JERSEY DOT'S

"Turning Problems into Solutions"

Tech Brief

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Think Jersey DOT

Flexible Overlays for Rigid Pavements

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SO, HERE'S THE PROBLEM…

- Funding is limited to reconstruct many of New Jersey's aging and deteriorating Portland cement concrete (PCC) pavements;
- Asphalt overlays are commonly placed over these aging PCC pavements as a quick and cheap means of rehabilitation;
- Unfortunately, many of these asphalt overlays develop transverse cracking over the pre-existing PCC joints/cracks within the first few years of service. This type of cracking over the pre-existing joints/cracks is called reflective cracking (Fig 1).
- NJDOT has attempted a number of different methods/technologies in the past to mitigate reflective cracking. Unfortunately, all methods evaluated to date have not succeeded any better than the conventional asphalt mixture.
- With NJ's PCC and composite pavement (asphalt overlay on top of PCC) continuing to deteriorate and current rehabilitation procedures failing within the first few years of service, an immediate solution is necessary.

Figure 1 – Reflective Cracking of Flexible (Asphalt) Overlays on Rigid (PCC) Pavements

AND, HERE'S OUR SOLUTION

- Develop and distribute a survey to the different state agencies to determine how they handle the mitigation of reflective cracking and what mitigation methods they have attempted;
- Utilizing the information from the survey and literature review, develop a methodology that can be used to evaluate how asphalt mixtures can be selected to withstand reflective cracking;
- Develop a database of NJ asphalt mixture properties that can implemented within the methodology;
- Calibrate the final methodology with test sections located in the Northeast and develop a final decision tree that NJDOT can utilized to select asphalt mixtures for composite pavement/PCC overlays.

We set out with a national survey and literature review to evaluate the mechanisms causing reflective cracking, test methods that can simulate these mechanisms, and how other states are currently handling the mitigation of reflective cracking. Figure 2 shows the state agencies that replied to the national survey. The literature review and survey indicated;

