



ASPHALT TECHNOLOGY NEWS

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NCAT CELEBRATES TENTH ANNIVERSARY WITH AN OPEN HOUSE

It is hard to believe, but NCAT has been in existence for 10 years now. We celebrated our tenth anniversary with an open house April 9-10. About 100 participants from state DOTs, the Federal Highway Administration (FHWA), academia, and industry from 20 states attended the event. Don Lucas, chief engineer of the Indiana DOT, was the keynote speaker at the dinner April 9. He stated that the primary customer of the hot mix asphalt (HMA) industry is the motoring public. Therefore, it is imperative that government agencies, industry, and academia cooperate with each other to satisfy our customer's needs: smooth and durable highways and

streets. We must start utilizing the Strategic Highway Research Program's (SHRP) Superpave technology to achieve this goal.

Mike Acott, president of the National Asphalt Pavement Association; Byron Lord, chief of the FHWA Pavement Infrastructure Division; and Ray Brown, director of NCAT, made presentations on the morning of April 10.

Acott cited many examples of NCAT'S achievements during the past 10 years, such as the development of HMA textbook, annual professor training course in HMA technology, a national rutting study, major participation in SHRP research, stone ma-

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Don Lucas, chief engineer Indiana DOT, was the keynote speaker at the NCAT open house.

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At the open house (from left): Bill Walker dean, College of Engineering, Auburn University; Ron Kenyon; Margaret Kenyon; Paul Parks, provost, Auburn University; and Tim Docter chairman, NAPA.

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trix asphalt (SMA) research, and the development of NCAT'S ignition oven for determining asphalt content without solvents. He stated that in addition to the industry sponsored research, NCAT is conducting numerous research projects for the FHWA, various state DOTs, and the National Cooperative Highway Research Program (NCHRP). Very rapid and successful implementation of SMA technology and the ignition test method for asphalt content in the U.S. can be attributed to NCAT'S central and active role at the national level, in co-operation with the FHWA, state DOTs, and the industry.

Lord cited NCAT as a perfect example of partnership between government, industry, and academia. He lauded the great vision of industry people like Ron Kenyon and John Gray in establishing a \$10-million

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E. Ray Brown, Director

Prithvi (Ken) Kandhal, Associate Director/Editor

James S. Killian III, Associate Editor, College of Engineering



Doug Hanson, assistant director NCAT (right) discussing the center's laboratory testing program with open house attendees.

At the open house (from left): Tim Docter chairman, NAPA; Ned Bechthold, Payne and Dolan; John Spangler Milestone Contractors, and Mike Acott, president, NAPA.



(OPEN HOUSE, Continued from page 2)

endowment fund for supporting NCAT at Auburn University.

Brown highlighted the progress made by NCAT since its inception in 1987. NCAT'S permanent staff has grown from 1 to 17 during the past 10 years. Its annual budget has increased from \$500,000 to about \$1.5 million. He cited five accomplishments in particular.

● **HMA Textbook.** The first-ever HMA textbook was developed by NCAT in 1991, and some 10,000 copies have been sold. It is used in many universities to teach HMA technology. Work is under way to publish a revised edition of the textbook in early summer. The revised edition will contain Superpave technology, stone matrix asphalt (SMA), and modifiers/additives.

.Professor Training Course (PTC). This course in HMA technology was developed by NCAT in 1988 for

university faculty so that they can teach HMA technology at their institutions. PTC has been held successfully every year since 1988. So far, some 123 professors from 38 states have been trained.

● **National Rutting Study.** NCAT undertook a major five-year rutting study in 1988 which involved many HMA pavements nationwide. The findings and recommendations from this study have been effective in minimizing or eliminating rutting on heavy duty pavements. Many state DOTs have implemented recommendations from this study.

● **NCAT Ignition Oven for Determining Asphalt Content.** This innovative method of determining the asphalt content of HMA mixtures without any solvents was developed by NCAT in the fall of 1994. Its high accuracy and precision was established in the spring of 1995 through a round robin national study in which 12 laboratories participated. Numerous NCAT ignition ovens are in use today and the number is increasing at a rapid rate, as many highway agencies are switching from solvent extraction methods to this method. The method is drawing world-wide attention because many agencies are phasing out the use of chlorinated solvents, which are considered hazardous to human health and the environment. Asphalt content can be obtained within 30-40 minutes by this method which also allows the determination of the recovered aggregate gradation.

● **NCAT Newsletter *Asphalt Technology News.*** The newsletter in your hand has been acclaimed by the HMA industry to be very practical and informative. It has provided a forum to the highway agencies and the industry for exchanging ideas and experiences in HMA technology.



William V. Muse, president, Auburn University, welcoming the open house attendees.



ASPHALT FORUM

NCAT invites your comments and questions. Questions and responses are published in each issue of Asphalt Technology News. Some are edited for reasons of consistency and space.

Rhode Island (Francis Manning, Rhode Island DOT)

In Rhode Island and other northeastern states, we often see abrupt deterioration of open-graded asphalt friction courses (OGFC) designed in accordance with FHWA-RD-74-2 after about 15 years. Usually the bond between the OGFC and the underlying dense-graded HMA course fails, resulting in OGFC delamination. Is this common elsewhere? Is it preventable? If so, what measures should be taken.

(15 years is a pretty good design life for OGFC, especially in the severe climate of the northeastern U.S. Many agencies such as Georgia DOT use polymer-modified asphalt binders to increase the durability of OGFC.
- editor)

Utah (Wade Betenson, Utah DOT)

We are purchasing two NCAT ignition ovens for asphalt content testing. We will evaluate these units as possible replacement for solvent extractions for project field testing when we do not need to recover the asphalt binder.

We also want to participate in the WesTrack in Nevada to check some of our Superpave mix designs.

Texas (Maghsoud Tahmoressi, Texas DOT)

We have evaluated asphalt content ignition ovens from Troxler, Thermolyne and Gilson. All gave satisfactory results. We will purchase 30 ignition ovens this year. We have elected to specify the internal weighing system for measuring the mass loss during ignition.

Connecticut (Charles Dougan, Connecticut DOT)

A six-mile Superpave project is tentatively planned for the 1997 construction season. It is a four-lane divided highway with an existing HMA pavement. The eastbound lanes will have two experimental test sections constructed with Superpave mixes and one control test section constructed with the standard ConnDOT mix. The westbound lanes will have the same three test sections but each requiring the use of 25 ± 5 percent recycled asphalt pavement (RAP).

Florida (Gale Page, Florida DOT)

We in the asphalt technology field have a unique opportunity with Superpave (both binder and mix). The quality control (QC) plan for asphalt binder suppliers

represents an opportunity for uniformity in handling materials from state to state. We should strive to use the Superpave specifications, and if changes need to be made they should be done on a national/regional basis with good reason. An example of this is "bumping" two grades of asphalt binder for standing traffic loads. Marshall mix design worked for its time. Superpave mix design will take us to the next higher level and will give us a better performing mixture.

