NCAUPG Annual Meeting Minutes
Milwaukee, Wisconsin
January 28-30, 2003

Chuck Van Deusen, co-chairman of the North Central Asphalt User/Producer Group opened the 2003 Annual Meeting and welcomed all of the participants. He then introduced **Gary Whited**, Administrator of the Wisconsin DOT's Division of Transportation Infrastructure Development.

Whited welcomed everyone to Milwaukee on behalf of the Secretary of Transportation and WisDOT. WisDOT has been a leader in the implementation of innovative programs such as contractor quality control, SMAs, comprehensive warranties, PG binders and Superpave mixes. Whited stated that the active participation of John Volker in the NCAUPG since the beginning has been very beneficial, as Volker brings good information back from every meeting of the group. Agencies and industry need leadership, technical expertise based on the latest information, and cooperation now more than ever as they cope with decreased funding, loss of experienced personnel and increased demand. Meetings such as this one can help to share information and foster cooperation. Whited wished everyone a successful and beneficial meeting.

Tom Harman, FHWA's Asphalt Pavement Team Leader, then provided an overview of the national activities underway in the asphalt area. Harman presented the research efforts as parts of a puzzle being completed to link together structural design, materials and construction. Many of the puzzle pieces are being developed through National Cooperative Highway Research (NCHRP) projects. He noted that project status reports and other information are available on the web at www4.trb.org/trb/crp.nsf/.

One of the key projects is NCHRP 1-37a, *Development of the 2002 Guide for the Design of New and Rehabilitated Pavement Structures: Phase II*, which is developing the proposed AASHTO 2002 Pavement Design Guide. The guide will use mechanistic-empirical principles in the design of new and rehabilitated pavements.

Two other structural design related projects that are currently underway include NCHRP 9-19, *Superpave Support and Performance Models Management* – the so-called models contract -- and NCHRP 9-30, *Plan for Calibration and Validation of HMA Models*. The models contract is developing a performance test for permanent deformation and fatigue cracking of HMA. Three candidate tests have been identified and are currently being validated. Project 9-30 is developing a statistically based plan to calibrate and validate the performance models used in the 2002 Pavement Design Guide.

The materials puzzle pieces include NCHRP 9-9(1), *Verification of Gyration Levels in the N_{design} Table*. This study, underway at NCAT, is looking at further refinements of the N_{design} table, including an evaluation of how well densification at N_{design} matches field compaction. Another study, NCHRP 9-16(1) also looked at the gyratory. The Asphalt Institute studied the *Relationship Between Superpave Gyratory Compaction Properties and Permanent Deformation of Pavements in Service* in an attempt to use the gyratory as a test to confirm mix quality. This recently completed study found that a parameter called N-Srmax can be used as a screening test to identify gross mix instability but it cannot be used as a fundamental test to predict field rutting, and it is relatively insensitive to changes in binder stiffness. The final report on this project is now available from TRB.

The models contract, 9-19, obviously has a strong tie to materials, as does NCHRP 9-29, *Simple Performance Tester for Superpave Mix Design*, which will evaluate first article performance test equipment for rutting and fatigue cracking and will refine the IDT for low temperature cracking prediction.

Environmental Effects in Pavement Mix and Structural Design System, NCHRP 9-23, will evaluate the latest version of the Integrated Climatic Model developed under NCHRP 1-37a and will verify the in-service binder and mix aging simulated by PP1 and PP2.

NCHRP 9-25, *Requirements for Voids in Mineral Aggregate for Superpave Mixtures*, is evaluating the volumetric design criteria to ensure adequate durability and performance. The parameters being considered include VMA, VFA and calculated binder film thickness. NCHRP 9-31, *Air Void Requirements for Superpave Mix Design*, is investigating whether the design air void content should vary with traffic level and climate. So far these studies suggest that defining the optimum binder content at 4% is reasonable. The rut resistance increases as VMA decreases, compaction increases and aggregate surface area increases. Fatigue resistance is mainly related to binder content.

One gap in the Superpave system seems to be the lack of a reliable test for stripping of a designed mixture. AASHTO T283, the currently specified test, has many drawbacks and limitations. NCHRP 9-34, *Improved Conditioning Procedure for Predicting HMA Moisture Susceptibility*, is one approach to fill this gap by refining mix conditioning using the Environmental Conditioning System (ECS) developed under SHRP. The conditioned mixture will then be evaluated using the 9-19 performance test.

