What started out in the U.S. four years ago as a National Asphalt Pavement Association demonstration of new technology to reduce asphalt production and paving temperatures at the 2004 World of Asphalt trade show has turned into a full-fledged effort by asphalt mix producers, asphalt binder suppliers, additive suppliers, and plant manufacturers to develop the best Warm Mix Asphalt technology. Since that time, the number of available technologies in the U.S. has increased from two to ten, and at least 72 field trials have been constructed throughout the country with more planned in 2008. Mixture types that have been produced with the emerging technologies include dense-graded, stone-matrix asphalt, and open-graded friction courses, and they have been successfully used with polymer modified binders, asphalt-rubber, and RAP.

Why all the interest in Warm Mix? Because it is the next logical evolutionary step in asphalt mixtures. Besides the obvious advantages in energy and emissions reduction, there are benefits that include potentially longer times to achieve compaction, longer haul distances, extension of the paving season, compaction aid for stiff mixes, improved working conditions and reduced aging of the binder. In short, Warm Mix Asphalt is the future.

To aid in the development and implementation of Warm Mix, NAPA and the Federal Highway Administration have formed a Technical Working Group comprised of asphalt mix producers, NAPA staff, FHWA and state DOT representatives, a labor union representative, and a representative of the National Institute for Occupational Safety and Health. This group was formed in 2005 and has been instrumental in encouraging and tracking field trials, promoting research, identifying potential issues, and communicating information. The National Asphalt Pavement Association has formed its own Warm Mix Asphalt Task Force in order to provide a forum for its members and to provide input to the Technical Working Group.

The technologies that have been developed to this point may be divided into three broad categories: 1) chemical additives, 2) material foaming techniques, and 3) plant foaming techniques. Within each of these, there are various products or processes that can be used to lower production temperatures at least 30°F, and with some, to as low as 100°F. The specific technology selected will depend upon a number of factors including cost, the degree of temperature reduction, the type of mix to be produced, and the need for plant modifications, among other considerations.

There are currently four chemical additives for Warm Mix applications. Sasobit from Sasol USA is a wax derived from coal gasification, that lowers the viscosity of asphalt at high working temperatures but that allows it to stiffen at service temperatures. Evotherm DAT is a chemical package from MeadWestvaco that includes modifiers to improve workability, coating, adhesion, and strength. Revix is a surfactant solution technology.

Continued on page 2 . . .
...Continued from page 1

developed by Mathy Construction that helps to coat aggregate particles and improve workability. Rediset is a product from Akzo-Nobel that improves workability and adhesion. Sasobit and Rediset can be added to either the binder or the mix, and Evotherm DAT and Revix are added in-line with the binder.

Material foaming processes are those using either zeolite or moist sand to foam the binder in the mixing process. PQ Industries and Hubbard Construction market Advera and Aspha-min, respectively, which are zeolite. Zeolite is an aluminum-silicate which contains a small amount of interstitial water that is released at high temperatures in the form of steam. McConnaughay Technologies markets the Low Energy Asphalt system that uses sand, at a 3 percent moisture content, to foam asphalt which has been used to precoat dry coarse aggregate in the drum or pugmill. The LEA system uses a chemical additive to improve adhesion. The small amounts of moisture in these processes produce steam in the asphalt mix which lowers the viscosity of the asphalt binder in the mix, making it more workable.

Plant modification systems use small amounts of water injected into the asphalt prior to the binder introduction to the mix. WAM-Foam, originally developed by Shell and Kolovie-
Resources are available to those who want to learn more about Warm Mix Asphalt. A web site containing a number of links, documents, and presentations on Warm Mix may be found at www.warmmixasphalt.com. NAPA has recently published Warm Mix Asphalt: Best Practices written by Brian Prowell and Graham Hurley, and it is available at www.hotmix.org. A report on the FHWA/AASHTO European Scan Tour will soon be available for download as well. Finally, an International Conference on Warm Mix Asphalt will be held in Nashville, Tennessee on November 11-13, 2008. Watch NAPA’s website (www.hotmix.org) for more information.

Pennsylvania Transportation Institute
Renamed to Honor Dr. Thomas D. Larson

Penn State’s Board of Trustees has approved the re-naming of the Pennsylvania Transportation Institute to honor Dr. Thomas D. Larson. Thomas D. Larson co-founded and served as first director of the Pennsylvania Transportation Institute.

University Park, PA – The Pennsylvania Transportation Institute (PTI) at Penn State has been renamed to honor the late transportation leader Thomas D. Larson following approval from the University’s Board of Trustees on Friday, January 18, 2008. The new name is The Thomas D. Larson Pennsylvania Transportation Institute.

Larson was a student and professor of civil engineering at Penn State who served as the first secretary of the Pennsylvania Department of Transportation and later as head of the Federal Highway Administration.

While at Penn State, Larson co-founded PTI in 1968 and served as its first director. PTI is an interdisciplinary center for research in the areas of transportation operations, transportation infrastructure and vehicle systems and safety. The center coordinates the research of 47 faculty affiliates and in fiscal 2005-2006 had research expenditures in excess of $7.5 million.

Larson also played a significant role in the development of Innovation Park at Penn State, a 118-acre research park that currently provides tenants with access to Penn State’s scientific, engineering, technology and business resources. At the state level, Larson retooled and improved the management of the Department of Transportation during his time as secretary. As head of the Federal Highway Administration, Larson helped implement policies that encouraged innovation, moved the national transportation system into the post-interstate era and championed research and technology. Upon retiring from this role in 1993, Larson returned to central Pennsylvania, where he actively pursued consulting activities, served on the advisory board of PTI and helped lay the groundwork for the new Schlow Centre Region Library.

Larson died in 2006. In 2007, The Thomas D. Larson Fund for Excellence was established in Penn State’s College of Engineering to promote professionalism in transportation.

