COST SAVING RECOMMENDATIONS FOR I-69

September 25, 2009

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Purpose

The purpose of this paper is to present suggestions for reducing the construction cost of an asphalt pavement for I-69 without compromising the integrity of the design. The following items will be addressed:

- Staged construction – potential savings of $700,000 per mile
- Subgrade Treatment – potential savings of $200,000 per mile
- Inside shoulder – potential savings of $109,000 per mile
- Reduced pavement thickness for inside (passing) lane – potential savings of $125,000 per mile.
- Other Questions from Commissioner Reed

Staged Pavement Construction

For new construction or reconstruction hot mix asphalt can be constructed in stages. Part of the final pavement thickness can be constructed at the time of initial construction. Ten to fifteen years later an additional thickness can be added to provide the final, ultimate pavement thickness.

- Design* pavement thickness using normal design for 20 years of traffic.
  - Design for Year 20 traffic requires about 14 inches of asphalt pavement.
- Since traffic will be low in early years and grow in the future asphalt pavement can be designed and built as staged construction.
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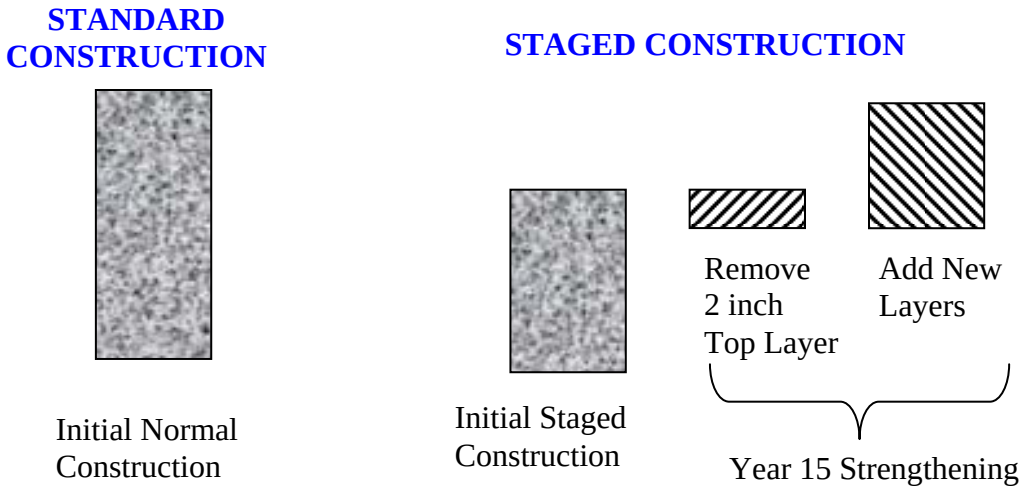
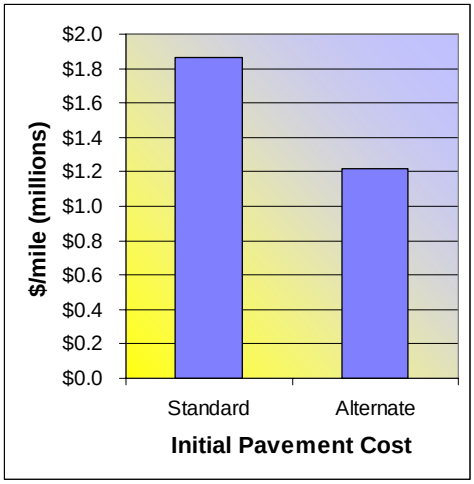
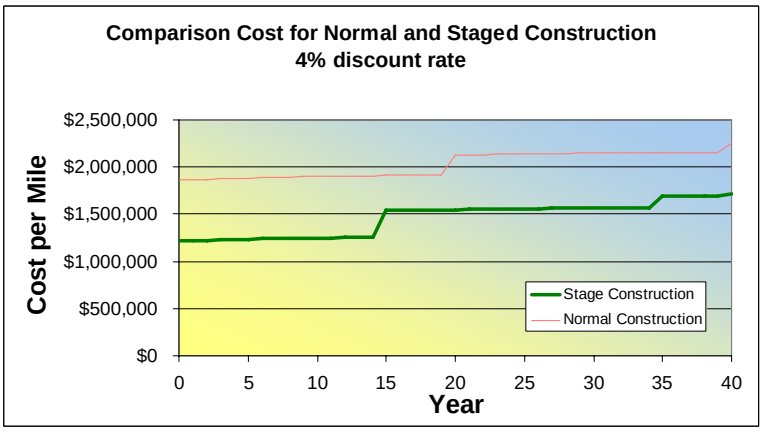


