Southeastern Superpave Center News

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Southeastern Asphalt User Producer Group Holds Annual Meeting

By Don Watson

The SEAUPG Annual Meeting was held November 12-15, 2012, in Hilton Head, SC. The meeting was well attended with about 230 registered participants. Several interesting topics were presented such as:

- Economic Issues
- NCAT Test Track Research
- Warm Mix Asphalt
- Asphalt Binders

Economic Issues

Among one of the first concerns expressed was the effect the lagging economy is having on asphalt producers and asphalt mix contractors. It was reported that liquid asphalt sales for 2011 were just over 23 million tons and were at their lowest point since 1982. During regional updates, agencies reported that asphalt mixture production was also lower than normal with Oklahoma showing a 39% reduction in tonnage for this year over years past.

Jay Hansen, Executive VP with NAPA, shared information about MAP-21 and its impact on the asphalt industry. He predicted a future business environment that may include a new federal Life Cycle Cost Analysis, material-specific discount rate, a mandate to implement the MEPDG pavement design program, and pavement selection based on greenhouse gas emissions. These are real issues facing the asphalt industry today and were discussed by congress during the development of the current highway funding bill. In the future, agencies can expect to see funding tied to pavement performance measures and additional government regulation and accountability. Jay encouraged SEAUPG participants to get involved and contact their congressional representatives regarding the adverse effect some of these issues will have on the asphalt industry, and plan to attend the NAPA asphalt fly-in to Washington on September 11-12, 2013.

NCAT Test Track

Randy West, NCAT Director, presented information concerning recent trends in RAP usage and RAP management as well as a summary of findings from the NCAT Test Track (Figure 1) for test sections with RAP and WMA experiments. Dr. West reported that NAPA surveys have shown that the average RAP content for asphalt mixes has increased from 12% in 2007 to 17% in 2010. He added that combining RAP and WMA technologies provides the greatest economic and environmental benefit. Test sections at the track have included up to 50% RAP as well as 50% RAP + WMA. Although some of the 2009 high RAP sections have thin cross-sections designed to fail in fatigue, there has been no cracking to date. The 2006 test sections with high RAP have limited low-severity cracking after 20 million ESALs of traffic loading. The sections combining RAP and WMA use have proven to be very beneficial.

Dr. Dave Timm discussed the Kraton high polymer section and its performance. The test section used a 7.5% SBS polymer dosage rate based on weight of asphalt cement. The high concentration of polymer allowed a reduction in pavement thickness of 1.2 inches. The high polymer mix performed equal to or better than the control section in all categories. It had higher dynamic modulus values, an approximate order of magnitude greater performance in beam fatigue,

Figure 1. Traffic Loading at the NCAT Test Track

an endurance limit 2.6 times greater, and significantly less rutting. Due to the exceptional performance, a decision was made to allow the section to remain in place for another 10 million axle loadings.

A test section with SBS polymer modified asphalt at typical dosage rates was compared to a section which used 11% #40 mesh ground tire rubber (GTR). Dr. Richard Willis presented the findings, which showed excellent performance from each of the test sections. Both binders graded as PG 76-22, but the crumb rubber binder had a high temperature true grade about 5°C higher than the SBS. Tensile strength results during moisture susceptibility testing were about 25% lower for the SBS mixture than for the GTR mixture. APA rutting results were less than 2 mm for both mixtures, but flow number test results were twice as high for the GTR mixture. Thus the research shows that both SBS and GTR mixtures can be expected to give equivalent field performance.

Warm Mix Asphalt

Matt Corrigan, FHWA, reported on WMA usage, the various WMA technologies, and WMA research. The presentation showed that at least 40 state agencies and all Federal Lands Divisions have specifications that allow WMA on federal aid or Federal Lands projects. It was estimated that WMA usage in 2010 saved more than 30 million gallons of fuel and reduced CO_2 emissions by 800,000 tons -- the equivalent of taking 150,000 vehicles off the road! Several WMA research projects were discussed, including upcoming research regarding performance tests and laboratory aging and conditioning. NCHRP has more than $6 million in WMA research planned, underway or completed.

Steve Jackson, of N.B. West Contracting in Missouri, presented a contractor's perspective regarding WMA implementation. Several WMA benefits he mentioned were:

- Preventing joint bumps,
- Reducing fuel consumption,
- Allowing higher recycled percentages,
- Allowing shipment of materials over longer haul distances,
- Serving as a compaction aid,
- Reducing emissions and
- Providing a better work environment.

Jackson also mentioned that WMA mixes are less likely to be subject to thermal segregation. This results in a more consistent mat temperature which translates to more consistent density. However, he cautioned that cold weather paving with recycled shingle mixes and WMA could be problematic because shingle mixes seem to cool faster than RAP or virgin mixes.

Dr. Isaac Howard, of Mississippi State University, discussed research findings of a project designed to determine how far asphalt can be hauled in case of emergency paving needs created by storms that cause power outages. These storms can also cause significant pavement damage which has to be repaired quickly. This field study consisted of loading trucks with mix using WMA technology and monitoring temperature over time using on-board instrumentation. Trucks were driven in a continuous loop and brought back to the plant at various time increments and placed. The haul time was to be increased until the mixture performed poorly. However, even after hauling for 10.5 hours, one test strip was still able to be compacted to 10% air voids with one roller. Thus it was determined that the asphalt industry can significantly improve disaster recovery by hauling mix from outside the storm-damaged area using WMA technology.

Asphalt Binders

Don Siler of Marathon Petroleum presented a summary of the SEAUPG Binder Task Group meeting, which reviewed the Multiple Stress Creep Recovery (MSCR) test requirements. The MSCR test is being considered as a replacement for the existing high temperature test for short-term aged binder because it may better relate to polymer modified binder properties at high temperatures. Some identified barriers to implementation were: lack of manpower to run the test, lack of suitable DSR equipment, concern about how the test may affect binder and polymer suppliers, and a lack of guidance. It was mentioned that some of those barriers have been, or are being, addressed. All 14 SEAUPG states are now participating in the MSCR Task Force which hopes to draft a supplemental specification and implement MSCR testing in 2013.

Jeff Withee, from FHWA's Office of Pavement Technology, provided an update from the Expert Task Groups on asphalt mixtures and asphalt binder. The FHWA is sponsoring workshops to inform agencies and suppliers of the MSCR specifications and the AASHTO TP 70 test procedure for the test method. The FHWA is also leading a cooperative effort to review testing precision and bias. He also discussed problems with using the current grading system for binders modified with GTR.