Aggregates and their relationship to HMA performance are being evaluated under NCHRP 9-35, *Aggregate Properties and their Relationship to Performance: A Critical Review*, and 4-30, *Improved Testing Methods for Critical Aggregate Shape/Texture Factors*.

Binder aging is the subject of NCHRP 9-36, *Improved Procedure for Laboratory Aging of Asphalt Binders in Pavements*, which seeks to develop and validate a lab method for aging of neat and modified binders.

NCHRP 9-33, *A Mix Design Manual for Hot Mix Asphalt*, is a proposed project that will develop a comprehensive mix design method (and documentation) incorporating the current Superpave volumetric mix design plus the performance tests from 9-19 and the tests and models from the 2002 Design Guide.

Construction is addressed through NCHRP 9-22, *Beta-Testing and Validation of HMA Performance Related Specifications (PRS)*, which is following up on the PRS and supporting software developed at WesTrack and integrating the requisite PRS elements into the 2002 Design Guide software. Construction issues also come into play in 9-16, 9-19, 9-29, 9-25 and 9-31 above.

Lastly, Harmon mentioned the related projects being conducted by FHWA under NCHRP funding. These include continuation of the activities of the mobile asphalt labs (the trailers) and the binder lab. FHWA is also conducting a study aimed at improved understanding of the performance of modified asphalt binders using the Accelerated Loading Facility (ALF). Other projects include evaluations of mix tenderness and fine aggregate specific gravity tests.

Becky McDaniel then updated the group on the recent activities of the North Central Superpave Center (NCSC). She reported that the NCSC continues to offer and improve its training courses every year. Customized training is being done more often in the sponsors' laboratories than in the early years of the center. The NCSC is also offering more web-based training, currently providing supplemental training videos on the binder rotational viscometer, dynamic shear rheometer and bending beam rheometer procedures on the web. The NCSC also recently produced a video on RAP usage in Superpave mixtures that will be distributed soon by the Transportation Research Board.

Communication is another significant activity for the center. The NCSC attempts to reach a wide audience through a wide variety of communication channels including the printed newsletters, distributed free of charge to over 4000 people nationwide; the web site, which is continually upgraded and expanded; dozens of face-to-face presentations; and numerous phone and e-mail requests for information.
The NCSC is expanding its efforts in equipment and test procedure evaluations. The FHWA is sponsoring an evaluation of about ten mixes from around the North Central region using the candidate simple performance tests. Preliminary results from this work will be presented later. The NCSC is also involved in running over 800 binder direct tension tests as part of a ruggedness evaluation to determine the critical test parameters and tolerances. As soon as equipment and protocols are available, the NCSC will also participate in a round robin

evaluation of an automated specific gravity device. Lastly, the NCSC agreed to take a larger role in the NCAUPG efforts on regional test standardization. The NCSC will determine the state-by-state variations in AASHTO T166 and prepare a white paper suggesting how to standardize the test protocol. Additional tests may follow.

The NCSC is also doing more special testing, especially for contractors. For example, the NCSC is assisting with low temperature Indirect Tensile Testing to support cold in-place recycling mix design. The NCSC has also conducted referee testing on some Indiana mixes that showed low air voids during production. Under new INDOT procedures, these failed materials may be left in place, at reduced pay, if they have adequate stiffness in spite of the low air voids. If the stiffness is not adequate, the materials must be removed and replaced at the contractors' expense. Other testing is available upon request.

Research continues to be another major activity. Research projects on the use of RAP in the North Central region, fiber-modified mixes and modified asphalt performance have recently been completed. On-going research focuses on performance testing in the Superpave Shear Tester and candidate performance tests, friction, noise, burner fuel contamination, and more. The NCSC is always willing to collaborate with other researchers on projects of mutual and regional interest.

The future plans for the NCSC include strengthening our ties to the states in the region and the NCAUPG. The NCSC is working with its participating states to identify projects and services of interest. They are also looking forward to moving into new lab and office space in the Summer of 2004 thanks to a 14,000 square foot lab addition being planned by the Indiana Department of Transportation. The NCSC is evolving along with the region, expanding its mission to hot mix asphalt issues in general as Superpave becomes routine across the region.

