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# 2013 Officers & Board of Directors

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<td>Pennsylvania Asphalt Pavement Association</td>
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<td>Lehigh Asphalt Paving &amp; Construction Co.</td>
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There are many priority activities going on right now that have or will have significant impact on our Industry. And, I am glad to see that there is so much involvement throughout our membership to address these priority activities.

Probably the most important effort is supporting Governor Corbett’s transportation funding plan that he proposed as part of his 2013-14 State Budget presentation. The proposal includes uncapping the oil franchise tax in three increments in 2013, 2015 and 2017 that would ultimately provide an additional $1.8 B annually. It also reduces the flat tax on a gallon of gasoline by 1¢ in July 2013 and another 1¢ reduction (total of 17%) in July 2014. It is estimated that 50,000 jobs will be created by this plan; and, conversely 12,000 jobs will be lost if nothing is enacted. Therefore, it is vital that we all take every opportunity with our legislators, community leaders, neighbors and acquaintances to explain the benefits that this plan will have on our infrastructure and our daily lives.

I attended the Annual NAPA Conference in Scottsdale along with 32 industry representatives from Pennsylvania. The focus of the conference was the recently formed Pavement Economic Consortium (PEC), NAPA’s concerted effort to combat the cement industry’s marketing and lobbying “blitz”. NAPA’s $1 M effort is guided by seven task groups (from “Best Quality and Competitiveness” to “Legislative”) that have identified about 25 projects for 2013. All 38 State Asphalt Pavement Associations have agreed to at least meet their suggested pledge amounts, and Pennsylvania was recognized numerous times for setting the “benchmark” in funding the P.E.C. Gary Hoffman and I are serving on NAPA task forces and committees to help “steer” this work particularly to assist us with issues right here in the state. Thank you all for your participation in this vital effort.

As most of you know, the Association has been working with the Pennsylvania Turnpike Commission (PTC) over the last year on their acceptance protocols for asphalt pavements. We hired Dr. James Burati, a nationally known expert in statistical specifications for construction, of Clemson University to assist us in this work. After numerous meetings, conference calls and a personal presentation by Dr. Burati, the PTC has made significant changes based on Burati’s recommendations. While the Turnpike’s currently proposed sampling and testing procedures are significantly improved over those of a year ago, there is still opportunity to make them better. We will continue to work cooperatively with the PTC.

Finally, as I noted in the last newsletter, my quality focus has resulted in the formation of a Quality Committee in PAPA. This committee has just completed a draft of a day-long training session on best practices spanning from estimating a project to final close out. This training is expected to be available to industry and PennDOT by April of this year.

As you can see, there is quite a bit going on right now, and your help and input is certainly welcomed. Please contact me or the Association office with any comments, suggestions or offers of assistance.

Vince Tutino
President
As a result of significant funding shortfalls necessary to properly manage and maintain roads and bridges, PennDOT, like many state agencies, has moved primarily to a preventive maintenance and preservation program. This program has specifiers using thin treatments that protect or preserve the surface, minimize changes to profile and geometrics, and are relatively low cost. But, these treatments do nothing to improve the structural capacity of the pavement section.

The Pennsylvania Asphalt Pavement Association began working with PennDOT in early 2011 with a goal to develop specifications and guidelines for a thin (less than 1 ½ inch) HMA overlay that would be part of the pavement preservation “toolbox”. A joint task force that included five PAPA representatives and DOT representatives from both Central Office maintenance section and materials section and also from one District was empanelled to meet this goal. A review of literature and of national surveys revealed that thin asphalt overlays are cost beneficial, seal the surface, are smooth and quiet, restore skid resistance, while minimizing changes to surface profile and still add some structural value to the pavement section.

A standard special provision (SSP) for Thin Lift 6.3mm polymer-modified HMA wearing course, use guidelines and tack coat requirements were distributed by CT M-11-004 and approved for use. The joint task force used best practices from more than 10 years of experience with ODOT “smoothseal” and NYDOT “6.3mm polymer-modified HMA” to develop the special provision. Key components of the ¼ inch to 1 ¼ inch thick wearing course are a fine densely-graded virgin aggregate matrix meeting SRL requirements, a high AC content PG 76-22 binder, and a Superpave volumetric design at 75 gyrations. A bituminous tack coat emulsion with a high percent asphalt residue (≥55%) and a low penetration asphalt residue was specified to provide good adhesion to the substrate and to prevent slippage of the overlay.

