



INDOT Research

TECHNICAL Summary

Technology Transfer and Project Implementation Information

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Development of Indiana's SPS9-A Site

Introduction

The SUPERPAVE system introduced the concept of performance-based binder selection process, in which the binder is required to satisfy certain performance-based criteria within a temperature range of interest and traffic conditions that are specific to the pavement location. The temperature range of interest depends on the yearly maximum and minimum air and pavement temperatures occurring at the location.

To validate the SUPERPAVE Binder Selection Program and to provide data for long term field validation of the SUPERPAVE methodology, SPS9-A sites were constructed in different parts of the country. Indiana's SPS9-A site was one such study, in which six different test sections were constructed at a 2.5-km long study site. Four of test sections (S-64-28, S-58-28, S-70-28 and S-70-28) were built with the same job-mix formula (JMF), but with different binder grades. PG64-28 was the recommended binder grade based on weather and expected traffic conditions at the site. To evaluate the influence of binder grade on the rutting performance, PG58-28 and PG70-28 were used in two of the test sections. PG64-16 was used in one section to study the influence of binder grade on low-temperature cracking. In addition to these four sections, one section (M-AC-20) was built with AC-20 using Marshall mix design to compare the performance of the older mix design methodology with the newly introduced SUPERPAVE. Finally, 15% recycled asphalt

pavement (RAP) was added to section (R-15%) with PG64-28 binder to evaluate the performance of RAP in comparison with the non-RAP control mixture and the other SUPERPAVE mixtures.

SUPERPAVE performance tests were conducted on plant-mix samples compacted to 7% and 3% air voids. These tests included creep compliance, indirect tensile strength, frequency sweep at constant height, simple shear at constant height and repeated shear at constant height. The parameters obtained from these tests; creep compliance, indirect tensile strength, critical pavement temperature, complex shear modulus, maximum shear deformation and permanent strain; were used to assess the relative performance of the mixtures.

Core samples were obtained from the field at six-month intervals and the layer thickness, percent air voids and binder content of these mixtures were determined. The binder from the surface layer was extracted and recovered in order to study the change in binder properties with age of the pavement. The properties of the recovered binders studied were penetration, viscosity, complex modulus, creep stiffness, fracture stress and failure strain.

In addition, distress surveys were conducted to evaluate the pavement condition at the end of 1.5 and 3.5 years. The distress surveys included transverse profiling, photographic surveys and manual surveys.

Findings

The results of field distress surveys at the end of 3.5 years indicated moderate transverse cracking in the section with the modified binder (S-70-28) and S-64-16. Minimal amount of

transverse cracking was observed in M-AC-20, S-64-28 and R-15%. S-58-28 exhibited no thermal cracking at the end of 3.5 years. In terms of longitudinal cracking, all sections

except the Marshall section (M-AC-20) exhibited moderate amount of cracking in the wheel path and outside the wheel path. Marshall section did not exhibit any longitudinal cracking, while S-64-16 exhibited the highest amount of longitudinal cracking. All sections showed minimal amount of rutting. S-64-28 showed the highest rut depth in comparison with the other sections. M-AC-20 showed the least amount of rutting. R-15% and S-70-28 showed “heaving” in the left wheel path of the driving lane.

Volumetric data from the field core samples obtained during the study period showed that the control section (S-64-28) had low initial air voids, which caused the air voids to drop below 3% at the end of one year. This could explain the higher degree of rutting observed in this section. Uniform mat thickness was indicated by surface and intermediate layer thickness data obtained from the cores. Neither excessive binder content, nor significant differences in binder content were observed between the SUPERPAVE test sections.

Most of the binder tests indicated binder stiffening with age, as expected. Penetration tests indicated that severe cracking may be expected in M-AC-20, R-15%, S-70-28 and S-64-16. While S-70-28 and S-64-16 did exhibit moderate cracking, M-AC-20, R-15% and S-64-28 showed only nominal amount of cracking.

Implementation

These results show that increasing the binder high-temperature grade from PG58-xx to PG64-xx based on expected traffic volume was a necessary step to improve the rut resistance of mixture. Sections with PG64-xx and PG70-xx showed better rut resistance than section with PG58-xx, with the exception of S-64-28, the poor performance of which was probably a result of the low initial air voids. This emphasizes the point that even when the aggregates and binders used in construction are adequate for environment and expected traffic, improper placement could lead to premature pavement distress.

Section with PGxx-16 performed poorly in terms of thermal cracking as expected. Sections with PGxx-28 and PGxx-22 showed lower amount of thermal cracking in comparison, except for PG70-28. The section with the lowest binder viscosity, PG58-28, showed no low-temperature cracking, while the section with the

The maximum passing high temperature determined from the Dynamic Shear Rheometer showed an increase with time in most of the binders, except for PG58-28. This increasing trend indicates an improvement in the rut resistance of the mixtures, which was validated by the minimal amount of rutting observed in the test sections. The relatively higher degree of rutting observed in S-64-28 may be attributed to the low *in-situ* air voids observed in the initial set of field cores and early-on in the life of the pavement. High degree of correlation was seen between critical temperature estimates obtained from Bending Beam Rheometer and AASHTO PP42 method.

Creep compliance and indirect strength tests predicted thermal cracking in M-AC-20 and S-64-16, since the critical mixture temperature was warmer than the minimum pavement temperature observed at the site. However, some cracking was also observed in S-64-28, S-70-28 and R-15% to varying degrees, which was not predicted by critical mixture temperature estimates, at the two air voids levels tested. The higher rut depths observed in S-64-28 and S-58-28 was indicated by the higher amounts of plastic strain observed in the repeated shear test.

highest binder viscosity, PG70-28, showed the highest amount of low-temperature cracking. Although the low-temperature grade was the same in both cases, binder viscosity appears to play a significant role in determining the resistance of pavements to thermal cracking in service.

Permanent strain values obtained from repeated shear testing appears to be a better indicator of rutting performance in the field than complex shear modulus ($|G^*|$) from frequency sweep testing. All the mixtures satisfied the minimum $|G^*|$ limit of 250 MPa at 10 Hz and 40°C, and showed nominal amounts of rutting in the field.

Based on the limited testing on unmodified and modified binders in this study, BBR tests on recovered binders appear to be adequate in predicting the low-temperature performance of the pavements.

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