Goals of the endowment are to engage undergraduate and graduate students in interdisciplinary programs; develop academic and research programs that demonstrate the importance of integrating public and private sector transportation issues; establish undergraduate scholarship and graduate fellowship support; enhance transportation-related teaching and research facilities; and provide students and faculty with state-of-the-art equipment and technology.
GUIDELINES ON THE USE AND APPLICATION OF CpK

By Bob Bowen, President, r. bowen international, inc.
Certified Quality Engineer (ASQ), Certified Quality Auditor (ASQ)

Introduction

There is a clear relationship between providing superior products and superior business performance. Success-oriented companies use a business philosophy focused on delivering quality products and services quickly, while increasing their profit margins. These companies continuously look for improvement opportunities that give them the greatest return on investment. To accomplish this, inspection techniques have gained wide acceptance and are used, in some form, in most business environments. However, by relying almost exclusively on product inspection to judge quality most businesses fall short of maximizing profit potential. To be truly successful, each business must have a sound approach to evaluate their process controls, measurement techniques, and other relevant contributing factors, by which process improvement decisions are made.

A proven technique to monitor quality improvement is the process capability index called “CpK” and is calculated as follows:

\[ CpK = \frac{\text{Minimum (recent average – lower spec limit), (upper spec limit – recent average)}}{3 \times \text{(standard deviations of the product quality parameter being measured)}} \]

Essentially, CpK is an instrument of management audit. It allows senior management to quickly determine the effectiveness of their quality system. A high CpK means that the quality control system minimizes scrap and downtime. A low CpK means that the quality control system is not effectively controlling loss and risk.

CpK provides a simple way for senior management to find hidden opportunities for profit and to discover less obvious causes of loss in day-to-day operations. It offers a simple statistic that becomes an objective basis to evaluate and communicate about quality that has a direct relationship to business performance.

Application of CpK

Senior management can utilize CpK in several ways as follows:

- Improvement monitor
  This is the preferred application of CpK. The most valid comparison are of four or more CpK’s for the same product parameter over four or more consecutive time periods. Four consecutive CpK’s demonstrating a value of 1.33 or better in an upward trend indicates statistically significant improvement in the operation being judged.

- Goal setting
  Senior management can drive improvement by setting CpK goals of 1.33 or beyond on specific aspects of specific processes. When using CpK to set goals, senior management must require a written improvement plan be set up to improve each specific CpK.

  In using CpK to set goals and monitor improvement there are no hard and fast criteria to label a particular result as “good” or “bad”. In general, however, as CpK approaches a value of 2.0, the process which produces the CpK is more robust and less likely to produce scrap or cost problems. Such a process has more room to withstand the normal variation in temperature, materials quality and staff turnover that tend to decrease profit. The best method to use CpK is to compare CpK’s on a specific parameter over time.

  On the other hand, as the CpK drops below 1.33 senior management should encourage corrective action by the following:
  1. Requiring the process average to be centered between the upper and lower specification limits;
  2. Reducing overall process variation; or,
  3. Reviewing the specification limits to determine if they are realistic and are identified at the value that they should be.

  Generally speaking, when the CpK is less than 1 the process needs immediate attention to prevent financial loss.

References

This article is based on first-hand experience with CpK by Bob Bowen, Jess Dulap and Mike Lohenitz of r. bowen international, inc., information from several national standards on quality improvement, and on a series of articles published by Bert Gunter in Quality Progress in 1989.◆
**Warranties Mean Quality and Better Performance**

By Victor (Lee) Gallivan, P.E., Asphalt Pavement Engineer, FHWA- Office of Pavement Technology

We are all aware of warranties for our appliances, cars, televisions, refrigerators, etc., but what about “our” roadways? Taxpayers in Pennsylvania have a substantial investment in the roadways throughout the State, and I am sure that all taxpayers and businesses want their dollars spent efficiently to ensure that full mobility is maintained.

One of the methods utilized to improve the performance of the roadways is to increase the quality of the project at the time of construction. Quality is an extremely important term as it applies not only to the design of the project and the materials being used to build the project, but also to the contractors operations. One area that has been successful in extending the performance concerns the contractors operations and the inclusion of pavement performance warranties. Improving the quality of the pavement will translate directly to longer life and a significant cost savings to the taxpayers.

Pavement warranties in the U.S. have been used since the Warren Brothers patented their product known as “Warrenite Bitulithic Pavements” in 1901 and offered 15-year warranties. The use of pavement warranties died after a couple of decades due to increased competition and the expiration of the Warren Brothers patent. As more contractors entered into the business of paving the roads in America, it made it harder for the Warren Brothers to maintain their business. When the Interstate construction began in the 1950s, warranties were clearly not allowed by the Federal Highway Administration, resulting in only limited warranty use by state and local transportation agencies. Following the revision of the federal regulation in 1994 to permit the use of warranties, state implementation has been on the rise with multiple states now utilizing various types of types of warranties with an emphasis on the Hot Mix Asphalt program.

The Federal Highway Administration has developed a new workshop to present the basic elements of a successful warranty program designed for state agencies that want to introduce, expand or update their programs, including those agencies that have had problems implementing warranties in the past. The intended audience includes state highway agencies, contractors/industry, and local FHWA representatives.

The FHWA utilized the best elements from successful warranties from various states and overseas to develop a basic warranty workshop that includes three specific elements; Background for Pavement Warranties, Selection Procedures for Pavement Warranties, and Management of Pavement Warranties. Guidance documents for the basic elements have been developed and are available online at: www.fhwa.dot.gov/pavement/warranty.

Selection of the right pavement for consideration of a warranty is vital as well as the importance of the specifications to clearly detail the requirements of the program. The warranty specifications need to be clear, concise and should include six basic building blocks.*See highlighted area below.

Are warranties successful? Several Agencies around the country are saying yes, and a few are saying no. Performance characteristics for HMA projects including rutting, smoothness (IRI), cracking (transverse and longitudinal), and friction seem to be a constant with the more successful Agencies. Identifying the appropriate risk to the Agency and the contractor in addition to utilizing an appropriate length of warranty are the key elements in successful warranties. Eliminating or minimizing subjective determinations “by the Engineer” is extremely critical.