Cameron Street (SR30) Demonstration Project

The first thin lift demonstration project, on the 4-lane North Cameron Street (SR 230) in Harrisburg, was bid and awarded to Hempt Bros. of Camp Hill, PA. The project in Engineering District 8-0 was constructed during the last full week in July, 2012, with all night time paving operations. The project consisted of placing a 1-inch Thin HMA Overlay on less than ½ mile of a jointed Portland cement concrete pavement and included some full-depth concrete patches. The concrete pavement slabs were stable, and the surface had been diamond ground within the last 5-years. A CSS-1h emulsion tack coat was specified on the project at a 0.06 gal/sq application rate. The overlay was sawed and sealed transversely to match the joints in the concrete pavement.

Hempt Bros. made six trial blends to develop a mix design that met specification requirements. The 6.3mm NMAS mix incorporated SRL-E Type A concrete sand and #4 aggregate material from their Toland sandstone source. The mix gradation is shown in Figure 1 and the mix volumetrics at 75 gyrations are listed in Figure 2.

Continued on page 7...
Penn State University (PSU) is under research contract to PennDOT to evaluate the performance of Thin HMA Overlay mixes on the first three demonstration projects. The PSU research team conducted materials laboratory testing, documented field operations, obtained field measurements and will periodically evaluate performance after construction over several years. Some of the findings from the first demonstration project of Thin HMA Overlay on the Cameron Street project are discussed below.

Mix Design Performance Evaluation

Laboratory testing of the mix design was done at PSU before construction to determine its resistance to rutting and fatigue cracking.

The Hamburg Wheel Tracking test was performed at 50°C for a total of 20,000 wheel passes. Rutting as a function of number passes was measured during the test. The rut depth in the mix must not exceed 12.5mm after 20,000 cycles for the mix to be considered rut resistant. The results indicate an excellent performance in terms of rutting resistance of the mix as shown in Figure 3.

The overlay test methodology was used to determine if the asphalt mix was susceptible to fatigue or reflective cracking. The test applied load has triangular waveform, and its magnitude is dictated by the specimen deformation which is limited to 0.6mm (0.025 in.) per load application. The total duration for one load cycle (reaching the maximum and returning to initial position) is 10 seconds. A total of four specimens were prepared from the mix and tested for this project. The results are shown in Table 1. All specimens passed the criterion for this test, i.e. exceeding 500 load cycles before the load drops to 93% of its original value, although there was significant variability in the results.

Construction / Field Measurements

Tack Coat Application / Evaluation

Actual average daily application rate for the CSS-1h emulsion tack coat varied in the range of 0.059 to 0.078 gallons per square yard (g/sy), with an overall average of 0.069 g/sy. The target was 0.06 g/sy. Four-inch diameter field cores were obtained to determine both density (average of 92%) and the thickness of the overlay. The cores included the overlay and the underlying PCC pavement with a thickness of 10 inches (Figure 4). The thickness of the overlay varied in the range of 1.01 to 1.17 inches with an average of 1.09 inches. Laboratory tests were conducted on the field cores, with shear force induced at the asphalt and concrete interface, to evaluate the tack coat

Continued on page 8...
effectiveness in bonding the layers. An average shear strength of 45 psi was obtained at the interface, which was considered acceptable (Figure 5). The tack coat strength is affected by the test temperature and the loading rate. These tests were conducted at a shear deformation rate of 1mm/min and at a temperature of 77˚F. The Shear Test apparatus is shown in Figure 6, and the horizontal movement of the overlay relative to the concrete can be noticed.

**Temperature Data During Construction**

To capture the mat temperature changes with time, a hand held infrared thermometer was utilized. Measurements were conducted at three locations. Rapid temperature drop was observed due to the layer thinness (Figure 7). Based on all data from hand held device measurements, the rate of drop within the first 15 minutes is between 7 to 12˚F per minute. Observed mat temperature drop compared favorably with that predicted by “Pavecool” software, and showed that only 13 to 15 minutes was available to achieve compaction before the mat temperature dropped to 175˚F.

**Temperature Measurements Using Infrared Imaging**

Continuous full-width measurement of the mat temperature was achieved using an infrared camera. It was found that for the most part, the temperature varied in the range of 290 to 315˚F immediately after placement. Overall, the temperature differences across the mat were less than 25˚F right after placement, indicating that thermal segregation was not of concern. It is recommended that when temperature variations are larger than 25˚F attempts should be made to reduce temperature difference, for example, through using a material transfer vehicle (MTV).

