INDOT's Revised HMA Specifications for 2017

APAI Mix Design Workshop

December 2, 2016

Primary Spec Changes and Potential Pitfalls

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Main 401 Issues of Concern…

- 4 hours of short-term aging
- % BR reduction in allowable maximum
- Dust/Eff AC and Volume of Eff AC (**QC & QA**)
- Change in PF formula for < 90 to ≥ 50 PWL
- VMA PF increased from 10% to 35%
- VMA minimum increased for 100.0% pay
- Change in appeals process

4 Hours Short-Term Aging (401.05)

- **Increased short-term aging in mix design to 4 hrs**:
  - Applies to T 283 also
  - Requires **full re-design** for any **existing** mixes (**402 included**)
- Will increase AC absorption relative to where we've been:
  - Impact ***primarily*** a function of the **aggregate blend water abs**
  - Higher water absorption (> 2.5%) blends affected more
  - AC grade may play a role (neat vs. modified)
  - May want to evaluate multiple Gmm's at various hours
- INDOT plans to hold **all 401 mix samples** (contracts let on or after 10-1-2016) in the oven a minimum of 4 hours
- ***How will INDOT age mix samples from projects let prior to 10-1-2016?...***

4 Hours Short-Term Aging (401.05)

- If contractor chooses to short-term age pay samples, results should compare better with INDOT, but:
  - Test turnaround for QC results will be delayed
  - Test completion/coordination may be challenging
- If contractor doesn't short-term age pay samples, difference in aging will contribute to differences with INDOT:
  - Be sure to consider this when evaluating a sample you're considering submitting an appeal on!
  - Not aging may increase variability in Gmb and Gmm results relative to INDOT, making it more difficult to establish an offset

Max Binder Replacement (401.06)

- **MAX % BR for <u>ALL</u> mixes reduced to 25%**
- MAX % BR from **RAS** for ALL mixes reduced to 15% **<u>AND</u>** 3.0% MAX by weight of mix (SMA mixes also)
- Potential ***advantages*** relative to other spec changes:
  - Min VMA increased
  - VMA pay factor increased
  - Dust/Eff AC and Volume of Eff AC requirements (QC)
  - Each of these changes will require **improved** control of the aggregate structure. Recycle ***generally*** contributes a large portion of the -200 material. Reducing recycle should help achieve a higher field VMA value and help reduce dust.

Dust/Effective AC (401.09)

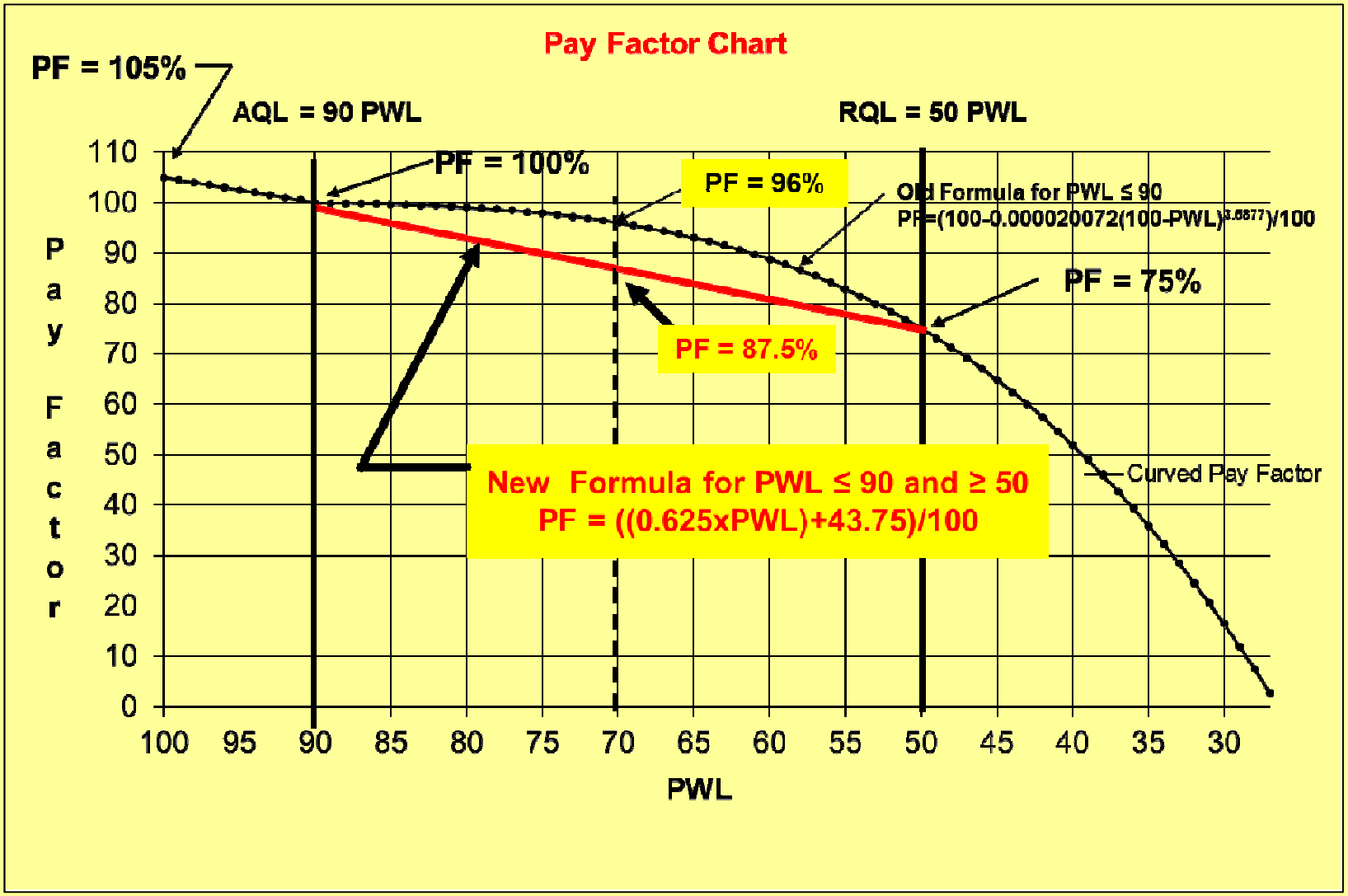
- **Now 1.4 Max in Design and Production**
- **"*The dust/calculated effective binder ratio and the volume of effective binder in the mixture will be determined and reported from the acceptance sample testing conducted in each sublot.*"**
- Dust/Eff AC Ratio:
  - If **>** 1.4 "***…take action in accordance with ITM 583…***"
- For 2017, INDOT to use Ignition Oven, **except for Pilot Projects**
- INDOT to perform decant gradation on **ALL** QA samples:
  - Potential degradation of agg (including -200) with use of Ignition Oven on some agg sources – impact on Dust/Eff AC?