Bonding is also a critical element that needs to be considered. Typical material and workmanship warranties are for 2-4 years from the date of final construction with performance specifications ranging from 5 to 20 years with the majority

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being short-term in the 5-7 year range. Determining the appropriate bonding amount over the term sometimes will make or break the program. The State of Florida uses guarantees, which are merely a written guarantee from a Contractor that all repairs will be done in accordance with the warranty specifications. If the Contractor does not follow through, the Contractor is barred from subsequent bidding until all repairs are completed.

Successful implementation of warranties requires several steps that include: an understanding that the use of warranties is a new way of doing business (change), support from management including the Agency, Contractor/Industry members as well as the local FHWA representatives, early involvement by all parties in the development of the program, and the ability to consider the lessons learned from others. Signing up for the FHWA workshop is one way of ensuring that the critical elements for a successful warranty program are incorporated in the Agency’s program. For more information on warranties or to schedule the “Basic Warranty” workshop in Pennsylvania contact the author at victor.gallivan@fhwa.dot.gov.

Porous Asphalt Pavement

By James R. Miller II, General Manager-Blacktop, New Enterprise Stone & Lime Co., Inc.

The project was part of the construction of a new Fulton County Medical Center which is located on the outskirts of McConnellsburg, PA. The project started in the early summer of 2007 and was completed in late summer of 2007. There were approximately 12,281 sq. yards of pavement of which 6,988 sq yards were porous pavement. The drainage bed and aggregate beneath the Porous Asphalt pavement was constructed by the prime contractor, Stone Valley Construction Company, and consisted of No. 3 aggregate and topped with No. 8 aggregate.

New Enterprise Stone & Lime Co., Inc. then placed 2.5" of the porous pavement which consisted of 11.3% dust, 61.2% No. 8 (1/2"), and 21.7% No. 67 (3/4") aggregates; 5.8% P.G. 76-22 asphalt along with 0.3% anti-strip and 0.3% fibers stabilizer.

The use of PG 76-22 and fibers allowed the plant to run at a high temperature (275° F to 290° F) and not the normal 200° F required on other pavements placed using PG 64-22. This permitted the plant to continue producing material for other projects helping the cost and profitability of the process.

The timeframe for transportation and placement of the material was critical to the operation to prevent drain down. A tight schedule was maintained and the layout of the project to prevent minimal hand work was also a very important part of the process due to the stiffness of the material.

The rolling operation started between 170° F to 190° F making three passes in static mode and one pass later to remove roller marks after the mat had cooled. The NAPA publication on Porous Asphalt Pavement came in very handy to further educate not only our paving crews during placement, but also the owner on the care of this pavement for the future.
QC/QA Sampling Strategies for HMA Construction

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Carl L. Monismith, Dr. Eng., P.E., The Robert Horonjeff Professor of Civil Engineering, Emeritus and Director, Pavement Research Center, ITS, University of California, Berkeley

INTRODUCTION

The purpose of this article is to describe a methodology to determine the best strategies for a sampling scheme and selection of sample size for QC/QA for hot mix asphalt (HMA) construction. Selection of sample sizes by both contractor and agency is illustrated to insure that the acceptable level of a HMA mix parameter is obtained with the risk balanced between the contractor and the agency.

In recent years there has developed an increased interest in insuring that the HMA as placed will meet certain performance requirements by measuring the actual performance parameters on test specimens prepared from in-situ samples rather than from surrogate values such as asphalt content or aggregate gradation. Examples include direct measures of mix stiffness and permanent deformation characteristics.

One such measure of permanent deformation characteristics, the Stabilometer “S” value is currently being considered as an acceptance measure by the California Department of Transportation (Caltrans) to be obtained on mix samples taken in-situ directly behind the paving machine. With the advent of the Mechanistic-Empirical Pavement Design Guide, the potential exists for other measures such as mix stiffness, which could be measured either in-situ or on specimens prepared from mix samples obtained at the time of construction (like those for the “S” value).

While it might be argued that the Stabilometer “S” value has a limited application in the United States at this time, it will be used to illustrate the general approach to be discussed in the following sections. The reason for its selection is based on the fact that extensive data of the type required for the approach to be presented herein are available including well documented values of test variability for both single and multiple laboratories (1). As results of other performance tests become more widely used, e.g., data from the “Simple Performance Test” a

associated with the Superpave mix design methodology (2) could be used. Moreover this approach can be applied to other construction control measures already in use such as HMA thickness or other specific mix parameters.

A methodology to determine the best strategies for sampling scheme and sampling size through statistical simulation of a fixed length of a one lane width placement of HMA is briefly described. The optimum sampling size so determined is then combined with the sampling size of the contractor and that of the agency to balance the risk to both organizations resulting in a mix that will meet the minimum performance requirement. This process is illustrated for the placement of about 10,000 tons of HMA over a five day period. For this total tonnage, the contractor is assumed to perform a specific number of tests (Stabilometer “S” value) for QC and the agency a lesser number of Stabilometer tests for QA. Results of the simulation provide the average Stabilometer “S” value that the contractor must obtain to insure that the quality requirements (minimum “S” value) are met.

To illustrate the approach, a brief discussion of hypothesis testing of inequality is introduced to illustrate the process used herein to insure that the risk will be the same for the contractor and the agency in producing HMA with a specified quality. In this example a null hypothesis has been established that the as-placed HMD will have an average Stabilometer “S” value greater than 37 (3).

Hypothesis Testing of Inequality

When the null hypothesis, termed $H_0: \mu \geq C_S$ (in this case the “S” value), is valid, the probability of erroneously rejecting it is at most the size of test $\alpha$. This probability is also termed a Type I error (contractor’s risk) as shown in Table 1. (4) When the null hypothesis

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Continued from page 7... is not true, the probability of erroneously accepting it is termed a Type II error (β, agency’s risk). The power is defined as the probability 1-β of correctly rejecting H₀ if H₀ is not true. From the agency’s viewpoint, it is necessary to have the test power as high as possible.

Table 1. Type I and Type II errors of hypothesis testing.