Alabama (Kee Foo, NCAT)

The high and low temperature grade in the PG grading system has the tendency to erroneously mislead a pavement designer to select a binder with higher range of service temperatures (for example PG 76-22) than that specified for the region (for example PG 64-22). The notion that PG 76-22 not only satisfies but exceeds the binder specification for PG 64-22 may not be entirely accurate at intermediate temperature, which is critical for fatigue cracking. A PG 64-22 binder is soft enough at the intermediate temperature of 25°C to prevent fatigue cracking. However, a PG 76-22 binder is required to be soft enough at a significantly higher intermediate temperature of 31 °C to prevent fatigue cracking. Therefore, a PG 76-22 binder may develop more fatigue cracking than the specified PG 64-22 binder, although both provide same resistance to low temperature distress (low temperature cracking) and PG 76-22 has higher resistance to high temperature distress (rutting) compared to PG 64-22. In other words, a PG 76-22 binder may fail to meet the fatigue cracking requirement for the specified PG 64-22. In view of the preceding example, the asphalt binder specification and grading should also have an intermediate temperature grade, for example, PG 64(25)-22, PG 76(25)-22, and PG 76(31)-22. By including the intermediate temperature grade, a PG 76(25)-22 binder can then be used when a PG 64(25)-22 is specified, while a PG 76(31)-22 is not considered appropriate.

Alabama (Charles Marek, Vulcan Materials Company)

Vulcan's R&D Technical Center has utilized the NCAT ignition oven to (a) rapidly determine the asphalt content, and (b) recover all fractions of the aggregate

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STONE MATRIX ASPHALT PERFORMANCE REVIEW

Stone Matrix Asphalt (SMA) is a premium hot mix asphalt (HMA) that has proven capable of providing excellent service on large traffic volume, high truck count roadways. Originally developed in Germany, its use has spread throughout Europe, Scandinavia, and most recently, the United States. The popularity of SMA is attributable to its anti-rutting capability. This ability to resist rutting under heavy loads is due to the stone-on-stone contact aggregate skeleton inherent in SMA. The mix has the further advantage of being durable due to its high asphalt binder content.

Since the first U.S. trial placements in 1991, the use of SMA has continued to grow throughout the United States with at least 23 states having completed SMA projects. Two of the largest users are the states of Georgia and Maryland. Georgia has 570,000 tons in service or under contract, and expects to let contracts for another 100,000 tons this year as they prepare for the 1996 Summer Olympic Games. Maryland has approximately 800,000 tons in service and plans to place an additional 200,000 tons in 1996.

Project Overview

In 1995, the Federal Highway Administration (FHWA) initiated a project to accomplish a performance review of all the SMA pavements in service throughout the United States. The purpose of the review is to assess current performance and identify any problem areas where changes to SMA materials, specifications and/or production and placement methods might need to be made. The performance review project awarded to NCAT has three main tasks: 1) Perform a literature review and develop a detailed performance review plan;

2) perform field surveys to assess performance, and 3) prepare a report detailing the findings and suggesting any necessary modifications to current SMA practice.

Task 1 has been completed. The initial performance review plan called for the review of 66 pavement sites in 21 states. However, since the performance review visits began, the number has grown to approximately 75 pavement sites in 23 states. These pavement sites extend from New Jersey in the east to California in the west; from Alabama in the south to Alaska in the north. This diversity in location allows for the determination of SMA performance in a wide variety of loading situations and climatic conditions.

Task 2 is nearly complete and involves on-site visits to gather data and make visual observations. The data gathered from each pavement site includes materials properties, job-mix-formula, construction data, rut depths, amount of cracking and bleeding, and ascertainment of aggregate damage, if any. An extensive file of photographs is also being compiled for each site.

The final task will be to prepare a report detailing the findings of the survey. This report will include the effects that aggregate type and gradation, voids, and stabilizing additives have on the performance of SMA. Any suggested changes to specifications and/or production and placement methods will also be included.

Overall SMA Performance Currently, all but approximately 13 sites in six states have been visited. The overall performance of the pavements has been very good. As a whole, SMA pavements throughout the na-

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Australian engineer Ian Rickards examining the Superpave gyratory compactor in the NCAT laboratory.

SOUTHEAST SUPERPAVE CENTER

The Southeast Superpave Center, located at NCAT, is up and running, with equipment delivered and operational. It will serve eight states: Alabama, Georgia, North Carolina, South Carolina, Mississippi, Florida, Virginia, and Tennessee. A management committee has been established which consists of representatives from each state as well as the Federal Highway Administration and the National Center for Asphalt Technology. The first meeting was held in Dallas Nov. 25, 1995. This year's meeting will be held in Atlanta Nov. 19. The center is funded through a Pooled Fund study established by the FHWA through the Alabama DOT.

The primary function of the center is to support implementation of the SHRP research results by state DOTs and industry in the Southeast. During the remainder of this fiscal year, the efforts at the center will be directed toward training personnel on Superpave mixture analysis procedures, and shakedown studies with the equipment.

During the next fiscal year, the center will conduct seminars on mixture analysis procedures. It will provide problem solving expertise on Superpave technology to the DOTs and industry within the region, and conduct a series of round robin studies (modified binders, unmodified binders, and Superpave gyratory). In addition, the center will conduct research as requested on various aspects of Superpave and HMA technology.

The primary tools to be used by the center are the Superpave binder equipment, the Superpave shear tester (SST) and the indirect tensile tester (IDT).

In Superpave mixture analysis, researchers have developed procedures to predict the development of permanent deformation (rutting), fatigue cracking, and low temperature cracking. Permanent deformation and fatigue cracking are considered load related distresses, while low temperature cracking is a nonload related distress. The mixture analysis system uses two pieces of

equipment to accomplish this goal, the Superpave shear tester (SST), and the Indirect tensile tester (IDT). With this equipment, a total of eight different types of tests can be performed on a given HMA mixture. The following is a brief overview of the equipment.

Superpave shear tester (SST) - The SST is used to do most of the load-related performance testing. The SST testing system consists of a loading device, specimen deformation measurement equipment, an environmental chamber, and a control and data acquisition system. Tests performed with the SST include the following:

- volumetric strain
 - . uniaxial strain
 - . simple shear at constant height
- frequency sweeps
 - . repeated shear test

Test results from the SST are used by the Superpave models to predict the permanent deformation and fatigue cracking which may occur in an HMA pavement during its service life. Testing is performed on 150 mm diameter gyratory specimens compacted to 7 percent air voids. Specimens are sawed to produce 50 ± 2.5 mm height test specimens.