John D'Angelo, a Virginia consultant and former FHWA binder expert, described the development of a performance specification for crumb rubber modified (CRM) asphalt binders. The new CRM specification will match the MSCR binder specification. He mentioned a couple of alternate DSR specimen geometries, such as parallel plate and Cup and Bob methods, that are being used to evaluate modified binders. As shown in Figure 2, the size of rubber particles has a significant impact on high temperature properties with the coarser rubber providing less stiffness.

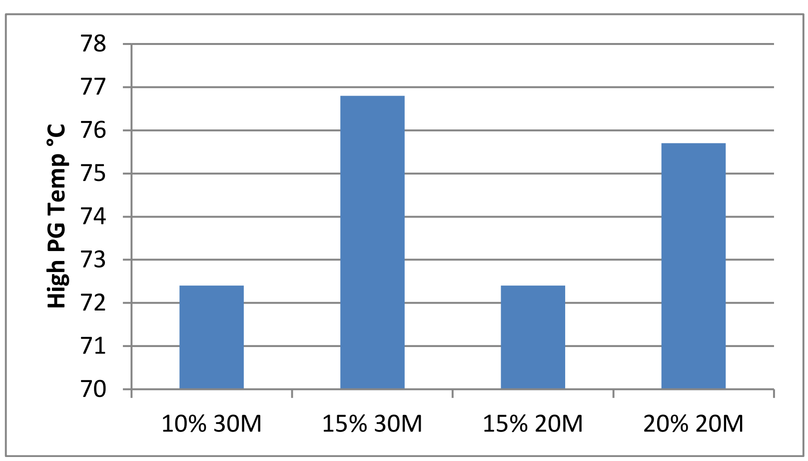

Figure 2. Effect of Rubber Particle Amount and Size on PG Grade

national superpave news

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RAP and WMA Become Mainstream

by Rebecca McDaniel

While reclaimed asphalt pavement (RAP) has been used to some extent since the 1970s, the use of warm mix asphalt (WMA) in the US is only about a decade old. Both technologies, however, are being used so frequently in many states that they have become routine. In fact, because they have become so mainstream, two groups that had been formed to explore issues with these technologies are now being disbanded.

As the use of RAP in Superpave mixes was becoming more common and RAP contents were increasing, various issues arose. The FHWA recognized that national guidance on the use of RAP was needed, especially for high RAP contents. Therefore, in 2007, FHWA formed the Reclaimed Asphalt Pavement Expert Task Group (RAP ETG) to coordinate, develop and refine recommendations and guidance for the use of RAP. This group of highway agency officials, industry representatives and academicians met ten times to discuss the status and findings of current research, develop guidelines for RAP use, survey state specifications on RAP use, report on the state of the practice and more. Under the guidance of chair Gerry Huber, the group also assumed responsibility for addressing issues related to recycling asphalt shingles.

One of the key activities of the RAP ETG was the periodic survey of state specifications and usage of RAP in mixtures, initiated by Cecil Jones, then of the North Carolina DOT. These surveys showed that the amount of RAP reportedly used in asphalt mixtures tended to lag behind the allowable RAP contents in state specifications. This was likely due to contractors' concerns about meeting mixture requirements with higher amounts of RAP and the frequent need to use softer binders for higher RAP contents; these softer binders were sometimes not readily available or were more expensive. Overall, the surveys were eye-opening and helped identify areas of improvement regarding RAP usage. Information about the surveys and other activities of the RAP ETG is online at www.morerap.us.

Also in 2007, the National Asphalt Pavement Association (NAPA) and Federal Highway Administration (FHWA) formed the Warm Mix Asphalt Technical Working Group (WMA TWG). This group of individuals from NAPA, FHWA, state DOTs, NCAT, industry and academia shared information on the burgeoning WMA industry. From a small number of products in 2004, the number of WMA technologies (products and processes) has grown phenomenally to over 30 today. The WMA TWG met periodically to review research on and field trial of these different products. One of the TWG's major accomplishments was identifying a number of research needs and securing funding for that research. Largely because of the TWG's efforts, seven National Cooperative Highway Research Program (NCHRP) projects on WMA have been funded. These are in addition to FHWA and individual state funded research efforts. Information on the WMA TWG activities is available at www.warmmixasphalt.com.

The newest NCHRP WMA project will address issues related to the use of recycled asphalt shingles with WMA technologies. This project is slated to begin in May 2013 and will last over three years. Because virgin binders are not heated as much when WMA is produced, there is some thinking that the reduced binder oxidation could be beneficial when mixed with the highly oxidized shingle binder. On the other hand, because the production temperatures are lower, there is concern that the shingle binder might not be softened enough to blend with the virgin binder. Understanding how the shingle and virgin binders work together is one issue the project will explore.

Both the RAP ETG and WMA TWG were deemed to be very successful. They reached out to agencies and contractors implementing the technologies and provided forums for the exchange of information. Guidelines were developed and research needs were identified. Were all of the questions answered? Certainly not. But significant strides were definitely made. Research and refinement will no doubt continue for decades to come.

The technologies have become so well accepted, however, that FHWA determined the need for specialized groups to focus solely on those technologies were no longer essential. The remaining issues related to RAP and WMA will be addressed by the existing Asphalt Mixture and Construction Expert Task Group. If appropriate, some issues may also be taken up by the Binder ETG.

Increasing the Durability of RAP Mixtures

by J. Richard Willis, Pamela Turner, Grant Julian, Nam Tran, Flavio de Goes Padula

It is commonly accepted that using reclaimed asphalt pavement (RAP) in asphalt mixtures can provide economic savings by reducing the demand for virgin binder and aggregates. However, state highway agencies limit the RAP contents allowed in their mixtures due to the lack of long-term performance data despite the fact that some 20 million tons of RAP are *not* recycled back into asphalt pavements each year.

Current escalations in the cost of virgin binder can be offset by using more RAP. Recent reports have suggested that material costs can be decreased by 20 to 35% by using 25 to 50% RAP in asphalt mixtures. One reason agencies are reluctant to increase RAP contents, however, is the general perception that RAP mixtures may be more susceptible to fatigue, thermal and reflection cracking. This is due to the fact that the RAP binder is aged, stiffer and less strain tolerant than a virgin binder. Before specifying high RAP percentages, agencies want assurance that high RAP mixes will provide satisfactory field performance.

