units and 2,300 psi for individual units. The maximum water absorption shall be 12 lb/cu ft for an average of three units.

(f) Sizes of Riprap

Gradation Requirements					
Percent Smaller					
Size, in.	Revetment	Class 1	Class 2	Uniform A	Uniform B
30			100		
24		100	85 - 100		
18	100	85 - 100	60 - 80		
12	90 - 100	35 - 50	20 - 40		
8				100	
6	20 - 40	10 - 30	0 - 20	35 - 80	95 - 100
3	0 - 10	0 - 10	0 - 10		35 - 80
1				0 - 20	0 - 20
Depth of Riprap, min.	18 in.	24 in.	30 in.		

The maximum dimension of individual pieces shall not be greater than three times the minimum dimension *and no dimension shall exceed the maximum size listed for the respective size of riprap*. The riprap will be visually inspected for size, shape, and consistency.

904.05 Structure Backfill

The material shall be of acceptable quality, free from large or frozen lumps, wood, or other extraneous matter. It shall consist of suitable sand, gravel, crushed stone, ACBF, or GBF. Structure backfill shall be in accordance with one of the gradations shown in the table below, or coarse aggregate No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, or No. 73 in accordance with the gradation requirements of 904.03(e). Coarse aggregate No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, or No. 73 shall be crushed stone or ACBF, class D or higher.

Sieve Sizes	Nominal Sizes and % Passing					
	2 in. (50 mm)	1 1/2 in. (37.5 mm)	1 in. (25.0 mm)	1/2 in. (12.5 mm)	No. 4 (4.75 mm)	No. 30 (600 µm)
2 1/2 in. (63 mm)	100					
2 in. (50 mm)	90 - 100	100				
1 1/2 in. (37.5 mm)	70 - 100	90 - 100	100	100		
1 in. (25.0 mm)	55 - 95	70 - 100	85 - 100			
3/4 in. (19.0 mm)	45 - 90	55 - 95	70 - 100			
1/2 in. (12.5 mm)	35 - 85	40 - 90	55 - 95	85 - 100	100	100
No. 4 (4.75 mm)	20 - 65	20 - 70	25 - 75	45 - 85	90 - 100	
No. 8 (2.36 mm)	10 - 50	10 - 55	15 - 60	25 - 75	75 - 100	
No. 30 (600 µm)	3 - 35	3 - 35	3 - 35	5 - 45	15 - 70	70 - 100
No. 200 (75 µm)	0 - 8	0 - 8	0 - 8	0 - 8	0 - 8	0 - 8

904.06 B Borrow

The material used for special filling shall be of acceptable quality, free from large or frozen lumps, wood, or other extraneous matter and shall be known as B borrow. It shall consist of suitable sand, gravel, or crushed stone ACBF, GBF, or other approved material. The material shall contain no more than 10% passing the No. 200 (75 µm) sieve and shall be otherwise suitably graded. The ratio of the fraction passing the No. 200 (75 µm) sieve to the fraction retained on the No. 30 (600 µm) sieve shall not exceed one-fifth. The use of an essentially one-size material will not be allowed unless approved. B borrow containing greater than 3% by dry weight organic material will not allowed.

Sieve analysis and organic material will be performed in accordance with AASHTO T 11 and AASHTO T 267.

904.07 Exceptions to AASHTO Standard Methods

(a) Exceptions to AASHTO T 2

Stockpile sampling shall be in accordance with ITM 207, unless otherwise approved.

(b) Exceptions to AASHTO T 11, T 27, and T 37

1. When tests are performed in the field where ovens are not available, test samples may be dried in suitable containers over open flame or electric hot plates with sufficient stirring to prevent overheating, then cooled to constant weight.

2. The balance shall be a Class G2 general purpose balance in accordance with AASHTO M 231.

(c) Exceptions to AASHTO T 27 for Coarse Aggregates

The size of test samples for coarse aggregate shall be as follows:

Aggregate Size	Minimum Weight of Test Sample
No. 2	25 lb
No 5, 8, 43, 53, 73, and 91	13 - 18 lb
No. 9	9 - 13 lb
Structure Backfill	
2 in. (50 mm)	25 lb
1 1/2 in. (37.5 mm) and 1 in. (25.0 mm)	13 - 18 lb
1/2 in. (12.5 mm)	9 - 13 lb
No. 4 (4.75 mm) and No. 30 (600 µm)	10 oz

(d) Exceptions to AASHTO T 85

The in-water weight shall be determined following the 15 h soaking period prior to determining the SSD weight.

(e) Exceptions to AASHTO T 103 and T 104

1. Counting the number of individual particles coarser than the 3/4 in. (19.0 mm) sieve will not be required.

2. For testing ledge rock, the ledge samples shall be crushed to obtain test samples for the designated increments passing the 1 1/2 in. (37.5 mm) sieve and retained on the No. 4 (4.75 mm) sieve. The factors used to calculate the weighted average loss are 30%, 40%, and 30% of the 1 1/2 in. (37.5 mm) - 3/4 in. (19.0 mm), 3/4 in. (19.0 mm) - 3/8 in. (9.5 mm), and 3/8 in. (9.5 mm) - No. 4 (4.75 mm) increments, respectively.

3. In the case of ledge rock, modify sections 3.3 and 6.2 of AASHTO T 103 and AASHTO T 104 respectively. When the sample received is deficient in material of a component size of any test portion, that material will be supplemented with the available component size to provide the test portion.

4. Modify section 8 of AASHTO T 103 and section 10 of AASHTO T 104. For materials designated as a coarse aggregate, the weighted loss will be calculated considering the material retained on the No. 4 (4.75 mm) sieve as 100% of the sample, and only the total weighted loss reported. In AASHTO T 104 sections 10.1.3.2 and 10.1.3.3 shall not apply, and unless otherwise noted only new solution will be used.