SUMMARY REPORT:
BREAKOUT SESSION 2

Testing and Treatments

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INTRODUCTION

Breakout Session 2 on Testing and Treatments was called to order at 10:00 a.m. on February 5, 2003, by session cochairs Eric Berger and Carl L. Monismith. Ground rules for the session were established. Essentially it was agreed that with the 6 h available, about 3 h would be devoted to testing, and 2 h to treatments. The first topic would be testing. Also, a limited time was allowed for presentations. Two participants, Gayle King and Ronald Terrel, had requested the opportunity to make brief presentations. It was emphasized that the session had the following objectives:

1. Identify best practices.
2. Identify gaps and barriers.
3. Identify research needs.
4. Suggest elements for a strategic plan, if possible.

In addition, some questions were posed.

In testing, key issues to be considered include the following:

- Screening versus fundamental property tests;
- Use of torture tests versus those that measure fundamental properties;
- Test reproducibility and repeatability;
- Cost and length of time to perform a test, practicality;
- Design or production test, or both;
- Best test method to identify moisture-related problems (does it relate to field performance?); and

- Improvements needed in existing test methods.

Also to be considered in the deliberations for mix testing were the following requirements, among others:

- Temperature (hot, cold),
- Loading (simulating traffic),
- Aggregate structure in mix representative of field compaction,
- Degree of saturation of specimen at time of test, and
- Water properties (e.g., pH).

The question was also posed, If good mix design, pavement design, and construction practices are followed, is a moisture sensitivity test required?

For treatments, key issues to be addressed include the following:

- Effectiveness of various additives,
- Best way to introduce additives,
- Cost-effectiveness,
- Environmental and worker safety issues,
- Documented evidence of impact on pavement life,
- Field performance and comparable data, and
- Performance over time and possibility of diminished effects.

Before the presentations, the following statements by Bill Maupin were introduced (he had been assigned to another session):

- Testing
  - Must be practical (if contractor is responsible for testing, it should be simple enough to be used as a design and production test).
  - Must indicate long-term performance (do some additives lose effectiveness over time?).
- Treatments: Do some polymer-modified asphalts react with antistrip additives to make them ineffective?

A list of the participants in this session, the majority of whom remained in attendance throughout the session, appears at the end of this report.

PRESENTATIONS

Gayle King

Gayle King, in his presentation, raised the issue of the mastic's [binder plus fines (minus No. 200 material)] role in mix stripping. He argued that the mastic might be responsible for a number of failures related to moisture; that is, the mastic is disintegrating in the presence of water and traffic. He stated that there is evidence of this situation from observations of performance in the wheelpaths of some in-service pavements. The sequence is the appearance at the surface first of light-colored material (filler), then asphalt. Eventually potholes form, resulting from absence of the binder. His studies using the Hamburg wheel-tracking device (HWTD) have shown this for a number of mixes. King stated that linear kneading compaction is used to prepare slabs for his tests. Only short-term oven aging (2 h) is used; otherwise, one might not observe this response in the HWTD.

A question was raised in this regard, based on the presentation by Dale Rand, that the Texas experience with HWTD indicated that stiffening of the binder (which would come about because of longer aging) reduced the likelihood of failure. King stated that this may be true, but it may also depend on how the stiffness increase in the binder is obtained. The performance of mixes containing modified binders in the HWTD may not always follow the Texas findings of improved performance with increase in stiffness (as measured in the PG system).

Ronald Terrel

Ron Terrel discussed the "pessimum voids" concept first presented by him during his Strategic Highway Research Program (SHRP) research, which resulted in the moisture sensitivity test—the Environmental Conditioning System (ECS). He argued that most dense-graded mixes are constructed in this range (approximately 6% to 10% air voids), whereby water can readily enter the mix but is slow to evaporate. This raises both design and construction issues.

DISCUSSION OF TESTING

Initially, the discussion was directed to an examination of a screening (loose mix or surface energy) test versus a test on compacted mix subjected to moisture action. Many agreed that a screening test would be useful to material suppliers and contractors if one is using new materials, or if one is doing a process control test. On the other hand, many felt that a moisture sensitivity test on the compacted mix should be included in the mix design process, and that a relatively quick field test on the compacted field mix for quality control and quality assurance purposes is also desirable.

Attention was then directed to existing tests, including AASHTO T283, the HWTD, the SHRP-developed ECS (and modifications), and various loose mix tests.

