US 41 Crack & Seat Case Study
A Practical Design

Kumar Dave, P.E., INDOT
David Holtz, P.E., INDOT
2015 Purdue Road School
March 2015
Outline

- INDOT Project Situation & Business Case
- Original General Plan & C&S Alternate plan
- Project History
- Pavement Evaluation
- Geotechnical Aspects of C&S & this project
- Pavement Treatment options/MEPDG
- Construction Actions & Results
- Conclusions/ Lessons learned
INDOT Project Situation & Business Case ...

Mr. Holtz
INDOT Mission

INDOT will plan, build, maintain and operate a superior transportation system enhancing safety, mobility, and economic growth.
INDOT FY 2015-16 GOALS

- **21st Century, One INDOT Results**

- **On-time and On-budget**
  - Deliver projects in accordance with key performance indicators and INDOT performance measures.
  - Deliver quality services according to identified work plans and within financial targets.

- **Take Care of What We Have**
  - Implement a plan that maintains steady improvement in pavement and bridge quality.
  - Ensure a commitment to safety.
  - Implement a talent management system that links strategy and operations to results.
  - Establish a culture of continuous improvement.

- **Customer Satisfaction**
  - Improve internal and external customer satisfaction.
  - Take an outside in view to ensure the highest level of customer service.
INDOT Profile

- Six district offices
- 3,400 employees
- $1 billion/annual capital expenditures
- 28,400 total roadway lane miles
- 5,300 INDOT-owned bridges
- Assists 42 railroads in planning & development of more than 3,880 miles of active rail lines
- Supports 69 Indiana State Aviation System Plan airports
INDOT VALUES

The Value of Values

1. **Respect** — Treat others fairly. Value the individual skills, experience, diversity and contributions of fellow employees.

2. **Teamwork** — Share information and seek input from co-workers and agency partners to achieve goals.

3. **Accountability** — Take personal responsibility for actions and decisions.

4. **Excellence** — Provide exceptional customer service through individual initiative, innovation and delivery of quality results.

Values are the core behaviors that all employees, as an organization, will support, promote and exhibit to achieve agency goals.
**Project Situation & Business Case**

- **Home furnace repair/replacement**
  - Contractor #1:
    - Good service life and reliability
    - $5,000
  - Contractor #2:
    - Good service life and reliability
    - $3,400
  - Contractor #3:
    - Good service life and reliability
    - $1,600
Home furnace repair/replacement

Vote for which one would you use?
- Contractor #1:
- Contractor #2:
- Contractor #3:
Project Situation & Business Case

- So ... ... ...
Project Situation & Business Case

- Why would pavement-roadway work be any different than home furnace repair/replacement?
  - Taxpayer funded?
  - $33 Million / $22 Million / $9 Million?
  - Roughly similar service life and future maintenance cycles?
**RESULTS: ROADWAYS**

**Pavement Surface Conditions Over 10-Years for Current Funding Trends**

<table>
<thead>
<tr>
<th>Year</th>
<th>Miles of Roadway</th>
<th>Pavement Condition</th>
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<tbody>
<tr>
<td>2014</td>
<td>9,486</td>
<td>Poor</td>
</tr>
<tr>
<td>2015</td>
<td>9,742</td>
<td>Poor</td>
</tr>
<tr>
<td>2016</td>
<td>9,513</td>
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<tr>
<td>2017</td>
<td>9,256</td>
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<td>2018</td>
<td>9,474</td>
<td>Fair</td>
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<tr>
<td>2019</td>
<td>9,395</td>
<td>Good</td>
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<td>2020</td>
<td>9,356</td>
<td>Good</td>
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<td>2021</td>
<td>9,318</td>
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<td>2022</td>
<td>9,279</td>
<td>Good</td>
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<tr>
<td>2023</td>
<td>9,240</td>
<td>Good</td>
</tr>
<tr>
<td>2024</td>
<td>9,202</td>
<td>Good</td>
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</table>

Assumes Flat $322M Annual Investments 2018-2024

Pavement condition should remain relatively static at the current investment levels.

IN policy for CAFR reporting, minimum requirement (12.2%)
ROADWAYS: PRIORITIES

Current Service Level

11.4% Poor in 2024

$394M Annual Investment
1,305 Miles of Poor Pavement

10-Years

INDOT’s Target Service Level

≤7.5 % Poor in 2024

$498M Annual Investment
826 Miles of Poor Pavement

10-Years

INDOT’s Recommended Service Level

≤4.75 % Poor in 2034

$561M Annual Investment
533 Miles of Poor Pavement

20-Years

What is the acceptable result for the taxpayer?
Owner Expectations:

- Engineers develop a better plan defined by a structured mental model construct:
  - Cognitive domain
  - Affective domain
  - Critical Reasoning
    - Intellectual Standards
    - Elements of Reasoning
  - Semi-formal Decision-making Process
Time to failure – Distress levels

Predicted Total Rutting (Permanent Deformation)

- Threshold Value
- @ Specified Reliability
- @ 50% Reliability

Rutting Depth (in)

Pavement Age (years)
Introductory concepts & framework

Introductory concepts & framework

Affective domain

Characterising by Value or Value Concept

Organising and Conceptualising

Valuing

Responding

Receiving

So which engineer’s recommendation would you use?