<table>
<thead>
<tr>
<th>Decision based on sample</th>
<th>H₀ True</th>
<th>H₀ Not True</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reject H₀</td>
<td>Type I Error (α)</td>
<td>Correct Decision</td>
</tr>
<tr>
<td>Accept H₀</td>
<td>Correct Decision</td>
<td>Decision Error (β)</td>
</tr>
</tbody>
</table>

For the contractor, under the null hypothesis H₀ : μ ≥ C₅, the acceptance region for the t test of size α is given by t ≥ -tₙ₋ₐ,ₙ₋ₚ (the region other than the critical region of Figure 1), i.e., the minimum requirement of the contractor has to be μ ≥ C₅ - tₙ₋ₐ,ₙ₋ₚ · SE (μ)  

![t-test distribution](image)

Figure 1. Schematic illustration of critical region for the t test of size α.

Under the null hypothesis H₀ : μ ≥ C₅, the power requirement that the agency can make the correct decision has to be,

μ ≥ C₅ + (Zₙ₋ₐ + Zₙ₋β) · SE (μ), or μ ≤ C₅ - (Zₙ₋ₐ + Zₙ₋β) · SE (μ)  

where Zₙ₋ₐ and Zₙ₋β are quantiles of a standard normal distribution.

It should be noted that if β = 0.5, then Zₙ₋β = 0 and if Zₙ₋ₐ ≡ tₙ₋ₐ,ₙ₋ₚ, with n – p >> 0, Equation 1 is equivalent to the lower bound of Equation 2.

For the case where the number of tests n₁ conducted by an agency is a fraction of the number of tests n₂ performed by the contractor, i.e., n₁ = k · n₂ (where 0 < k ≤ 1), the standard deviation is SE (μ) = \( \frac{S_p}{\sqrt{n_1 + n_2}} \)

Hence, we have the contractor’s minimum requirement:

μ ≥ C₅ - \( \frac{t_{n-\alpha, n-p}}{2} \) \( \frac{1+k}{k} \) \( \frac{1}{\sqrt{n_1 \cdot n_2}} \) · S_p,  

and the upper and lower bounds of power requirement of the agency:

μ ≥ C₅ + \( \frac{t_{1-\alpha, n-p}}{2} \) \( \frac{1+k}{k} \) \( \frac{1}{\sqrt{n_1 \cdot n_2}} \) · S_p,  

μ ≤ C₅ - \( \frac{t_{1-\alpha, n-p}}{2} \) \( \frac{1+k}{k} \) \( \frac{1}{\sqrt{n_1 \cdot n_2}} \) · S_p,  

where S_p is the root-squared of pooled sample variance.

As an example, consider the following case: H₀ : μ ≥ 37, S_p = 6.6, α = β = 0.05, and n₂ = 40, n₁ = 4, (i.e., k = 0.1) (N.B. the value of S_p is a representative value for the Stabilometer test data [1]).

The contractor’s minimum requirement is:

μ ≥ 37 - \( \frac{t_{0.05, 36}}{2} \) \( \frac{1+0.1}{0.1 \cdot 40} \) · 6.6 = 34.09  (34.1), and the upper and lower bounds of the agency’s power requirement are:

μ ≥ 37 + \( \frac{t_{0.95, 40}}{2} \) \( \frac{1+0.1}{0.1 \cdot 40} \) · 6.6 = 42.69  (42.7), and

μ ≤ 37 - \( \frac{t_{0.95, 40}}{2} \) \( \frac{1+0.1}{0.1 \cdot 40} \) · 6.6 = 31.31  (31.3).

**Sampling Scheme Simulation**

To illustrate the approach, it was assumed that the Stabilometer “S” value tests on a specific mix can be represented by a normal distribution. Four types of sampling schemes, as shown in Figure 2, were considered for a segment of a lane of paving divided into transverse and longitudinal strips. Mix sampling schemes for this segment are shown below with the solid points (diamonds) representing the contractor QC sample locations and the shaded points (circles) the agency QA sample locations.

1. **Type I**: one random QC sample from each cell; one random QA sample from one random cell of each transverse strip.
2. **Type II**: three random QC samples and one random QA sample from one random cell of each transverse strip.

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(3) Type III: one random QC sample from each cell; one random QA sample from one random cell of three random transverse strips.

(4) Type IV: three random QC samples and one random QA sample from one random cell of three random transverse strips.

For this sampling simulation, a total of 7,200 points with a standard normal distribution of “S” values were used to generate three data patterns: (1) random pattern, (2) transverse strip pattern with 12 transverse strips, and (3) longitudinal strip pattern with 6 longitudinal strips. The Type II sampling scheme yielded the most consistent distribution patterns of QC and QA.

![Sampling Schemes](image)

**Figure 2. Four types of sampling schemes.**

**Sampling Size Simulation**

A simulation was also conducted to provide an indication of the minimum size of samples from a paving segment that would provide: 1) sampling consistency between the contractor (QC) and the agency (QA) and 2) a stabilized pooled sample estimate of standard deviation of stability value, $S_p$. This simulation included the following assumptions: 1) paving width-12 ft; 2) velocity of paving machine-15 ft/min; 3) segment length-900 ft; and, 4) 4 inX4 in square represents one stability sample. In addition, it was assumed that the HMA layer was 8 in. thick with a unit weight of 145 lb/ft$^3$ for a total of 500 tons.

With respect to the sampling consistency and sampling stabilization, the simulation results indicated that the best sampling strategy for this 900 ft one-lane paving project were: (1) one QA sample and two QC samples from behind the paver at randomly selected locations every 30 ft or (2) one QA sample and two QC samples from each truck (assuming 20 tons capacity).

**Case Study**

The example consists of a one-lane section of paving with twenty 900 ft lots, i.e., approximately 10,440 tons, for a construction period of 5-days. The contractor is assumed to conduct 40 tests ($n_2 = 40$) and the agency decides to conduct only one-tenth of 40 tests ($n_1 = 4$). A simulation study similar to those discussed in the previous sections was performed. Results clearly indicate that the sampling size needed for the sampling consistency between QC and QA (Figure 3a) and the standard deviation of (Figure 3b) to reach stabilization is much larger than 40.