Effective AC Volume (401.09)

- **Volume of Eff AC ≥ Spec Min VMA-4.0% Voids**
- Volume of Eff AC = **VMA-Voids**
- When QC value is **<** than Spec Min VMA-4.0% Voids "***…take action in accordance with ITM 583…***"
- Example for a 9.5mm NMAS QC pay plate sample:
  - VMA = 15.4% and Voids = 4.6%
  - QC Volume of Eff AC = 15.4%-4.6% = 10.8%
  - Minimum acceptable Volume of Eff AC = 15.0%-4.0% = 11.0%
  - Sample requires action, since 10.8% is < 11.0%

PF **Equation** for **PWL ≥ 50 to ≤ 90**
401 Mix ≥ 1 Lot (401.19)

- **PF equation for PWL ≥ 50 to ≤ 90 now a "straight line" equation vs. curved**
- Old equation:
  $PF = (100.00 - 0.000020072 \times (100.00\text{-}PWL)^{3.5877}) / 100$
- **New equation:**
  PF = ((0.625 x PWL) + 43.75)/100
- **Results in a greater reduction in pay for PWL values in this range as compared to old equation!**


Pay Factor Chart
PF = 105%
AQL = 90 PWL
RQL = 50 PWL
PF = 100%
PF = 96%
Old Formula for PWL ≤ 90
PF=(100-0.000020072(100-PWL)^3.8877)/100
PF = 75%
PF = 87.5%
New Formula for PWL ≤ 90 and ≥ 50
PF = ((0.625xPWL)+43.75)/100
Curved Pay Factor
Pay Factor
110
100
90
80
70
60
50
40
30
20
10
0
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30
PWL

VMA Pay Factor ***Increased*** (401.19)

- **New** PF = 30% Voids + **35% VMA** + 35% density
- AC removed as a PF in D-G mixes, but it still has to be:
  - Determined for calculating VMA
  - Reported for comparison to INDOT AC result
- **Increase** in VMA **PF** requires **improved** VMA control:
  - Dan's slides included graphs showing acceptable standard deviation of VMA under current spec vs. needed reduction in standard deviation of VMA under new spec
  - We'll discuss VMA variability more later…

VMA Minimum ***Increased*** (401.19)

- **VMA minimum for 100.0% pay increased to Spec Min**
- 401 Mix **≥ 1 Lot**:
  - VMA spec limits (LSL and USL):
    - LSL **increased** to spec minimum
    - USL = **spec min + 2.0%**
- 401 Mix **< 1 Lot**:
  - See changes to VMA pay factors in table on next slide:
    - Penalty for being < spec min
    - Penalty for being > 1.5% above spec min
    - Values adjudicated as failed material:
      - VMA more than 2.5% > spec min, or
      - VMA more than 2.5% < spec min
- We'll talk more about **increasing** VMA later…

VMA		
Dense Graded Deviation from Spec Minimum	Open Graded Deviation from Spec Minimum	Pay Factor
> + 2.5		Submitted to the Office of Materials Management*
> + 2.0 and ≤ + 2.5		0.25
> + 1.5 and ≤ + 2.0		0.65
> + 0.5 and ≤ + 1.5		1.05
≥ 0.0 and ≤ + 0.5	All	1.00
≥ - 0.5 and < 0.0		0.85
≥ - 1.0 and < - 0.5		0.65
≥ - 1.5 and < - 1.0		0.45
≥ - 2.0 and < - 1.5		0.25
≥ - 2.5 and < - 2.0		0.00
< - 2.5		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.		

Change in **Appeals** Process (401.20)

- **Tolerances established that must be exceeded to appeal:**
  - Binder Content **0.25**
  - MSG, BSG Gyratory and BSG Core **0.010**
  - If the difference between QA and QC tests are within the tolerance shown above, **NO appeal will be allowed**

- ***"A $500.00 credit adjustment will be included in a quality adjustment pay item in accordance with 109.05.1 (e) for each appealed sublot that did not result in an improvement to the SCPF or Lot PF."***

Change in **Appeals** Process (401.20)

- "The request for the appeal of a sublot shall be submitted within seven calendar days of receipt of the Department's written results for the sublot."
- This applies to PWL and QC/QA, so as it stands, we have to appeal a given PWL sublot within seven days of receiving the results, even if we don't have ALL results for the entire lot.
- **However, INDOT removed this requirement from the proposed specification for the 2017 Pilot Projects. Therefore, Industry and APAI needs to pursue this same adjustment for ALL 2017 projects, including those let on or after 10-1-2016.**

Change in **Appeals** Process (401.20)