- $33 Million?
- $22 Million?
- $9 Million?
US 41, road reconstruction from 0.75 miles N of SR 352 to 0.05 miles S of US 52 (9 miles), Benton County
Project Situation & Business Case

- US 41:
  - Secondary 4-lane divided highway severely deteriorated, i.e., D-cracking “cancer”
  - Traffic: 2014: 5150 (AADT), 38% (1,950) trucks – interstate trucks # = 10-26K(+/-)
  - Original concept: $33 million pavement rubblelization, 13% of one annual program?! 
  - Isn’t going to happen!
Programmed as $33M major pavement Rehab project (Rubblelization) in 2011

Different options (5-6) were analyzed

Designed with least cost/lane mile/year to own/operate
Informed Owner’s Considerations

What We Want:

- Best Service Life/Cost ratio
- Acceptable Service Level
- Least Cost to Own/Operate
Original General Plan & C&S Alt

- Kumar Dave
Original General Plan & C&S Alt

- US 41 from 0.75 miles N of SR 352 to 0.05 miles S of US 52 (9 mile), Benton County
- Programmed as $33M major pavement Rehab project (Rubblelization) in 2011
- Different options (5-6) were analyzed
- Designed with least cost/lane mile/year
- Constructed in 2014 within $10M
- Saving of $20(+)M of tax payers money with smooth pavement as end product
Project History

- US 41 is a 4 lane divided highway
- Traffic 2014: 5150(AADT) w/38% trucks
- SBL: original 9” JPCP built 1976 with skew joints spaced at variable slab length (12’,18’,19’,13’) ... approx 3400 jts
  - No major rehab done except asphalt joint patching (partial)
- NBL: original 8” CRCP built in 1971 was rubblized and overlayed in 1991-92 with HMA overlay approx 9 inch average.
Pavement Evaluation

- Field evaluation-Existing pavement pictures
- Core Report
- FWD Report
- Pavement Management data
- Old contracts review
Original General Plan & C&S Alt

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Pavement Evaluation
Major Distresses

SBL:D Cracking (3400 joints), Spalling
NBL: Thermal cracks, stripping, rutting, ravelling, segregation
Pavement Evaluation
PCR(2011):
  NBL:  63
  SBL:  69

Pavement Management data

<table>
<thead>
<tr>
<th>Direction</th>
<th>IRI (200 inches/mi)</th>
<th>Rutting (0.40 inches)</th>
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<tbody>
<tr>
<td>Northbound</td>
<td>191</td>
<td>0.26</td>
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<tr>
<td>Southbound</td>
<td>265</td>
<td>0.11</td>
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Pavement Evaluation

- High Surface deflection > 10 mils
- Pavement strength decline $S_n = 3.33$
- Remaining ESAL = 30,000
- Elastic modulus of concrete = 897,165 psi
- Elastic Modulus of HMA = 536,789 psi
- $S_n$ of Rubblized = 5.10
- CBR = 4.60, K-value = 445 pci
Geotechnical Aspects of C&S

- We asked INDOT geotech to give their recommendation
- Is this project suitable for C&S?
- What about moisture condition?
- Is drainage require?
- Nayyar Siddiki will present Geotech aspects of C&S
Nayyar Siddiki, M.S., P.E.
Geotechnical Construction & Technical Support Engineer
INDOT
2015
Subsurface Investigation @ US 41, Benton County
US 41, Benton County

Historical Geotechnical Information

- Engineering Soils Map of Benton Co. (JHRP) Feb, 1969
- Geotechnical Data Bank (In house)
- Resilient Modulus Data
- Falling Weight Deflectometer
US 41 Geotechnical Investigation

- *Total No. of Borings : 12 (RB-1 thru RB-12)
- Type of Sampling: Three continues split spoon samples
- Soil Samples Collected: 108 Nos.
- Samples tested for Moisture: 108 Nos.
- Water Monitoring Wells: 6
- Depth of Monitoring Wells: 10 feet

*Borings were planned where FWD has modulus < 6000psi
### US-41, Natural Moisture