One suggested method of increasing the durability of high RAP mixtures is to adjust the virgin binder grade. Current AASHTO M 323 recommendations for changing binder grades are based on the RAP contents. When between 15 and 25% RAP is used in an asphalt mixture, current guidance suggests that mix designers should reduce both the high and low temperatures by one performance grade. When more than 25% RAP is in the mixture, blending charts should be used to determine the appropriate virgin binder grade.

Recent research at NCAT has also suggested that the performance of RAP mixtures might be related to volume of virgin binder in the mix rather than the performance grade of the virgin binder. Other work from the 2009 Test Track has shown that incorporating WMA in high RAP mixtures can increase mixture durability.

This research was conducted to assess and quantify whether increasing the volume of effective virgin binder, using a softer binder, or using a warm-mix asphalt (WMA) technology aided in improving the durability of high RAP mixtures.

Multiple laboratory tests were conducted to quantify changes in the durability of the various RAP mixtures.

The linear amplitude sweep (LAS) test is an accelerated binder fatigue test that has been proposed to replace the current Dynamic Shear Rheometer (DSR) intermediate temperature $G^*\sin\delta$ parameter. The $G^*\sin\delta$ parameter is based on the assumption that asphalt binders in pavements function in the linear-viscoelastic range and are, therefore, insensitive to strain levels. These assumptions have long been challenged, especially as modified asphalts have been shown to exhibit increased fatigue resistance and non-linear strain response. The LAS test was developed to account for actual damage resistance as well as pavement structure and traffic loading. The end result is a prediction of binder fatigue life, N_f, as a function of strain magnitude.

The energy ratio test procedure, developed at the University of Florida, was used to assess an asphalt mixture's resistance to top-down or surface cracking. The results from three tests – resilient modulus, creep compliance, and indirect tensile strength – are used to determine the energy ratio. A higher energy ratio provides more resistance to surface cracking.

The overlay tester (OT) was used to assess the resistance of the RAP mixtures to reflective cracking. Tests were performed largely in accordance with a Texas DOT test method (248-F). Loading occurs when a movable steel plate attached to the asphalt specimen slides away from the other plate (Figure 1) at a rate of one cycle every 10 seconds with a sawtooth waveform in controlled displacement mode. The maximum load the specimen resists is recorded for each cycle. The test continues until the sample fails, defined as a 93% reduction in load magnitude from the first cycle.

The rutting susceptibility of asphalt mixtures is commonly assessed using the Asphalt Pavement Analyzer (APA). While the objective of this research was to determine how increasing the volume of effective binder or reducing the asphalt binder performance grade affected the mixture durability, one does not want to sacrifice rutting resistance for durability.

Moisture susceptibility testing was performed on the completed mix designs in accordance with AASHTO T 283. All three mixtures met the required tensile strength ratio of at least 0.80 using 0.5% liquid anti-strip by weight of the virgin binder.

Blends of the virgin and extracted RAP binders were created corresponding to the amounts of each binder in the 10, 25 and 50% RAP mixture designs. (Mixing the RAP and virgin binders results in complete mixing of the virgin and RAP binders, which may not actually occur during production.) The blends with the PG 67-22 virgin binder were then adjusted to correspond to an increase in the effective virgin binder content by 0.25 and 0.5%. The increase in virgin binder should theoretically increase the fatigue life. Asphalt pavements with higher asphalt contents tend to have better fatigue life due to the increased asphalt binder film thickness surrounding the aggregate particles. The reduction in overall binder stiffness due to the increased virgin binder should also improve the fatigue life.

While the 25% RAP binder test results follow the expected trends, deviations from expectations occurred in the 10 and 50% binder blends. For example, the 10% RAP mix design increased its binder fatigue life by adding an additional 0.25% virgin asphalt to the binder blend; however, using an additional 0.5% virgin asphalt added no additional fatigue life to the optimum blend. This same trend was noticed with the 50% RAP binder blends; however, it was also noted that the 50% RAP binder blends had longer fatigue lives than the 10% RAP binder blends.

Overall, the PG 58-28 virgin-RAP binder blends had longer fatigue lives than the PG 67-22 virgin-RAP binder blends. The reduction of fatigue life caused by increasing the RAP content from 25 to 50% is more noticeable for the PG 58-28 binder blends. The reduced sensitivity of the PG 67-22 binder to the addition of RAP when compared to the PG 58-28 binder is most likely due to the increased intermediate temperature stiffness. The PG 58-28 binder is still fairly soft at intermediate temperatures, as evidenced by its true grade intermediate temperature of 15.5°C. The PG 67-22 binder is stiffer with an intermediate true grade temperature of 23.9°C. The addition of the RAP binder would not have as great an effect on the intermediate temperature properties of the PG 67-22 binder as it would on the PG 58-28 binder.

Using a WMA additive to increase the fatigue life of the binder blends had more of an effect at higher RAP contents. This increase in fatigue life was even more pronounced for the 50% RAP mixtures as the WMA increased fatigue lives by approximately 32% at both strain levels.

In summary, using the softer binder had the greatest impact on blended binder fatigue life. The use of WMA additives showed the greatest effect when used in conjunction with high RAP mixtures.

The fracture energy results were mixed in that the FE of both the 10 and 50% percent RAP mixtures were positively affected by using WMA additives, softer binders, or additional virgin asphalt. However, the 25% RAP mixture with the optimum asphalt content using the standard binder had the greatest fracture energy of the 25% RAP mixtures.

Statistical analysis to assess differences in Overlay Tester results for the RAP mixtures showed that there were no statistical differences between any of the variables. This finding is probably due to the high variability of the data. While there were no statistical differences, changing the binder grade, increasing binder volume, or using WMA increased the cycles until failure.

Statistical analysis of the APA results showed the rutting of the mixtures to be statistically equivalent. All the test results indicated the RAP mixtures would be considered resistant to rutting.

Statistical analysis of the APA results, shown in Figure 1, showed the rutting of the mixtures to be statistically equivalent. All the test results indicated the RAP mixtures would be considered resistant to rutting.

additional asphalt or WMA showed the greatest increase in ER.

• OT test results were not statistically affected by the addition of virgin binder, WMA technologies, or using a softer binder at any RAP content. However, additional asphalt and WMA technologies made the greatest numerical increase in cycles to failure for 10% RAP, and additional virgin asphalt or softer binders increased the cycles to failure the most for the 50% RAP mixtures. No real increase was seen for the 25% RAP mixtures.