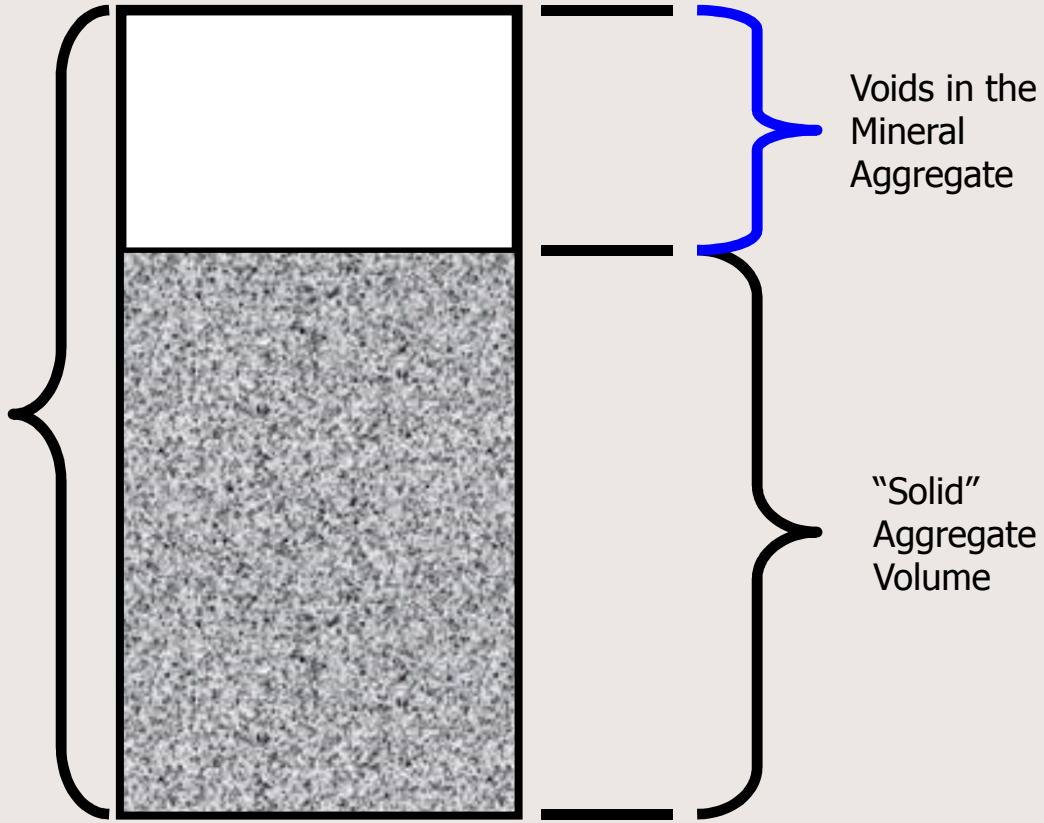
- If an appeal is allowed:
  - Result will be used in **ALL** calculations (same as now)
  - Backup sample will be tested in accordance with the applicable test method for the sublot requested ***for all tests exceeding the sublot standard deviation (tolerance) criteria*****:**
    - Example:
      If the difference in AC is 0.34% and we appeal, but we're good with INDOT's Gmm even though it is 0.014 different than our Gmm value, INDOT will re-test AC and Gmm since both exceed the allowable difference (0.25% and 0.010, respectively).


Let's Talk VMA

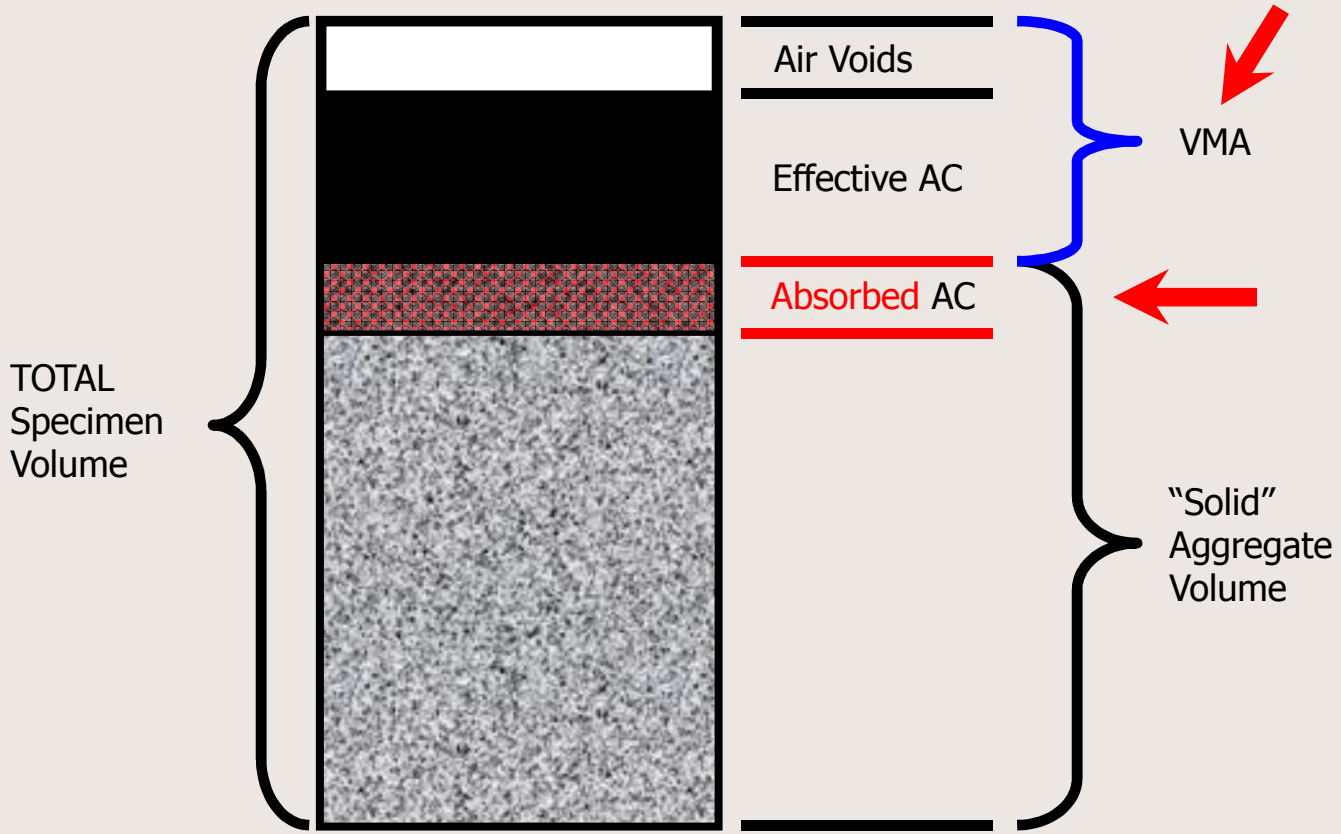
Why Is **VMA** Important?

