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Tech Brief

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Evaluation of Poisson's Ratio for Use in the Mechanistic Empirical Pavement Design Guide (MEPDG)

FHWA-NJ-2008-004 December 2008

SO, HERE'S THE PROBLEM…

- The Mechanistic Empirical Pavement Design Guide (MEPDG) requires two main input parameters to conduct the elastic layer analysis; 1) Modulus and 2) Poisson's Ratio.
- To date many people have assumed that the Poisson's Ratio is a constant value for most, if not all, materials;
- Limited research has shown the Poisson's Ratio of hot mix asphalt (HMA) can be predicted as a function of modulus;
- However, the prediction equation used in the MPEDG was generated based on HMA produced with Neat binders and tested in the Indirect Tension Test mode.

AND, HERE'S OUR SOLUTION

- Evaluate typical AASHTO test procedures, recommended to generate modulus input parameters for the MEPDG, to determine if the test procedures can also be used to measure the Poisson's Ratio. The test procedures selected were; 1) Dynamic Modulus test (AASHTO TP62) for HMA and 2) Resilient Modulus test (AASHTO T307) for aggregates and soils.
- Using the MEPDG, evaluate the sensitivity and general trend of pavement distress caused by changes in HMA and aggregate/soil material Poisson's Ratio values.

For HMA, the Dynamic Modulus test equipment was modified to evaluate the radial strain, later converted to horizontal strain, due to the applied load (Figure 1). However, although the test equipment was modified, the test procedure was identical. Utilizing the modified equipment, a number of different asphalt mixtures were evaluated that had various aggregate gradations and binder grades.

For the aggregate/soils, the Resilient Modulus test equipment was also slightly modified to measure the horizontal strain (Figure 2). Testing had been proposed to be conducted on materials that varied from crushed quarry process aggregate to clayey subgrade soils.

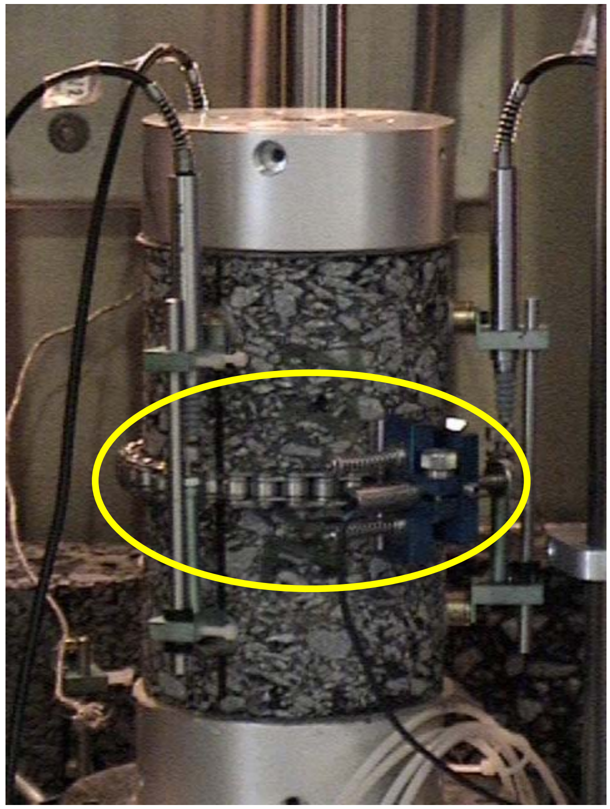

Figure 1 – On-sample Circumferential Deformation Measurement Set-up for Hot Mix Asphalt Specimens

Figure 2 – Resilient Modulus with Radial LVDT Test Set-up

THIS IS WHAT IT CAN DO

By selecting the appropriate input parameters, in this case the Poisson's Ratio, for input into the MEPDG, a better prediction of the pavement distress can be accomplished. Ultimately, this will help state agencies establish better calibration of pavement distress models and more accurate pavement designs.

HERE'S WHAT WE CAME UP WITH…

The use of the Dynamic Modulus test was capable of determining Poisson's Ratio values (Figure 3) with the results for unmodified binders seeming very reasonable and compared well with expected results.