**Core Densities**

Because of concern over the ability to obtain representative cores, the mat density was accepted based on rolling pattern developed with an on-site test strip. Additionally, nine cores were taken full-depth through the concrete pavement, and the overlay was removed by sawing to determine in-place densities. The average density and standard deviation for these nine core densities were 92.1% of MTD and 1.5% as shown in Figure 8. Core number 7 which is circled in red and had the lowest density

**Continued on page 9...**
Friction measurements were made with a smooth tire by PennDOT’s Pavement Testing Section in accordance with ASTM E-524. Measurements were taken on the concrete pavement surface in March 2012. Friction testing was done on the completed Thin HMA Overlay within one month of construction.

The average friction (SN₄₀) value on the concrete surface was about 25, and the average friction value on the THMAO surface was 55. This is a marked improvement in skid resistance which was expected. Friction test results are shown in Figure 9.

Ride quality (smoothness) measurements were also performed by PennDOT’s Pavement Testing Section before and after the overlay. Road profile measurements were converted to the International Roughness Index (IRI) (ASTM E-1926) in inches/mile. The lower the IRI number, the smoother is the surface. The IRI number on the original concrete surface averaged about 120 inches/mile. This is only a “fair” ride according to FHWA’s rating. The average ride number on the THMAO surface was about 80 inches/mile and represents a “good” ride. This is a significant improvement for only a 1-inch thick overlay. Ride quality (IRI) results are shown in Figure 10.

Summary / Findings

The results of the laboratory and fields tests and observation of construction practices on this first THMAO demonstration project indicate that the overlay should perform successfully in its intended purpose. Laboratory testing of the designed mix showed good resistance to rutting and cracking. Horizontal shear testing revealed good bond strength between the Thin HMA Overlay and the concrete pavement and good resistance to sliding thus corroborating the tack coat specification.

Four-inch diameter full-depth cores removed and tested for density showed that, if carefully removed and handled, cores could be used to determine in-situ density. The exception might be a core taken directly on a joint or other discontinuity in the existing pavement. Variation in temperature across the mat immediately behind the screed showed reasonable consistency. Because of the thinness of the overlay, the mat temperature dropped quickly and only provided 13 to 15 minutes to achieve compaction before the 175˚F threshold occurred. Higher minimum air and pavement temperatures for placement of THMAO should be considered.

The surface friction and ride quality (two of the most important characteristics from the motorists’ standpoint) on this section of roadway was improved markedly by the THMAO. Friction numbers increased from an average of 25 to an average of 55. And, the smoothness indicated by the IRI number improved from 120 to 80 in./mi. and from only “fair” to “good” category.
PENNDOT RECOGNIZED WITH THE ASPHALT PAVEMENT ALLIANCE “PERPETUAL PAVEMENT” AWARD

George W. McAuley, Jr., P.E., Assistant District Executive for Maintenance in PennDOT’s District 10-0, accepted the Asphalt Pavement Alliance prestigious “Perpetual Pavement” award at PAPA’s annual conference in December 2012. The award was for the 41 year old pavement on S.R. 210 in Armstrong County. IA Construction was the contractor on the original construction.

CONGRATULATIONS TO THE THREE PAPA MEMBERS WHO RECEIVED “QUALITY IN CONSTRUCTION” AWARDS AT THE 2013 NAPA CONFERENCE IN SCOTTSDALE, ARIZONA

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CHAIRMAN SHUSTER VISITS ASPHALT JOB

U.S. Congressman Bill Shuster, Chairman of the House Transportation and Infrastructure Committee, toured a New Enterprise Stone & Lime Co., Inc. construction project last fall.

This PennDOT project is in Blair County SR 3013 Section 005 at Claysburg, PA. It consisted of 2 miles of roadway improvements, safety upgrades, asphalt overlay and a widening of the existing structure over Poplar Run.

Chairman Shuster is a strong advocate for transportation infrastructure renewal, and he recognizes the many jobs in the construction industry and in ancillary business.
PUTTING THE RUBBER BACK "IN" THE ROAD:

By: John R. Kibblehouse, Jr.
Secretary and Treasurer
The H & K Group, Reading Materials, Inc.