*Pavement design will be per the FHWA Mechanistic Empirical Pavement Design Guide as used by INDOT.

- Strengthen pavement in future as traffic increases. As traffic volumes increase, increased thickness will be required.
- Based on projected growth patterns the final pavement thickness would be constructed at Year 15.
  - The first pavement would serve for 15 years before the final thickness is added.
- At Year 15 pavement strengthening layers can be added.
  - At Year 15 remove upper 2 inches
  - Add 6.5 inches Hot Mix Asphalt



- Estimated pavement costs
  - Cost per mile using the full 20 year traffic is $1.9 million.
  - Using the staged-construction approach, the cost is reduced to $1.2 million per mile.



  - The graph shows expected cost for 40 years.
  - At Year 15 the pavement would be surfaced with a high quality surface like Stone Matrix Asphalt (SMA). Typical life cycle for SMA pavements is 20 years. The staged-construction pavement would be surfaced with SMA when pavement thickness is added in Year 15.
  - **Net Savings of Stage Construction for initial construction is a cost saving of about $0.7 million per mile.**

Stage Construction Considerations

Stage Construction is not a decision to just split the pavement in part. This can cost a tremendous amount of additional money. Consideration must be given at the bridge approaches, shoulders, safety shoulders and median. Proper planning in the design can minimize these future costs when the final pavement thickness is made. Other than a small amount of additional depth on the outside shoulder no other significant increase in cost should occur. These costs can easily be estimated in the design process of

developing the life cycle cost estimate. (See Appendix A for further discussion on these design considerations.

Subgrade Treatment (See Appendix B for technical discussion.)

- Specify INDOT Specification Type 1A subgrade treatment which allows only the lime stabilization or compacted aggregate options.
- Design using 12 inches of compacted aggregate as a structural layer.
    - Net effect of using aggregate as a structural layer is to reduce the pavement thickness by 2 to 3 inches.
- INDOT is very conservative in how it addresses the subgrade in the pavement design in the MEPGD (thickness design program).
    - INDOT arbitrarily reduces the soil stiffness in half.
    - Net effect of entering unreduced subgrade stiffness is to reduce pavement thickness by 1 to 2 inches depending on circumstances.
- The combined effect of using the aggregate layer as a structural layer and entering unreduced soil stiffness into the program will reduce the pavement thickness by 3 to 5 inches.
    - The full 20 year design pavement thickness is estimated to be about 10 inches instead of 14 inches.
    - The staged pavement construction would be about 8 inches.
    - **Net cost savings of implementing subgrade design changes is**
        - **$500,000 per mile for the full 20 year design**
        - **$200,000 per mile for the initial staged construction.**

Inside Shoulder Four Foot Shoulder Cross-Section (See Appendix C for discussion.)

- Current Design Guide requires the four foot inside shoulder be constructed to the same thickness as the main lanes.
- Suggest constructing the inside shoulder using the pavement cross section for the outside shoulder.
- **Estimated cost saving $109,000 per mile.**

Reduced Pavement Section on Inside (Passing) Lane (See Appendix D for discussion.)

- On rural interstate pavements the lane split for truck traffic is generally 80% in the outside travel lane and 20% in the inside travel lane.
- Currently both travel lanes are built to the same pavement cross section. As a result the inside lane is over-designed
    - Design and construction of each lane separately can be done.
- **Estimated cost saving of using a thinner inside lane is $125,000 per mile.**

Other Questions from Commissioner Reed

The Commissioner raised some other questions or ideas during his conversation. We are not prepared at this time to fully address each but will summarize current thought.

