Report Number ___

NCAT Test Track Findings

Report Prepared by

E. Ray Brown, Buzz Powell, Randy West, and David Timm

National Center for Asphalt Technology

February 2005

NCAT TEST TRACK FINDINGS

1. Introduction

The NCAT test track was designed and constructed to develop and evaluate better ways to design and construct hot mix asphalt (HMA) pavements. The track has been in service since 2000. Several findings have been identified and implemented by individual states and other findings will likely be adopted in the near future. The ongoing research at the track continues to provide valuable information regarding pavement materials and mixtures, construction procedures, and structural pavement design.

The test track research can be divided into two cycles of tests. The first cycle began in 2000 with loading of forty-six test sections (Figures 1 and 2). The only variable among the sections in the first cycle of tests was the properties of the mixtures in the top four inches. This cycle of tests was completed in 2002 after ten million Equivalent Single 18-thousand pound Axle Loads (ESALs) had been applied to the sections.

Figure 1. Overview of the Test Track.

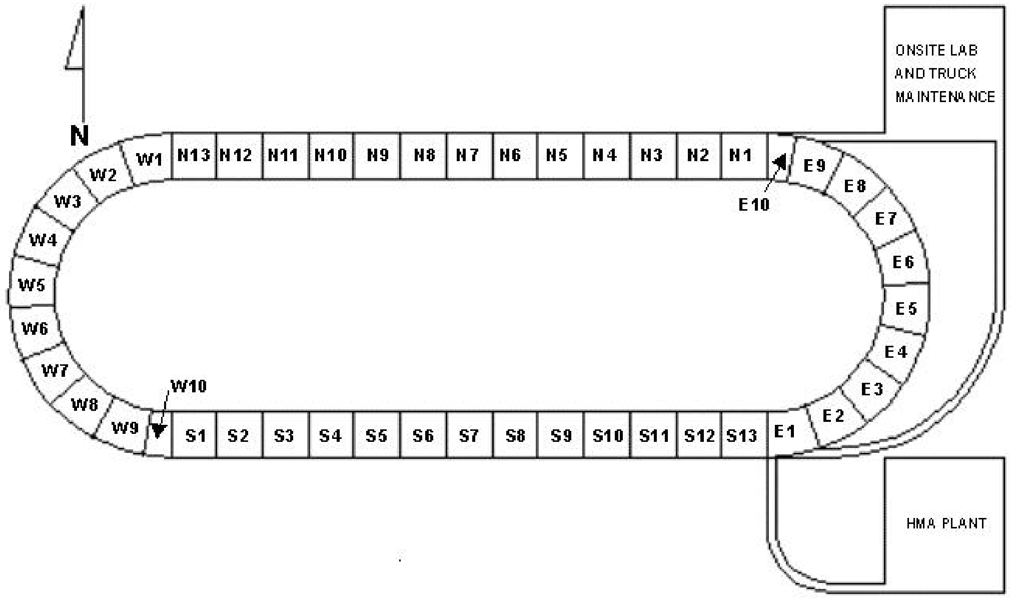

Figure 2. Illustration of the Forty-Six Sections at the NCAT Test Track

The second cycle of tests began in 2003 when parts of the test track were reconstructed. Eight sections were removed full depth and reconstructed to provide different thicknesses of HMA. Some of the structural sections used modified asphalt and others used non-modified asphalt in adjacent sections. Fourteen sections were milled and overlaid with a new mix to be evaluated. The remaining sections were left in place to evaluate the effect of two more years of traffic (another ten million ESALs) and to determine the effect of an additional two years of exposure to the environment on durability.

The objective of this report is to provide a listing of the most significant test track findings to date. This includes the findings at the conclusion of the first cycle of tests as well as the interim findings for the first five million ESALs of the second cycle of tests. This is a summary report and the detailed findings are not presented here. The details of this research along with the data and analysis can be found in other reports.