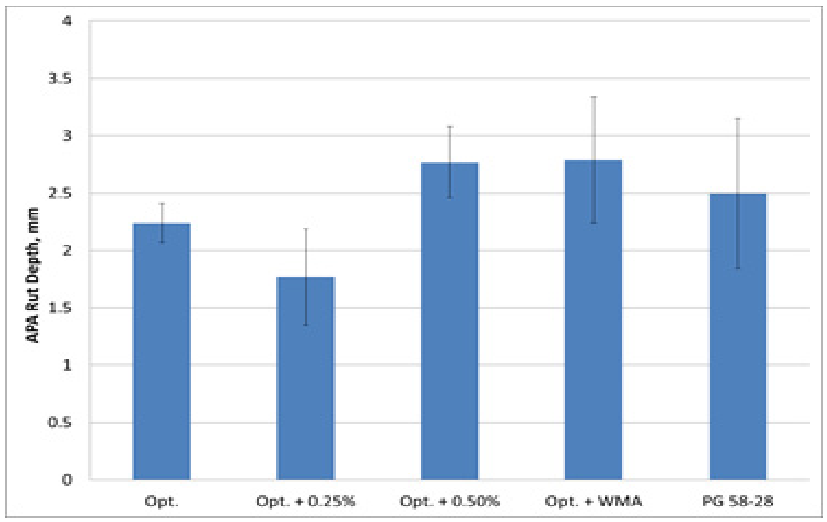

Figure 1. APA Rut Depths for 50% RAP Mixes with Different Binder Contents, WMA and Binder Grade

Conclusions and Recommendations

The following conclusions can be drawn based on the experimental plan and results.

• Using a softer binder had the greatest impact on improving the fatigue life of all the RAP binder blends based on the LAS binder fatigue test.

• Using a softer binder grade, additional virgin asphalt, and WMA technologies improved the FE of both 10 and 50% RAP mixtures; however, no increase in FE was noticed for the 25% RAP mixtures.

• The ER decreased when using the softer virgin asphalt or increasing the effective virgin asphalt content of a mixture for the 25% RAP mixtures. For the 10 and 50% RAP mixtures, using a half percent

• Using a softer binder at low RAP contents increased the rutting in the asphalt mixtures.

Based on this limited study, technically sound and cost effective options for enhancing the durability of high RAP mixtures appear viable. When using less than 25% RAP, using an additional 0.5% virgin asphalt or incorporating a WMA technology should provide additional durability. At 25% RAP, a softer binder or WMA technologies should be used to increase the mixture durability. Finally, use of an additional 0.5% or a softer binder should be allowed to increase the mixture durability.

These options should be validated in the field and further analyzed on a regional basis.

Mississippi MEPDG Climate Data Input Files Illustrate Need for Evaluation

by Michael Heitzman and David Timm, NCAT, Auburn University; Gene Takle and Daryl Herzmann, Climate Science Program, Iowa State University; Dennis D. Truax, Department of Civil and Environmental Engineering, Mississippi State University

The mechanistic-empirical pavement design guide (MEPDG) software package includes climate files that are limited in geographic density and limited in length of time. For example, in Mississippi there are climate input files from only 12 weather stations and only seven of the 12 have more than eight years of climate record. There are only three weather stations in the northern half of the state. This limits the ability of the MEPDG to reasonably predict pavement performance.

A recent study by a team from Auburn, Iowa State and Mississippi State Universities applies climate science to build more accurate historic climate files and build future climate files (called virtual climate files) by applying accepted models of long-term changes in global climate. The study examines how the improved climate data input files impact the pavement performance prediction. The improved climate data input files use a longer period of climate history and information from significantly more weather stations.

The basic weather input to the MEPDG pavement model is a multi-year time sequence of hourly weather variables for a particular location. When the pavement model is run using past climate as input for a location, the meteorological input file contains hourly temperatures, precipitation, etc., that are influenced by occurrences of El Niños, La Niñas, and hurricanes. These irregular but important regional climate influences exist and evolve in response to changes in sea-surface temperatures that also slowly change in time. At a given location, the hourly progression of temperatures is strongly influenced by these "remote" conditions.

Global climate models simulating future climates do not simulate future year-to-year changes in sea-surface temperatures and therefore do not produce plausible future El Niños and La Niñas. Large-scale conditions leading to hurricanes are simulated with global climate models, but the hurricanes themselves are not produced by such models. Therefore, simply using global climate model output to represent future weather sequences would miss important and known influences on climate variability.

There are a couple of ways to address this dilemma. The simplest method is to start by using a global model to create two proxy climates: a "contemporary climate" (e.g., representing the 1990s) and the "future scenario climate" (e.g., representing the 2040s). This global model of the atmosphere is given an accurate amount of solar radiation at the "top" of the atmosphere and greenhouse gas concentration in the atmosphere representing each 3-minute time step for the 10-year period. As a result, the region simulated (i.e., continental US) has the basic seasonal and daily cycles of weather variables for each longitude, latitude, and altitude point within the model.

The "contemporary" climate of the 1990s developed by the combined global/regional model will differ somewhat from the actual historical records for the 1990s for several reasons. First, the land surface in the regional climate model does include major topographical features such as mountains and major water bodies, but does not specify conditions smaller than about one fourth the size of a typical county. So it might not include the influence of a small lake or city. Also vegetation does not "green up" naturally in the model but is changed abruptly in the spring. Furthermore, effects of clouds are not represented accurately because they can occur on many spatial scales and have physical properties that are too small to be fully represented in the regional model. As a result of the approximations used to account for these deficiencies, the regional model produces a "contemporary climate" that has realistic seasonal and daily cycles but may have a systematic "bias"; that is, the regional model may always be a 1-2°C too cool or too warm for a particular location in a particular month when compared with the recorded historical climate.

The "future scenario climate" uses the exact same global model with the exact same land surface (e.g., cities of same size, same agricultural regions, etc.) and same solar radiation as the model that was used for the "contemporary climate." The only difference is that the global model used to create the boundary conditions for the regional model had a different amount of greenhouse gases in the atmosphere than was used for the contemporary climate. The result was generally that there were slightly higher temperatures in the lower atmosphere with subsequent changes in evaporation, cloudiness, etc.

Virtual climate files were developed for nine regions across Mississippi. The nine virtual climate regions are bound by the distribution of climate data generated by the global/regional model. Similar to development of the historic files, the virtual climate regions extend into adjoining states, like the coastal counties of Louisiana, to acquire data for developing the climate files. The method used to build the virtual climate files for Mississippi is only one of several approaches that could be selected by a particular state. The approach used in Mississippi determines the changes projected by the global/regional climate model and applies the changes to the 40-year historic file.