Contract Size – The industry through ICA has consistently requested project size that will allow Indiana contractors of smaller size to effectively compete against the national contractors. The maximum size suggested is $30 million to $35 million. APAI agree with this suggestion and urge it to be continued. The struggle to buy right of way may result in even smaller contracts to meet the schedule. In the event the jobs are staged by pre-grade and paving contracts the maximum size for paving contracts should be in the $15 million range.

Design-Build or similar process – The industry through ICA has supported design-build contracting on those jobs where it is in INDOT's best interest to use this manner of contract award. Design-Bid-Build will not allow the schedule to be met. APAI are in agreement Design-Build or a similar process will be necessary to accomplish this work. The Commissioner did suggest something other than the current 30% of design prior to bidding the project. The 30% appears to be the industry norm based upon risk. Discussion with the designers should occur if this is considered. Design of the pavement not being included in the 30% or pavement design being part of the design-build contract is encouraged.

Warranty – APAI has supported and in the past have suggested warranties as a means to improve pavement performance at less direct inspection cost to INDOT. Past warranty jobs have proven to very successful. APAI is willing to discuss warranty of a different time length or other features.

APAI Initiatives

Perpetual HMA Pavement – Perpetual HMA Pavement is a HMA industry initiative that design HMA pavements based upon stresses in the base pavement. It requires a base course that prevents water from moving from the subgrade up into the pavement. It produces a pavement that never needs to be replaced, except for the wearing surface. It can be constructed as stage construction. (See appendix E for details.)

Warm Mix Asphalt & Increased RAP – Two cost saving technologies currently being evaluated by INDOT should be used in this construction.

- Warm mix asphalt (WMA) reduces fuel usage and, hence, cost. INDOT monitored some non-department use in 2008 and has been constructing INDOT projects in 2009 under special provision.

- Also, increased amounts of reclaimed asphalt pavement and the use of post-consumer asphalt shingles are two cost-reduction technologies that INDOT is currently assessing**.**
- **If these techniques are used the cost per mile will be further reduced.**

Longitudinal Joint Construction – The improper construction or compaction of longitudinal joints may result in an HMA pavement not performing as desired. Increased attention to this construction may result in a better joint and a better performing pavement. APAI is currently working with INDOT to develop a specification to improve performance.

Summary

This paper describes cost saving strategies for design of an asphalt pavement.
These strategies have been selected to optimize the pavement design to the conditions of I-69 without reducing the expected pavement performance.

- Staged construction $700,000 per mile
- Subgrade treatment $500,000 per mile
- Inside shoulder cross section $109,000 per mile
- Thinner inside driving lane $125,000 per mile

The total available cost savings is not just the sum of the above suggestions, but a total cost saving of $1,000,000 should be achievable.
Since the total expected pavement cost for an asphalt pavement is $1,900,000 per mile this represents more than a 50% saving in pavement cost.
We cannot quantify the savings in initial cost, life time cost or time offered by the ideas expressed in Questions to the Commissioner or APAI Initiatives. We are sure they can be substantial but only further development will determine the amount.

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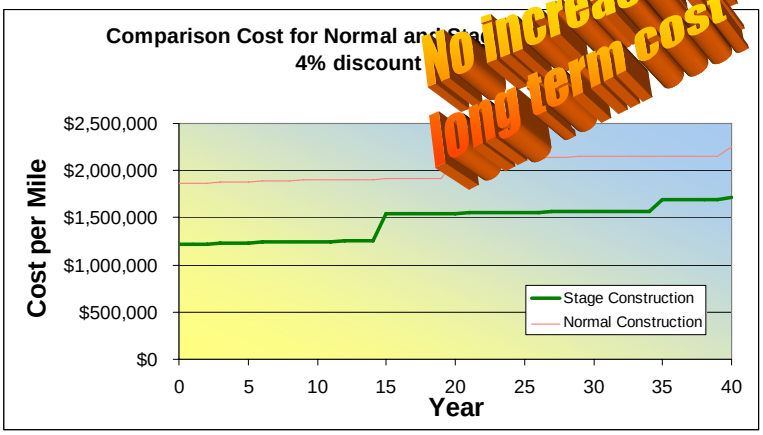
Appendix A