Reading Materials First in PA to Utilize Crumb Rubber Modified Asphalt

Reading Materials, a member of The H&K Group Family of Companies and headquartered in Skippack, PA, was the first in the state to embark on a large-scale Pennsylvania Department of Transportation (PennDOT) paving project utilizing Asphalt Rubber Gap Graded Friction Course.

This PennDOT approved pilot project (ECMS 87631) began in early August 2012 and was completed by The H&K Group’s Reading-based affiliate, Windsor Service, by November 30, 2012. Consisting of a seven-mile stretch located on Interstate 78 in Berks County, “Section 20-M,” between Frystown and Rehersburg, this ground-breaking project required milling, patching, concrete repair, and finally, both leveling and wearing courses of Crumb Rubber Modified (CRM) asphalt paving.

Specified by PennDOT as a means of creating a high performance, yet durable and flexible surface on a high-traveled, interstate roadway, this pilot CRM paving project enabled Reading Materials to ultimately team with Massachusetts-based All States Materials Group as the sole CRM asphalt provider for the pilot. Other states, including New Hampshire, Massachusetts, and California have used similar mixes and found it to be more flexible and durable than traditional asphalt mixes.

The crumb rubber product utilized for this pilot mix design was supplied by Liberty Tire Recycling of Pittsburgh, PA. Comprised of recycled tire rubber that is finely ground at ambient temperature, crumb rubber is blended with liquid asphalt to create the finished product known as "asphalt rubber". The field blending of these components, resulting in the production of "asphalt rubber" was supplied by All States Materials Group.

In general terms, crumb rubber, when blended to asphalt at temperature of >350 degrees causes the rubber particles to swell, absorbing the light ends of the liquid asphalt binder, thereby creating a high viscosity elastic binder that remains both flexible at low temperatures and stiff at higher temperatures when cured. From a technical standpoint, crumb (tire) rubber contributes polymer, carbon black and anti-oxidants to the CRM asphalt product. This final asphalt product, according to All States Materials Group, “is a very adhesive and cohesive high viscosity binder that gives high film thickness on the aggregates, improving durability and resistance to oxidative aging, rutting, raveling, de-lamination, shoving and thermal and reflecting cracking.”

PennDOT’s specified mix design for the I-78 overlay project required a minimum of 7.6% CRM asphalt, which consisted of ~15% recycled tire rubber by weight in the asphalt rubber. The final CRM mix design was prepared and approved by The H&K Group’s Quality Control Team and designated for production at the Group’s Lebanon Materials asphalt plant facility in Annville, PA. All States Materials Group worked directly with Reading Materials to supply specialized equipment to field blend the CRM asphalt at Lebanon Materials asphalt plant facility that would enable critical application and blending of crumb rubber to the final asphalt product. Using a PennDOT Approved Warm Mix Asphalt Technology pre-blended in the virgin asphalt binder, the final CRM asphalt mix was produced at a lower temperature than standard asphalt mixes, therefore classifying it as a “warm-mix” product.

One minor obstacle encountered during application of this innovative CRM mix was handling of the asphalt post-production. Given the slightly “sticky texture” of the CRM product, Windsor Service paving crews observed that the material had a tendency to adhere to the paving equipment. However, it was discovered that Downy® Fabric Softener, when applied to the rollers and spray bar system, acted as an effective lubricating agent and helped prevent sticking.

Reading Materials’ Windsor Service paving crews completed the overlay portion of ECMS 87631 on October 15, 2012. Delivered materials quantities for the project included 240,000 SY of milling, 16,000 tons of CRM leveling course at 2 inches, 15,000 tons of wearing course at 1 ½ inches of 12.5mm Asphalt Rubber Gap Graded Friction Course.

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BENEFITS OF CRUMB RUBBER MODIFIED ASPHALT

- Gives a high film thickness
- Resists oxidative aging
- Resists cracking at low temperatures and rutting at high temperatures
- Prevents raveling of open-and-gap-graded mixes
- Can reduce HMA lift thickness, preserving curb reveal and clearances under overpasses
- Uses recycled material, reduces scrap tire inventories
- Durable, high performance binder extends the serviceable life of your HMA pavements