Design Procedures

The next session of the meeting focused on Design Procedures. **Monte Symons**, FHWA, spoke on preparing for the AASHTO 2002 Design Guide. He remarked that the Design Guide will be a major change in how we accomplish designs and will bring the designer "closer to reality," taking account of traffic, structural features, materials, construction, climate and performance.

The products of the research will include, among other things, software to aid in design of both asphalt and concrete pavements. Symons described the software and its ease of use in some detail. There will be three different design levels, requiring different types and amounts of input data. The Level 3 design relies on default values and "educated guesses." The guide is nearing completion, with verification of the flexible design and debugging the reliability analysis pending. More information is available at the website www.2002designguide.com.

Mike Heitzman, Iowa DOT, then outlined what Iowa has done to help local agencies adopt Superpave mixes. He noted that the name itself seems to frighten some of the locals, who think Superpave is expensive and too complicated for county roads. Therefore, they now talk about "gyratory mix design for low volume roads." Locals are encouraged to adopt the system because it is a superior mix design process and eliminates the need to have two systems in place.

The DOT used a team approach to address implementation and included county and industry personnel in the effort. Training and public relations have proven to be very important elements to increase the comfort level. The DOT collected over 100 Marshall mixes and analyzed how those mixes compared to the Superpave criteria. Based on this analysis, the DOT developed mix design criteria for three traffic levels below 1 million ESALs. They also prepared a Material Selection Guide and developed guidelines to estimate the design ESALs based on the number of trucks per day. A mix design for a local road can be accomplished by following an eight step process, summarized in a Mix Selection Guide. Five pilot projects in 2001 used the process, and over 40 used it in 2002. A study for city streets is beginning in 2003. The goal is to use Superpave on all routes in 2004.

Tom Harman then returned to discuss the candidate Simple Performance Tests. He noted that a large number of tests were evaluated to see if they could meet the requirements of a simple performance test for rutting and/or cracking. Specifically, could they compliment the Superpave volumetric mix design procedure, use gyratory specimens, have a high correlation to rutting or cracking and identify inferior mixes? If they could also be tied to structural design and be applicable to QC/QA, that would be even better. Eventually, three candidate tests were identified; complex modulus, /E*/; flow time, FT; and flow number, FN. The complex modulus test has the advantage in that it can relate to both rutting and fracture, and will be the basis for structural design using the 2002 Design Guide. Concerns about the test include its repeatability and how it ranks modified mixes. The FT is a simple test using simple equipment, but FN may possibly best simulate traffic loading. Three NCHRP studies, summarized earlier, are investigating various aspects of these tests and their implementation. Based on the NCHRP 9-29 first articles, it appears the test equipment may cost in the range of $25 – 45,000 and an automated specimen fabrication system may cost another $12,000.

Becky McDaniel then briefly summarized some preliminary results of testing five Superpave and one Marshall mix from the North Central region using the simple performance tests. This work is ongoing and will eventually include testing seven Superpave, one Marshall and two SMA mixes. The candidate simple performance tests will be conducted and compared to results from the Superpave shear Tester (SST). The primary goal of this work is to begin to develop a base of experience with these tests applied to typical North Central materials. Another is to provide feedback to FHWA and the states on practical testing issues. At this point in the testing, the NCSC mixes seem to compare favorable to mixes from other test sites, including the FHWA-ALF project, WesTrack and MinnRoad. Interestingly, the Marshall mix produced the lowest complex modulus. This study will be concluded this Summer.

Ron Collins, from Pavement Technology, then spoke about Life Cycle Cost Analysis (LCCA). He noted that LCCA is an under-utilized tool that can help you look beyond initial costs to the life of the pavement. It may be more economical in the long run to use a more expensive mix if it lasts longer than a less expensive mix. For example, he offered a cost comparison of placing 2000 tons of high volume mix for a total of $76,000 that lasts ten years versus 2000 tons of SMA at a total cost of $94,000 with a life of 13 years. In this case, the SMA works out to be a more cost effective option, based on material costs and performance life alone.