Next, the study examined how the improved climate data input files impact pavement performance prediction. The improved climate data input files use a longer period of climate history and information from significantly more weather stations. Sensitivity analysis measured the impact of the three different climate input files (MEPDG, Historic, and Virtual) on the predicted performance of three common types of pavements used in Mississippi. The first pavement is a conventional 9-in. jointed plain concrete pavement on a lime stabilized base. The second pavement is a 12.5-in. thick HMA pavement directly on subgrade. The third pavement is a 4.5-in. thin HMA pavement placed on a permeable asphalt base and granular base. These are significantly different pavement sections and should have different predicted pavement performance.

The predicted performance for each of the three pavement types was examined for each of the climate regions defined for Mississippi. The analysis examined the 40-year response of the PCC pavement and the 20-year response of the two HMA pavements. To keep the level of analysis manageable, the predicted pavement faulting and ride for the PCC pavement and the predicted pavement performance rutting and ride for the HMA pavements were examined.

The largest differences in predicted performance for the thin HMA in this analysis are in five climate zones where the results indicate that the MEPDG climate input data would predict more pavement distress than the higher quality historic and virtual climate input files. There is a consistent small difference between the predicted performance between the historic and virtual climates. This reflects the increase in temperatures built into the virtual climate input files. For all three pavement types, the MEPDG pavement performance prediction in one of those climate zones, zone 4, shows more distress, especially for the thin HMA pavement. Figure 1 shows the plot of predicted performance for rutting for each of the three climate input files. The predicted performance using the historic and virtual files was very similar. The predicted rutting performance for the MEPDG climate clearly shows a significant difference.

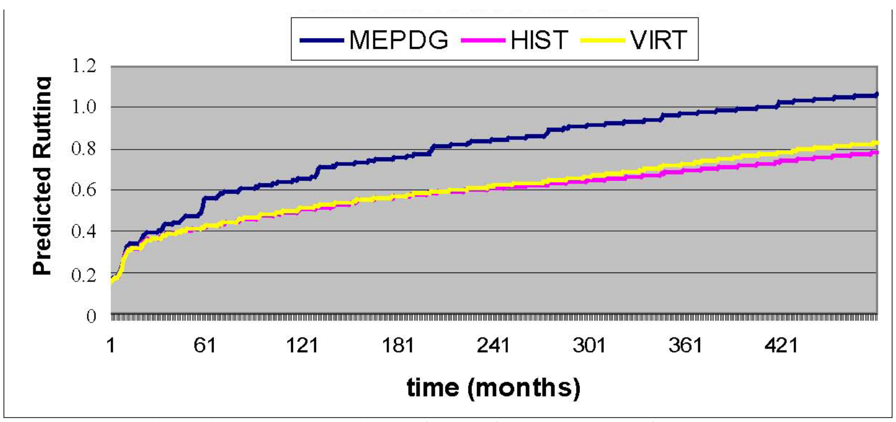

Figure 1. Predicted Rutting Based on Three Climate Input Files

The pavement surface temperatures were compared to better understand the difference in rutting performance using the three climate input files. This analysis was performed to examine if the pavement surface temperatures corresponded with the predicted performance, specifically for the HMA rutting in climate zone 4. Based on the predicted rutting performance, it would be reasonable to expect the pavement surface temperatures using the MEPDG climate files to be higher than the historic and virtual pavement surface temperatures. Further, the model for the virtual climate temperature did slightly increase over time and the MEPDG output pavement surface temperatures should show a slight increase from the historic to the virtual climate. In July and August, the MEPDG 5th quintile average pavement surface temperature is more than 10°F higher than the pavement temperature using the historic and virtual climate data. The 5th quintile temperatures would have the most severe impact on predicted pavement rutting.

The 5th quintile averages clearly show the MEPDG climate input file is generating higher temperatures than the Historic and Virtual input files. The next step in the analysis examined the specific climate input data files for climate zone 4 to isolate the differences. The first observation was that the MEPDG climate file for that zone only contains 88 months of climate data and the Historic file contains 434 months of data. Examining the climate input data on a combined basis did not identify information to support the higher 5th quintile averages shown in the MEPDG output file.

The next step was to look more directly at the climate data. The procedure used in MEPDG to apply the climate data is not bound by the year of the climate file or the year of construction. The MEPDG initiates the climate on the month of construction. Most of the data show similar summer and winter maximum temperatures, but there are two consecutive months (month 13 and 14) of high summer maximum temperatures one year after construction when the MEPDG climate input is 10°F higher than the Historic climate input. This is likely a major difference in the two climate files that is creating the significant change in predicted pavement rutting performance.

However, the MEPDG climate input file for zone 4 is only six years of data. For the MEPDG pavement performance prediction software to complete a 20-year performance projection, the MEPDG climate input file is repeated multiple times. Each time the climate file is repeated, the same two-month high temperature event re-occurs as part of the climate input. Re-examining Figure 1, the impact of this event in the rutting prediction is clearly evident. Each step in predicted rutting corresponds with the repetition of the MEPDG climate file.

The key limitation is the need to properly calibrate the MEPDG prediction models for Mississippi pavement performance. Only one of the six predictions (thick HMA rutting) is close to the actual measured performance. For all three pavements, the ride

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Evaluation of Weather Station Data Recommended to Determine Appropriate Test Temperatures

by Adam J. Taylor and Don Watson

The temperature data from area weather stations are important because they are used to determine inputs for the Mechanistic-Empirical Pavement Design Guide (MEPDG) and for establishing an appropriate test temperature for rutting susceptibility using the Flow Number (FN) procedure (AASHTO PP79-11). However, an informal review of weather station data for one agency has demonstrated that the present climate files may have data that is not representative of the project itself due to the effect of small, isolated, mountainous areas. According to NCHRP Report 629, a 0.5°C change in sample temperature can change a mixture's flow number by 7.5%. Therefore, the test temperature used will have a significant impact on the results which are used to determine acceptability of an asphalt mixture with respect to rutting resistance. The appropriate FN test temperature is a calculated value based on the 50% reliability high pavement temperature at a depth of 20 mm below the surface as taken from the LTPPBind v 3.1 software.

This temperature is based on the geographical location, elevation, and recorded ambient temperatures within the area. This temperature will then be used for the FN test, performed using the conditions recommended in NCHRP Projects 09-33 and 09-43 for HMA and WMA, respectively. LTPPBind v3.1 was utilized to gather all available data from weather stations within the agency borders. A total of 34 weather stations had available data for the region.