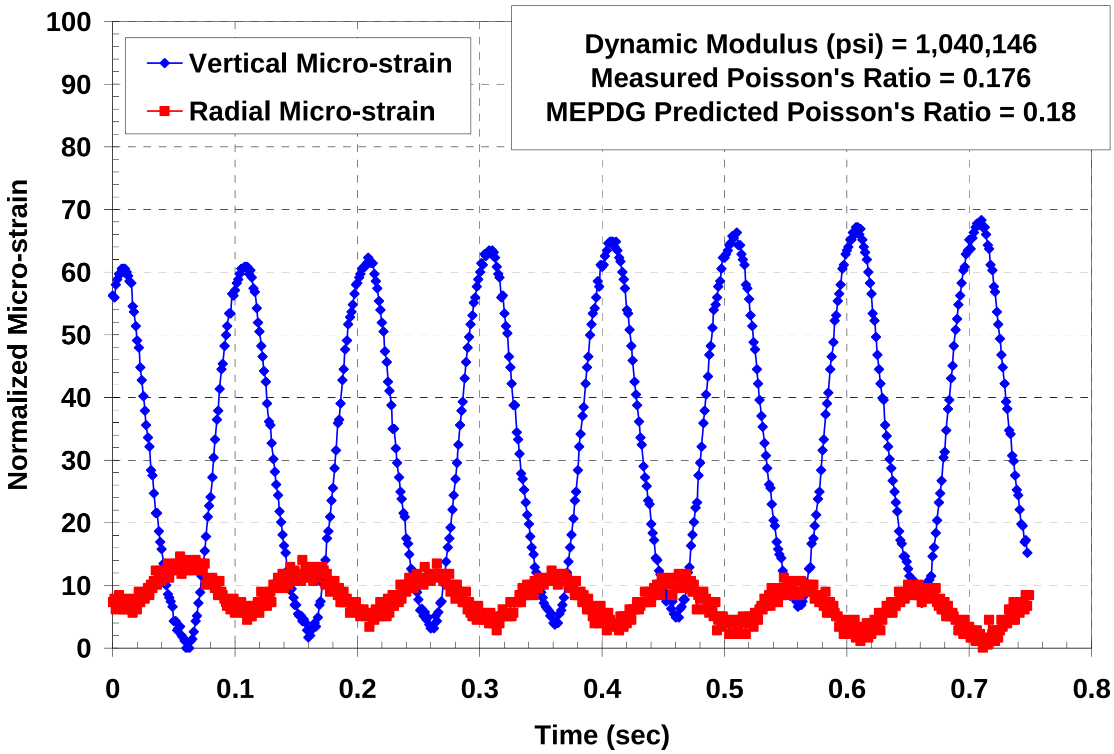

Figure 3 – Vertical and Radial Micro-strains of 12H64 Sample at 70°F and 10 Hz

However, the testing also showed that the Poisson's Ratio was a function of not only the HMA material stiffness, but that the amount of polymer modification also influenced the measured Poisson's Ratio (i.e. – as the PG grade increased, the Poisson's Ratio measurements decreased). Figure 4a and b shows how the Poisson's Ratio values varied as a function of dynamic modulus and PG grade. The database of test results were then used to generate new Poisson's Ratio prediction equation coefficients for the different PG grades that would most likely be used in New Jersey.

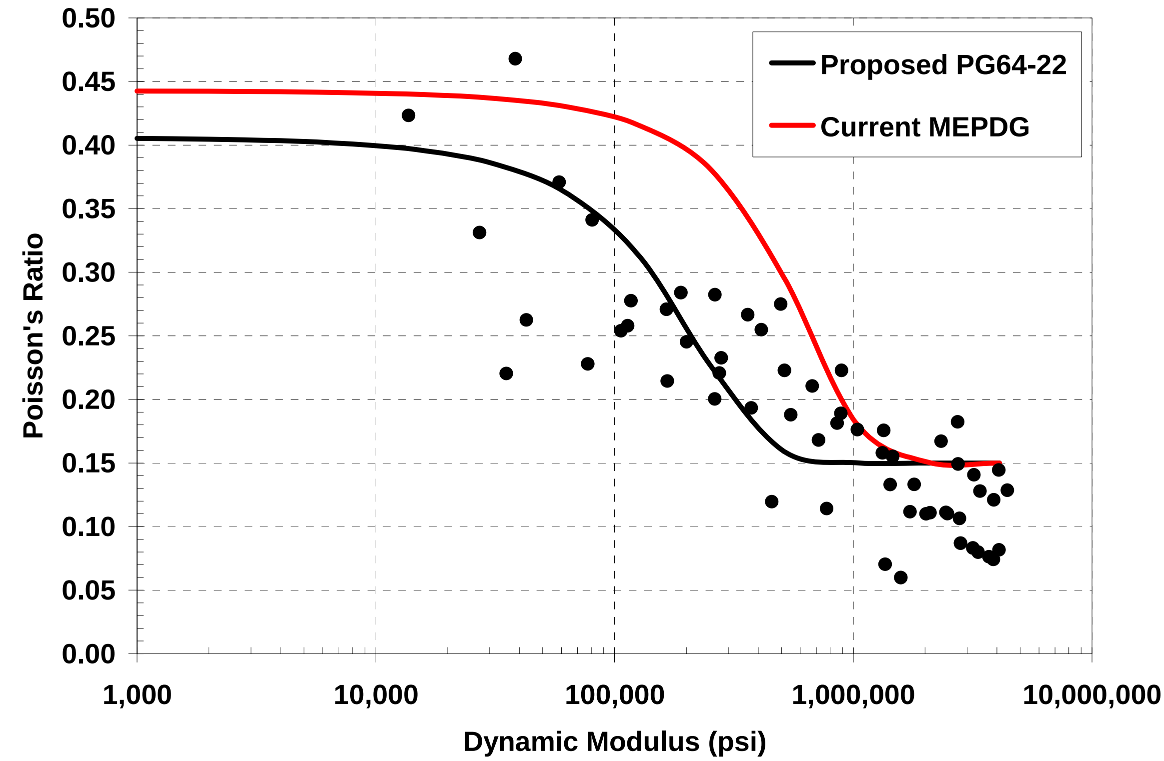

Figure 4a - Proposed PG64-22 Poisson's Ratio Prediction Equation

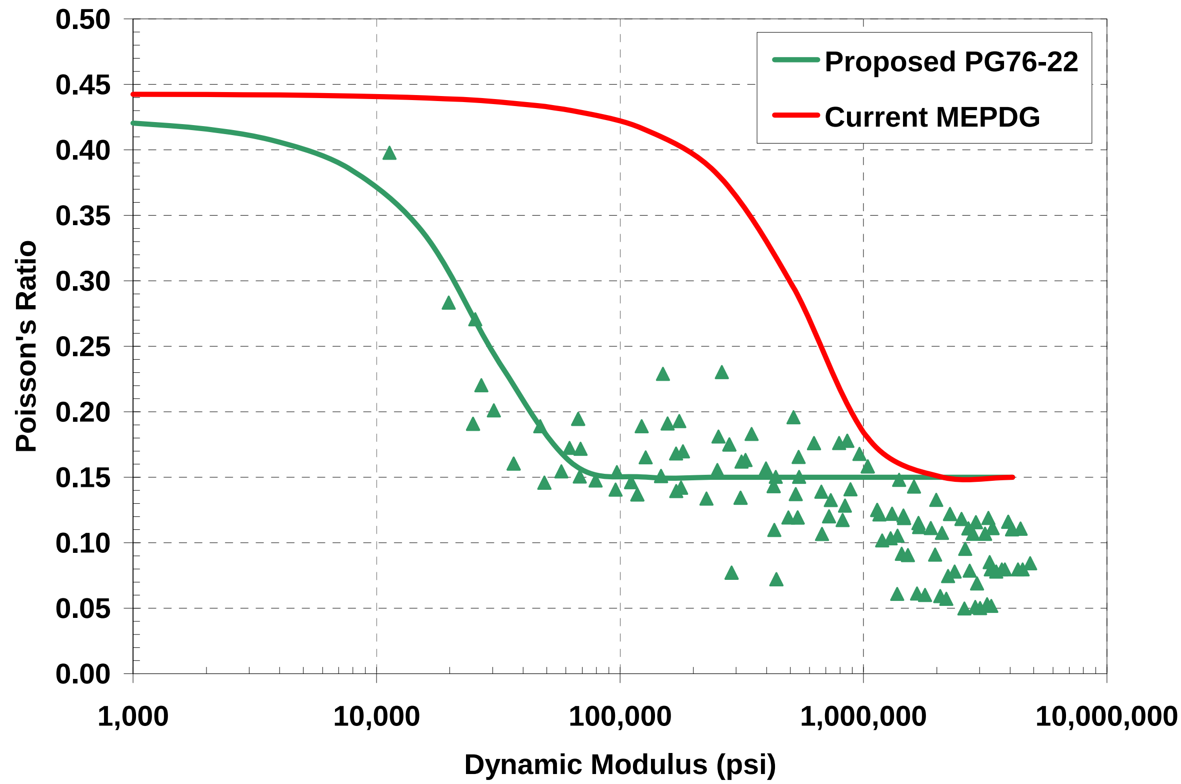

Figure 4b – Proposed PG76-22 Poisson's Ratio Prediction Equation

Laboratory testing using the Resilient Modulus test to also evaluate the Poisson's Ratio showed that the Resilient Modulus test produced Poisson's Ratio values that were not within the linear elastic range of the aggregate/soil (i.e. – resultant vertical strain was found to be too high to comply with elastic theory). Therefore, it is recommended that the Resilient Modulus test protocol (AASHTO T307) not be used to also measure the Poisson's Ratio of aggregates/soils.

The sensitivity analysis showed that as the Poisson's Ratio values of the HMA increased;

- Rutting in the HMA decreased;
- Top-down longitudinal cracking decreased; and
- Bottom-up alligator cracking slightly decreased.

For aggregates (base course layer), the Poisson's Ratio seemed to only significantly affect the Top-down longitudinal cracking. As the Poisson's Ratio increased, the amount of Top-down cracking increased for a HMA with a PG64-22 asphalt binder. However, when a polymer modified PG76-22 asphalt binder was used, minimal differences in all pavement distresses were found.

THE BOTTOM LINE…

The Poisson's Ratio can be successfully measured using current test procedures and equipment commonly used during Dynamic Modulus testing of HMA. The laboratory evaluation showed that not only was the Poisson's Ratio a function of HMA stiffness, but also the extent of polymer modification. This resulted in different Poisson's Ratio Prediction Equation coefficients for a PG64-22 and PG76-22 asphalt binder mixtures.

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

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

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