USES OF CRUMB RUBBER MODIFIED ASPHALT

Crumb rubber modified asphalt is formulated for durability and high performance applications. While designed for applications where high performance is needed, it may also be used for any hot mix asphalt paving project, and has proven effective on streets, highways and airfields. It is an ideal product for stress absorbing membrane interlayers (SAMI). The high film thickness makes it especially useful for special mixes such as open-graded friction courses (OGFC), paver placed surface seal, gap-graded mixtures and stone matrix asphalt (SMA). These mixes give outstanding performance in heavy-duty applications. The open mixes greatly improve visibility in wet weather and substantially reduce road noise, however, the problems encountered using conventional mixes like raveling have been eliminated by the CRM mix designs. The crumb rubber asphalt’s thicker film reduces drain down and aging of asphalt, giving the durability to makes these mixes most effective. To account for the rubber, the designs are a little different; typically higher voids in mineral aggregate (VMA) and higher binder contents (typically 20% higher) are needed.

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Pavement engineers have been producing long-lasting hot-mix asphalt (HMA) pavements since the 1960s. Research has shown that well-constructed and adequately designed flexible pavements can perform well for extended periods of time (1). Many of these pavements in the past forty years were the products of full-depth or deep strength asphalt pavement designs, and both have design philosophies that have been shown to provide adequate strength over extended life cycles (2).

Full-depth pavements are constructed by placing HMA on modified or unmodified soil or subgrade material. Deep strength pavements consist of HMA layers on top of a thin granular base. Both of these design scenarios allow pavement engineers to design thinner pavements than if a thick granular base were used. By reducing the potential for fatigue cracking and containing cracking to the upper removable/replaceable layers, many of these pavements have far exceeded their design life of 20 years with minimal rehabilitation (2). The successes seen in the full-depth and deep strength pavements are the results of designing and constructing pavements that resist these detriments to the pavement’s structure. In recent years, pavement engineers have begun to introduce a methodology of designing pavements to resist the two main pavement distresses seen on roadways, and with this change in thinking has come the idea of perpetual pavements or long-lasting pavements.

Ferne (3) explained this concept by saying a “long-life pavement is a well-designed and constructed pavement that could last indefinitely without deterioration in the structural elements provided it is not overlooked and the appropriate maintenance is carried out.” Pavement performance is more than a function of design. Trafficking, climate, subgrade and pavement parameters (such as modulus), pavement materials, construction, and maintenance levels all contribute to how a pavement will perform over the course of its life (4, 5).

While one might think pavements designed to last longer would incur more costs than pavement with shorter life-cycles, research has shown that perpetual pavements have the following benefits (6):

- Perpetual pavements eliminate reconstruction costs at the end of a pavement’s structural capacity.
- Perpetual pavements lower rehabilitation-induced user delay costs.
- Perpetual pavements reduce use of non-renewable resources like aggregates and asphalt.
- Perpetual pavements diminish energy costs while the pavement is in service.
- Perpetual pavements reduce the life-cycle costs of the pavement network.

**STRUCTURAL DESIGN**

One way to decrease the probability of bottom-up fatigue cracking is to increase the thickness of the pavement structure. Thick pavements have been shown to limit cracking to the surface of pavements by reducing the maximum strain at the bottom of the HMA (2).

When the tensile strain at the bottom of the HMA is reduced, most engineers believe that the critical location for strains in pavements is relocated from the base of the HMA to the surface of the structure where tire interaction and binder aging contribute to hardened and weaker wearing courses that are prone to top-down cracking (1, 7). At this point, since the distresses in the pavement are contained to the wearing course, it is possible to avoid deep structural maintenance and focus on functional maintenance such as skid resistance and ride quality (3). To eradicate the surface cracks, a “mill and fill” maintenance plan is appropriate for extending the pavement’s life (1).

While mitigating fatigue cracking is important in creating a perpetual pavement, one cannot sacrifice rutting protection for fatigue life. Studies at the National Center for Asphalt Technology (NCAT) Pavement Test Track (8) and by Rolt (7) have shown that thick pavement structures tend to prevent structural rutting in the subgrade and limit rutting to the surface layers of the pavement structure. This being the case, additional structural life would not be necessary to keep the pavement in-use. Surface treatments would be adequate for keeping the roadway in-service (1, 8).

**MIX DESIGN AND MATERIALS**

Increasing the thickness of a pavement is not a guarantee that the pavement will have a long service life. Washington State’s study of long-lasting pavements showed that in many
cases pavements with shorter life-cycles in Washington were thicker than more fatigue resistant pavement structures (1). Other studies have shown that while increasing the thickness of a pavement will decrease the tensile strain at the bottom of the HMA layer, the magnitude by which this reduction occurs is mix dependent (9).