Stage Construction Design Considerations

Staged-construction can be used on I-69 without an increase in long-term costs. This is NOT a case of "Pay me now or pay me later".

- Significant real savings are achievable because the road is new and because I-69 will not be a through route until other states complete their sections. As a result, traffic volumes will build slowly.
- Because of the unique circumstances regarding I-69, the cost of building the ultimate pavement thickness can be pushed into the future without a penalty to performance.
- The graph shows expected cost for 40 years.
    - The staged-construction can be built with a normal asphalt surface because traffic volumes are lower. Life or the normal surface is 15 years.



Estimated Long Term Cost for I-69 Pavement Construction

    - At Year 15 when the pavement strengthening occurs, the pavement will be surfaced with a high quality surface like Stone Matrix Asphalt (SMA). Typical life for SMA pavements is 20 years.
    - The figure shows cash flow using a discount rate of four percent as per normal INDOT procedures.

Pavement Design and Construction Details

- Use Nationally Accepted Design Methodology (Mechanistic Empirical Pavement Design Guide, or MEPDG)
    - Design for 15 year traffic
    - At year 15, design for 20 year traffic
- Bridge tie-ins
    - Construct full pavement thickness on short sections at end of bridges (300 to 500 feet or length of guard rail).
    - Use one extra layer of base at bottom account for thickness difference between stage construction and full construction designs.
    - Guard rail height is not an issue.
    - At Year 15 these sections will have 2 inches removed and replaced.
- Bridge clearance and sign height

  - Bridge clearance and sign height should be set so that heights remain in compliance after strengthening occurs.
- Pavement Outside shoulders
  - Use staged design on shoulders.
  - Lower initial traffic allows thinner shoulders during the initial construction period.
  - Use 3 inches asphalt on 8 inches aggregate.
  - Construct shoulders to minimum allowable cross slope (2.5%)
  - During strengthening construct shoulder with 4.5% slope.
  - Thickness at shoulder line will be 7.5 inches HMA
  - Thickness at outside edge of shoulder will be 5 inches, an increase of 2 inches.
  - For normal construction the initial thickness of 4 inches would be overlaid with 1.5 inches for a total thickness of 5.5 inches.
  - Minimal side slope adjustment is required for the two inch difference in elevation.
- Pavement Median shoulders
  - Staged design on shoulders. – Construct initial shoulder section as per outside shoulder as suggested in “Inside Shoulder Cross Section” in this document.
  - No milling of inside shoulder is necessary prior to pavement strengthening
  - Place additional mainline pavement thickness on shoulder less mainline milling depth and amount to cause proper slope.
  - Median is a separated median
    - Providing enough dirt for the safety shoulder upon completion of the final pavement elevation. This can be accomplished by placing a less than 6:1 slope safety shoulder by raising the break point from the ditch slope to 6:1 and placing more dirt strategically through the median. When final pavement is placed, this dirt can be adjusted to accomplish the 6:1 slope.
  - Median is standard or not separated median
    - Providing enough dirt for the 6:1 safety shoulders are built at less slope and the median ditches can be built shallower than the normal design would be. This dirt will be used to create the 6:1 safety shoulder when the final pavement is placed on the road.
  - Both Median situations should allow the final 6:1 shoulder to be constructed without borrow and truck hauling. The work should be completed using normal grading equipment.