LCCA can also include consideration of user costs related to delay, congestion, accidents, etc. User costs can exceed the cost of construction and can definitely affect the comparison of alternates.

Collins cited other examples that showed increasing the life of a pavement by one year could yield an 8% reduction in the equivalent annual cost. Georgia did a life cycle costs analysis of SMA mixes and found that the increased surface life of these mixes led to a 38% reduction in annual cost.

Collins summarized that making a mix that lasts longer can result in a more economical mix in the long run, less disturbance for the traveling public, safer roads due to improved performance and more money available for other projects.

John Volker then summarized the WisDOT experience with pavement warranties and their impacts on LCCA. WisDOT developed its first warranty specification in 1994 with FHWA and industry and let its first three contracts in 1995. In 1997, they extended the warranty concept to overlays of PCC pavement. So far, they have let 45 warranty projects covering a total of 330 lane miles.

One of the primary benefits of warranties WisDOT has seen is superior performance in terms of greatly reduced pavement distress and increased smoothness. The use of warranties has extended the service life from about 18 years to about 23 years, resulting in improved life cycle costs for warranty pavements. Other benefits included reduced delivery costs for the DOT, reduced maintenance costs and more opportunities for contractor innovation. There are hurdles to overcome, however. Warranties represent a wholesale change in how the DOT does business, and sometimes relaxing control can be difficult. WisDOT was fortunate to have an excellent

Pavement Management System that gave them the data to ensure that it was possible for contractors to achieve the quality needed for a warranty.

The use of warranties in Wisconsin will continue to grow. All asphalt projects will be considered for a warranty, and longer warranty periods or tighter distress criteria will be studied.

Judie Ryan, WisDOT, wrapped up the afternoon session with a summary of the Technicians' Workshop. This year's workshop consisted of two round table forums, one formal session and breakout sessions on aggregates, binders and mixtures. At the first round table forum, the states shared experiences and approaches to construction and quality control, including certification, test procedures, equipment and inspection. As expected, there is quite a bit of variability between the states. (See the presentation on the web for additional details.)

Ryan noted that the breakout sessions were not as effective this year as in years past due to the fact that many states could only send one person to the meeting, if they were able to attend at all, and that person could not be in three places at once. Everyone benefits from increased participation at these meetings. In the binder session, **Becky McDaniel** gave a short training presentation on DSR rheology. The group then discussed antistrip additives, MP1a implementation and PG+ specifications.

The aggregate group shared information on QC testing, contractor assurance testing and standardization. The group recommended research on identifying a practical field test method for determining fine aggregate SSD. Four states, Iowa, Kansas, Missouri and Nebraska, noted that they have agreed to disagreed on Technician Certification, but they are still in favor of working towards test standardization.

The mixtures group discussed performance testing, warranties and test procedure standardization. **Ayesha Shah** and **Steve Bowman** of the NCSC summarized their experience to date with practical testing issues related to the determination of the complex modulus. The group suggested kick-starting regional standardization by choosing one or two test procedures to evaluate and standardize. AASHTO T166 was suggested as one likely candidate for standardization of the procedure.

At the mix design roundtable, the entire group discussed a wide variety of issues, including mix design software, the Lottman test, RAP use, volumetric properties, design criteria, performance testing, design lab requirements and more.

The Technicians' Workshop concluded with a formal session on the AASHTO 2002 Design Guide and Wisconsin binder round robin testing. **Monte Symons** presented a discussion of the guide. He noted that the final product likely will not be available until late 2003 or perhaps early 2004. Specimen fabrication and compatibility with field cores will be big issues for technicians. **Tom Brokaw**, WisDOT, reported that the binder round robin testing, with over 70 participants, shows that the coefficient of variation of the test results appears to be consistent and is typically lower than the AMRL listed values.

The group concluded that there are benefits in standardizing test procedures, including more efficient sharing of research results, certification and technology transfer. They recommended asking the NCSC to analyze past survey data and look at possible standardization of one test method as a pilot. They also see value in these Technicians' Workshops and recommend continuing them in the future, hopefully with greater participation again.

Warranties

Rick Kreider, Kansas DOT and moderator of the Thursday morning sessions, thanked the state asphalt pavement associations for their support of the previous evening's reception.