AASHTO T283

Although AASHTO T283 is a standard test, it was stated that there are variations of the test in use by various states. Differences include degree of saturation and specimen compaction procedure. Application of too high a vacuum during the saturation process can result in damage to the specimen. Differences in permeability resulting from different aggregate gradings (e.g., coarse versus fine Superpave® gradings) will influence performance. Density gradients both horizontal and vertical, produced by gyratory compaction, can also influence test results. It was emphasized that a quality assurance program is imperative to obtain reliable and reproducible test results. That is, both testers and laboratories must be certified.

Based on the results of NCHRP 9-13 (*NCHRP Report 444: Compatibility of a Test for Moisture-Induced Damage with Superpave Volumetric Mix Design*) prepared by University of Nevada at Reno staff, modifications have been incorporated into AASHTO T283 in the 2002 version of the test. These changes should assist in reducing variability in test results. There is the concern, however, that favorable test results do not guarantee good field performance, nor do poor results necessarily mean that the mix will fail in service.

Hamburg Wheel-Tracking Device

Many participants felt that some form of repeated loading of the mix in the saturated condition is essential and is a plus for the HWTD. (Note: It was mentioned by a number of discussants that the Asphalt Paving Analyzer with its standard loading configuration does not meet this requirement.) To date, the HWTD has exhibited poor repeatability, indicating the necessity for standardization. Individual agencies that use the HWTD extensively have developed their own protocols for its use. However, no generally accepted method has been adopted that could provide guidance nationwide. Applicability of the HWTD for field testing was also questioned. It was observed that failure in the HWTD should not be attributed to moisture sensitivity unless "fines" appear in the water covering the specimen.

Environmental Conditioning System

The results of the discussion of this test methodology were that it is a very promising approach but is not yet ready for widespread use as a laboratory mix evaluation procedure for moisture sensitivity.

Loose Mix Tests

Many in the group felt that tests on loose mix do not provide in-service performance information. Rather their role is for screening purposes. In this regard, it was noted that an ultrasonic test on loose mix might serve as a quick test.

Permeability Tests

Some discussion was devoted to the role of mix permeability in moisture sensitivity evaluation. It was observed that in the pessimum voids range, there is not a definitive relationship between permeability and calculated air void content. This situation is likely related to different degrees of interconnectivity of voids—for example, as a function of aggregate gradation. It was suggested that porosity (a measure of accessible air voids) might be a better measure of accessibility of water to the laboratory test.

Discussion was also devoted to the use of air permeability to measure the propensity for ingress of water into the mix. This has been used for compaction control of mixes in the field (e.g., Washington Department of Transportation as early as the 1960s). Air permeability is relatively easy to measure and may serve as a useful part of moisture sensitivity testing.

Summary

Many agreed that the tests being used today do not measure fundamental properties. Nevertheless, the tests, such as AASHTO T283 and the HWTD, may be useful in the near term so long as they use standard procedures and are calibrated to local conditions. An important issue not addressed in these discussions is the impact of long-term aging of the binder on the effects of moisture on asphalt mixes. There is some evidence that aging of the asphalt binder may increase the moisture sensitivity of mixes. However, this could be one of the needed research activities.

Current Practices: Testing

Rather than using the designation "best practices," the group agreed to use the term "current practices." Members of the group identified three existing tests, which can be used in some manner to assist in mitigating moisture sensitivity in asphalt mixes:

1. AASHTO T283-02,
2. HWTD, and
3. Loose mix testing.

That the use of one or more of these tests can produce mixes with at least short-term resistance to moisture is predicated on the assumptions that the mixes are well designed and produced, and that they are properly constructed. In addition, it is assumed that one or more can be used for initial mix design and production control.

For the AASHTO T283-02 methodology, a number of issues to address are as follows:

1. It is essential that successful modifications to the procedure be incorporated and that a standard procedure be followed. Presumably, the T283-02 procedure reflects many of these developments.
2. Reproducibility and repeatability of the method are crucial to ensure successful application. For example, the successful use of the procedure by the Colorado Department of Transportation has resulted from its program of certification of both testers and laboratories, and their proficiency evaluation program.
3. Specimen preparation should be standardized; this includes both the specimen compaction procedure and strict control of the degree of saturation of the resulting test specimen.
4. A standard procedure for air void determination is essential.
5. Because mix permeability varies as a function of aggregate gradation, determination of the degree of saturation based on calculated air void content might be misleading at times. Therefore, consideration should be given to other procedures to define the degree of saturation.
6. The procedure must be calibrated for local conditions.
7. A disadvantage of the procedure is the lack of repeated loading to simulate the effects of traffic.