Indirect tensile tester (IDT) - As with the SST system, the IDT system consists of an axial loading device, specimen deformation measurement equipment, and a control and data acquisition system. The IDT is a device used to measure the HMA mixture's creep compliance and tensile strength at low to intermediate temperatures. Tests performed on the IDT include:

- . Indirect tensile strength at intermediate temperature
- . Indirect tensile creep at low temperatures
- . Indirect tensile strength at low temperatures

Test results from the IDT are used by the Superpave models to predict fatigue and low temperature cracking. Testing is performed on specimens that are identical to those used in SST testing.

If you would like additional information on the Southeast Superpave Center, its capabilities or even a tour, please contact Doug Hanson at (334)844-6240 or Shane Buchanan at (334)844-6252.

—Doug Hanson

JOIN US!

We at NCAT hope you enjoy this issue of Asphalt Technology News. It is provided free of charge. If you wish to be added to our mailing list, please send your business card or your name and mailing address to:

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PUTTING RESEARCH INTO PRACTICE

The following papers were presented at the annual meeting of the Transportation Research Board (TRB) held in Washington, D. C., in January. We are reporting observations and conclusions from these papers which may be of value to field engineers. These comments are obtained mostly from research projects with a limited scope; before application to practice we recommend that you read the entire paper to determine its limitations. Titles of the paper are given, with names of authors in parentheses, followed by a brief summary.

1. HOT MIX ASPHALT SEGREGATION: MEASUREMENT AND EFFECTS (Williams, Duncan, and White)

Early distress of asphalt surfaces has been associated with HMA segregation. A non-destructive test that identifies and quantifies HMA segregation would be a significant contribution to HMA technology. Non-destructive test methods, including thermal imaging, air permeability, and nuclear gauge (both density and asphalt content), were examined in this study to determine their effectiveness in detecting segregation and sensitivity in measurement. The thermal imaging equipment was tested in the field on an existing HMA pavement, at a HMA plant, and at a paving project to determine its overall effectiveness and sensitivity. The basis for using this equipment was that different sized aggregates (which result from segregation) would retain or gain heat at different rates and thus have different temperatures. An air permeameter was used on labo-

ratory - made HMA slabs. Since connected air voids of compacted, segregated mixtures would vary, then the permeability (air or water) has a potential to correlate with the level of segregation. A nuclear moisture/density gauge was used on laboratory prepared HMA slabs to measure the density and asphalt content of the compacted HMA. When moisture measurements are made, the "count" depends on the hydrogen atoms in the water. Since asphalt cement binder also contains hydrogen atoms, the nuclear moisture density gauge should be able to measure relative asphalt contents in segregated HMA mixtures. Coarse mixtures contain lower asphalt contents than finer mixtures. Segregated HMA mixtures were also tested for rutting and stripping by the Purdue wheel tracking device.

Four HMA mixtures were studied in the laboratory. These included surface mixes, 12.5 mm (1/2 in.) nominal maximum size, and binder mixes, 25.0 mm (1 in.) nominal maximum size. Two aggregate types, limestone and gravel, were utilized. Five levels of segregation (two on coarse side and two on fine side) were obtained in the laboratory.

The following conclusions were drawn from this study:

- Thermal imaging technique was found to be ineffective in detecting segregation other than enhancing the naked eye's view. It also did not detect segregation occurring below the surface. Further, the thermal images do not yield quantitative results making the inspection process rather subjective.

- The air voids in segregated HMA mixes increase from very fine to very coarse segregation. However, the air permeameter was only successful in detecting

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Korean engineers S. H. Lee and Y. B. Cho observing the gyratory compaction process in the NCAT laboratory.

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for subsequent evaluation and testing. Limited testing was performed on aggregate recovered from cores after "burning" in the ignition oven. Sulfate soundness of the aggregate exhibited excessive losses, four to ten times greater than expected, and many times greater than obtained after the cores were extracted with solvent using ASTM D2 172. My questions to the Asphalt Forum are as follows:

- (1) Is the aggregate obtained from the ignition oven after "burning off" the asphalt binder suitable for subsequent testing for quality?
- (2) Does the temperature to which the aggregate is subjected in the ignition oven create high stresses and internal fracturing of the aggregate such that the physical properties including grading are significantly changed?
- (3) Can the oven be operated in a manner that will burn off the asphalt binder while providing an aggregate suitable for subsequent quality testing?

(The NCAT ignition test was primarily developed to rapidly determine the asphalt content of HMA mixtures without the use of solvents. A nationwide round robin study in which 12 laboratories participated (Asphalt Technology News, spring, 1995'), showed that the grading of the aggregate after ignition remains essentially unchanged. However NCAT has undertaken a research project to assess the effect of ignition on other physical properties of the aggregate such as bulk specific gravity and water absorption. Preliminary test data indicate that these properties are significantly affected by the ignition process. Lower ignition temperatures will be investigated to minimize the effect on aggregate properties if those properties are to be evaluated. However lower ignition temperatures will increase the testing time. Again, we must emphasize that the primary purpose of the ignition test is to determine the asphalt content and gradation of HMA mixtures. - editor)

Arizona (Don Nielsen, Consultant)

In your fall, 1995 issue, there is a short item on page 12 about a Nordic research project that shows significant noise reduction accomplished with a porous HMA pavement. This fact has been known for a long time, but the main problem in colder climates is that moisture trapped in the air voids expands when it freezes, popping out the aggregate. Asphalt rubber (asphalt modified with 20 percent crumb rubber) when used in porous pavement mixtures can cope with such expansion and contraction.

(Porous pavement is commonly called open-graded asphalt friction course or OGFC in the U.S. - editor)

Australia (John Bethune, Australian Asphalt Pavement Association)

An NCAT Troxler ignition oven has been purchased by VicRoads and is currently being evaluated by the Australian Road Research Board Transport Research.

What are suitable safe bitumen solvents to replace chlorinated solvents which are being phased out in some instances, due to their harmful effects on the environment? Even with the use of ignition ovens, it will still be necessary to extract the bitumen binder for further testing. Some are advocating the use of toluene which is a flammable solvent, and requires suitable precautions such as the use of flame-proof fume cupboards and ovens.



At the open house (from left): Bob Thompson, Thompson-McCully Co.; Byron Lord, FHWA; Chris Jones, Couch, Inc.; Don and Daniel (Gallagher Gallagher Asphalt Corp.)

very coarse segregation. Further, it was sensitive to surface segregation but not to blind segregation.