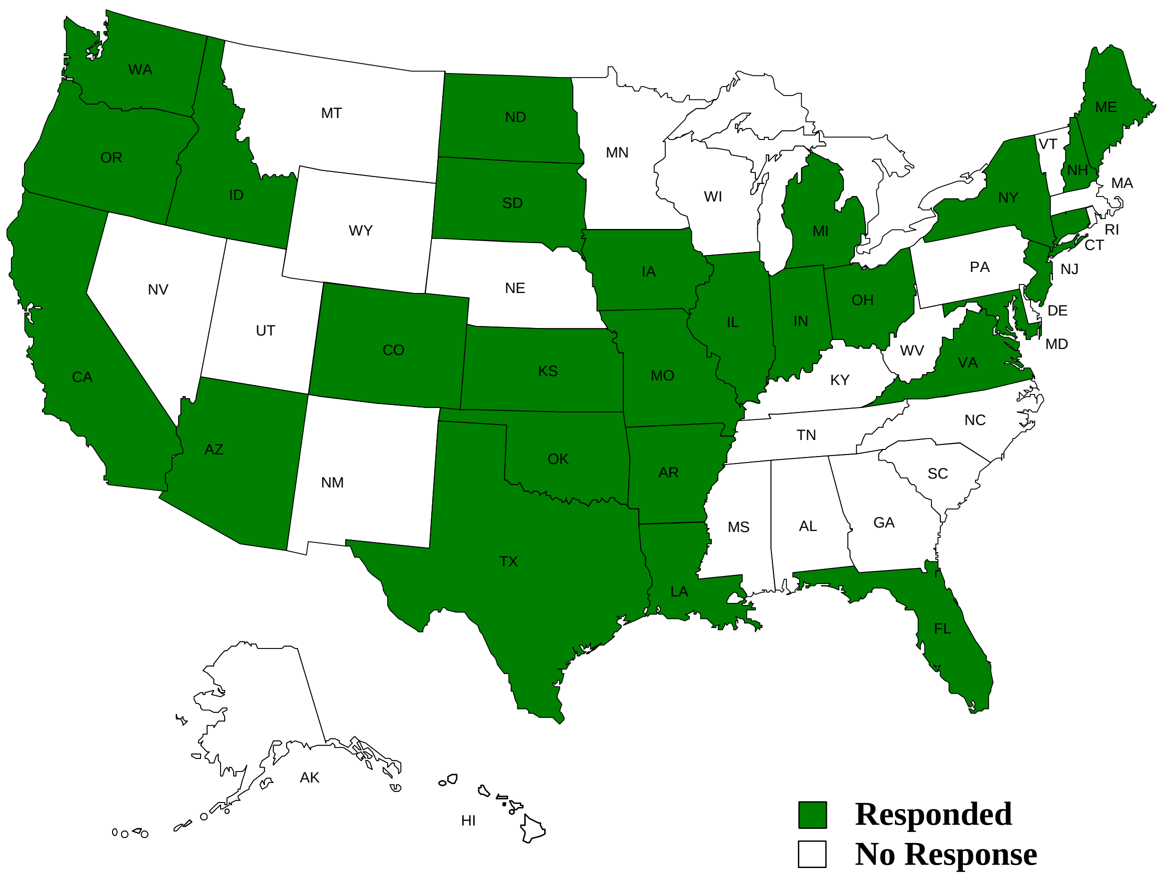

Figure 2 – National Survey on Reflective Cracking - Respondents

- The major mechanism generating reflective cracking is the tensile stress/strain generated at the bottom of the asphalt overlay. The tensile stress/strain is a coupled resultant of vertical deflection at the PCC joint/crack associated with traffic loading and horizontal deflection at the PCC joint/crack associated with the expansion and contraction from environmental cycling.

- The shearing mechanism at the PCC joint/crack, commonly indexed with the measured Load Transfer Efficiency (LTE), is not a crack initiator but an accelerator.
- A number of mechanical tests exist for the cracking evaluation of asphalt mixtures. However, to properly evaluate the reflective cracking potential of asphalt mixtures, it is important that the mechanical tests are capable of simulating the movements commonly associated in the field. Therefore, the following mechanical tests are recommended for laboratory simulation of field movements associated with reflective cracking of asphalt overlays:
  - Flexural Beam Fatigue (AASHTO T321)
  - Overlay Tester (TxDOT Tex-248-F)
- The critical reflective cracking condition in composite/PCC pavements is when the air/pavement temperatures are already cold and the climate is under-going a cooling cycle.
- Research has shown that when field deformations at the PCC joint are accurately measured, these deformations can be utilized in laboratory test devices and provides reasonable estimates on the ability of the HMA mixture to resist the reflective cracking movements.
- Reflective cracking was found to occur almost equally in granular, cement-treated, and bituminous treated base courses at the time intervals specified, with composite pavements supported on granular base courses tending to have a lesser reflective cracking life.
- Low temperature asphalt binder grade was found to be related to the time until reflective cracking is observed. The survey results indicated that states that use a low temperature PG grade one to two grades lower than recommended by LTPPBind (at a 98% reliability level) for the HMA mixture immediately overlaying the PCC pavement, have a better chance at retarding reflective cracking longer.
- A number of reflective cracking mitigation methods have been attempted by the state agencies over the years. Statistically, the best performing mitigation methods were found to be the SAMI’s and the Reflective Crack Relief Interlayer mixes (Strata®-type mixes). The worst performing mitigation methods were found to be the paving fabrics and geogrids. However, it should be noted that even the best mitigation method only had a 50% success rate, when considering a successful method was defined as one that provided five years before reflective cracking was observed.

Based on these results, Rutgers University developed an analysis procedure that would utilize methods to predict the vertical and horizontal movements in the pavements. Once these parameters were determined, the movements were simulated in laboratory test equipment to determine the fatigue life of various asphalt mixtures under field conditions. Evaluating the fatigue lives of the different mixtures provided guidance as to which NJ mixtures performs best for a given pavement condition. This provided a means of cost effectively selecting asphalt overlays. This methodology was then verified using field test sections in New Jersey, Massachusetts, and Pennsylvania.