- Essential Asphalt Mix Properties:
  - Stability
  - Durability
- **VMA** promotes **durability** by providing adequate room between the aggregate particles for AC and Voids

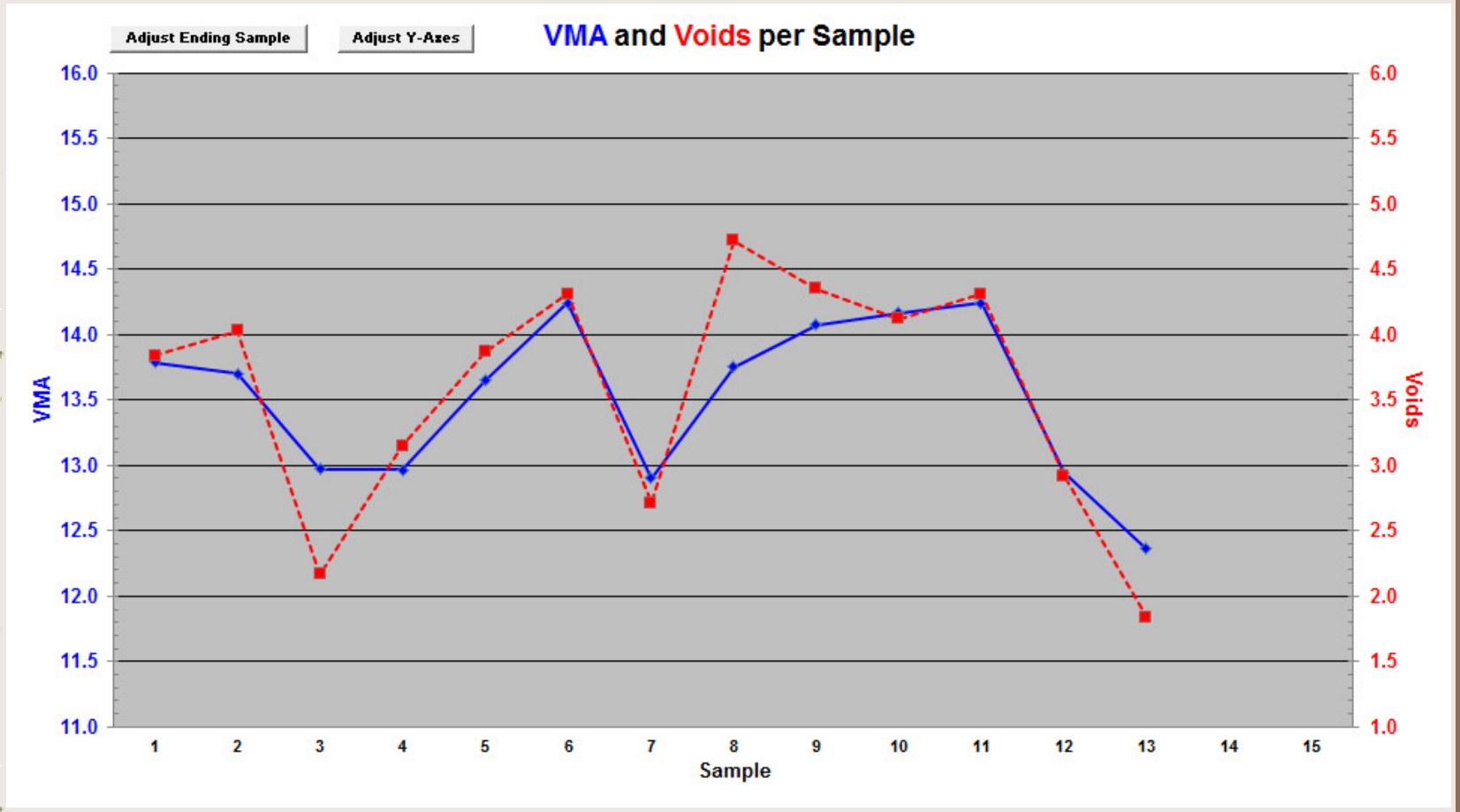
VMA Is All About the **Aggregate**!



VMA = Voids + Effective AC

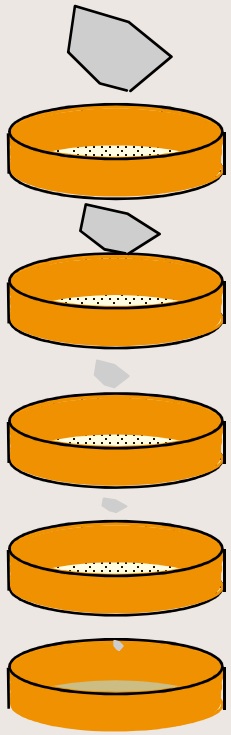


VMA *drives Air Voids*



What Drives **VMA**?

- Gradation
- Shape
- Texture
- Strength



Gradation

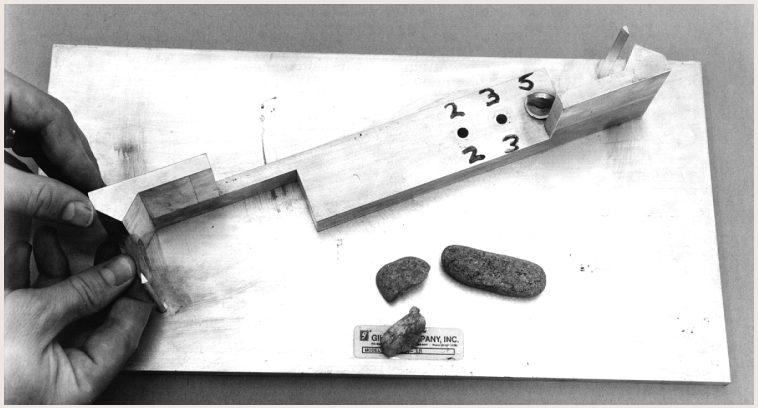
- **Predominant factor** in aggregate packing (**VMA**)
- Overall blend gradation influences mix **sensitivity** to gradation fluctuations:
  - **Sensitivity impacts consistency!**