. Segregation results in significant variation in the asphalt content which increases from very coarse to very fine segregation. (NCAT studies have shown that the asphalt content varies approximately by 0.1 percent when the material passing 2.36 mm (No. 8) sieve varies by 1 percent due to segregation in HMA binder mixtures. - editor) Nuclear moisture/density gauge measurements may be used in combination to identify segregation, because the gauge reads asphalt content as moisture content.

. Segregated HMA mixes exhibit significant loss in performance (both rutting and stripping) when tested in the Purdue Wheel Tracking Device.

2. USE OF GEORGIA LOADED WHEEL TESTER TO EVALUATE RUTTING OF ASPHALT SAMPLES PREPARED BY SUPERPAVE GYRATORY COMPACTOR (Collins, Shami, and Lai)

The Georgia Loaded Wheel Tester (GLWT) developed by the Georgia Department of Transportation (GDOT) has been used since 1985 in the laboratory to evaluate the rutting potential of HMA mixtures during the design stage. In the GLWT testing, a compacted HMA beam specimen is subjected to an elevated temperature in a loaded wheel system under repetitive loading conditions and the permanent deformation (rutting) induced under the wheel path is measured. Three beam specimens can be tested simultaneously. The equipment has been upgraded over the years. At the present time, a dedicated rolling compaction machine fabricates 125 mm wide by 300 mm long by 75 mm thick HMA beam specimens simulating the field compaction of HMA mixtures. According to the GDOT Test Method CDT- 115, HMA mixtures which develop more than 7.5 mm rut-depth on the beam samples after being subjected to a wheel load of 100 lbs. (450 N) in magnitude and 100 psi (690 kPa) contact pressure for 8,000 cycles at 40°C testing temperature are deemed unsatisfactory in rutting resistance and are, therefore, rejected. It should be noted that Utah DOT and Maryland DOT both use 5.0 mm rut-depth value as a pass/fail criterion.

Superpave volumetric mix design is most likely to be adopted by many states in the U.S. in the near future. However, this mix design procedure does not include any mechanical test to determine the rutting potential of the designed mix. Some highway agencies would like to use some sort of a torture test, similar to GLWT, as a supplement to the Superpave volumetric mix design system. However, the GLWT uses beam specimens made by a rolling compactor whereas the Superpave uses 150-mm diameter cylindrical specimens

compacted in a Superpave gyratory compactor (SGC). This study was undertaken to promote the concept of using GLWT as a supplement to Superpave volumetric mix design by utilizing SGC compacted cylindrical specimens rather than beam specimens in the GLWT.

Two gyratory samples were placed in a specially designed high density polyethylene (HDPE) split mold so that they could be tested in the GLWT identical to the beam specimens. It was decided to use SGC specimens 150 mm in diameter and about 75 mm in height. This sample height was chosen to avoid any changes on the GLWT when testing these specimens. Specimens of this size can also be obtained by trimming the standard SGC samples or obtained from the field by coring. A testing program was developed to develop correlations between the rut-depths of HMA mixes using the standard beam samples and the gyratory samples. The test program used three HMA mixes of different degrees of rutting resistance ranging from high to low rut susceptibility. Both the beam and gyratory samples of each mix were tested at 40°, 50° and 60° C temperatures for 8000 cycles by the CDT- 115 procedure. In most cases, two gyratory specimens placed in the gyratory sample mold and two beam specimens were tested side-by-side in the GLWT. The rut-depth results obtained were then analyzed.

Statistical analysis of the test data showed that the rut depths obtained on the gyratory samples were comparable to those obtained on the beam specimens. Therefore, there is a potential of using GLWT in conjunction with the Superpave volumetric mix design in the laboratory.

3. ISSUES PERTAINING TO THE USE OF THE SUPERPAVE GYRATORY COMPACTOR (McGennis, Anderson, Perdomo and Turner)

This laboratory study examined the effect of mold diameter, compaction temperature, short term aging period, and type of Superpave gyratory compactor (SGC) on the evaluation of design aggregate structure and design asphalt content when performing Superpave volumetric mix design. The following experiments were conducted and observations made.

● **Mold Diameter.** Two mold sizes, 150 mm (standard) and 100 mm were compared. If both gave comparable results, then the smaller mold could be used, which would save time in processing and batching aggregate especially in laboratory research projects. Five 19 mm and two 12.5 mm size design aggregate, structures were used in the evaluation, which consisted of determining the density as a percentage of maximum specific gravity (% Gmm). In 47 out of 84 comparisons (56 percent), the γ_0 Gmm obtained in 150-mm and

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100-mm molds were significantly different. Of the 47 cases where the 90 Gmm were not equal, 46 exhibited a significantly higher % Gmm using the 150-mm mold when compared to the values using the 100-mm mold.

● **Compaction Temperature.** One design aggregate structure, two asphalt binders (one unmodified and the other polymer-modified), and five compaction temperatures (120°, 135°, 150°, 165°, and 180°C) were used to evaluate the effect of compaction temperature on optimum asphalt content and VMA at Ndesign. Variation in compaction temperature did not seem to substantially affect volumetric properties of the HMA mixture containing unmodified asphalt binder. However, variation in compaction temperature did significantly affect the volumetric properties of the same mixture containing a modified binder. There is an immediate need for a more rigorous method of establishing mixing and compaction temperatures for modified asphalt binders.

● **Short term aging period.** HMA mixtures were aged for 0, 0.5, 1, 2, and 4 hours before compaction in the SGC to determine the effect of aging period on the maximum specific gravity (Gmm) of the loose mixture and the bulk specific gravity of the compacted HMA specimen (Gmb). The data generated from this experiment generally indicated that as aging time increased, Gmm increased (due to increased absorption of asphalt binder) and Gmb decreased.

● **Compactor Comparison.** Four SGCS (Pine, Troxler, Rainhart, and modified Texas gyratory compactor) were evaluated by compacting six HMA blends and determining optimum asphalt contents. There were less significant differences in the four SGCS at Ndesign and Nmaximum. In five of six comparisons, the design asphalt contents were higher by 0.2 -0.6 percent when using the Troxler SGC compared to the Pine SGC. Caution should be exercised in drawing conclusions regarding the comparison of the compactors. Contrary to this experiment, FHWA research (reported by D'Angelo in the Journal of the Association of Asphalt Paving Technologists, Vol. 64, 1995) has shown the Pine and Troxler SGC units to be substantially equivalent.

4. INFLUENCE OF AGGREGATE PROPERTIES ON PERFORMANCE OF HEAVY DUTY HMA PAVEMENTS (Ahlich).

The research described in this paper was conducted to achieve the following objectives: (a) to characterize and quantify aggregate shape and texture and (b) to develop relationships between these physical properties of aggregates and the permanent deformation (rutting) characteristics of HMA mixtures. Specifically, this study addressed the Federal Aviation Administration (FAA) specification P-40 1 for HMA mixtures and air-

craft loading conditions. The aggregate sources for this laboratory evaluation included limestone, gravel (crushed and uncrushed) and natural sand materials. The limestone and crushed gravel aggregates met the requirements of Item P-401 and served as the accepted high quality aggregate. Uncrushed gravel and natural sand materials were used in conjunction with the crushed aggregates to produce the various particle shape and texture blends. Eleven different blends were used to prepare HMA mixtures.