Engineers have compiled knowledge and research to create a composite pavement structure which can be utilized to increase the chances of a flexible pavement achieving long life. This pavement structure (Figure 1) includes a rut and wear resistant impermeable upper layer of HMA. In many cases, a stone matrix asphalt (SMA), an open-graded friction course (OGFC), or a dense Superpave design is used for this lift. Below the wearing course, engineers design a rut resistant and durable intermediate layer. Finally, the base layer of the HMA needs to be a fatigue resistant, durable layer. This final lift is designed many times at increased asphalt content and reduced air voids (10).

**MECHANISTIC-EMPIRICAL PAVEMENT DESIGN**

Mechanistic-empirical (M-E) pavement design and analysis, though not a new concept, has recently made great advances toward widespread implementation throughout the United States. Currently, there are existing M-E pavement design methodologies (11, 12, 13), but as the new M-E Pavement Design Guide (MEPDG) is implemented, more attention is being spent on proper material and pavement response characterization (14). Material properties are needed in this design framework to determine theoretical load-induced responses in pavement structures.

Since perpetual pavement design relies upon maintaining pavement responses below some critical thresholds, it is well suited to M-E pavement design. To capture the fatigue and rut lives of pavements, engineers can estimate pavement responses so the pavement will have sufficient life. In perpetual pavement design, two mechanistic pavement responses are typically studied and limited. The first limiting response is the vertical compressive strain at the top of the subgrade. This pavement response has been linked to subgrade or structural rutting. In order to minimize this distress, engineers typically design for a maximum of 200 \( \mu e \) at this location (5, 15).

A second limiting pavement response is the tensile strain at the bottom of the HMA. As discussed above, this mechanistic response is limited to mitigate the possibility for bottom-up fatigue cracking (10). The longitudinal strain at this pavement location has proven to be critical in thinner pavements, and in a fully-bonded pavement, it is always the location of highest tensile strain. In protecting a perpetual pavement against fatigue cracking, engineers typically attempted to keep the tensile strain at the base of the HMA below 70 \( \mu e \) (5). However, other engineers propose that one should limit the strain anywhere from 60 to 100 \( \mu e \) based upon laboratory testing (16). Both of these estimates may be conservative based on recent NCAT research (17).

Engineers must learn to select mixtures which will allow a durable, yet economically competitive, pavement to be constructed. This would reduce the construction and material costs for state agencies at a time where funding is extremely limited. This would also cut back on the enormous amount of natural resources being consumed. Two strategies which can easily be incorporated into pavement design are using stiffer mixtures for the intermediate pavement layer and developing fatigue resistant base mixtures.

**INTEGRATING STIFF MIXTURES INTO PAVEMENT DESIGN**

Stiff mixtures can be used to effectively reduce either the necessary thickness of the overall pavement structure or reduce the tensile strains at the bottom of the pavement. However, one must choose carefully where to place these mixtures as some have concerns stiffer mixtures will be more prone to top-down cracking if they are placed at the surface. Therefore, high modulus mixtures are optimally placed in the intermediate layer of the pavement structure. One simple method of increasing the stiffness of the intermediate layer is to allow or increase the amount of reclaimed asphalt pavement (RAP) in the mixtures.

Mixtures placed at the 2009 National Center for Asphalt Technology (NCAT) Test Track have shown that using high RAP content mixtures (50 percent) can both increase pavement stiffness and reduce the overall tensile strain at the bottom of the pavement. Three test sections, all 7 inches thick, were constructed as part of a high RAP experiment to determine the effects of increasing RAP content on structural performance and response. One section, S9, was built as a complete virgin mixture at hot mix temperatures. The other two test sections (N10 and N11) were designed using 50 percent RAP. Section N11 was produced using a warm mix foaming technology (17).

Continued on page 15...
Both test sections which used high RAP contents showed an increase in the average in-place mixture stiffness between 16 and 43 percent (Test Track report) (Figure 2). This increase in stiffness directly correlated to a decrease in the measured strain at the bottom of the asphalt layers in the test sections by between 7 and 31 percent (Figure 3). These results show that either higher modulus mixtures (such as high RAP content mixtures) can be used to either reduce the tensile strain at the bottom of an asphalt pavement or could be used to create a thinner asphalt pavement with equivalent tensile strains.