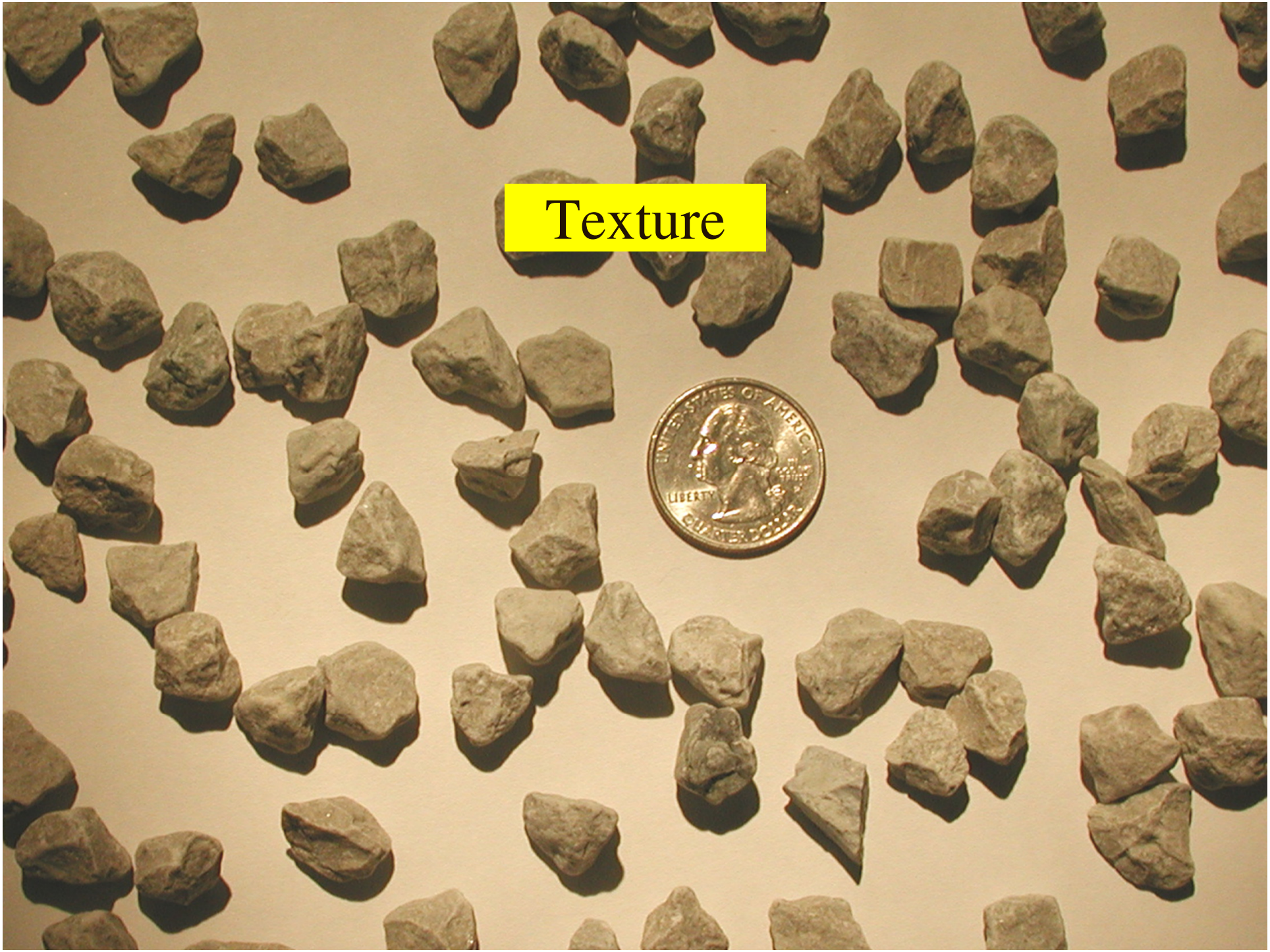
Gradation

- Mix size impacts influence of a given product
- Product amount in a mix impacts its influence

Shape

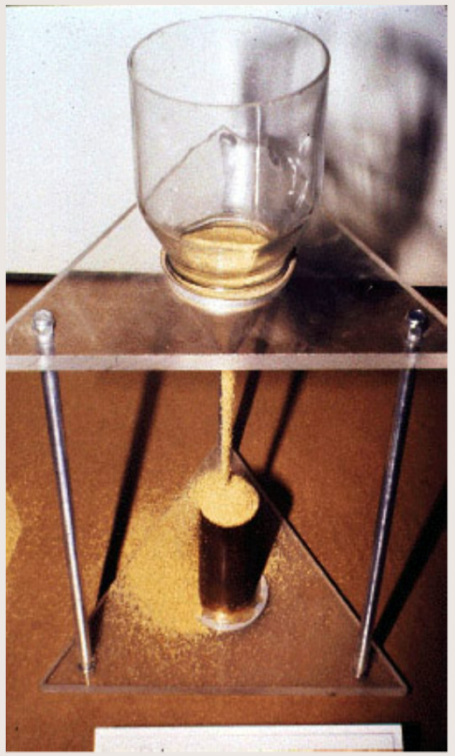
- Round, Cubical, or Flat and Elongated
- Influences aggregate packing (**VMA**)