Coarse aggregates and fine aggregates were separated by No. 4 (4.75 mm) sieve. The aggregate particles were characterized with the Particle Index (ASTM D 3398), Uncompacted Void Content for Fine Aggregate (ASTM C 1252), modified ASTM C 1252 for coarse aggregate, Unit Weight and Voids in Aggregate (ASTM C 29), and direct shear tests for fine aggregate. The HMA mixtures were evaluated for rutting potential using the confined repeated load deformation (dynamic creep) test.

The following conclusions were drawn from this study.

● The particle index test (ASTM D3398) characterized the shape and texture of the aggregate blends very effectively. The particle index test results produced strong relationships with percent crushed particles (composite, coarse, fine) and the natural sand content.

● The modified ASTM C 1252 test used for coarse aggregate produced good correlation with percent crushed coarse aggregate.

● Both the rodding and shoveling procedures of ASTM C 29 produced excellent correlations with percent crushed coarse particles. The rodding procedure produced void contents approximately 4 percent lower than the shoveling procedure.

● Method A of the ASTM C 1252 test produced stronger relationships with percent crushed fine particles and the natural sand content than did Method C.

● The direct shear test method for fine aggregates did not correlate well with percent crushed fine particles and the natural sand content in the aggregate blend.

. Based on their strong correlations and simple test procedures, the promising alternatives for specification requirements to characterize aggregate particle shape and texture instead of percent crushed particles are: modified ASTM C 1252 test for the coarse aggregate fraction and the ASTM C 1252 test for the fine aggregate fraction.

5. SHORT-TERM AGING OF HOT MIX ASPHALT IN COLORADO (Aschenbrener and Far)

Superpave has recommended a procedure for short
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SPECIFICATION CORNER

Wisconsin - The Wisconsin DOT built three warranty projects in 1995. Two projects will be built in 1996 with HMA on pulverized old HMA surface and crushed stone mixture. One project will be built requiring an HMA overlay over an old concrete pavement. |

Alaska - Standard specifications for highway construction are being revised in 1996 to include HMA quality control/quality assurance (QC/QA) and price adjustments based on the experience in the past.

Ohio - The Ohio DOT has completed a round robin study of NCAT ignition test method, in which eight laboratories participated. Aggregate degradation, internal/external weighing systems, and calibration procedures were also evaluated. A report has been completed. The ignition ovens are being allowed for gradation purposes in 1996. Based on the asphalt content data collected in 1996, the ignition oven may potentially be allowed for acceptance of asphalt content in 1997 or 1998.

Ohio will place three or four Superpave HMA projects in 1996 with some modifications to the Superpave mix design procedures. A loaded wheel test will be required for mix design and initial production in lieu of the restricted zone on a gradation modified to encourage coarse grading. A PG 64-28 will be standard binder instead of PG 58-28 or PG 58-34 binders.

Ohio is closely following the Ontario HMA industry's work with steel slag aggregates. Steel slag is not allowed in Ohio HMA surface mixes due to performance and production control (QC/QA) problems.

Georgia - The Georgia DOT has let contracts for two HMA projects (involving about 60,000 tons) using a modified version of Superpave specification. The asphalt binder specification requires an intermediate performance grade PG 67-22, which yields properties similar to the AC-30 currently used in the state.

Arizona - The Arizona DOT has developed a pay adjustment table for out of specification performance grade (PG) binder. This table was developed through analysis of SHRP data relating binder test results to performance, and from local experience. Under the Arizona acceptance system, the asphalt binder from each supplier will be tested for acceptability immediately prior to construction. Once an acceptable result is obtained, construction begins and the HMA contractor's binder tank is sampled once per half shift. Only about 25 percent of the samples taken will be tested for acceptance.

New York - The New York State DOT will construct at least ten full Superpave HMA projects (which include both PG binder and Superpave mix design) in 1996. It is estimated that full Superpave implementation is possible for contracts planned for construction in 1999. The implementation of PG binder specification will take place on all projects let for construction in 1998.

Kentucky - The Kentucky Transportation Cabinet has approved a supplemental specification to their bituminous materials specification. This supplemental specification allows for the use of Superpave performance grading system or conventional asphalt grading system as follows: PG58-22 or AC-10; PG64-22 or AC-20; PG70-22 or PMAC-IC; PG76-22 + elastic recovery or PMAC-ID. PG76-22 binders are required to have a minimum elastic recovery of 50 percent and a maximum storage stability of 2.2 degrees C. 1996 will be an optional year for Superpave binder specification implementation. This option will be beneficial to both the state and industry for easing into full Superpave implementation in 1997.

Florida - The implementation of Superpave is a focus. Superpave volumetric mix design replaces Marshall mix design. The contractor is required to conduct two volumetric checks on HMA per day for quality control. Superpave mix design density becomes target density for current nuclear density specification. Asphalt content and gradation acceptance tables remain the same. The goal is to implement Superpave on interstate projects by 1997. At the present time about 120,000 tons of HMA is being placed on I-75 following Superpave specifications.

(Continued on page 13)

NCAT ON THE INTERNET

As we informed you in the last Asphalt Technology News, NCAT'S World Wide Web site is located at <http://www.eng.auburn.edu/center/ncat>. Our site can be accessed through Prodigy, CompuServe, America Online, other private carriers, and Internet Servers.

We would like to list all asphalt related web sites (including state DOTs) on our home page. Please send us the address of your web site.

(RESEARCH, Continued from page 10)

term aging of laboratory-mixed HMA samples to match the aging that occurs in HMA production, storage, transportation, laydown, and compaction. This laboratory procedure also allows the asphalt cement binder to be absorbed by the aggregate similar to what occurs in the field during HMA construction. The procedure involves spreading the loose HMA mixture to a specified thickness and placing it in a forced-draft oven for 4 hours at a temperature of 135°C (275°F).

The purpose of this study was to investigate the length of time needed for the short-term aging of HMA mixtures used in Colorado under local conditions. This was accomplished by (a) comparing the quantity of asphalt absorption into the aggregate between laboratory-mixed and field-produced HMA samples, and (b) comparing test results from the Hamburg wheel-tracking device between laboratory-mixed and field-produced HMA samples. A previous study in Colorado has shown the Hamburg wheel-tracking device is very sensitive to short-term aging.