![Sampling Consistency and Stabilization](image)

**Figure 3. Sampling consistency and sampling stabilization of SP.**

Figure 4 illustrates the agency’s power requirement ($\beta = 0.05$) and the contractor’s minimum requirement ($\alpha = 0.05$) for $H_0 : \mu \geq 37$ with $S_p = 6.6$ and $k = 1/10$. If $n_2 = 40$, then the contractor has to aim at a higher null hypothesis $H_0' : \mu \geq 45.54$ and ensure that $\hat{\mu} \geq 42.69$ so as to satisfy the power requirement of the agency and still retain an $\alpha = 0.05$ level; whereas, if $n_2 = 300$, then the criterion would be reduced to $\hat{\mu} \geq 39.08$ under the null hypothesis $H_0' : \mu \geq 40.12$.

![Power Requirement](image)

**Figure 4. Agency’s power requirement under H0: $m \geq 37$ and various minimum requirements of the contractor under different null hypotheses.**
Continued from page 10 . . .

Suppose that the contractor is responsible for producing the stability population \( N(\mu, \sigma) \), which can be normalized as used in the simulation. The location and dispersion of the stability population will affect the probability of \( \hat{\mu} \geq \mu_n \) where \( \mu_n \) is minimum requirement at sample size \( n \) that satisfies the power requirement of the agency. To inspect the effect of the stability population, Figure 5 presents the \( P(\hat{\mu} \geq \mu_n) \) versus the sample size \( n_2 \) at various presumed stability populations. It indicates that the higher the mean location of the stability population the higher the \( P(\hat{\mu} \geq \mu_n) \) for a specified sample size. If \( n_2 = 40 \), then the stability population has to be at least \( N(45.54, 6.6) \) to satisfy the power requirement and maintain its \( \alpha \) level; whereas, if \( n_2 = 300 \), the necessary stability population distribution becomes \( N(40.12, 6.6) \).

In summary, the sampling plan with \( n_2 = 40 \) and \( n_1 = 4 \) for the 5 day construction period is suitable only if the contractor can guarantee production of high quality mix following the distribution \( N(45.54, 6.6) \).

![Figure 5. Effect of stability population produced by the contractor.](image)

**Caltrans Stability Data**

To illustrate that stability values of the magnitude listed in the previous section Table 2 has been included. This table lists the statistical summary of standard deviations of stability results and the differences of measured and target stability values for 18 QC and 17 QA projects recently constructed in California. The current Caltrans stability requirements are varied for different types of mixes. Hence, the differences of measured and target stability values were used to identify the QC/QA testing variability.

<table>
<thead>
<tr>
<th>Calibration S</th>
<th>Project-Based Ss</th>
<th>Project-Based (Pooled)</th>
<th>Measured S – Target S</th>
</tr>
</thead>
<tbody>
<tr>
<td>QC</td>
<td>QA</td>
<td>QC/QA</td>
<td>QC</td>
</tr>
<tr>
<td>Range</td>
<td>(1.22, 5.80)</td>
<td>(1.51, 6.16)</td>
<td>(2.06, 5.89)</td>
</tr>
<tr>
<td>Mean</td>
<td>2.97</td>
<td>2.70</td>
<td>2.97</td>
</tr>
<tr>
<td>SD</td>
<td>1.15</td>
<td>1.10</td>
<td>0.94</td>
</tr>
<tr>
<td>No. of Projects</td>
<td>17</td>
<td>17</td>
<td>17/17</td>
</tr>
<tr>
<td>No. of Tests</td>
<td>356</td>
<td>283</td>
<td>639</td>
</tr>
</tbody>
</table>

Figure illustrates the distribution and density functions of the stability difference of pooled QC and QA projects respectively. As listed in Table 2, there are about 6 ~ 8 stability units on average that are greater than the target values. Figure also indicates that (1) only 5% of testing results are below the target values and (2) the QC density function shows an apparent two-mode pattern. While the reason for this is not apparent, it might represent different construction control procedures or different materials quality.

![Figure 6. Pooled QC/QA distribution and density functions.](image)

**Findings and Discussions**

An attempt has been made to illustrate an approach and the extent of testing required using a performance test to insure reasonable quality in as-placed HMA. Stabilometer “S” value test results were used in this example since extensive data were available. It should be emphasized that the same approach could be applied...
using other test parameters to control the quality of the as-constructed mix.

Based on Stabilometer test results, the brief discussion of hypothesis testing, and the simulation results of sampling scheme and size, the following observations and suggestions are offered:

1. Cooperation between the agency and the contractor is essential. It is necessary to have the testing process, test equipment, test results, and specimen preparation as consistent as possible between the two organizations.

2. The simulations of sampling scheme and size suggest that the best sampling strategies for a 900 ft long by 12 ft wide HMA section are to take one QA sample and two QC samples from behind the paver at randomly selected locations every two minutes (assume the paving speed is 15 ft per minute), or equivalently, randomly take one QA sample and two QC samples from a 20-ton truck for every unloading.

3. Increasing the sample size is actually beneficial for both agency and contractor since it reduces the potential for dispute and guarantees the quality of the constructed mix. By extension, it is advisable for the agency to provide incentives to encourage the contractor to increase sampling size and testing.

4. To ensure the success of the proposed QC/QA guidelines, the Contractor’s minimum value of the test parameter must exceed that required by the agency.

5. From the case study with QC and QA sampling plans of 40 and 4 tests, respectively, the Contractor must aim for an average test result that exceeds that of the agency by 6 to 8 units. Alternatively, the Contractor may opt to increase the sample size to ensure that a lower average test parameter is achieved.

A concluding general observation relates to the concern for developing longer lasting pavements at this period of time because of increased costs of both pavement materials and increased traffic that must be accommodated. The added costs of testing by both the contractor and the agency are a very small proportion of the total costs associated with long lasting pavements. Accordingly an “attitude adjustment” for both parties relative to QC and QA testing would enhance long-term pavement performance.

References
Speed of Construction Vital in Rebuilding Original Pennsylvania Turnpike

By Chuck MacDonald, Director of Communications, National Asphalt Pavement Association (NAPA)

When first constructed, the Pennsylvania Turnpike was an engineering marvel. The road snaked across the rolling countryside, poked through tunnels in the Allegheny Mountains, and gave motorists a means to travel quickly from Pittsburgh in the west to Philadelphia in the east. It was America’s first superhighway, predating the Interstate Highway System by more than a decade. And it was all concrete.