The data were analyzed to determine the effect of geography on FN temperature. Figure 1 shows the recommended flow number temperatures calculated from all 34 weather stations within the region. Inspection of Figure 1 shows that the majority of the collected temperatures are in the 60 to 65°C range. There is also a smaller cluster of data in the 56-59°C range and two data points at 47-49°C. Inspection of a topographical map showed that these low temperature areas are in mountainous areas. As a result of this evaluation, the data were further analyzed to determine the effect of elevation on the required FN test temperature.

The data shows a clear separation between weather stations above or below 1,000 m (0.62 miles) in elevation and between weather stations above or below 3,000 m (1.86 miles) in elevation. The weather stations with elevations above 1,000 m have recommended FN temperatures below 60°C. The two aforementioned data points with recommended temperatures below 50°C are at elevations above 3,000 m.

When determining a recommended FN test temperature, LTPPBind v3.1 typically looks at the data from the five closest weather stations. However, there is a software option to rule out one or more of these stations if the engineer feels that the data is not representative of the conditions where the mix will be placed. A prime example of this would be in determining the required test temperature for a project within the geographical region that is less than 1,000 m in elevation. According to LTPPBind v3.1, the temperatures from the five closest weather stations to the project were 62.9, 49.0, 58.0, 56.4, and 62.4°C. However, three of these five weather stations are at higher elevations than the project. If the area to be paved is at a low elevation, then using data from weather stations located at high elevations would create an irresponsible test condition in the FN test. Practically this means the flow number test may deem a mix to have acceptable rutting resistance while the environmental conditions may be harsher than the testing conditions. This will lead to greater rutting in the field than was predicted in the lab. Using only weather stations at low elevations (below 1,000 m) would likely generate a more representative testing condition for this region.

The results shown in Figure 1 indicate the majority of the weather stations (27 stations) were in the lower elevation range (≤1,000 m). Figure 2 looks at the histogram and cumulative distribution function (CDF) of the recommended FN temperatures for weather stations at elevations less than 1,000 m. For

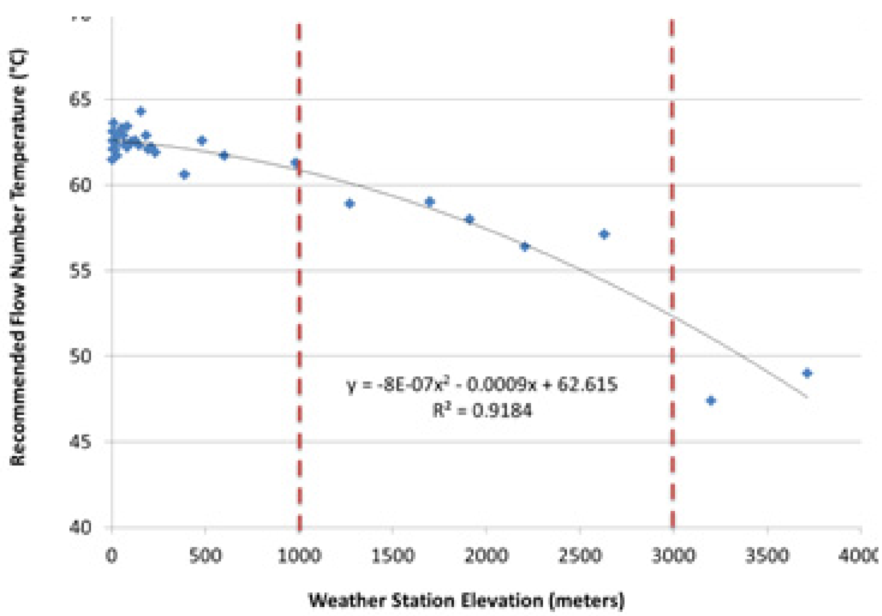

Figure 1. Recommended FN Temperature vs. Weather Station Elevation

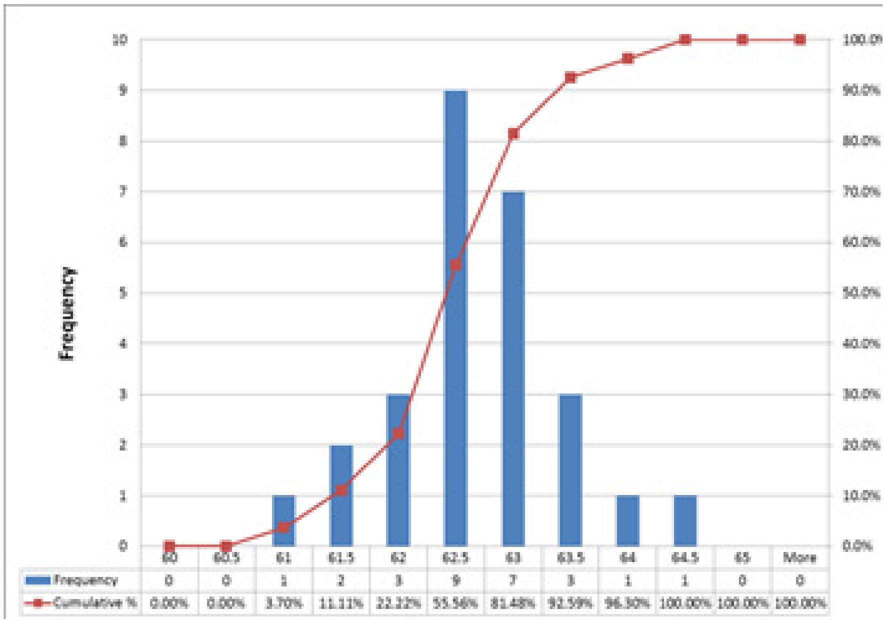

Figure 2. Histogram and CDF of FN Test Temperatures for Elevations below 1000 m

simplicity, selecting one temperature for this elevation range would be beneficial. However, that temperature must adequately represent the majority of the measured environmental conditions. The raw data for these low elevation weather stations indicate the recommended FN temperature range between 60.6°C and 64.3°C (a 3.7°C difference), with an average of 62.4°C.

