Defining Success – KYTC Pavement Design and Beyond

Paul C. Looney, P.E.
Deputy State Highway Engineer – KYTC
July 20, 2017
Focus of the Pavement Program

- Implementation of the AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG)
- Refining strategy for determining pavement rehabilitation priorities
- Technological solutions for evaluating existing pavement grades
- Ensuring subgrade stabilization
Our Unique Relationship

• The relationship between KYTC and KTC is unique

• Some states have similar relationships, but no state is identical to Kentucky

• KYTC has been able to use this relationship to aid many of our KYTC programs
Actionable Research Results

- State Planning and Research (SPR) projects developed the techniques used in these projects.
- Implementation of these techniques has provided valuable information on a variety of projects.
- Ultimately, these research results provided value to KYTC by allowing for better informed decisions.
Why a new AASHTO Design Process?

• Late 1950’s Field Experiment
• Single Climate Location, Ottawa Illinois
• Single Soil Type
• Limited Material Variations
• Short Duration About 2 years
• Empirical Design – Performance Based Design
• Never Fully Calibrated for Local Conditions
What is the new AASHTO Process?

Mechanistic – Empirical Process, Nationally Calibrated Analysis Process vs Thickness Determination (AASHTO 93, Kentucky, and others)
It predicts performance
Kentucky’s Current Process

• Developed in the early 1980’s, started in the 1950’s

• Mechanistic – Empirical based process (based on theory and field experience)

• Catalog of Designs developed late 1990’s
KYTC Vision of Implementation

- Catalog of Designs for majority of projects
- Standardized inputs for more complex designs and use of AASHTO software
- HMA Pavements
- PCC Pavements
Implementation Steps

KYTC identified the following steps for successful implementation:

• Materials and traffic libraries, KYTC-specific user input guide

• Identify key stakeholders, KYTC Divisions and industry

• Continuous verification, calibration, and validation
Examples of Technologies Implemented

• Ground Penetrating Radar (GPR) for forensic Evaluation

• LiDAR for roadway surface drainage analysis

• Falling Weight Deflectometer (FWD) evaluation and other forensic tools
Use of Ground Penetrating Radar for Void Detection and Hydro-Geochemical Water Testing Results at the Cumberland Gap Tunnel
Background of Cumberland Gap Tunnel

- 4-lane twin-bore mountain tunnel
- 4600 feet long
- Carries US-25-E under Cumberland Gap between Kentucky and Tennessee
- Completed in October 1996
- Costs of construction $280 million
- Currently operated and maintained by the Cumberland Gap Tunnel Authority (CGTA)
History of Challenges Encountered

• Pavement settlement observed in roadway
• GPR utilized to evaluate void extent
• Evaluation of water chemistry revealed calcium deficient water in areas where sandstone overburden was present
• Calcium deficient water was dissolving the limestone roadway base
Void area beneath concrete pavement southbound tunnel

GPR signal has negative amplitude (noted as black space) because it doesn’t have anything to bounce off of (air voids).
Multiple void areas beneath concrete pavement northbound tunnel
Remedial Repairs

- Initial use of Uretek foam and cement grout, temporary fix, voids continued to grow
- Ultimate remedial fix was to replace the entire roadway with a granite backfill base and new concrete pavement in both tunnels, approximate cost $10,000,000
- GPR evaluation of entire tunnel used to determine extend of potential void areas
### Example of Mapped voids
Stations 125+00 to 130+00

#### 2002 Foam
- April 2008
- June 2010

<table>
<thead>
<tr>
<th>Condition</th>
<th>Southbound S.F.</th>
<th>Northbound S.F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voids before grout (April 2008)</td>
<td>760</td>
<td>1304</td>
</tr>
<tr>
<td>Foam</td>
<td>816</td>
<td>n/a</td>
</tr>
<tr>
<td>Void in grouted area (June 2010) re-void</td>
<td>756</td>
<td>1256</td>
</tr>
<tr>
<td>Void outside of grouted area (June 2010)</td>
<td>312</td>
<td>228</td>
</tr>
</tbody>
</table>
Final Results

- GPR results determined that a little less than 50% of tunnel roadway was impacted
- Final repair based on GPR results cost less than 50% of the original $10,000,000
- Subsequent GPR evaluations to monitor performance have indicated a stable condition
Roadway Surface Evaluation Using LiDAR

- High wet weather crash rate area observed after rehabilitation
- Mobile LiDAR used to evaluate roadway surface geometry
- Waterfall analysis conducted to determine water drainage paths
Areas where water is draining from hi-side of super back to the barrier wall-shoulder area—per design

Shoulder water draining back out onto roadway surface

Recorded accident locations
Water draining from hi-side of super back to the barrier wall-shoulder area

Shoulder water draining back out onto roadway surface
Final Results

• Areas of concern were isolated for remedial action, cost savings over repair of entire roadway section

• Cross slope corrected to ensure proper drainage

• Reduction in crash rates observed
Forensic Evaluations—Used to Refine Rehabilitation Costs

- Subsurface Pavement Evaluations, Louisville Southern Indiana Ohio River Bridges (LISORB)
  - Determine in-situ conditions for use by design-build teams
  - Ground Penetrating Radar, Falling Weight Deflectometer, Pavement coring

- KY 15 -- provide FWD, GPR, and coring for pavement rehabilitation project to assist with cost reductions for the pavement design.

- KY 80 -- provide FWD, GPR, and coring for re-alignment project to identify cost savings for the pavement design.
Forensic Evaluations
GPR/FWD Example Results
Comparison of GPR data to field conditions
Final Results

• Knowledge of in-situ conditions allows for better rehabilitation and construction decisions

• In many cases, thinner pavement designs were achieved in some areas

• Helps prevent overdesign of rehabilitations which maybe required if overlay conservative approach is used
GPR Evaluation of PCC Pavement Reinforcement

- Initial forensic evaluation for suspected high tie bars
- Utilized GPR to evaluate both tie bar and dowel basket locations
- Significant areas found with missing tie bars and baskets out of alignment
High Tie Bars
High Dowel Baskets
Misaligned Dowel Baskets
Final Results

• Repairs made while still under construction contract

• Savings of potential future maintenance cost

• Development of concrete pavement reinforcement alignment specification and testing method.
Focus of the Pavement Program

- Implementation of the AASHTO Mechanistic-Empirical Pavement Design Guide (MEPDG)
- Refining strategy for determining pavement rehabilitation priorities
- Technological solutions for evaluating existing pavement grades
- Ensuring subgrade stabilization
Bringing research forward – Project Development

• Project Development Bootcamp

• Bootcamp Xpress

• Guidebook for Project Development

• Critical Path for Project Development
Questions?