2. Research Findings

A number of findings have been identified and adopted by the various sponsors. While research is continuing, there is sufficient data to support the findings that have been adopted and presented here. Some of the areas in which findings have been implemented include: high precision diamond grinding to remove bumps, fine-graded vs. coarse-graded mixtures, effect of binder grade on rutting, evaluation of structural characteristics of HMA pavements, performance of SMA mixtures, performance tests to predict rutting, improved performance through increased asphalt content, validation of accelerated loading facilities, effect of aggregate properties on performance, and comparison of Hveem and Superpave.

2.1 High Precision Diamond Grinding to Remove Bumps

During construction and maintenance of HMA there are times that high areas in the pavement surface need to be leveled. A good way to do this is to use high precision diamond grinding. There has been some concern about how well these areas will perform when subjected to traffic and environmental conditions. It is also not clear how well these areas will perform if not sealed.

At the test track there were eleven transverse joints built during the original construction and several additional ones during the reconstruction that had to be leveled. These joints actually met the straightedge requirements prior to grinding but clearly there was a bump at the joints and grinding was necessary to provide improved smoothness. The grinding process was performed on a number of joints resulting in a very smooth surface that could hardly be felt when driving over these joints. After grinding, the surface appeared to be very smooth and tight. Even though eleven joints were leveled with the grinding equipment during the first cycle of tests, none of them had any performance issues during the initial two years of traffic. Some of these leveled areas have now been in place for up to 5 years with no performance problems.

2.2 Fine-Graded vs. Coarse-Graded Mixtures

With the implementation of Superpave specifications in the mid 1990's, most agencies began to emphasis the use of coarse-graded mixtures. The Superpave requirements have encouraged the use of coarse-graded mixtures especially for high volume roadways. One reason for increased use of coarse-graded mixtures was that the N(initial) criteria made it very difficult for fine-graded mixtures to meet the specification requirements.

Research at WesTrack indicated that fine-graded mixtures performed significantly better than coarse-graded mixtures in rutting and fatigue. This really confused many agencies since Superpave encouraged the use of coarse-graded mixtures.

Since the inception of Superpave, some coarse-graded mixtures have experienced permeability problems. This permeability generally seems to be due to a lack of adequate density but it has been a problem for many coarse-graded projects. Typically fine-graded mixtures that are a little low on density do not have permeability problems, however, coarse-graded mixtures do appear to have permeability problems when the density is a little low.

Due to the problems discussed above, many states have had concerns about which type of mixture (coarse-graded or fine-graded) to use. Because of these issues several states were interested in evaluating these two aggregate gradings. The results of several side-by-side comparisons at the track have shown that the amount of rutting expected is approximately the same for coarse-graded and fine-graded mixes.

Based on work at the test track, the state of Alabama has changed their specifications to require that fine-graded mixes be used on their high volume roadways. The track showed that these mixes would provide good resistance to rutting and would also minimize the permeability problem.

Based on work at the track, North Carolina has revised their specifications to allow more fine-graded mixtures to be used. The contractor is now given the option to use either fine-graded or coarse-graded mixes and the decision is usually fine-graded mixtures since they are more workable and easy to compact. North Carolina has revised their specifications for N(initial) making it easier to use fine-graded mixtures.

As a result of work at the track and work at their own accelerated loading facility, the state of Florida now allows fine-graded mixtures to be used.

2.3 Effect of Binder Grade on Rutting

The Superpave guidelines recommend that the high temperature PG grade be bumped for higher traffic to minimize rutting. One of the purposes of the first cycle at the track was to look at the effect of bumping the high temperature grade. There were several sections where the only variable was the grade of binder. The results from the first cycle of testing indicated that on the average, there was more than a 50 percent reduction in rutting when the high temperature grade was bumped form PG 64 to PG 76. This is a two grade bump which is typical of many projects on high volume roadways. This information will be helpful for states doing life-cycle cost analysis for modified vs. non-modified asphalt binders. As a result of this information some states have increased the number of projects where grade bumping is specified.