The data in Figure 2 show the majority of measured values fall in the same range as the average (62.0°C to 62.5°C). However, according to the CDF, 44% of the weather stations have a recommended FN temperature higher than 62.5°C. By increasing the testing temperature to 63°C, 81.5% of the measured weather station FN temperatures are at or below the recommended test temperature. This is also the practical maximum test temperature for the AMPT, as the heating package is not designed to go above 64°C. Selecting a maximum test temperature to encompass 100% of the environmental variability is not recommended, since this testing environment would likely be too conservative (lower FNs) for the majority of tested mixes. Utilizing a test temperature of 63°C allows most of the environmental variability at the lower elevations to be encompassed by this test temperature while still remaining on the side of a conservative testing parameter.

Given these data and the results of this analysis, it is proposed that the FN testing temperature be related to the elevation that coincides with the majority of the paving site. For very high elevations (above 3,000 m), it is recommended the test temperature be 49.0°C for this agency. This temperature represents the maximum of the recommended temperatures (two weather stations) above an elevation of 3,000 m. For elevations above 1,000 m but below 3,000 m, there were five available weather stations. The recommended FN temperature in this elevation range was between 56.4°C and 59.0°C (a 2.6°C differential). Testing FN samples at 59.0°C would provide a conservative testing condition for this elevation range.

In summary, the flow number testing temperature for one particular agency using NCHRP 09-33 testing parameters is recommended as a function of paving site elevation.

As mentioned, these results are for one particular agency. It is recommended that each agency review their own weather station data to see if similar conditions may exist (especially in mountainous areas) that would adversely affect the selected temperature for conducting the Flow Number test.

MEPDG Climate Data Files

continued from page 7

prediction underestimates the increase in roughness. The second limitation is how the MEPDG currently uses climate input data. The current software starts at the beginning of the climate data without regard to the year. For calibration of the MEPDG models, the climate should match the time period of the measured performance. For example, if the pavement section for calibration is constructed and open to traffic in 1985, then the climate file for calibration should also start in 1985. Using the proper historic climate data for the correct time period will create a more accurate set of calibration factors than using the MEPDG climate files.

For this project, several sources of climate data were used to build accurate Historic data files which compiled 40 years of information. From this study, it is clearly shown that attempting to use small climate data files when conducting MEPDG pavement modeling can be expected to excessively exaggerate pavement distress predictions. This is because otherwise minor anomalies and extreme climate events that are likely to be included in the small database will be replicated several times in the modeling analysis as the system attempts to fill the database for the pavement performance period. Therefore, there are several recommendations to consider when conducting pavement performance modeling. These are:

- It is important to build a suitable climate database when the period of record is short. To do this, obtain the services of climate scientists to help build an extensive, accurate historic dataset.
- Use accurate historic climate data for MEPDG calibration. Pavement performance collected for calibration is influenced by the historic climate for the site.
- The climate input data file should coincide with the performance period of the calibration. Using climate files that do not match the calibration time period may diminish the accuracy of the calibration.

Intelligent Compaction Successfully Demonstrated in Indiana

By Rebecca McDaniel and Victor (Lee) Gallivan

The Federal Highway Administration has now completed a three-year national Transportation Pooled Funded (TPF) project on intelligent compaction (IC). As a part of this project, a full scale field IC demonstration for hot mix asphalt (HMA) pavement construction was conducted in West Lafayette, Indiana, in 2009, to showcase HMA IC technology to Indiana Department of Transportation (INDOT) personnel and paving contractors.

The TPF project evaluated the process on both soils/aggregates and HMA in twelve states across the country. Sixteen completed reports for these projects can be found at the IC web page at www.intelligent.compaction.com. The webpage is designed to be a one stop location to share knowledge on IC activities in the US.

The FHWA definition of Intelligent Compaction (IC) is a process that includes vibratory rollers equipped with a measurement/control system, an onboard integrated report system that includes global position system (GPS), and an onboard color-coded display. The IC system then will collect, analyze, and report on various parameters 3000 to 4000 times a minute.

The Indiana Department of Transportation (INDOT), in partnership with Milestone Contractors, identified a project on US 52 in West Lafayette, Indiana, for inclusion in the study. The five-mile long project is a four-lane highway with two lanes in each direction. The scope of the project consisted of milling 50 mm of the existing HMA pavement, then placing 63.5 mm of 19-mm intermediate course and 37.5 mm of 9.5-mm surface mixture.

This demonstration project included the use of a Sakai double drum IC roller and a Bomag double drum IC roller as a replacement for the existing rollers supplied by Milestone. Both rollers included Global Positioning Systems (GPS), stiffness/compaction measurement systems, temperature measurement systems, and real-time display monitors. The demonstration tests included IC mapping of the existing asphalt shoulder and milled existing HMA surfaces; Falling Weight Deflectometer (FWD) testing on the milled surface; evaluation of the IC measurements by both rollers; and correlation of non-nuclear density gauge measurements and HMA core density measurement values.

After three days of IC field study, INDOT hosted an open house at their research facility to discuss preliminary findings and demonstrate the IC rollers to 75 visiting representatives from the state and industry. Seven different construction firms were represented at the open house and two other DOTs (Illinois and Kentucky) were also present to learn about the IC technology.

The IC open house activities included presentations from the TPF IC research team, as well as Bomag, Sakai, and Trimble GPS manufacturers.

Industry representatives identified and discussed some of the findings from the week's testing and presented a list of IC benefits for contractors that have been observed across the country. The benefits included:

- Maximum productivity of the compaction process,
- Improved density of pavement materials,
- Measurement and record of materials stiffness values,
- Identification of non-compactable areas,
- Improved depth of compaction,
- Collecting compaction bonuses,
- Operator training & self-training,
- Improved rolling patterns,
- Improved QC personnel allocation,
- Reputation for quality ,
- Better documentation,
- Complete record for the project, and
- Warranty paving – proof rolling

George Chang, from the Transtec Group, presented the preliminary finding from this IC demonstration project that included some of the mapping results from the shoulders and mainline, roller passes and temperature displays. One particular set of displays, which included the roller passes before and after using the IC roller, attracted the most attention and led to a lot of discussion. "The IC benefits are real and immediate!" said Chang, "The sky is the limit on what IC can do to help produce better pavement products!"

The figure below graphically shows the improvements possible with the use of IC. The top graph shows an inconsistent coverage of the pavement whereas the bottom graph shows more uniform consistency. The roller operations on this project were not exclusive to Indiana as the same "rainbow" rolling pattern has been found across the country.

According to Lee Gallivan, FHWA, IC technology has evolved over the years and is being recommended by the FHWA as a quality control tool for industry. All the reports from the national study and the final report (FHWA-HIF-12-002) are available for all to review on the website. Generic IC specifications for use in soils and asphalt materials are also available for agencies to consider including in their programs.