Nine projects were selected throughout Colorado for this research project to represent different aggregates, asphalt cement binders, HMA haul distances, and HMA plant types. The water absorption of aggregates used ranged from 0.55 to 2.06 percent. The HMA stayed at elevated temperatures for approximately one to two hours for a majority of projects. Samples of HMA were obtained from the field and tested for maximum specific gravity (G_{mm}) to determine the amount of asphalt binder absorbed. These field samples were also compacted and tested for rut depth in the Hamburg wheel-tracking device. Similar maximum specific gravity and rut depth determinations were made on laboratory-mixed HMA samples subjected to short-term aging for 0, 2, 4, and 8 hours.

The following conclusions were drawn from this study:

- Based on asphalt absorption, laboratory-mixed HMA samples should be aged for one to eight hours to match the asphalt absorption that occurred in field-produced samples. Six of the nine sites were between two and four hours. In most cases, the difference in the amount of asphalt binder absorbed between two and four hours was less than 0.3 percent asphalt content, although absorptive aggregates (2 percent water absorption) had up to 0.7 percent asphalt content difference between two and four hours.
- Based on the results of Hamburg wheel-tracking device, laboratory-mixed samples should be aged for one to three hours to match the aging of the field-produced HMA.
- When performing short-term aging on laboratory-mixed HMA mixtures, it is critical that the maximum specific gravity (G_{mm}) samples be aged for the same

SUPERPAVE VOLUMETRIC MIX DESIGN WORKSHOPS

Superpave volumetric mix design workshops will be held at NCAT on December 11-13, 1996; January 22-24, 1997; and March 26-28, 1997. These workshops consist of two and a half days of intensive lecture, demonstration, and hands-on training on Superpave mix design procedures. Upon completion the participants will be able to conduct the Superpave mix designs in their laboratories.

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length of time as the laboratory compacted samples used for determining the HMA bulk specific gravity (G_{mb}).

- Laboratory-mixed samples should be aged immediately after mixing and not allowed to cool. Reheating HMA samples that were cooled does not produce the same test results as HMA samples that were not allowed to cool. This phenomenon needs further investigation.
- It is recommended to use a short term aging time of two hours at the compaction temperature in Colorado. If experience indicates that longer than two hours is necessary, then times longer than two hours should be used.

(SMA PERFORMANCE, Continued from page 5)

tion show little to no rutting, cracking, bleeding, or aggregate damage. Areas where distress has been encountered have been attributed to other components such as the base course, poor drainage or to unsatisfactory mixture properties. A wide range of materials has also been encountered in SMA construction. The use of different types of aggregates, grades of asphalt cement, stabilizer types, and types of mineral filler are contributing to a large database on SMA materials and their effects on mixture performance.

Summary

SMA has been used successfully in Europe and Scandinavia for more than 20 years to resist rutting and provide durable pavements. This technology is now being transferred to the United States where a review of in-service SMA pavements shows them performing well. The data gathered and knowledge accumulated from this performance review should provide the guidance necessary for future application of SMA in the United States.

—John Haddock

(SPECIFICATION, Continued from page 11)

Texas - QC/QA specification is in its second year of full implementation. We have had good results and have identified need for major changes in specifications.

Montana - According to Montana's experience, polymer-modified asphalt binders do not always prevent or retard moisture-induced stripping of HMA. Because of this, HMA mixes are indirectly tested for moisture susceptibility by using the unmodified, virgin asphalt binder in standard stripping tests. This testing is completed prior to the actual production and laydown of the modified HMA. Should the unmodified mix indicate a propensity to strip, the addition of hydrated lime is specified for the modified mix.

Polymer-modified asphalt cement will be used in the final surfacing layer on all interstate projects, and will additionally be used in all roadway pavements statewide that currently exceed 300 daily equivalent single axle loads (ESAL'S).

Superpave binder and gradation specifications will be used on five HMA projects across Montana in 1996.

Maximum percentages of recycled asphalt pavement (RAP) that can be used in base and surface courses have been established.

Michigan - Michigan is moving toward adopting the Superpave-based asphalt binder classification system this year - one year ahead of the nation's goal. The 1996 edition of the Michigan Department of Transportation highway specifications book will specify only Superpave performance grades of binders for HMA pavements.

Maine - Work is still continuing on QC/QA specifications. Six projects will be bid with full QC/QA specifications in 1996. A bonus will be paid for density only. No disincentives will be assessed. The gradation and asphalt content will have to meet an acceptable composite pay factor before a bonus will be paid for density.

The material transfer vehicle (MTV) is being included in some interstate projects. The cost benefit is difficult to assess but the ride quality shows a significant improvement.

Utah - Quality control and quality assurance (QC/QA) specification is increasingly being used for HMA projects. Asphalt content, aggregate gradation, VMA, and density are factors used for control and pay adjustments. Percentages within limits are used to determine bonuses and deductions. QC/QA programs for the supply of asphalt binder are planned for this year. The amount of RAP in recycled mixes is limited to 25 per-

cent. In recycled HMA mixes, the low temperature grade of the PG binder is increased one step.

Missouri - The Missouri Highway and Transportation Department (MHTD) started testing mineral and cellulose stabilizing fibers used in SMA mixes in 1995. Test method MHTD T60 is being used to determine the following items: Alpine Sieve Analysis, Mesh Screen Analysis, Ash Content, pH, Oil Absorption, Moisture Content, Fiber Length, Fiber Thickness, and Shot Content. This test procedure has been adopted from NAPA Publication IS 118.

Starting in 1996, MHTD will allow either viscosity-graded or performance graded (PG) asphalt binder for use on highway projects.

As recommended by the North Central User Producer Group, MHTD will use performance graded asphalt binders only for highway projects in 1997.

Nebraska - Following a four-year transition, "end-result" specification will be implemented this year, which will involve contractor mix design and QC testing. Field control will be based on air voids, minimum VMA, and minimum asphalt content.

Australia - Preparation of a national heavy duty HMA specification is proceeding as scheduled. Production of the HMA plant process control guide has just commenced.



At the open house (from left): Ray Brown, director NCAT; Jon Epps, University of Nevada; Ron Kenyon; and Mike Kelly, Asphalt Materials, Inc.