Warranties were discussed in more detail in the next session. **Gary Whited**, WisDOT, reported on the European Scan Tour, in which he participated. A group of 14 US representatives met with five countries – the UK, Germany, Spain, Sweden and Denmark -- to discuss warranties in 2002.

Most European countries use one to four year warranties on materials and workmanship (M&W) and have for a long time. Some are using five-year performance warranties and many are looking at ten or more years. Under a materials and workmanship warranty, the contractor is responsible for correcting distresses resulting from defects in materials or workmanship for those work elements that are within his control. These contracts typically use method specifications. Performance warranties, on the other hand, include full responsibility for pavement performance and utilize performance related specifications. Under these contracts, contractors are responsible for some or all of the pavement design as well.

All of the countries use best-value procurement, not low bid. The contract award includes considerations of contractor safety records, innovation, schedule, environmental issues and more. They feel this is crucial to the warranty programs. Spain and the UK have also used Design-Build-Finance-Operate (DBFO) contracts lasting 25 to 30 years.

Recommendations from the Scan Team for future warranty implementation include suggestions for FHWA, the states and industry. They recommended, for example, that FHWA require M&W warranties on all federally funded projects, promote legislative changes to allow best-value procurement and explore the development of long-term performance warranties. States should create model AASHTO warranty specifications, implement M&W and short-term performance warranties and also work toward best-value procurement. Industry needs to become educated on warranty issues and risks, participate in discussion and bid on warranty contracts.

Whited concluded that warranties are a good tool, but cautioned they are not a silver bullet.

Erv Dukatz, Mathy Construction, then shared experiences from two design-build projects in Minnesota. They are similar in that each involved 30% concept design by the DOT that laid out the pavement design and specifications, then the contractor finished the remaining 70% of the design and drawings. They differed in that the project on TH14 was a $60 million project with one bridge whereas the one on TH52 included 20 bridges, $240 million and a technical review of the contractors. For the TH52 project, each proposal was given a technical score based on project management, project approach and understanding, project schedule, and alternate technical concepts and innovation. The bid price was then divided by the technical score to determine the low bid.

The TH52 project included warranties on the HMA pavement covering cracking, debonding, raveling, flushing, rutting and popouts. The PCC pavement on the project was also warranted against cracking, joint deficiencies and surface defects. Both warranties were for 5 years.

Dukatz commented that design-build projects offer lower agency costs, equal or better construction quality and the possibility of a longer warranty period. He recommended allowing innovation on the part of the contractor and suggested avoiding prescriptive repairs, which stifle innovation. He recommends instead that the agency establish quality measures then let the contractor determine how best to achieve that level of performance. The successful implementation of Design-Build projects requires a clear understanding of the expectations for performance, but can offer the best quality for the best cost, if innovations are allowed.

Noise

The next session covered the growing issue of pavement noise. **Bob Bernhard**, of the Institute for Safe, Quiet and Durable Highways (SQDH) at Purdue University, gave a summary of sound generation on pavements. Bernhard said by understanding and controlling noise generation at the source – the tire-pavement interface – we may be able to reduce the need for noise barriers. FHWA does not currently allow pavement type to mitigate the need for a barrier wall, but is willing to look at data relative to the effectiveness of pavements to reduce noise.

Bernhard described the many mechanisms that can generate noise at the tire-pavement interface, including tread compression, vibration, oscillation and adhesion; the stick-slip phenomenon that causes high frequency squeaks and squeals; and air pumping at the front and behind the tire. Noise can be amplified at the tire through sound radiation due to vibration of the tire carcass or sidewall; the horn effect, which can amplify sound in the horn-shaped space between the tire and pavement; Helmholtz resonance near the entrance and exit from the contact patch; channel resonance in "organ pipes" formed by the tread pattern in the tire foot print; and resonance within the tire cavity. These different mechanisms can produce or amplify different frequencies of sound, and are affected by different features of the tire and pavement.

Europe has been working with quiet pavements for some time. They have fairly extensive experience with porous asphalt mixes, which have proven to be durable, but may lose their noise reducing capacity due to plugging of the voids. Twin-lay pavements, used in Europe, have a porous layer with a tighter, smaller aggregate structure on top to reduce clogging of the pores in the porous layer. They also use rubberized asphalt and are beginning to look at other options as well.