The promise of Intelligent compaction is so great that it is one of the innovative technologies included in the FHWA's second Every Day Counts initiative (EDC2).

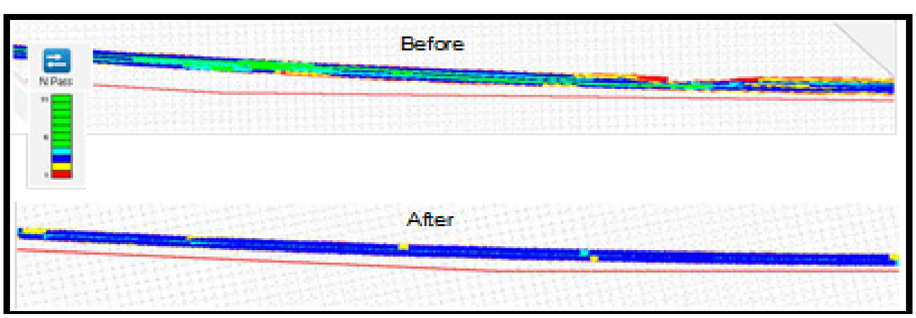

Figure 1. Before and After Comparison Shows the Improved Uniformity with IC

Long Term Performance of WMA to Be Studied, Added to Database

by Rebecca McDaniel

States and industry have embraced the use of warm mix asphalt (WMA) more quickly than any other new asphalt technology. Today at least 47 states have specifications allowing the use of WMA. This is a tremendous amount of growth since 2004 when WMA was first demonstrated at the World of Asphalt. Agencies and industry are adopting WMA based on early performance indicators, economics and sustainability considerations. The long term behavior of these mixes, however, is still largely unknown.

The lack of a long performance history and the widespread adoption of WMA have led the Federal Highway Administration's Long Term Pavement Performance (LTPP) program to initiate an effort to monitor and study the long term field performance of various WMA technologies on a national level.

LTPP is the only part of the original Strategic Highway Research Program (SHRP) that is still on-going. LTPP was originally envisioned as a States and industry have embraced the use of warm mix asphalt more quickly than any other new asphalt technology. Today at least 47 states have specifications allowing the use of WMA. This is a tremendous amount of growth since 2004, when WMA was first demonstrated at the World of Asphalt. Agencies and industry are adopting WMA based on early performance indicators, economics and sustainability considerations. The long term behavior of these mixes, however, is still largely unknown.

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LTPP is the only part of the original Strategic Highway Research Program (SHRP) that is still on-going. LTPP was originally envisioned as a 20-year program to study, essentially, why some pavements perform better than others. Through LTPP, a database of material properties, pavement cross sections, construction details, traffic, climate and field performance has been developed that is unparalleled. There is no other database of its type and scope in the world. This database has been used in the development of the MEPDG and many other studies.

LTPP has studied the performance of pavements through two approaches. General Pavement Study (GPS) sections were existing pavement sections incorporated in the program, while Specific Pavement Study (SPS) sections were specially constructed to investigate certain factors. There are nine existing SPS experiments focusing on issues related to both flexible and rigid pavements. Over 2500 test sections have been monitored under LTPP, and there are still over 700 test sections under study.

SPS sites typically include numerous test sections so that different variables can be compared. SPS sites also gave states the opportunity to construct supplemental sections that were not needed for the national study but were of particular interest to the state. Those supplemental sections were tested and monitored on the same schedule as the other sections.

Now, plans are being laid to add the first new experiment, designated SPS 10, to the LTPP program since the early 1990s, when SPS 9 was implemented to study the field performance of Superpave mixtures and PG binders. The new experiment will add to the LTPP database pavements constructed using WMA technologies with several different variables. An expert task group has been formed to help guide the development of the program. Nichols Consulting Engineers (NCE) is charged with developing the plans for the experiment. Different climatic regions and WMA technologies will be included. Each SPS 10 site will also include a hot mix control section for comparison. At this point, WMA pavements with RAP will be included in the study. Pavements with WMA and RAS are not being included in the national study, but could be supplemental sections if a state is interested. Details are under consideration with solicitation of test sections to begin in 2013.

SPS 11 on pavement preservation techniques is also in the preliminary planning states, pending additional funding.

Expanding the LTPP program to include WMA is seen as an exciting development by which we can take advantage of the existing LTPP program and resources to evaluate the long term performance of this new technology.

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Calendar of Events

2013

February 10-13	**NAPA Annual Meeting** Scottsdale, AZ www.asphaltpavement.org
Feb 25-March 1	**Asphalt Technology Course** NCAT Auburn, AL http://www.ncat.us/education/training/index.html
March 19-21	**World of Asphalt/ Association of Modified Asphalt Producers** San Antonio, Texas www.modifiedasphalt.org www.worldofasphalt.com
March 25-28	**Asphalt Mix Design** NCAT Auburn, AL http://www.ncat.us/education/training/index.html
April 7-10	**Association of Asphalt Paving Technologists Meeting** Denver, CO www.asphalttechnology.org
April 22-25	**Asphalt Binder Training** NCAT Auburn, AL http://www.ncat.us/education/training/index.html

NAPA, Partners Update Research Roadmap

by Rebecca McDaniel

In 2007, the National Asphalt Pavement Association (NAPA), Federal Highway Administration (FHWA), American Association of State Highway and Transportation Officials (AASHTO), the National Stone, Sand and Gravel Association and the Asphalt Institute collaborated to develop an outline of needed research in asphalt pavements and materials. At that time, seven program areas and 69 projects were identified. The program areas include long life pavements, structural design, materials characterization and mix design, construction and quality management, innovative contracting and surface characteristics. (Workforce development was originally included but has since been removed from the roadmap.)

The roadmap was intended to reflect the shared vision of the asphalt community regarding research needed to address current and future challenges. By enumerating the research needs in some detail, it was hoped that research in those areas could be undertaken by various organizations collaboratively for the benefit of the entire community. NAPA's Committee on Research and Technology (CART) used the document as a strategic plan to guide research efforts and to help identify the top needs at various points in time.

Since that document is now over five years old, work is underway to update and refine the roadmap. An invited group of leaders in the industry met in July 2012 to review the existing roadmap and discuss whether particular items had been addressed and could be removed from the roadmap. The group also identified new or more critical needs to reflect changes in the state of the practice since 2007.

The new roadmap should be available in 2013. The document can then be used by FHWA, states and other organizations to determine where there is overlap in the needs and where collaboration to solve today's challenges can occur.