Texture

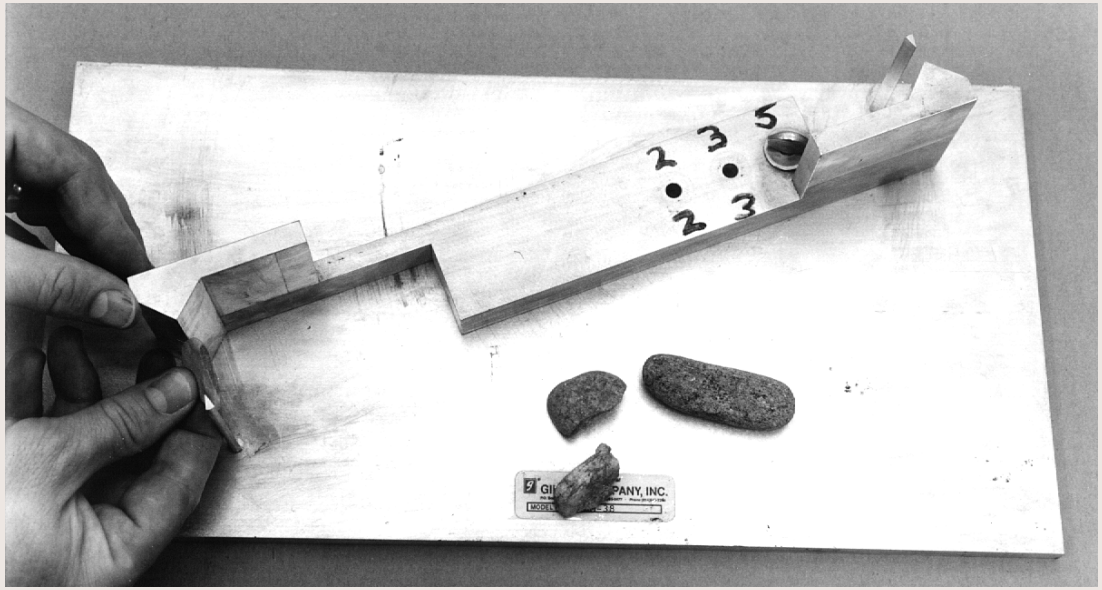
Fine Aggregate Angularity

- **Method A**:
  - **Fixed** Gradation
  - Measures **Loose** Voids that are a function of **Shape and Texture**
- **Natural** 37 – 44%
- **Manufactured** 42 – 52%
- Increase FAA can help VMA, especially if strength of the fine aggregate is sufficient



Strength

- Related to G_{sb} from a <u>given</u> aggregate source
- **<u>Significantly</u>** influenced by particle **SHAPE**



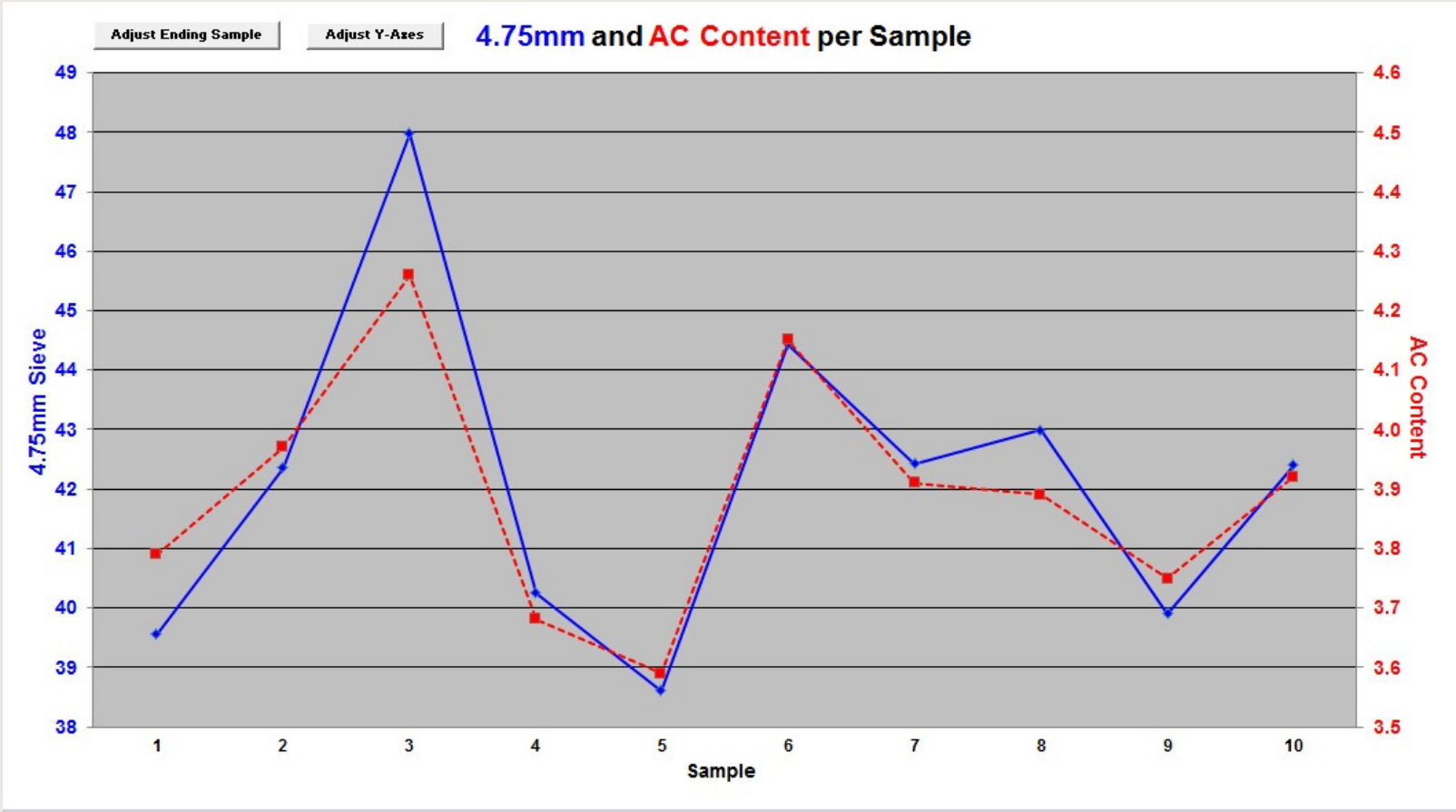
How Can You **Increase** VMA?

- **Gradation**:
  - Add/increase 11's and/or 12's
  - Use/increase manufactured sand vs. natural sand
  - Reduce -200 (pretty much 1:1)
    - Request cleaner products
    - Waste dust
  - Reduce recycle?
- **Shape**:
  - Increase angularity (CA and/or FA)
- **Texture**:
  - Use manufactured vs. natural products
  - Other available products with better micro-texture?
- **Strength**:
  - Available products and corresponding quality?
  - Strength is influenced by particle **shape**

How to Improve VMA **Consistency**

- Communicate with your agg suppliers:
  - Consistency of gradation, shape, strength, texture and Gsb
  - Share results regularly
- Consistent (BEST) practices at the plant and on the road
- Obtain ***representative*** mix samples
- Handle and test mix samples accurately, consistently, with knowledgeable personnel using properly calibrated and maintained equipment

Watch For **Segregated** Mix Samples!