Research on quiet pavements is increasing in the United States, including at SQDH. In the United States, Georgia, Alabama and Florida use open-graded asphalt for noise and splash control. Arizona uses rubberized pavement and is doing an extensive evaluation of noise. California uses rubberized asphalt, open-graded asphalt and is working with PCC pavement noise as well. Wisconsin did a study of PCC tining to reduce annoyance. SQDH has sponsored a number of studies of pavement noise, noise barriers, porous asphalt and concrete, friction and more.

Bernhard closed by describing the Tire Pavement Test Apparatus (TPTA) at SQDH and showing a video of the TPTA in action. The device consists of a 12 foot diameter wheel with realistic pavement segments mounted around the outside. Two rolling tires revolve around the wheel and noise is measured in a variety of places near the tire. The device has been used successfully to evaluate PCC tining and texturing as well as various tire sidewall and tread patterns. Asphalt segments will be constructed this Spring for testing.

Bernhard concluded that existing quiet pavement solutions can reduce noise by 1-4 decibels compared to conventional pavements. With an increased understanding of the fundamentals of noise generation, controlling pavement construction, maintaining durability and maintaining friction, significant reductions of 5 to 10 decibels should be possible.

Next, **Doug Hanson**, NCAT, said that sound caused by transportation systems is the number one noise complaint in many locales. Tire-pavement noise is the primary source of this noise at speeds over 30 mph for cars and over 45 mph for trucks. Noise walls can provide some benefit, but are of little to no help 400 to 500 feet from the pavement or for homes in line of sight to the roadway; i.e. they only help those homes in the acoustical shadow. Plus, noise barriers can be very expensive, costing $20 per square foot or well over $1 million per mile. Quiet pavements could be an effective way to reduce tire-pavement noise generation and propagation.

NCAT built a noise trailer for the Arizona DOT and now has built one for themselves. The trailer is enclosed and can measure sound pressure and/or sound intensity using microphones positioned near the trailer tires. The FHWA Traffic Noise Model (TNM) uses sideline noise measurements to evaluate the need for a noise barrier.

Since the trailer collects close-proximity sound measurements, there is a need to establish a relationship between the two measurement locations.

NCAT research to date has shown about a 1.5 decibel difference between two types of tires. They have also demonstrated that as speed increases, so does the noise level and the close-proximity measurements are about 15 decibels higher than the sideline measurements (statistic al passby method). Noise measurements made on the NCAT track show some relationship between noise and pavement texture. Other measurements show the effects of pavement type (dense vs. open, PCC tining, etc.). This research is preliminary, but promising.

Larry Scofield of the Arizona DOT wrapped up the noise session with a presentation summarizing Arizona's investigation of pavement noise. The DOT is very interested in the use of pavement type as a noise mitigation factor due to its potential effectiveness and favorable economics.

Scofield outlined several myths or opinions about tire-pavement noise and what the DOT has learned so far. They do not have definitive answers to all of these issues yet, and they are continuing to investigate. The first myth is that asphalt rubber open graded friction courses lose their noise attenuation properties as they age. One set of preliminary data from ADOT does seem to show that 12 year old friction courses have higher noise levels that three year old friction courses, but they do not appear to be as high as initially expected. ADOT will continue testing these pavements seasonally (four times per year) to see how the pavements change with age. The noise level is also related to pavement smoothness, increasing as roughness increases.

The second myth is that all pavement surface types provide the same noise characteristics. Sound intensity data from I-10 clearly shows a difference between surface types. A third myth is that pavement type does not affect noise generation. Again, data from I-10 shows a striking different between noise levels at various frequencies for different pavement types.

The fourth myth is that random transverse tining of PCC pavements improves the noise properties. An Arizona study compared random transverse to longitudinal and uniform transverse tining. The results showed that the random tining produced more noise than the other two tining patterns at speeds from around 60 to 70 mph.

Another myth is that you cannot use roadway, or close proximity, noise measurements to predict sideline noise. ADOT has data that shows a relationship between the two measurement locations, as do other studies in Texas and elsewhere. Close proximity measurements are much easier to collect and have fewer site constraints than sideline measurements.