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<th>Boring No.</th>
<th>Sample</th>
<th>Depth</th>
<th>% Moisture</th>
<th>Boring No.</th>
<th>Sample</th>
<th>Depth</th>
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<td>SS-2</td>
<td>3-3.5</td>
<td>24.7</td>
<td>RB-8</td>
<td>SS-1</td>
<td>2-2.5</td>
<td>17.5</td>
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<td>3.5-4</td>
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<td>SS-2</td>
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Findings and Recommendations

- Subgrade Soils: Silty Clay Loam (A-4 or A-6)  
  (Stiff to very Stiff, Silt dominated Soils)

- Soil Densities: 115 to 125 pcf (estimated)

- Optimum Moisture Content: 13 to 16 % (estimated)

- Subgrade Modulus (FWD): 6000 psi

- Subgrade Soils Permeability: $10^{-5}$ to $10^{-6}$ cm / sec
Cont’d.

- Silty Soils with high moisture gets unstable, consideration should be given to the moisture in cracking operation

- Foundation Soils Resilient Modulus: 5000 psi (estimated)

- 12 in. Concrete Pavement without Granular Subbase

- 18 in. Concrete at depth of 4 ft (RB-10)

- Moisture Range: Normal at most of the locations except RB-7 thru RB-9
Pavement Evaluation

- Review of old contract
- SBL: R-9908(1975): 9” Plain concrete on 6” uniform subbase(sp provision) on compacted subgrade...mainline and shoulder
- Skewed & Random spaced Joints at 12, 18, 19, 13
- Shoulder: Tapered from 9 to 6”
Pavement Evaluation

- Review of old contract
- NBL: R-19614(1991): Rubblization (first project)
  - 110 lbs/syd Bituminous Surface 11, MV
  - 220 lbs/syd Bituminous Binder 8 or 9, MV
  - Variable Base 5 MV (660 lbs/syd min)
  - 8” CRC to be rubblized
  - With geocomposite underdrain...
Pavement Evaluation

- Review of old contract
  - Has geocomposite pvmt underdrain
  - Had problem with the leachate
  - Had segregation problem (at the plant)
  - Skipped rubblizations at the intersections
  - Equipment broke many times
  - Oldest rubblization equipment and youngest Foreman
Pavement Treatment Options

- SBL
  - CPR
  - 4” HMA overlay
  - 4.5” HMA overlay over c&s
  - 4.5” SMA overlay over c&s
  - 7” HMA overlay over rubblized PCCP
  - 9” Unbonded conc overlay
  - 9” PCCP slab replacement
Pavement Treatment Options

- NBL
  - 4” HMA overlay over 2” mill
  - 4” SMA overlay over 2” mill
  - 2” HMA overlay over scarification mill
  - 2” SMA overlay over scarification mill

Pavement Reconstruction
12.5” HMA
9” PCCP
Pavement Treatment Options

- Pavement Reconstruction
  - 12.5” HMA
  - 9” PCCP

- All the above options were analyzed through MEPDG & Chapter 304 of IDM
- United Consulting did above analysis
- Pankaj Patel (INDOT) reviewed
Economic Analysis Summary

- **NBL**
  - 4” HMA overlay over 2” mill: $17,000
  - 4” SMA overlay over 2” mill: $16,000
  - 2” HMA overlay over scarification mill: $11,668
  - 2” SMA overlay over scarification mill: $12,000

Pavement Reconstruction
- 12.5” HMA: $32,500
- 9” PCCP: $41,000
Economic Analysis Summary

- SBL
  - CPR: 71,000
  - 4" HMA overlay: 45,000
  - 4.5" HMA overlay over c&s: 16,500
  - 4.5" SMA overlay over c&s: 15,000
  - 7" HMA overlay over rubblized PCCP: 22,000
  - 9" Unbonded conc overlay with patch: 41,000
  - 9" PCCP slab replacement: 29,000
Underdrain Construction
Underdrain Construction

- Table
Underdrain Construction
Cracking operation video

IMG_1978.MOV
Seating video

Seating 062314.MOV
Patching joints

Type 1
Type 2
Patching milling 2.MOV
Milling video

IMG_3136.MOV
SMA Surface paving video

IMG_3185.MOV
Conclusions

- C&S is one of the effective slab reduction technique
- C&S is 80% cheaper than reconstruction
- Uses existing material
- No hauling of existing pavement
- It prevents reflective cracks in HMA overlay
- Some structural value is lost with C&S
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- C&S is 80% cheaper than reconstruction
- Uses existing material
- No hauling of existing pavement
- It prevents reflective cracks in HMA overlay
- Some structural value is lost with C&S
- Construction and Geotech is important.
Acknowledgements

- Mr. David Holtz
- Mr. Pankaj Patel
- Mr. Matt Taylor
- Mr. Scott Chandler
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- Mr. Dale Wolfe
- Mr. Nayyar Siddiki
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Questions?