Appendix B

Subgrade Treatment

- Currently Type 1 treatment is typically used which allows for three options
  - 24 inches soil compaction
  - 16 inches lime stabilization
  - 12 inches of compacted aggregate

- Instead specify Type 1A which allows only the lime stabilization or compacted aggregate options.
- Design using 12 inches of compacted aggregate as a structural layer.
    - Under current design
        - The compacted aggregate is not considered a structural layer.
        - The compacted aggregate is given a stiffness value equal to subgrade.
        - This is much lower than the actual stiffness and is unnecessarily conservative.
    - Net effect of using aggregate as a structural layer is to reduce the pavement thickness by 2 to 3 inches.
- In the MEPGD (thickness design program) the soil stiffness is arbitrarily reduced in half.
    - APAI has meeting with INDOT Pavement Engineering Group on November 13th to discuss consultant review of pavement thickness design method.
    - The new method handles subgrade support differently than the older method.
        - The input subgrade support should not be reduced from the initial strength.
        - Within the program the input strength is reduced with time. If a reduced value is input, there is a double reduction, one inside the program and one in the input value.
        - Net effect is unrealistically soft subgrade conditions and extra pavement thickness design.
    - Net effect of entering unreduced subgrade stiffness is to reduce pavement thickness by 1 to 2 inches depending on circumstances.
- The combined effect of using the aggregate layer as a structural layer and entering unreduced soil stiffness into the program will reduce the pavement thickness by 3 to 5 inches.
    - The full 20 year design pavement thickness is estimated to be about 10 inches instead of 14 inches.
    - The staged pavement construction would be about 8 inches.
    - Net cost savings of implementing subgrade design changes is
        - $500,000 per mile for the full 20 year design
        - $200,000 per mile for the initial staged construction.

Appendix C

Inside Shoulder Cross-Section

- Currently the four foot inside shoulder is constructed to the same thickness as the main lanes.
    - Originally set up this way for ease of construction.
    - Increases the cost to INDOT
- Suggest constructing the inside shoulder using the pavement cross section for the outside shoulder.

  - Can easily be achieved.
  - Already done for concrete pavements with asphalt shoulders
- Estimated cost saving
  - Full 20 year design
    - Full pavement section $218,000 per mile for the two inside shoulders.
    - Shoulder pavement section is $109,000 for the two inside shoulder.
    - Cost saving $109,000 per mile.

Appendix D

Reduced Pavement Section on Inside Lane

- On rural interstate pavements the lane split for truck traffic is generally 80% in the outside travel lane and 20% in the inside travel lane.
- Currently both travel lanes are built to the same pavement cross section.
  - As a result, the outside lane is designed to match the traffic
  - The inside lane is over-designed
- If thickness design is done separately for the inside and outside lanes there are some cost savings to be obtained.
  - A non-standard cross section must be developed but conceptually the different thickness for inside and outside lanes can be implemented.
- Estimated full 20 year pavement thickness for the inside lane is expected to be 11 inches.
- The cost saving of using a thinner inside lane is $125,000 per mile.

Appendix E

Perpetual HMA Pavement

Perpetual pavement design is an approach for hot mix asphalt pavements

- Has gained recognition in the last 10 years.
- Generally, a pavement wears out because of aging and abrasion at the surface and because of cracking that initiates at the bottom of the pavement.
  - Repairing damage caused by aging and surface abrasion is relatively easy.
  - The upper 2 inches of pavement are removed and replaced.
- Cracking from below is more difficult to repair.
  - Pavement structural strength is substantially decreased.
  - Rehabilitation requires
    - Thick layers of new pavement to be added
    - Or complete reconstruction of the pavement.
- INDOT partnered with China (Shandong Province Department of Transportation)
  - Experiment was done to design and construct perpetual pavement sections
  - In China, heavy trucks are common,
  - In 2005 five pavement sections were built
    - Three were designed according to INDOT standards
    - Two were designed according to Chinese standards

- Each section contained embedded instrumentation to evaluate pavement response under load.
- All of the Indiana designed sections are perpetual.
- One of the two Chinese sections is perpetual.
- The results of this experiment will be presented at Perpetual Pavement Conference in September 2009.