In conclusion, Scofield summarized that pavement type does affect noise generation and roadway measurements can be used to evaluate noise characteristics. He stated that noise should be managed just like friction, roughness, rutting and cracking.

Gyratory Angle Verification

The final session of the Annual Meeting dealt with a widespread issue – gyratory angle verification and compactor comparisons. First, **John D'Angelo** of FHWA summarized the impending changes in AASHTO T312 to include Dynamic Angle Verification (DAV). D'Angelo indicated that AASHTO is balloting changes to the standard for compaction in the gyratory to allow the use of either an external angle of 1.25 ± 0.02^{o} or an internal angle of 1.16 ± 0.02^{o}. A separate provisional test standard will be written to cover the method of calibrating the internal angle.

The process of calibrating the internal angle is somewhat time consuming. It requires six compactive efforts just to check the angle. More compactions are required if the angle must be adjusted. Measurements are made with the DAV at the top and at the bottom of the mix because the compliance changes from top to bottom due to ram location (top or bottom), ram size, reaction block, etc.

D'Angelo noted that the situation with gyratories is not any worse that it was with Marshall hammers. In fact, he said the gyratories are ten times better. The difference is that now contractors are doing more of the design, testing and inspection. Everyone is watching and comparing results with everyone else to an extent never seen before.

He also noted that maintenance of gyratories has typically been poor nationwide. Proper maintenance according to the manufacturers' recommendations is essential for good operations.

Erv Dukatz, Mathy Construction, followed and agreed that maintenance is a major issue with gyratories. He noted a case where a year after factory calibration the DAV gave internal angles of 1.009 on top and 0.988 on bottom, well below the accepted angle. The external angle was also out of tolerance. Inspection showed that the rollers on this particular gyratory were worn after 250 hours of use, causing the angle problems. Dukatz indicated that the angle itself accounts for about 10% of compactor comparison problems, and maintenance accounts for the rest.

Since the internal angle is sensitive to mix stiffness, Dukatz calibrates with the stiffest mix he has in the lab, then everything softer will be in tolerance. He recommends that if you have an apparent compactor problem, first look at the maintenance and wear on the machine, then check that samples are being handled the same way (temperature, reheating, aging, etc.) and finally, if you still have a problem, check the internal angle.

Dave Andrewski, INDOT, related some Indiana experience with the DAV. In 2000, Indiana began pilot projects using volumetric acceptance based on VMA, air voids of a gyratory sample, binder content and in-place density. In 2003, they will be using volumetric acceptance on all HMA projects. In general, they have had good agreement on all of the factors except the bulk specific gravity of gyratory samples.

Andrewski described one project where the contractor had low air voids. Finally, the internal angle of the contractor's gyratory was checked and compared to the state's gyratory. After the internal angle was adjusted to $1.16 \pm 0.02^{\circ}$, the contractor placed 66,000 Mg of the same mix without penalty. The state had to allow the external angle to be out of tolerance, to adjust the internal angle. Although there are certainly other factors to look at, the DAV made great improvements in this case.

Next, **Steve Koble**, from Brooks Construction in Indiana, recounted his experience with a low air void mix. They had test results showing the voids at 2.9%, but INDOT test results came back at 0.9%. They compared many factors before trying the DAV. After changing the internal angle, they placed over 200,000 tons of mix without penalty. In fact, they will get a bonus on the project for their volumetric properties. The DAV allowed them to achieve a complete turnaround on this project and gives them much more confidence going into next season.

Lastly, **Rick Kreider** weighed in on the DAV, relaying results from Kansas. He presented results showing comparisons between bulk gravities determined by contractors and the DOT from 2000 through 2002. There were some discrepancies in 2000, but in the last two years the comparisons have been quite good. Kreider credits the contractors with becoming well educated.

The DOT has seen a few comparison problems, but they have not been severe. They will use the DAV to resolve discrepancies between the state and contractor, and may adopt the internal angle in 2004.

Chuck Van Deusen closed the meeting, commenting that we hit a lot of hot buttons in the last day's session, dealing with noise, warranties and gyratories. He announced that the next meeting will be held in the Omaha, Nebraska, area January 27-29, 2004.