Main 402 Issues

402 Changes

- 402.04 Design Mix Formula
  - References 401.04, which in turn references 401.05
  - Increased short-term aging **in mix design** from 2 to **4 hrs**:
    - Applies to T 283 also
    - Requires **full re-design** for any **existing** mixes
- 402.06 Job Mix Formula (**Now BLANK**):
  - JMF removed
  - AC "target" for 402 mixes will be the **DMF** AC:
    - The AC "target" is **not** adjustable
    - Plant (truck sample) results must be +/- 0.7% from the **DMF** AC

Main 410 Issues

410 – SMA

- 410.05 SMA Mix Design
  - ITM 220 (Degradation on PCS in SMA) reference added
  - Design gyrations **reduced** from 100 to 75
  - Short-term aging time increased to **4 hours**
    - Includes mix for T 283 as well
    - Requires **full re-design** for any **existing** mixes
  - Δ Pb required to be $\leq$ 0.20%
  - VMA criteria **adjusted** for 12.5mm NMAS (**16.0%**)

410 – SMA

- 410.05 SMA Mix Design
  - Gradation control limits:
    - Now by **weight**, **no longer by volume**
    - 12.5mm NMAS upper limits adjusted on 9.5mm, 4.75mm and 2.36mm sieves:
      - 9.5mm – was max of 85.0%, now 80.0%
      - 4.75mm – was max of 40.0%, now 35.0%
      - 2.36mm – was max of 28.0%, now 24.0%
    - Modified to allow minimal amount of oversize material from **SMA** RAP material (see note beneath table)

410 – SMA

- 410.06 Recycled Materials
  - Allows use of SMA RAP back into SMA:
    - "*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*: (see SMA RAP GRADATION table).
    - Use of SMA RAP impacts SMA mix gradation control bands and allowable gradation of the SMA RAP
    - Allowing use of SMA RAP to reduce the need for virgin CA
    - Note requirement to have INDOT sample and test SMA RAP per ITM 590 and provide Gsb

410 – SMA

- 410.08 **J**ob **M**ix **F**ormula (**JMF**)
  - **Maintained** for SMA because gradation and AC are still **targets** during production
    - Includes allowance of a combined blend Gsb change associated with reporting and targeting ingredient %'s different than DMF
  - **Note binder content target for JMF can only be adjusted +/- 0.3% from the DMF AC**
- 410.14 Spreading and Finishing
  - Wording added to allow use of oscillation with oscillatory rollers but prohibits use of vertical impact force

Main 414 Issues

414 – UTBWC

- 414.03 Design Mix Formula
  - **JMF** removed
  - Requires mix design to be performed by lab approved by INDOT
  - Now includes requirement to report gradation, combined blend Gsb, MSG and BSG
  - Wording added to require MSG to be determined by AASHTO T 209 and BSG by AASHTO T 331
  - **Increased short-term aging in mix design to 4 hrs**

Other Spec Changes

Other Revisions to Std Specs (904.03)

- SMA CA to comply with **AS** aggregate classification
- CA angularity table revised:
  - ESAL categories adjusted to reflect removal of category 1 and 5 mixes
  - CA angularity for mix at > 4 in. depth from surface changed to 95/90
- HMA CA table removed and replaced with various wording to explain allowable CA aggregate types relative to ESAL category
  - Note addition at end: "***Crushed stone and gravel may be used up to a maximum 20% by volume of material retained on the No. 4 (4.75 mm) sieve when blended with a high friction aggregate.***"

Other Revisions to Std Specs (904.03)

- SMA CA table removed and replaced with "*SF slag, sandstone, cr dolo and polish resistant aggs in accordance with 904.03 (a) may be used in SMA mixtures provided the mixture is designed in accordance with ITM 220.*"
- HMA CA (Surface Agg Requirements):
  - Note 1 under table revised by adding sentence "*When also blended with cr stn or grvl, the comb aggs cannot exceed 50% of the ca by weight when blended with ACBF or sandstone or cannot exceed 40% of the ca by weight when blended with steel furnace slag.*"
  - Note 2 under table revised to "*Aggregates* in accordance with ITM 221 may be used."
  - Note 3 added under table "*Cr stn or grvl may be used when blended with ACBF or sandstone but cannot exceed 20% of the ca by weight or cannot exceed 15% of the ca by weight when blended with steel furnace slag.*"


ITM changes

ITM **580**-16T

(Sampling HMA) Revised 9/21/16

- 7.1.1 Plate Samples – Minimum plate sample weights increased for 9.5, 12.5, 19.0 and 25.0 mm plates for use in determining MSG and Binder Content to keep all plates the same size, especially since a 5th plate is being added (**ALL PROJECTS**) to obtain additional mix in case combined blend Gsb determination is required of the extracted aggregate when deemed necessary relative to Gse falling outside the +/- 0.020 control limits (field Gse vs. design Gse, **Pilot Projects only**).

- 9.0 Documentation – Now spells out what information is to be provided on each plate sample container and that it shall be on the **ENDS** of boxes that are being used

ITM **590**-16T

(Gsb Determination from Extracted Aggregate) Revised 4/26/16

- "***The test method covers the procedure to determine the total aggregate bulk specific gravity value from extracted HMA mixture.***"
  - Applicable to all HMA mix samples, regardless of where they are obtained, including the use of cores for forensic testing?
- Doesn't state the type of extraction fluid INDOT intends to use, but we believe it to be trichloroethylene (**TCE**) or similar, which should minimize the amount of non-extractable AC

ITM **590**-16T

(Gsb Determination from Extracted Aggregate) Revised 4/26/16

- Not sure how many comparisons INDOT has made of resulting Gsb values from lab-batched samples that were extracted with different solvents, including citrus based
- Fluid type ***may*** play a role in the Gsb results determined from the extracted aggregate