As a result of the work at the test track, the Florida DOT has specified the use of PG 76-22 in the top structural layer for traffic level D and in the top two structural layers for traffic level E.

2.4 Evaluation of Structural Characteristics of HMA Pavements

Eight structural sections were built in 2003. These sections included variations in thickness of HMA and in the binder grades. At the time this report was prepared these structural sections had been subjected to five million ESALs. The instrumentation of these sections has allowed stress and strain measurements to be made under moving traffic and will allow correlation of these stress states to performance.

Pavement response measurements from sections are providing an initial validation experiment upon which states can refine their use of the existing AASHTO Design Guide through more representative layer coefficients and consider adoption of emerging mechanistic-empirical methodology via the measurement of seasonal stresses and strains.

The Oklahoma DOT believes that information from the new structural sections will prove valuable in shaping their pavement design process. Using this information to support the perpetual pavement design concept could save millions by ensuring that pavements are not over-designed but are designed sufficiently thick for long life.

2.5 Performance of SMA Mixtures

SMA mixtures have been used in the US for almost 15 years with very good results. Since SMA was adopted in the US, one of the requirements has been to use only crushed stone. This has precluded the use of crushed gravels. Some states only have sands and gravels available so this requires these states to haul in aggregates from other states often making SMA too expensive to use. In effect this prevents some states from using SMA even though this type of mixture has provided very good performance. Evaluations were conducted at the track using crushed gravel in SMA mixtures and it was determined that the SMA mixture had less cracking than a similar mixture designed using Superpave requirements. As a result of this finding, the State of Mississippi has now begun placing gravel SMAs in an effort to maximize long term performance using local gravel materials.

Georgia invests heavily in SMA mixes for heavy traffic applications. Their effort at the track was intended to serve as a life cycle cost analysis in which environmental and traffic conditions are identical for both SMA and Superpave designed mixtures. While both sections have exhibited exemplary rutting performance (less than 2 mm with no statistical difference between the two), the Superpave section has demonstrated an increase in macrotexture since the time of construction, which is indicative of the loss of fines associated with weathering. It has also begun to exhibit centerline cracking. In contrast, the higher binder content SMA section has exhibited only a slight change in macrotexture and it does not appear to be at risk for cracking. Continued traffic on these sections is intended to confirm these observations.

The State of Alabama has evaluated several mixes including fine-graded, dense-graded, coarse-graded, SMA and OGFC gradations. Many of these mixtures were produced with neat, SBS-modified and SBR-modified binder. All these sections were built with the same aggregate sources. As a result of this and other research at the track, Alabama has since changed their specifications to include more widespread use of both SMA and OGFC. Alabama believes that the improved durability of the SMA and the drainability of the OGFC make these mixes very desirable for the higher traffic volume roadways.

Oklahoma is beginning to specify SMA on projects in Oklahoma. Several sources, including the test track work, have bolstered their confidence in the SMA mixture.

2.6 Performance Tests to Predict Rutting

There is great interest in the pavement engineering field to identify a reliable test that can predict rutting performance. NCAT conducted several performance tests on the mixtures placed at the track including dynamic modulus, repeated load tests, and wheel tracking tests. While significant rutting was not observed at the track, it is believed that sufficient rutting was observed to determine if trends between some of the performance tests and rutting exist. The results showed that the dynamic modulus had no correlation with rutting. The confined repeated load test and the wheel tracking tests did have trends with rutting.

As a result of the testing at the track, the Oklahoma DOT has gained confidence in their newly-implemented APA specification. That confidence would have taken 10 or 15 years to develop without the use of the track. That is too long to verify whether or not a new specification is satisfactory.

2.7. Improved Performance through Increased Asphalt Content

Generally speaking, as much asphalt as possible without causing rutting or bleeding is used in an asphalt mixture. Based on results from the test track Alabama has determined that more asphalt can be added to their mixtures without causing problems. This higher asphalt content results in improved durability leading to a longer pavement life. Tennessee is also evaluating mixtures to determine if more asphalt can be added without causing rutting problems.