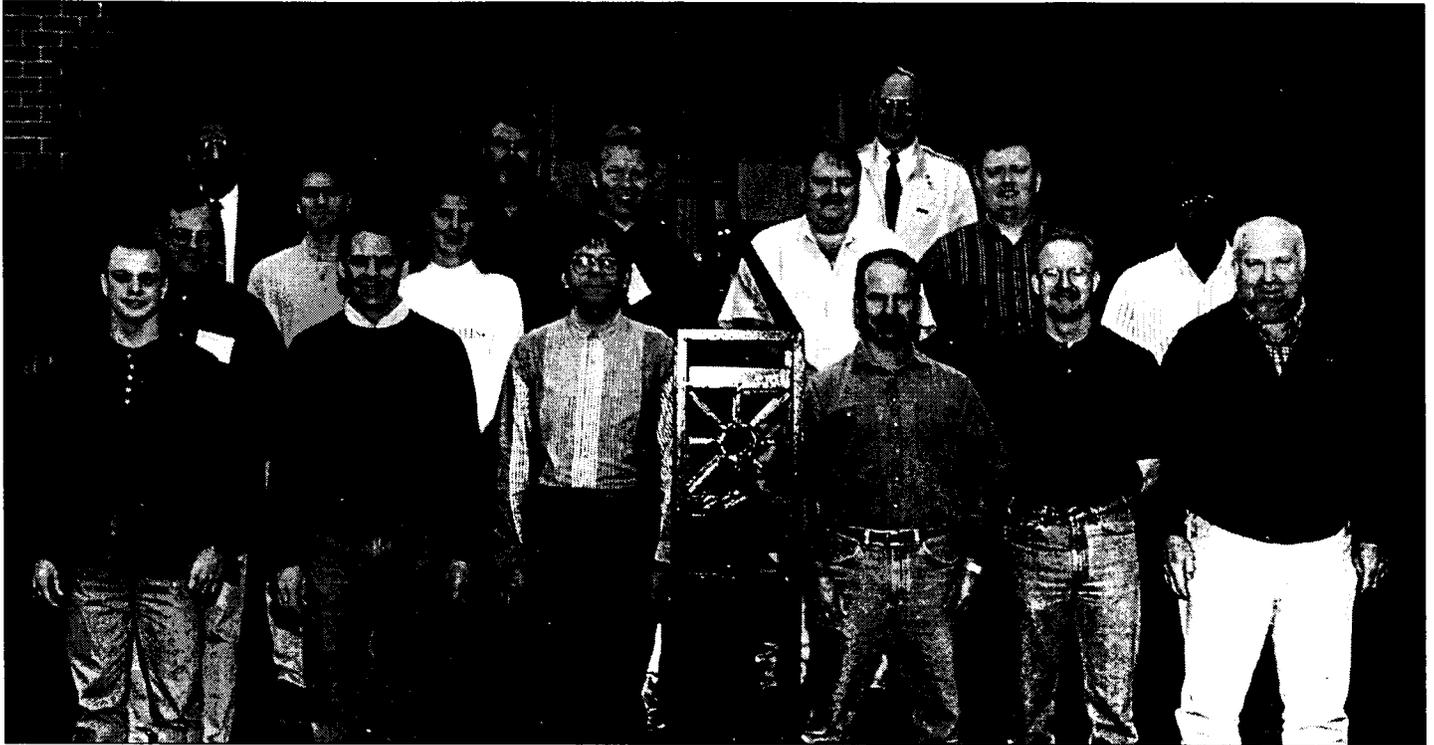
RESEARCH IN PROGRESS

The following research projects pertaining to hot mix asphalt (HMA) pavements are currently in progress.

STATE	PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	OBJECTIVES
Alaska	Rutting of Alaskan Pavements	Alaska DOT	\$200,000	October '96	Evaluate studded tire wear on HMA pavements
Arkansas	SHRP Mix Designs for Arkansas	Hall, University of Arkansas	\$170,000	June '97	Compare Superpave mix designs in comparison to present standards.
Florida	Evaluation of Asphalt Additives for Rut/Crack Resistance	Tia, University of Florida	175,000	1996	Title self-explanatory
	Determination of Suitability of RAP in HMA	International Center for Aggregate Research	100,000	1997	Determine effect of RAP on HMA quality
Georgia	Evaluation of RAP in Stone Matrix Asphalt	Brown, Georgia DOT	72,000	December '96	Title self-explanatory
	Round Robin Testing of Modified Georgia Loaded Wheel Tester	Lai, Georgia Tech and Caylor, Georgia DOT	270,000	October '96	Title self-explanatory
Idaho	Development of Mechanistic Based Overlay Design System	Bayomy, University of Idaho	40,000	December '95	Title self-explanatory
Indiana	Locating the Drainage Layer in Bituminous Pavements	White, Purdue University	150,000	December '96	Assess the performance of internal drainage layer.
Louisiana	Evaluation of Superpave Binder Tests	Abadie, Louisiana Transportation Research Center (LTRC)	195,000	April '97	Title self-explanatory
	Evaluation of Fundamental Engineering Properties of Stone Matrix Asphalt (SMA) Mixtures	Mohammad, LTRC	75,000	November '96	Title self-explanatory

STATE	PROJECT	RESEARCHER(S)	COST	COMPLETION DATE	OBJECTIVES
Louisiana	Evaluation of Fundamental Engineering Properties of HMA Mixtures Containing Hydrated Lime	Mohammad, LTRC	75,000	March '96	Title self-explanatory
	Evaluation of Fundamental Engineering Properties of Large Stone HMA Mixtures	Mohammad, LTRC	258,000	June '96	Title self-explanatory
Montana	Methods for Remediation of Stripped Asphalt Pavement	Stephens, Montana State University	137,000	May 2000	Title self-explanatory
New Jersey	Alternate Methods for Asphalt Recovery	Vitillo and Connolly, New Jersey DOT	170,000	1997	Develop test method for asphalt recovery from mixture
Ohio	Durability' of Recycled Asphalt Concrete Surface Mixes	Abdulshafi, CTL	\$145,000	April '97	Determine durability of recycled HMA containing varying amounts of RAP
	Benefits of Adding Waste Fiberglass Roofing Shingles in HMA	AbdulShafi, CTL	\$96,000	October '96	Title self-explanatory
South Carolina	Study of NCAT Ignition Oven for Control of Asphalt Mixes	Burati, Clemson University	49,000	July '96	Title self-explanatory
	Development of Quality Assurance Program for Asphalt Mixtures	Burati, Clemson Univeristy	150,900	April '97	Title self-explanatory
Texas	Development of Permeability Test for HMA	Button, Texas A&M University	200,000	1997	Title self-explanatory
	Evaluation of Performance of Coarse Matrix High Binder Mixes	Button, Texas A&M University	200,000	1996	Title self-explanatory
FHWA	Evaluation of Crumb Rubber Modifier (CRM) in Asphalt Pavements, Phase II	Oregon State University	2,500,000	September '99	Develop guidelines for the use of CRM in HMA pavements
	Accelerated Field Test of Performance-Related Specifications for HMA	Nevada Automate Test Center	9,736,000	October '98	To construct and operate a test track for verifying Superpave mix design procedures

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Field Management of Hot Mix Asphalt Volumetric Properties

Background

The Federal Highway Administration (FHWA) Demonstration Project No. 74 has clearly shown that significant differences exist between the volumetric properties of laboratory designed and plant produced hot mix asphalt (HMA) mixes. The volumetric properties include voids in the mineral aggregate (VMA) and the voids in the total mix (VTM). This project was undertaken to develop practical guidelines to help HMA contractors reconcile these differences, thereby assisting them to produce consistently high quality HMA mixes.