HERE'S WHAT WE CAME UP WITH…

A new analysis approach for asphalt mixture selection/overlay design of composite/PCC pavements was developed and presented (Figure 2). The analysis approach requires the knowledge of; 1) Vertical deflection at the PCC joint/crack, 2) Magnitude of traffic loading, preferably as axle load spectra but also ESAL's can be used, and 3) Asphalt mixture properties measured by the Flexural Beam Fatigue and Dynamic Modulus test. The predicted reflective cracking fatigue life was compared to the measured cracking from the test section monitored in the field. The predicted values matched the measured percent of transverse joints cracked quite well. Using all eleven test sections in the study, the average percent difference between the predicted and measured percent of cracked transverse joints was 57%. However, one of the test sections in I476 in Pennsylvania, where limited joint deflection data was collected, was determined to be an outlier in the data. By eliminating this point and only looking at ten test sections, the average percent difference between the predicted and measured dropped to 9.3%.

- The horizontal mode of the fatigue cracking response of asphalt mixture placed on composite/PCC pavements can be estimated using the TTI Overlay Tester. Analyzing data generated using the TTI Overlay Tester and field parameters estimated from pavement characteristics and climate conditions showed that typical dense graded mixtures utilized by state agencies have minimal horizontal deformation fatigue lives under typical field conditions. It was found that most dense graded mixtures could not withstand horizontal deformations as low as 0.01 inches without the rapid onset of cracking. Therefore, if dense graded asphalt mixtures are proposed to be used, it was recommended to check to determine if the horizontal deformation of the PCC joint/crack was greater than 0.01 inches. If so, the dense graded mixture should not be used. Meanwhile, reflective crack relief interlayer (RCRI) mixtures were found to have significant horizontal deformation fatigue lives and were found to absorb almost 100% of the horizontal deformation resulting from the expansion and contraction of PCC slabs. This is significant as RCRI mixtures can be placed at the bottom of an asphalt overlay to mitigate 100% of the horizontal deformation and then the designer can appropriately select asphalt mixture to withstand the residual vertical deformation remaining in the asphalt overlay in the area of the PCC joint/crack.
- A final asphalt overlay/mixture selection process was developed to allow state agencies to select more appropriate asphalt mixtures than can withstand the vertical and horizontal modes of deflection at the PCC joint/crack that result in reflective cracking. The process utilizes three main steps;
    - Estimate the magnitude of horizontal deformation to be expected for the proposed asphalt overlay thickness. Depending the results, either a conventional dense graded mixture or a reflective crack relief interlayer is recommended.
    - The next step evaluates the resistance to cracking due to the vertical deformation at the PCC joint/crack using the Deflection Spectra Approach. As stated earlier, simply because the asphalt mixture selected for placement immediately on top of the PCC pavement can withstand the climate-related horizontal movement, it does not mean it can withstand the

traffic load associated vertical deflections. Depending on the vertical mode analysis, an RCRI-type mixture may need to be recommended to ensure both horizontal and vertical resistance to cracking.

- The final step in the process is to once again utilize the Deflection Spectra Approach on asphalt mixtures that will be placed as intermediate and/or surface courses within the asphalt overlay. As shown in the Literature Review, National Survey and test section data, asphalt mixture containing higher percentages of asphalt binder, as well as better low temperature asphalt binder properties, perform better in this zone of the asphalt overlay.

The analysis procedure has also been put into a simplified Excel Spreadsheet for NJDOT use. The spreadsheet conducts the analysis shown in Figure 3 and includes a number of different NJDOT asphalt mixtures with calibrated material coefficients for use in the horizontal and vertical cracking analysis.