2.8. Validation of Accelerated Loading Facilities

Two sponsors of the track work, Florida and Indiana, utilize accelerated loading facilities. It is important that the performance measured using these accelerated loading devices is similar to that which would be expected on the roadway. The NCAT test track offers an opportunity to calibrate the other accelerated loading devices to what would be expected on the roadway.

Indiana's participation included work to validate the testing performed with Purdue's automated accelerated pavement test (APT) device. Materials needed to produce mixtures and construct sections at the Purdue APT were hauled to the test facility after construction at the NCAT Track had been completed. A local contractor produced and placed the mixes in Purdue's indoor facility, which was then used to apply accelerated loading through a mechanized loaded truck tire. It was found that relative differences in rutting between various test sections measured at the Purdue facility were similar to the differences observed at the NCAT Track, which validated the use of their APT for conducting local rutting comparison studies at reduced cost. The State of Indiana is now evaluating the ability of the APT to predict pavement response data for various pavement structures that have been built at the track.

The state of Florida has validated their HVS in comparison to various sections at the track. The Florida DOT validated the HVS for a number of mix types and they continue to look at the comparison of results between the test track and the HVS. At the time this report was prepared the comparisons between the track and the HVS have been very good.

2.9 Effect of Aggregate Properties on Performance

Aggregate tests generally do not correlate well with performance. Hence, most aggregate specifications used by states have been derived over time and often don't correlate very well with performance. One property, LA Abrasion, has been used to classify aggregate quality for many years. It is expected that there is at least a rough correlation between LA abrasion and performance but it is doubtful that there is a good correlation.

Some aggregates have been excluded from use in the State of South Carolina because they exhibited a loss in LA abrasion that exceeded the State's specification requirements. One of these sources of aggregates was used in an HMA mixture and placed on the track for evaluation. No significant production problems were encountered during the construction of this section, no significant difference in macrotexture changes were observed, and rutting performance was similar to that of other sections with acceptable materials. Based on the results of these tests, South Carolina has changed their specifications to allow the use of this aggregate source with higher LA abrasion loss material.

South Carolina also evaluated another source of aggregates that had little record of use. Based on work at the track the DOT determined that this aggregate polished and therefore was not accepted for use in surface mixes. Testing the aggregate on the test track allowed the aggregate to be safely tested without having to place and test it on an active highway.

Mississippi and Tennessee constructed sections to look at blending limestone into gravel mixes to determine its effect on performance. At the conclusion both states verified that they can make mixes with all crushed gravel that will provide good performance if they control the mix properties and use good construction properties. As a result of this study Mississippi increased the amount of limestone allowed in a mixture from 30% to 50%.

Tennessee has investigated SMAs and OGFCs at the track and intends to construct sections using these two mix types on their existing roadways.

Mississippi is evaluating the performance of a 4.75mm mix and based on the performance will decide whether to use this finer mixture on existing roadways. South Carolina has begun to allow the use of smaller nominal maximum aggregate size mixtures in their surface mixes.

2.10 Comparison of Hveem and Superpave

Oklahoma has compared the performance of Hveem designed mixtures with Superpave designed mixtures. At the time these sections were built, Oklahoma did not have experience with Superpave methodology and was eager to facilitate an objective field comparison. Although both mixes exhibited good field performance, slightly less rutting was observed in the Superpave section. The test track results gave Oklahoma incentive to move forward with adoption of Superpave. The test track gave Oklahoma a much better evaluation of the two design methods than a laboratory study.

3. Summary

Some of the findings from the tests at the NCAT test track are listed above. The implementation of these findings has resulted in a considerable savings to each state through the use of improved materials, mixtures, design procedures, or construction procedures. Testing is continuing and additional findings will be developed as the tests progress.

The test track through accelerated loading has provided answers to many questions that would have taken years on the highway system and would have created safety problems during the research period. The test track has offered a safe, accelerated method to accomplish research that otherwise would have to be conducted on existing highways.