On its first Sunday in 1941, the turnpike carried some 27,000 vehicles. The system carries 500,000 vehicles daily in some areas today. Not only has the number of vehicles changed, the weight of the vehicles has changed as well. Today fully-loaded trucks weighing 125,000 pounds cruise these roads, dwarfing the size of those original trucks.

“Because the original road has deteriorated so much, the roadway needs to be completely rebuilt from the subgrade up,” said Mike Flack, assistant chief engineer-construction for the turnpike. So far, about 50 miles of the original 140-mile turnpike has been rebuilt – with asphalt.

Turnpike officials have budgeted some $4.3 billion over a 10-year period on roadway projects. Unlike many road projects that depend on state or federal funds, these undertakings will be funded through existing toll revenue that drivers pay to use the turnpike. Toll increases provided the necessary revenue not only to accelerate the reconstruction effort, but also to begin work in several parts of the state simultaneously.

The challenges to the massive project are many. “There are sinkholes in the east and some swampy soil in the western part of the state,” said Flack. “There are a multitude of engineering issues such as drainage, soil stabilization, material quality and availability, and there’s always traffic which cannot be delayed or stopped.”

The new road will be more than three times thicker than the original concrete roadway. The minimum design consists of a 2-inch Superpave wearing course, a 3-inch Superpave binder course, an 8- to 10-inch bituminous concrete base course, a 4-inch permeable base course treated with asphalt, 6 to 8 inches of subbase, and a stabilized subgrade.

Lindy Paving of New Castle, PA, was one of the contractors involved in the project. The company used 700,000 tons of asphalt in creating 12 miles of new highway from the Somerset exit to the Allegheny Tunnel.

Speed of construction was an issue that was never far out of the minds of the crew and supervisors. “We had to schedule 24-hour shifts to keep up with the deadlines at times,” said Dan Ganoe, operations manager for Lindy Paving. “The sheer size of the job was a major challenge. And because the traffic is so heavy on the turnpike, getting all our materials delivered at the right time and our equipment in place at the right time was difficult.”

Lindy Paving brought a portable asphalt plant to the job site in order to facilitate getting the asphalt to the paving crew in a timely manner.

Like all the contractors, New Enterprise Stone and Lime in New Enterprise, PA, had to pay special attention to the subgrade when they excavated the old road to make way for a new asphalt pavement. “The subgrade had a lot of shale and rock, which we were able to use to build a foundation for the new road,” said Mike Sulesky, construction manager. “But we needed to do undercuts and shot rock backfill in some areas that were soft and unstable.”

The crew used 550,000 tons of asphalt to construct the road, which was 22 inches thick when finished. The New Enterprise team did their paving between milepost 85 and 94 west of the Somerset interchange. The project began in May 2002 and was completed at the end of 2004.

Engineers and the paving team also eliminated a dangerous double curve east of the Donegal interchange. By moving a one-mile segment of the turnpike onto a new alignment and constructing a third eastbound lane for six miles, the New Enterprise project team created a straighter, safer roadway for motorists.

Allen A. Myers Co., Worcester, PA, (affiliat-
ed with Independence Construction Materials) has also dealt with challenging scheduling and traffic control. The paving team began work in May, 2006 and is scheduled to finish before the end of 2008. The company expects to use more than 300,000 tons of asphalt for the project. The contract calls for full-depth reconstruction and widening on 5.3 miles of roadway between King of Prussia (Valley Forge exit) and the Schuylkill River Bridge just before the exit to I-476. “Since two lanes of traffic had to be open at all times, we had to use temporary lanes and off ramps in order to do the work necessary for a full-depth job like this,” said Eugene Eshbach, project engineer for the company. “Because of the time pressure and restricted space, we needed to have material delivered on a just-in-time basis. It arrived just before we needed to put it into the road.”

The restricted working space was a headache for many of the contractors. In certain areas the Allen Myers Co. team had to rebuild three lanes in each direction in just 200 feet of space. They had to rent yards off site to store some of the materials and equipment. “Speed of construction was key,” said Eshbach. “There was no way we could use materials that needed time to cure. We did the work and put the traffic back on the new road right away.”

Companies like Lindy Paving, Allen A. Myers, New Enterprise, and many others are key partners with the Pennsylvania Turnpike officials in completing the rebuild of this historic highway. “We’ve had a good relationship with our contractors who are doing the work,” said the turnpike’s assistant chief engineer Flack. “When it’s all done we hope to have a better, safer, wider road. And satisfied customers who use it.”

Reprinted by permission of National Asphalt Pavement Association from its Hot-Mix Asphalt Technology (HMAT) magazine.

“There was no way we could use materials that needed time to cure. We had to put the traffic back on the new road right away.”
HMA PLANT: Energy Saving Tips

By Bill Garrett, Partner, Meeker Equipment Co., Inc.

PAPA is a great organization and is always developing ideas and information to help us with our Hot-Mix Asphalt businesses. The intent of this series of articles is to help us better control our energy cost, with some “Back to Basics” concepts and information.

COLD FEED BINS & CONVEYORS:

The next area of the plant to examine for energy savings, once we have the Stockpiles managed and saving energy, is the Cold Feed Bins.

1. **Feed Ramp** being flat and of the shortest distance to your stockpiles reduces the loaders energy and over all maintenance (reduces operating cost $$).

2. **Three Side Bin Extensions** allow the loader to feed the lower side of the bin while reducing segregation between bins (less segregation improves quality and reduces penalties $$). Also minimizes spillage and clean up around the bins.

3. **Tapered bin discharge** (5% is ideal taper) to the feeder, reduces wear along the skirt side walls (less maintenance $$) and allows for free flow of material reducing energy required of the feeder (less $$). Also, feeders with troughing idlers are reducing maintenance by eliminating the skirts along the side walls of the bin feed.

4. **Covered Bins**: Reduces moisture into the aggregate, (1% increase in moisture, reduces production 12% or raises drying cost 12%, $$).