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A final report is available online at
http://www.state.nj.us/transportation/refdata/research/

If you would like a copy of the full report, please FAX the NJDOT, Bureau of Research, Technology Transfer Group at (609) 530-3722 or send an e-mail to Research.Bureau@dot.state.nj.us and ask for:

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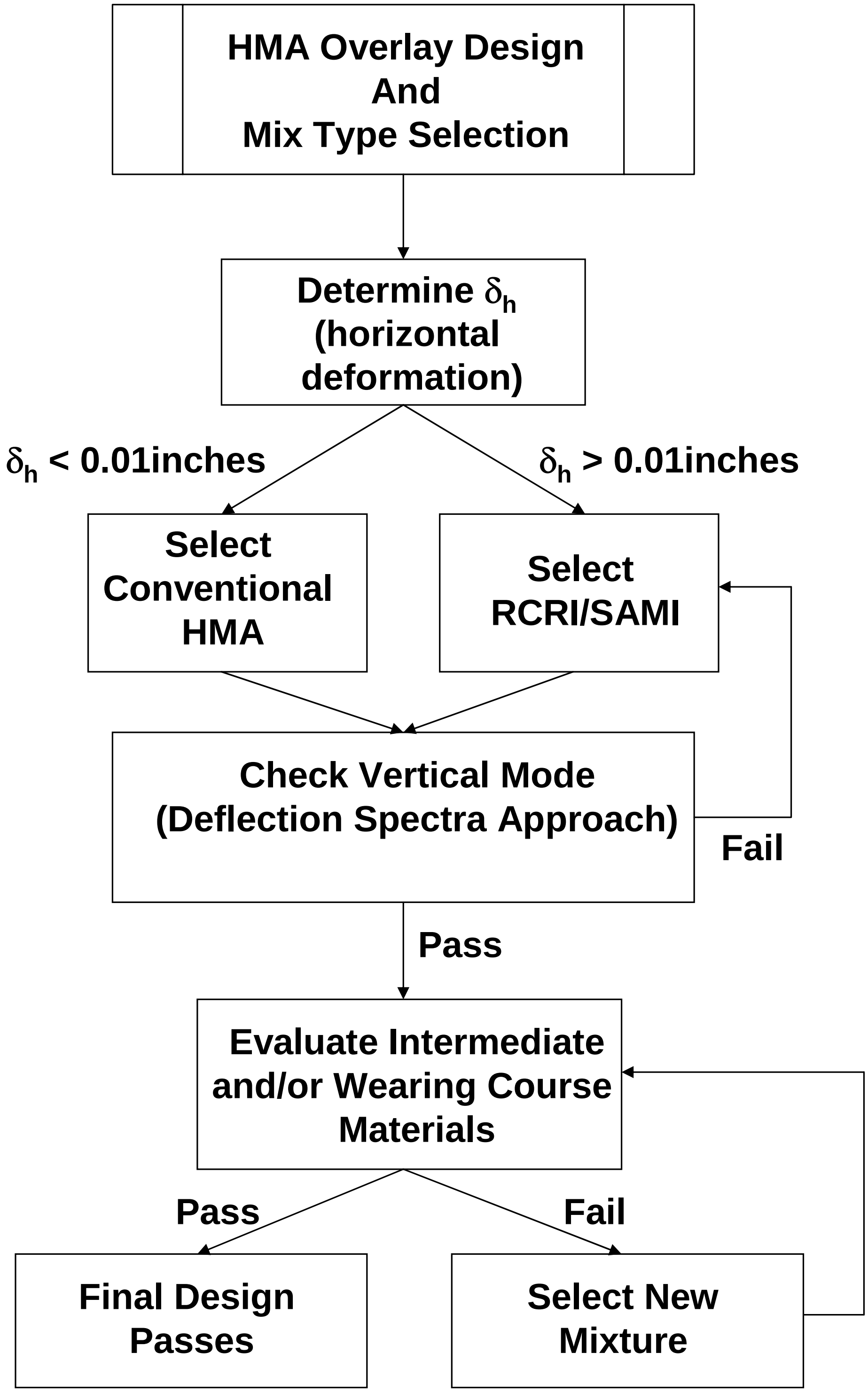

Figure 3 – Flowchart for Hot Mix Asphalt Overlay Design and Mixture Selection