**FATIGUE RESISTANT BASE LAYER**

The fatigue resistant base HMA layer is one of the most important pavement components for increasing the pavement’s resistance to fatigue cracking in high strain environments. Before designing the mixes, it is important to understand the end-goal of the mix design. If the engineer is designing a stiff structure, the tensile strain at the base of the asphalt pavement will be reduced. A thicker pavement structure might provide similar results. If a pavement is designed thick enough or stiff enough where the tensile strains at the base of the HMA are insignificant, a fatigue-resistant base layer is not necessary, and the mix used for the intermediate layer can be used for the base layer (2, 10). As is the case for most pavement structures, however, the tensile strains at the base of the pavement are critical in the design process. Therefore, one must design a fatigue-resistant mix to protect the long-life pavement (16).

Two basic principles for improving the fatigue life of this base layer have been proposed in research. They are as follows (2, 10, 15):

- Use a softer binder
- Use a higher binder content

While softer binders allow mixes to stretch without cracking, the most common method for increasing the fatigue life of a pavement is incorporating a higher asphalt content in the mix design (2, 13). Layers which incorporate the use of excess asphalt above the optimum have become known as “rich-bottom” layers, and they have been used extensively to reduce fatigue cracking in pavements by California, Illinois, Oklahoma, Texas, China, and NCAT (18).

Additional asphalt has been known to have the following benefits on pavement structures (18):

- Additional asphalt allows for greater compaction
- Additional asphalt improves fatigue resistance
- Additional asphalt at the bottom of a pavement does not affect rutting
- Additional asphalt reduces moisture susceptibility

In-place air voids in the field are typically near 7.0% on most projects; however, the additional asphalt in rich-bottom mixes allows in-place air voids to be reduced to less than 6% in many cases (19). This increased asphalt content and density in the mix design is critical in providing the pavement with durability and flexibility by increasing the voids filled with asphalt (VFA). The increased flexibility allows the pavement to stretch and inhibits fatigue cracks (2).

Research has been conducted in the past few years to determine the needs and limitations of pavement structures including rich-bottoms. Owners would still like to have the pavements as thin as possible to help reduce initial costs, so research has been conducted to determine the most appropriate location and thickness of the rich-bottom layer. Today, it is recommended that rich-bottom pavements be built with about a 0.5% increase in asphalt in the bottom lift that is between 2 to 3 inches in thickness. Thickness beyond three inches proved to have insignificant benefits to the fatigue life of the structure. This layer should be at least 6 inches below the surface to protect it from possible damage due to its lack of shear resistance (20).

While most pavement design engineers will agree that increasing the asphalt content in the mix design is the most appropriate way to provide additional fatigue life to a pavement,
different agencies design their rich-bottom layers using varying design methodologies. On the I-710 project in California, an additional 0.5% asphalt was added beyond optimum in a 3 inch lift to increase the fatigue life of the layer (15).

While increasing the asphalt content is a viable option for increasing fatigue life, some engineers feel that just “bumping” the optimum asphalt content may not provide realistic definitions of the mix characteristics (19). To correct for this, many states design their rich-bottom layers for a reduced air void content. States like Texas, Oregon, and Ohio design for 3% air voids in the laboratory. The recently placed perpetual sections at the NCAT Test Track were designed by the Oklahoma DOT for 2% air voids. This translates into 5 to 7% air voids in the field. While there is a different design process, the end results are much the same. The needed reduction in air voids typically requires about an additional 0.5% asphalt content (18).

Laboratory and field data from the 2009 Test Track have also shown that other types of mixtures can prove to be fatigue resistant. While commonly assumed that high RAP mixtures will be prone to cracking, both the hot high RAP and warm High RAP base mixtures had between 8 and 41 percent higher fatigue endurance limits than the control virgin mixture. The fatigue endurance limit is commonly used to assess a pavement’s ability to withstand strain without accruing damage. Other technologies such as Kraton’s highly modified polymer binder and Trinidad Lake Asphalt (TLA) pellets were used to successfully increase the fatigue resistance of the asphalt mixture. These data give engineers options for reducing overall pavement thickness while determining which technology/design method is most appropriate and cost-effective for their project (17).

**SUMMARY**

Pavement engineers understand the components of a pavement necessary to help it achieve a long lifespan. A rut-resistant upper layer of the pavement is going to allow the structure to withstand rutting, and the fatigue resistant base layer will help mitigate the presence of fatigue cracking. However, when these concepts are combined with stiff intermediate layers or technologies which can improve the fatigue resistance of the base asphalt mixture, the asphalt industry will be able to design, produce, and construct more thinner, economical, and durable asphalt pavements.