For the HWTD, a positive feature of the test is that it includes repeated loading. In addition, stripping can be identified by transport of fines from the mix being loaded into the surrounding water. Issues to be addressed include the following:

1. Test conditions and criteria should be established for the specific environment in which the mix will be used, and they depend on mix characteristics.
2. A standard method of specimen preparation including specimen size and compaction procedure is required.
3. Improvements in equipment are required, for example, where rut depth is measured.
4. A standardized procedure that can provide guidance nationwide is lacking.
5. Repeatability and reproducibility are concerns.
6. No precision and bias data are available.

Loose Mix

This testing is recommended primarily for screening purposes. Potential procedures include

1. Static boiling,
2. Use of a rolling bottle (to input mechanical energy to coarse mix in water), and

3. Ultrasonic testing of coarse mix in water.

Gaps in Current Knowledge

Major gaps identified include the following:

1. Lack of criteria and procedures for local calibration of test methods,
2. Test correlation with failure mode, and
3. Lack of well-documented field performance data.

The third item is a particularly severe deficiency in the moisture sensitivity area. It is extremely important that data be collected that can be related to field performance—performance that can be directly attributed to moisture sensitivity, not to improper mix design, poor control of mix production, or inadequate mix compaction.

Research Needs

Many agreed that it is important to complete the ECS research, which includes provision for simulated traffic loading, and therefore its influence on pore water pressure effects on mix performance; measurement of dynamic modulus as influenced by moisture (significant mix characteristic used in AASHTO 200X pavement design and rehabilitation procedure); and considerations of water quality, for example, as measured by pH. Other needs include defining the effects of long-term aging on moisture sensitivity characteristics and continuing the development of tests that measure fundamental properties related to the moisture sensitivity of mixes.

DISCUSSION OF TREATMENTS

In addition to the key issues listed in the introductory remarks, three items were identified:

1. The need to verify whether treatment is in the product (binder or mix),
2. Potential incompatibility of binder and additive, and
3. Mix design procedure if treatment (additive) is incorporated.

In considering first the mix design methodology, it was observed that if a mix design is accomplished without some form of treatment and the additive is incorporated subsequently, some agencies may not evaluate the treated mix. Many participants felt that the final mix design should be done with the treatment/additive included. For example, the Oregon Department of Transportation (ODOT) contract documents state that if the aggregate is to be lime treated, the mix design is performed with lime incorporated in the mix. It was also noted that ODOT requires that if lime is added later, the original design is redone with lime added.

For lime treatment, a number of participants indicated that dry lime on wet aggregate was very effective. Nevada reported that this form of lime addition worked well in the laboratory but that, in participants' experience, marinating was required in the field. The cost of marinating is high. Thus, it was noted that if the requirement that the plant mix pass the test is enforced, then the contractor will take the necessary steps to introduce the lime properly. It was suggested that one way to improve the dry lime on wet aggregate option is to conduct the mixing in an enclosed pug mill before the aggregate is mixed with the asphalt.

The question was raised about the addition of lime to the asphalt. Since this is under investigation, it was recommended that this be listed as a research topic.

Discussion of liquid antistrip additives produced a number of useful recommendations. Considering addition at the refinery versus at the hot-mix plant site, there was agreement that on-site addition is preferred.

The issue of softening of the binder by the additive was raised. It was noted that the majority of high-quality antistrip additives in use today do not reduce binder stiffness. Nevertheless, the binder should be required to meet the specification after the addition of the antistrip material.

Other treatments were also discussed, including the use of cement (versus lime), polymer coating on aggregate, and polymer modification of the binder. It was noted by Arizona that although cement had been permitted for a number of years, lime treatment has now substantially replaced it for aggregate treatment.

Polymer coating of aggregate is being evaluated. Currently, the quantity of polymer added is about 1 lb per ton of aggregate. Compatibility with a specific aggregate must be checked. It was reported that the material serves to waterproof the aggregate surface (very thin applied film) and is compatible with the asphalt.

Verifying the amount of additive in the mix is still a problem. It was noted, however, that there is a device that can be used to determine the amount of liquid antistrip additive in the binder by measuring its change in pH.