5. **Non Stick bins liners** reduce wear and allows for easier flow of materials from the bin, all reducing operating costs ($$).

6. **Covered conveyors** to keep moisture out and prevent wind from lifting the scaled conveyors and sending false weight readings to the control system (reducing failures and precisely adding the correct asphalt binder $$)

7. **Properly supported conveyors** and never hanging screen decks on conveyors, while always maintaining correct belt tension for long life and accuracy.

8. **Raised tail pulleys** for easy clean up, saves time and encourages quality ($$).

Whenever your production equipment is well maintained and accessible for easy cleanup, there is cost savings through the time saved and quality mix consistently produced.

We hope you have found these simple cost saving ideas easy to implement, in your efforts to reduce energy and operating cost at our HMA facilities.◆
Check Out New Web-Enabled Plant Diagnostic Tool

By Bob Frank, President, Compliance Monitoring Service

This web application lets you adjust variable inputs and automatically calculates drying cost and maximum production rate. You shouldn’t be surprised that the two are related!

To get started, set the top slider to your normal dryer exhaust temperature. Percent oxygen may be harder to determine. As a rule batch plants run between 13% and 17% oxygen due to fugitives. Drum plants can range between 10% and 15%. The higher the burner firing rate at the time of reading the lower the oxygen percentage. 14% is a good starting point for most plants.

Move on down the right hand slider bars, matching normal operating conditions at your plant. The shell loss slider is more seat of the pants than all the others since there are so many variables involved - size of dryer, production rate, insulation, shell temperature. Without getting bogged down in details, if you have a large un-insulated dryer the slider should be hard right, middle for smaller drums. If insulated put the slider on the left. Leave reject at zero for starters.

By now the “roll of lifesavers” on the bottom right should be close to your average drying cost in gallons of fuel oil per ton of mix. The size of each colored disk is proportional to how much fuel went into making your aggregate hot verses going up the stack.

Try all this with the new Plant Diagnostic Tool added to PAPA’s home page – www.pahotmix.org. Check it out and send me your questions or comments. Next month we’ll take a look at airflow. Bobfrank2@aol.com

One last thing, if you have trouble getting the lifesaver roll to match your plant, increase the waste slider. This gives you a good indication of how much material is heated but doesn’t make it out the gate. ◆
PAPA’s 2008 Regional Technical Meetings

By Ronald J. Cominsky, P.E., Executive Director

PAPA hosted its Regional Technical Meetings on February 26 – 28, 2008. The Eastern Regional meeting was held at the Lehigh Valley Holiday Inn Convention Center (Briengsville) on February 26; the Central Regional Meeting was held at the Penn Stater Conference Center (State College) on February 27; and the Western Regional Meeting at the Holiday Inn (Indiana) PA on February 28, 2008. There was excellent attendance again --- Eastern 132, Central 86 and Western 130. Mr. Jeffrey Frantz chaired the Regionals.

Key agenda items were round-robin test results, proposed base course density specification, HMA payment results, proposed Bulletin 27 revisions, SUPERPAVE permeability research, Local Acceptance Specification status, laboratory standard operating procedures and ISO 9000 (PASIN) pilot projects update.

Mr. Dean Maurer from the Materials and Testing Division (MTD) provided power point presentations on several of the agenda topics. A special feature at each of the three Regionals was a brief training program presented by Mr. Frank Colella on “PennDOT’s New Method Specification for Constructing HMA Longitudinal Joints.” PAPA extends its appreciation to both of these individuals for their presentations.◆
As with any organization, PAPA faces many challenges in the coming year. One challenge which I don’t understand, however, is lack of communication from member companies. The association needs your input on those issues which affect all of us in order to make sound, informed and appropriate decisions. Decisions which may affect our industry for many years to come. Our officers and directors stand ready to represent you, but must be made aware of the issues to do so.

Another challenge facing us, funding for infrastructure, is less easily solved. I urge each of you to stay in close contact with all of your elected officials, local, state and federal, in order to educate as well as encourage these individuals to place a high priority on funding our infrastructure at adequate levels. The economic well-being of our communities is at stake. Finally, as we use these cold winter days to refurbish our equipment, may I suggest spending some time on our most valuable asset, our people. This is an excellent time to offer safety training as well as training on other aspects of the job ahead.  

PAPA is actively searching for ideas for upcoming editions of the newsletter. If you would like to write an article or provide PAPA with a company profile, please contact Millie at 717-657-1881 or millie@pahotmix.org. We look forward to hearing new and interesting ideas!
GP-13 and Waste Derived Liquid Fuel Guidance Document Expected To Be Finalized Shortly

At February’s Environmental Update Conferences, members were informed that DEP is nearing issuance of General Permit-13, an air emissions operating permit for existing hot mix asphalt plants. A companion document, the Waste Derived Liquid Fuel Guidance Document, is expected to be finalized concurrently, and terms and conditions from the Waste Derived Liquid Fuel Guidance Document are incorporated into GP-13.

Advantages to using GP-13 at existing asphalt plants include:

- Uniformity of emission limits for all plants
- Uniformity of procedures for receiving and burning waste derived liquid fuel
- The ability to use reclaimed asphalt pavement in hot mix products, and, the ability to switch fuels, including the use of biofuels if desired.

DEP has also confirmed to PAPA’s Environmental Committee that under the Waste Derived Liquid Fuel Guidance Document, the ash content permissible in waste derived liquid fuel will be increased from 0.5% to 1.0%

Use of GP-13 is considered important to the industry, as well as to DEP, as high levels of compliance can be attained in industries when operating permit conditions are uniform and well understood. In the future, to keep plants operating in the most efficient manner, those using GP-13 will need to conduct Spring “burner tuneups” as national air emissions issues increasingly focus on greenhouse gases, and ozone non-attainment. The “spring tuneup” is expected to cost between $900 to $1200 per plant, and will need to be completed by June 14th. Plants will also have the option of buying their own equipment, and with DEP approval, completing the tuneup using in-house forces.