**REFERENCES**

12. Kentucky Transportation Cabinet. Pavement Design Guide (2007 Revision) for Projects off the National Highway System less than 20,000,000 ESALs, less than 15,000 AADT, and less than 20% trucks. Kentucky Transportation Cabinet Division of Highway Design, Lexington, KY, 2007.
Environmental Update

By: Steve Bright
PAPA Environmental Committee Chairman

Stormwater Issues at Asphalt Plants

Recently, questions have arisen for some asphalt plants with respect to stormwater issues. The main issue is when does all or some of stormwater runoff become "process water" in the asphalt mix production process. Based on information from NAPA, asphalt mix plants in many instances are exempted from stormwater programs and specific effluent limits related to "process water" for several reasons:

⇒ The consensus among key people in the industry is that there is only contact between asphalt cement and stormwater in the loading area where asphalt mix loaded onto trucks has spilled onto the ground. This would constitute mixing of asphalt cement with stormwater, producing "process water".

⇒ 40 CFR 443.20 is applicable to discharges from production of asphalt concrete (liquid asphalt cement), but not a “cured” asphalt pavement mix (e.g., HMA and WMA).

⇒ "Process water" is not generally considered the same as stormwater, and process water has its own set of regulations.

For these reasons, stormwater discharges from an asphalt plant site are usually not considered process water. However, solids present in stormwater leaving an asphalt plant site have been given recent attention by PADEP. If turbid water from aggregate or sand storage piles leaves the mix plant area by surface water sheet flow, or via a drainage ditch, culvert or by roadway truck “tracking”, issues regarding solids/sediment discharges may arise as brought forth by State or local agencies. Best Management Practices for stormwater must be implemented to minimize the potential for solids causing turbidity in stormwater discharges.

The Association’s Environmental Committee will continue to monitor issues related to stormwater discharge as the year progresses and keep the public informed.

PAPA has scheduled Environmental Seminars on March 25, 26 and 27th to update industry on current environmental issues including stormwater runoff based on two meetings that PAPA has held with the DEP Central Office personnel.

For more information on this, call Gary R. Brown, P.E. at RT Environmental Services, Inc. at (610) 265-1510 or the PAPA office at (717) 657-1881.

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PAPA Calendar of Events

MARCH 25, 2013
EASTERN ENVIRONMENTAL WORKSHOP
HOLIDAY INN, BREINIGSVILLE, PA

MARCH 25, 2013
MOISTURE SENSITIVITY TASK FORCE MEETING
PAPA OFFICE, HARRISBURG, PA

MARCH 26, 2013
CENTRAL ENVIRONMENTAL WORKSHOP
RAMADA CONFERENCE CENTER, STATE COLLEGE, PA

MARCH 27, 2013
WESTERN ENVIRONMENTAL WORKSHOP
FOUR POINTS SHERATON, MARS, PA

MARCH 27, 2013
QUALITY INITIATIVE COMMITTEE MEETING
PAPA OFFICE, HARRISBURG, PA

APRIL 18, 2013
EXECUTIVE COMMITTEE MEETING
NITTANY LION INN, STATE COLLEGE, PA

APRIL 19, 2013
BOARD OF DIRECTORS MEETING
NITTANY LION INN, STATE COLLEGE, PA

APRIL 23, 2013
LIFE-CYCLE COST ANALYSIS MEETING W/ PENNDOT
HARRISBURG, PA

JUNE 12, 2013
STATE TRANSPORTATION INNOVATION
COUNCIL (STIC) MEETING
FISH & BOAT COMMISSION, HARRISBURG, PA

SEPTEMBER 11 & 12, 2013
NAPA ADVOCACY FOR ASPHALT
HYATT REGENCY WASHINGTON ON CAPITOL HILL

PAPA Annual Conference
JANUARY 28-30, 2014

Go To www.pahotmix.org For The
Current Asphalt Cement Index Price

Following is the tentative Letting Schedule for Construction Year 2013:

January 17 and 31
February 14 and 28
March 14 and 28
April 11 and 25
May 9 and 23
June 6 and 20
July 11 and 18
August 1, 15 and 29
September 12 and 26
October 10 and 24
November 7
December 5 and 19