There are worker safety issues and environmental concerns in hot-mix production using various treatments. For example, dust may be a safety problem in the use of dry lime on wet aggregate, and there may be fumes associated with the use of liquid antistrip materials. Because government agencies and contractors both are aware of the safety and environmental issues associated with the currently used treatments, the decision was made to not include this aspect in the recommendations.

Relative to the impact of type of treatment on pavement life, Nevada indicated [on the basis of a study of eight projects, [Sebaaly et al. 2003 (*1*)] that lime treatment extended pavement life by an average of 3 years. It was also noted that in Oregon lime treatment increased pavement life by about 2 years. Many in the group believed, however, that there is little documented information in this area and that an effort should be made to document field performance on a more widespread basis.

The necessity for studies of the comparative performance of pavements in specific environments with different treatments was discussed. An example of this type that is under way in South Dakota was reported by P. Sebaaly. The study, in two locations of the state, includes comparisons of the untreated mix with mixes treated using different methods for lime addition and liquid antistrip material. The project has been under way for less than 3 years, and no differences in field performance have been observed thus far. Many agreed that studies of this type are important.

The question of potential reduction in effectiveness of treatment with time was discussed. Because little, if any, information is available, this should be an area of proposed research.

The incompatibility of some modified asphalts and liquid antistrip additives was briefly discussed. One example was presented in which an asphalt modified with phosphoric acid was blended with liquid antistrip, with the result that the effects of both the modification and antistrip were negated. This should be considered a gap in knowledge.

Best Practices: Treatments
Best practices identified by members in attendance are the following:

- To ensure that the proper additive (both type and amount) is used, mix design should be performed incorporating the specific additive planned for use. It was observed that some material specifications, for example, aggregate gradations, might not reflect the potential for additives such as lime. Thus, some modification in requirements may be required for these conditions.
- Recommended best practice for the addition of lime is dry lime on wet aggregate. Associated with this is the requirement that acceptance of the mix be based on mix production data. Consideration should also be given to a method specification for incorporation of lime, for example, closed twin-shaft pug mill mixing of lime with aggregate before mixing with asphalt/binder. In some circumstances, coated aggregate with plastic (high plasticity index) fines should include a period of marination before mixing with asphalt/binder.
- The best practice for incorporation of liquid antistrip with the binder is on site where the mix is being produced. Acceptance should be based on certification of product type and amount. Binders with liquid antistrip additives should be tested after the antistrip has been added to ensure that the material meets the specification requirements.

Gaps in Current Knowledge
The following gaps were identified:

1. Lack of a standard method to verify the quantity of additive, particularly lime, in the mix.
2. Lack of documented field performance data for mixes containing the different treatments and additives for a range of environmental and traffic loading conditions. The performance data should include comparable mixes without treatment to assist in life-cycle cost analysis.
3. Lack of documentation of compatibility of various additives with conventional asphalts and modified binders.

Research Needs
Identified research needs include the following:

1. Development of a field test to determine uniformity of distribution of an additive (e.g., lime) in the mix.
2. Documented field performance data of side-by-side comparisons of mixes containing a range in treatments/additives for different environments and traffic loading conditions (e.g., similar to the South Dakota experiment referred to earlier).
3. Evaluation of aging of aggregates in stockpiles.
4. Evaluation of the characteristics of asphalt in which lime is blended before mixing with aggregate, for example, at the refinery or on site.
5. Evaluation of common moisture sensitivity mitigation treatments to determine whether there is any deterioration in their performance over time in pavements experiencing different environments and traffic loading conditions. Development of documented field performance data is required to determine whether, in fact, such behavior actually occurs.

ACKNOWLEDGMENTS

The cochairs thank all of the participants in the session. Participants' willingness to share their extensive experiences with the group contributed significantly to achieving the goals of the breakout session. The cochairs also gratefully acknowledge the efforts of the two recorders for the session, Jennifer Kwong of Caltrans and Julie Nodes of the Arizona Department of Transportation. Their extensive notes were most helpful in preparing this report.

REFERENCE

1. Sebaaly, P. E., E. Hitti, and D. Weitzel. Effectiveness of Lime in Hot-Mix Asphalt Pavements. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1832*, TRB, National Research Council, Washington, D.C., 2003, pp. 34–41.

BREAKOUT SESSION ON TESTING AND TREATMENTS: ATTENDEES

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