Plants may continue to use their existing permit, or “opt in” to use GP-13. GP-13 is for use at existing hot mix asphalt sites, and will not be able to be used automatically at new “Greenfields” hot mix asphalt plant sites.

For more information on GP-13 call Gary Brown at RT Environmental Services at (800) 725-0593, Ext. 34. A future Paving The Way will announce when GP-13 is available.

Porous Pavement Receiving Increased Attention In Pennsylvania

Ronald Cominsky, P.E., Executive Director of the Pennsylvania Asphalt Pavement Association, at Paving The Way press time, was expected to announce the availability of a new Porous Asphalt Pavement Guide for use in Pennsylvania. In December 2006 the Pennsylvania Department of Environmental Protection finalized a Stormwater Manual, used for the design of site plans, highways, and all types of improvements, throughout the state. The Porous Asphalt Pavement Guide will provide considerable information on the use of porous pavement for sites throughout Pennsylvania, above and beyond the information available in NAPA’s Porous Pavement Guide, and the Pennsylvania Department of Environmental Protection’s Stormwater Manual.

Gary Brown, P.E., member of PAPA’s Environmental Committee has met with Department of Environmental Protection officials, who have agreed that porous pavement is a key Best Management Practice which can have wide use in Pennsylvania. Porous pavement is an open graded asphalt course, which allows rainwater and snow melt water to “seep in”, addressing concerns about increased runoff at development and redevelopment sites. Porous pavement can be used with and without a “reservoir” course, and a recent University New Hampshire study debunked many of the “myths” about porous pavement, and demonstrated that the use of porous pavement can reduce salt consumption by 75%. Simple use of snow plowing is more effective, negating the need to use salt to deice in many storms, because the black color of the pavement and ability of “snow-melt” water to actually infiltrate the pavement, warms the pavement, so melting down to a dry surface occurs more quickly.

The University of New Hampshire has also issued on their web page “Specifications” for porous pavement, as well as a “power point” presentation, which provides information on when subbase drainage is needed, as well as how “freeze thaw” concerns can be addressed by the installation of underdrains, which may be needed depending on the permeability (infiltration rate) of the soil beneath the subbase.

Porous pavement is an important new product for the industry, which can be used widely to address stormwater concerns in Pennsylvania. The porous pavement guide will be made available to all members, and will be distributed to engineers involved in site plan design, and of course, all of those involved in producing and placing HMA in our industry’s many successful HMA construction projects.
### 2008 PENNDOT LETTING SCHEDULE

Following is the tentative Letting Schedule for Construction Year 2008:

<table>
<thead>
<tr>
<th>Month</th>
<th>Letting Dates</th>
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<tbody>
<tr>
<td>January</td>
<td>10 and 24</td>
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<td>February</td>
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<td>November</td>
<td>6 and 13</td>
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<tr>
<td>December</td>
<td>4 and 18</td>
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Based on project types, projects will be advertised five (5) to seven (7) weeks prior to the letting date. All lettings will be held on Thursdays at 11:00 A.M. unless otherwise advertised.

### 2009 PENNDOT LETTING SCHEDULE

Following is the tentative Letting Schedule for Construction Year 2009:

<table>
<thead>
<tr>
<th>Month</th>
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<tbody>
<tr>
<td>January</td>
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<tr>
<td>February</td>
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Based on project types, projects will be advertised five (5) to seven (7) weeks prior to the letting date. All lettings will be held on Thursdays at 11:00 A.M. unless otherwise advertised.

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### NEW MEMBERS

The following companies have recently joined the Association.

#### ASPHALT REFINER MEMBERSHIP

**Bitumar USA Inc.**

6000 Pennington Avenue  
Baltimore, Maryland 21409

Contact: Alan C. Keyser, Sales Manager  
Cell No.: (410) 370-0360  
Telephone No.: (410) 354-9550  
Fax No.: (410) 354-9552  
E-mail: alan.keyser@bitumar.com

*Bitumar USA Inc.* - Manufacture, distribution and marketing of performance-graded asphalt cements, including polymer-modified asphalt cements.

#### ASSOCIATE MEMBERSHIP

**NSM Insurance Group**

555 North Lane, Suite 6060  
Conshohocken, Pennsylvania 19428

Contact: Michael J. Fitzpatrick  
Product Specialist  
Telephone No.: (610) 941-9877  
Fax No.: (610) 941-9889  
E-mail: mjfitzpatrick@nsminc.com

**NSM Insurance Group** is a national full-service property and casualty insurance services firm specializing in the asphalt pavement industry. Through our Clean Streets Program we can provide all lines of coverage and state-of-the-art risk management services at compelling prices.

#### ENGINEERING AND ARCHITECTURAL CONSULTANT MEMBERSHIP

**L. Robert Kimball & Associates, Inc.**

615 W. Highland Avenue  
Ebensburg, Pennsylvania 15931

Contact: Oscar T. McConnell  
Vice President & Operations Manager  
Telephone No.: (814) 472-7700  
Fax No.: (814) 472-7712  
E-mail: mconflRKimball.com

**A Full Service A/E Civil, Environmental, Mapping & Survey, Geotechnical, Architectural, Transportation, and Telecommunications.**

The Hot-Mix Asphalt Association welcomes the new members. The membership contributes to making our industry a much stronger organization. We look forward to your participation in the Association. ◆
### Price Index

**Consolidated Procedure – Pennsylvania Department of Transportation/Department of General Services**

(Contract 5610-36)

- Be sure to check PAPA’s website - [www.pahotmix.org](http://www.pahotmix.org) - for monthly Price Index

#### Dates To... RE MembeR!

- **Executive Committee Meeting**
  - April 10, 2008
  - Carnegie House
  - State College, PA

- **Executive Committee Meeting**
  - September 18, 2008
  - Carnegie House
  - State College, PA

- **49th Annual Asphalt Paving Conference**
  - December 9 - 11, 2008
  - Hotel Hershey
  - Hershey, PA

- **Board of Directors Meeting**
  - April 11, 2008
  - Carnegie House
  - State College, PA

- **Board of Directors Meeting**
  - September 19, 2008
  - Carnegie House
  - State College, PA

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