ITM **590**-16T

(Gsb Determination from Extracted Aggregate) Revised 4/26/16

- This is the ITM INDOT will reference/follow whenever they determine a field Gsb on extracted aggregate (i.e. **Pilot Projects**)
- Eventually, Contractors will/may need the ability (inside or outside their organization) to have this done in order to determine results in a timelier manner than INDOT may be able to provide
- In that scenario, it will be imperative those results accurately ***predict*** the Gsb INDOT will eventually provide

ITM **591**-16T

(Δ Pb Determination) Revised 4/26/16

- "***This test method covers the procedure to determine the delta Pb, (Δ Pb), 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.***"

ITM **591**-16T

(Δ Pb Determination) Revised 4/26/16

- Pba estimated is shown relative to the combined blend water absorption:
  - **50%** of water abs, when water abs combined is **< 1.25%**
  - **65%** of water abs, when water abs combined is **≥ 1.25% but ≤ 2.50%**
  - **80%** of water abs, when water abs combined is **> 2.50%**
  - **Water abs value of 1.0% used for RAP, RAS, Baghouse Fines and Mineral Filler**

ITM **591**-16T

(Δ Pb Determination) Revised 4/26/16

- Pba, relative to past mix designs, will likely increase due to **4 hours** of short-term aging:
  - When design Pba results are ***significantly*** different than those suggested (previous slide), Gsb determination of the actual ingredient materials used during the design should be considered
  - Other issues impact Pba as well, such as porosity of the aggregate particles, mix temperature, time the mix is held at temperature, AC grade and the ***accuracy*** of the corresponding MSG (Gmm), **especially when the supplemental procedure (i.e. dry back) is being utilized or should be utilized**

ITM **802**-16P

(Random Sampling) Revised 4/26/16

- A3 plate added for **ALL PROJECTS**
- For the **Pilot Projects**, the A3 plate will be used by INDOT if mixture must be extracted for Gsb determination (function of field Gse vs. design Gse tolerance issue)
- "***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.***"

ITM **802**-16P

(Random Sampling) Revised 4/26/16

- Plate layout diagram adjusted to reflect A3 plate addition
- Not sure how INDOT intends to address obtaining extra mix needed (potentially) for Gsb testing when it involves 4.75 mm NMAS mixes that allow samples to be obtained somewhere other than plates

Main Changes to INDOT Directives

Directive **303**

(Plate Sample Prep and SGC Fabrication) Revised 9/2/16

- ***4 hours of short-term aging on pay plate samples being implemented by INDOT on ALL PROJECTS in 2017:***
  - ***Short-term aging NOT required by Contractors***
  - ***INDOT unsure at this time regarding INDOT aging plate samples from projects let prior to 10/1/2016, where mix designs utilized 2 hrs of short-term aging***
- ***A3 plate required on ALL PROJECTS in 2017***

2017 Pilot Projects

Pilot Projects (401.09)

- A **test strip** will be required for each DMF (401 mix):
  - If done on site, acceptable test strip to be completed within first 300 tons of 1-1
  - Can be off site (and ahead of time) with INDOT's involvement
  - Specs written to allow INDOT **10 business days** to turnaround results, primarily for combined blend aggregate Gsb

Pilot Projects (401.09)

- INDOT plans to **extract** mix sample from test strip (or mix made prior to start of initial placement of a given DMF), recover the aggregate and determine a combined blend aggregate Gsb to verify the DMF Gsb

- If the resulting Gsb is ≤ +/- 0.010 of the DMF Gsb, the DMF Gsb will be used for calculating VMA

- If the resulting Gsb is > +/- 0.010 from the DMF Gsb, another sample will be extracted (test strip or 1-1), Gsb determined and the two Gsb values averaged for use in VMA calculation

Pilot Projects (401.09)

- INDOT also plans to determine Gse of the test strip sample (or mix made prior to start of initial placement of a given DMF) to verify the DMF Gse
- If the resulting Gse is ≤ +/- 0.010 of the DMF Gse, the DMF Gse will be used to establish the target and the resulting +/- 0.020 control limits
- If the resulting Gse is > 0.010 from the DMF Gse, another Gse will be determined from a second mix sample (test strip or 1-1), and the two Gse values averaged to establish the target and the resulting +/- 0.020 control limits

Pilot Projects (401.09)

- **Field Gse** will be determined for each sublot sample and compared to DESIGN Gse
- Several things impact Gse, such as:
  - Time for oven aging/sample reheating
  - AC content determination and
  - Gmm determination
- There may be an ***offset*** between QC and QA Gse results
- The intent of Gse monitoring is to readily identify potential changes/shifts in the combined blend aggregate Gsb

Pilot Projects (401.09)

- Contractors **may** need to short-term age their Gmm to:
  - To better compare with the design and/or INDOT, and
  - To reduce variability in their Gse results, allowing them to more easily recognize when Gse is moving as a function of aggregate Gsb and not due to variation in Pba
- Contractors **may** also need to short-term age their Gmb samples
  - To better compare with the design and/or INDOT, and
  - To reduce variability in their Gmb results
- **But…be careful with highly absorptive aggregate blends relative to production and placement issues**

Pilot Projects (401.09)

- If two consecutive INDOT Gse values are outside +/- 0.020 (**and both in the same direction**), INDOT will extract mix, recover aggregate and determine Gsb for each of the two sublots:
  - Resulting average Gsb from extracted aggregate will be used for VMA calculation (i.e. pay) of the two sublot samples in question and all mix going forward
  - The two corresponding Gse values will also be averaged and used as the new target and to establish new +/- 0.020 control limits, until such time that INDOT's pay plate data requires another investigation and potential change in Gsb and Gse

Pilot Projects (401.09)

- INDOT plans to utilize Centrifuge Extractions with TCE (Trichloroethylene):
  - Does not appear non-extr AC will be accounted for on **Pilot** Projects
- INDOT to perform decant gradation on **ALL** QA samples:
  - Potential difference in degradation of agg (including -200) vs. use of Ign Oven on some agg sources, and impact on Dust/Eff AC?

Pilot Projects (401.20)

Wording **changed** for **2017 Pilot Projects** to allow entire lot to be evaluated before having to make decision on whether or not to appeal

401.20 Appeals

The 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: