Joint Transportation Research Program

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Risk Management of Low Air Void Asphalt Concrete Mixtures

Introduction

Various forms of asphalt pavement distress, such as rutting, shoving, and bleeding, can be attributed, in many cases, to low air voids in the mixtures during production and placement. The occurrence of low air void contents during plant production may originate as a result of an accidental increase in binder content or mix fines (or both). When low air voids are encountered during production, the specifying agency must decide whether to require the material that has already been placed to be removed and replaced or whether it can be left in place with a reduction in pay. This decision involves a performance risk to the department of accepting a mix that may perform poorly and a monetary risk to the contractor who may be required to remove and replace a mix that could perform satisfactorily. Consequently, the Indiana Department of Transportation (INDOT) initiated this research project to develop an objective decision-support tool for dealing with such events that is based on projected rutting performance of the pavement system.

Findings

The study was conducted along three paths. In the first, INDOT sponsored two pavement test sections at the National Center for Asphalt Technology (NCAT) Test Track. The second path involved testing mixes in the INDOT Accelerated Pavement Testing (APT) Facility. Lastly, a simplified mechanistic analysis, using a software program called QRSS (Quality Related Specification Software) was used in an attempt to simulate the effects of low void mixtures on pavement performance and service life.

- The two sections INDOT sponsored at the NCAT Test Track were subdivided in two and a third section served as the control. The four test sections incorporated low void surface mixes produced by either increasing the fines content or the binder content. Performance was measured by the progression of rutting.
- Significant rutting developed in all of the low void mixes. Mixes with excessive binder contents tended to rut faster than mixes with a change in gradation, but the rutting was unacceptable in all cases.
- The results suggested that removal be considered for mixtures with air voids below 2.75% but that no pay adjustment was necessary for air voids above this level. However, the NCAT results were limited to one pavement structure, one set of materials, one climate, and low voids in the surface mix only.
- In the APT, low air void mixtures were placed in either the surface or the intermediate course and different materials were used. The pavement response (permanent deformation of the top pavement layers) resulting from 13,000 APT wheel passes was measured using a laser based system.
- Similar rutting developed in each lane, regardless of whether the low void mixture was in the surface or the intermediate layer and regardless whether the low voids were caused by excess binder or a change in the gradation.
- A mechanistic model was developed to extend the APT study and examine the rutting behavior when the low void mix was placed lower in the pavement. The model was able to accurately reproduce the rutting observed in the APT, indicating the model worked reasonably well. Modeling suggested that

rutting would still occur even if the low void mix were deeper in the pavement structure but that the rut would be wider than if the surface mix rutted.

- The Quality Related Specification Software (QRSS) was used in an attempt to expand the dataset to include different mixes, binders, traffic levels, air void contents, and locations in the pavement. QRSS uses the same models as the Mechanistic Empirical Pavement Design Guide (MEPDG, now called Pavement ME) to predict and compare the performance of as-designed and as-built mixtures. The comparison is based on predicted pavement stiffness (dynamic modulus), distress (permanent deformation, in this case), and change in service life. The concept was that the change in service life could be used objectively to determine when to remove and replace a mix as well as what monetary penalty to assess in cases where a substandard mix could be left in place at reduced pay.
- Attempts to predict the behavior of the mixes at NCAT using QRSS were unsuccessful as rutting was under-predicted in all cases. The predictions of the performance in the APT were more successful, suggesting that perhaps QRSS could be used as intended.
- Additional predictions of performance were mixed in terms of producing reasonable, expected results. Rutting was sometimes less than would be expected. Excessive changes in mixtures were required to yield a change in service life of greater than two years. In some cases, substantial changes in mix properties produced no appreciable change in the service life, contrary to experience. This mixed performance may be due, in part, to the fact that this study examined very low void contents and accelerated loading conditions that far exceeded typical construction variations, which is what QRSS was developed to do. QRSS is limited in the range of variables and the number of MEPDG runs used to develop the predictions; the cases explored in this study may have been outside the range of conditions QRSS was made to assess.
- The results of these efforts were used along with engineering judgment to formulate a draft decision-support tool that considers the traffic level and air void content.

Implementation

The results of this study should be used as shadow specifications on several projects to assess the effects of testing variability and the monetary impacts on contractors if low void mixtures are produced. The shadowing can be used to refine the levels and consider penalties. This could also be accomplished by examining air void data from acceptance testing on past construction projects to assess the impacts of the proposed limits.

In addition, the Office of Research and Development could test mixtures for the shadowed projects (or others) and perform additional runs of the MEPDG to expand the dataset and verify the accuracy of the QRSS predictions.

Lastly, INDOT and the researchers should stay abreast of any further refinements of the QRSS software that could allow for direct input of test results, rather than relying on prediction models based on limited mix parameters. If these refinements are made, the predictions used in this study to assess the performance of low void mixtures could be revisited and the decision-support tool further refined.

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