Approach

HMA mix design and field test data from 24 FHWA demonstration projects were entered into a database. The data included mix composition (asphalt content and gradation) and volumetric properties. The data were analyzed to identify and, if possible, quantify the independent variables (such as asphalt content and the percentages of material passing No. 200 and other sieves) significantly affecting the dependent variables (such as VMA and VTM). Based on the preceding work, troubleshooting charts have been constructed to correct and reconcile differences between the volumetric properties of the job mix formula (JMF) and the produced mix.

Findings

The following conclusions were drawn based on the statistical analysis of field data from 24 FHWA demonstration projects.

Significant differences existed between the volumetric properties of the laboratory designed and plant produced hot mix asphalt, although their composition (asphalt

content and gradation) was about the same.

- VMA is affected most by the amount of material passing No. 200 sieve (P200) and the relative proportions of coarse and fine aggregates.

- VMA can be increased by reducing the amount of P200 material or natural sand in the HMA mixes. VMA can also be increased by moving the aggregate gradation away from the maximum density line (MDL), especially for HMA mixes with no natural sand.

VTM is affected most by asphalt content, P200 material, and the relative proportions of coarse and fine aggregates.

- VTM can be increased by reducing asphalt content or P200 material or both.

- Use the flow charts in Figures 1 and 2 and Table A as general guidelines for reconciling the VMA and VTM differences between the laboratory designed and plant produced HMA mixes. Before using the flow charts, it is assumed that the plant produced HMA's mix composition (asphalt content and gradation) conforms to the JMF.

- Attempt to reconcile the differences between the volumetric properties of laboratory designs and plant produced mixes during first day's production by testing at least four subplot samples and using the average test values.

After the differences in the volumetric properties are reconciled, maintain control charts for mix composition (asphalt content and gradation) and volumetric properties (VMA and VTM) during the entire production period.

Reference

P. S. Kandhal, K. Y. Foo, and J. A. D'Angelo. Field Management of Hot Mix Asphalt Volumetric Properties. ASTM Special Technical Publication 1299, 1996.

TABLE A. Effect of P200 and Asphalt Content (AC) on VTM

VMA (:Percent)	Change in VTM for every percent by weight change in	
	P200	AC
12		-1.35
13	-0.02	-1.21
14	-0.10	-1.07
15	-0.17	-0.93
16	.025	-0.78
17	-0.33	-0.64
18	-0.40	-0.50

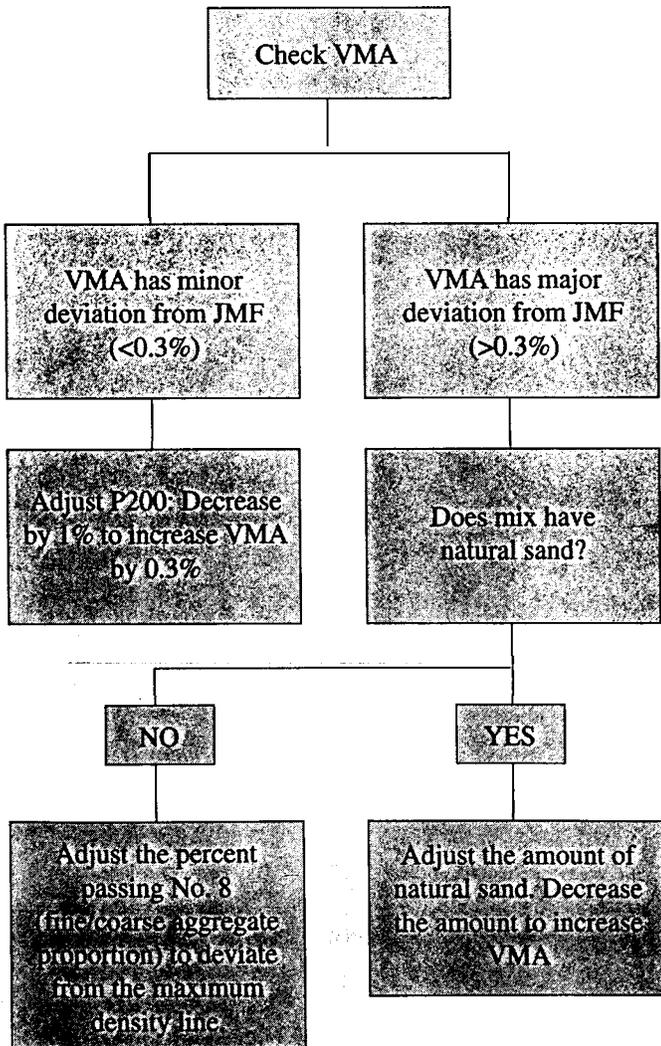
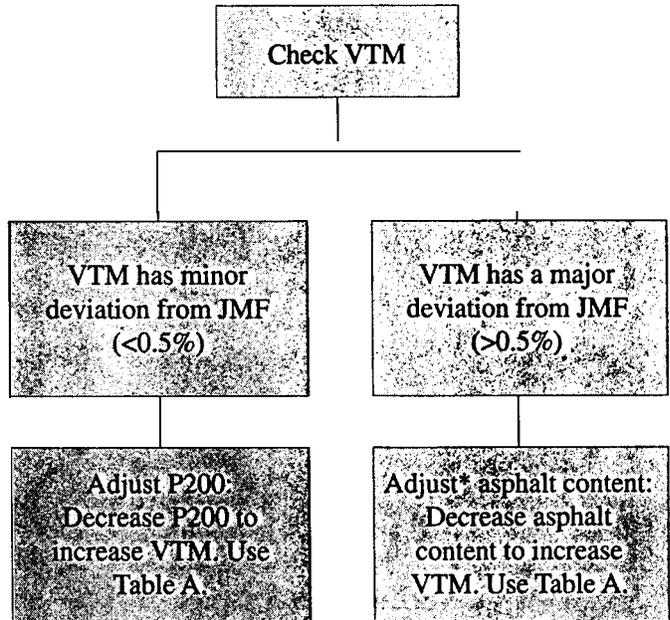


FIGURE 1. Flow Chart for Reconciling VMA.



* Before adjusting the asphalt content, ensure that the VMA of the produced mix has been reconciled with that of the job mix formula.

FIGURE 2. Flow Chart for Reconciling VTM.