TRB Superpave Mixture and Aggregate Expert Task Group
Denver, Colorado

The meeting was convened on February 20, 2002 by Chairman Jim Musselman of the Florida Department of Transportation. Those members attending were:

James A. Musselman, Florida DOT (Chair) Ronald A. Sines, New York DOT (Vice-Chair)
John R. Bukowski, FHWA (Secretary)

Jimmy Brumfield, Mississippi DOT Gerry Huber, Heritage Research
John Cheever, Aggregate Industries Larry Michael, Maryland DOT
Erv Dukatz, Mathy Construction Lon S. Ingram, Kansas DOT
Frank Fee, Citgo Julie Nodes, Arizona DOT
Kevin Hall, University of Arkansas Randy West, APAC Inc
Adam Hand, Granite Const. Co.

Mike Anderson, Asphalt Institute
John D’Angelo, FHWA (liaison Binder ETG)
Ted Ferragut, TDC Partners (Support Staff)
Neil Hawks, TRB (Support Staff)
Tom Harman, FHWA (Support Staff)
F. M. Harvey, Wyoming DOT (liaison AASHTO Subcommittee on Materials)
Haleem Tahir, AASHTO (liaison)

Those “friends of the ETG” attending were:

Tim Aschenbrener, Colorado DOT David Jahn, Martin Marietta
Jim Bibler, Gilson Company Laura MacDonald, City of Aurora
Mike Bienvenu, Troxler Laboratories Kent Newman, Corps of Engineers
Tom Brovold, TestQuip Bob Peterson, Asphalt Institute
Ken Brown, Troxler Laboratories Roger Pyle, Pine Instruments
Don Christensen, AAT Ali Regimand, Instrotec Inc
Bob LaForce, Colorado DOT Bill Schiebel, Colorado DOT
Charles Paugh, FHWA-SaLUT Scott Shuler, Lafarge
Frank Dalton, Pine Instrument Co. Roger Surdhal, FHWA CFLD
Lee Gallivan, FHWA Indiana Division Jack Weigel, Payne & Dolan
Donna Harmelink, Colorado DOT Bob Welch, FHWA CFLD

Call To Order Musselman
Jim Musselman (FDOT) welcomed the group. The Chairman reviewed the agenda (Attachment A), emphasized the essential functions of the ETG, and reviewed previous meeting Action Items. Chairman Musselman asked the attendees for self-introductions. One issue that was discussed was how effectively action items from the meeting are being handled, particularly items that are reviewed by the TRB Superpave Committee prior to their submission to the AASHTO Subcommittee on Materials (SOM).

Update of Selected NCHRP Projects Bukowski
John Bukowski (FHWA) briefed the ETG on the status of selected NCHRP projects, 9-9(1), 9-14, 9-16, 9-19 (Task C), 9-22, 9-33 and 9-34.
Results of NCHRP Project 9-16

Mike Anderson (Asphalt Institute) reviewed the status of the NCHRP 9-16 project on determining if a relationship exists between Superpave gyratory compaction (SGC) properties and the rutting potential of an asphalt mixture. He indicated that the draft final report was delivered to the research panel and was awaiting final review and comments. Assuming a normal review and revision process, the final report was expected to be available in the summer.

Mike presented the key findings of the NCHRP 9-16 project. By using an SGC with the capability of measuring shear stress during compaction, the user can determine the peak of the shear stress curve as a function of the number of gyrations. This peak, identified as N-SRmax (read as the number of gyrations, N, at the maximum stress ratio) in the research, appeared to be sensitive to asphalt binder content and aggregate characteristics. Based on the laboratory experiment, the N-SRmax parameter was recommended for use as a mixture screening tool. It was noted that while N-SRmax appeared capable of identifying gross mixture instability, it did not appear capable of actual performance prediction. The utility of the N-SRmax parameter as a mixture screening tool was generally validated through experiments involving actual mixtures in-service.

Finally, Mike discussed some of the implementation issues with using N-SRmax as a mixture screening tool. These include: (1) the lack of SGCs currently available with the capability of measuring shear stress; and (2) the relative insensitivity of SGC properties, including N-SRmax, to asphalt binder stiffness. He also briefly discussed future research needs and the development of a draft AASHTO practice to help users begin to use N-SRmax.

Update on Subcommittee on Materials

Rick Harvey (WYDOT) and Haleem Tahir (AASHTO) briefed the ETG on the status of several provisional standards and other upcoming changes.

Status of Projects 90-01 & 90-03

John D’Angelo briefed the ETG on the status of 90-01 and 90-03.

Status of Projects 90-07 & 90-09

Tom Harmon (FHWA) briefed the ETG on the status of the 90-07 and 90-09 projects. The role of these teams is to review and comment on the scope of work of the designated FHWA (NCHRP funded projects, provide input for FHWA consideration, coordinate presentation of deliverables to the ETG for deliberation and make recommendations for ETG action.

NCHRP 90-07, entitled, “Understanding the Performance of Modified Asphalt Binders in Mixes,” is being conducted by the FHWA Office of Infrastructure, R&D and funded by NCHRP. The focus of this study is to conduct laboratory binder and mixture characterization to validate and assess proposed enhancements to the Superpave binder specification. TheModifiers included in the study were identified in cooperation with the TRB Binder ETG. 90-07 is building on a previous study conducted by FHWA entitled, “SHRP Binder Validation,” where 3 un-modified and 2 modified materials were tested in the laboratory and under the FHWA Pavement Testing Facility (PTF). The new study incorporates 9 new modifiers and 2 un-modified materials. Laboratory testing includes new protocols for the DRS (dynamic shear rheometer) and mixture performance testing including: SST, French, and Hamburg.

Figure 1. Comparison of Mixture Performance Testing (SST) to NCHRP 9-10 DSR Protocol
Preliminary data shows promise with proposed protocol. Full-scale testing of these modified binders will be conducted with the FHWA PTF, funded through a national pooled fund study, TFP 5(019). Sections are scheduled for construction during the summer of 2002.

NCHRP 90-09 entitled, “Development of Asphalt Mastic Tests to Predict Pavement Performance,” is being conducted in parallel with 90-07 using the same materials and performance data to related binder mastic testing to pavement performance.

**Report of Binder ETG Activities/Issues**

John D’Angelo provided a recap of Binder ETG activities.

**Miscellaneous Issues/Issues from the floor**

Several issues were brought to the floor during the Open Forum discussion. Specifically:

1. Concern exists in several states regarding the potential for premature pavement cracking to occur as a result of under-asphalting mixtures developed using the current Superpave N-design and volumetric criteria. It was noted this issue is being researched by NCHRP as part of Projects 9-25 and 9-31. These projects are being completed by Dr. D. Christensen of Advanced Asphalt Technologies, LLC. Frank Fee indicated he would have the states concerned with this issue contact Dr. Christensen so their concerns could be addressed by these two research projects.

2. The need for a well-defined procedure for the field acceptance of Superpave mixture was discussed. At previous ETG meeting the FHWA presented a field acceptance procedure utilized by their mobile laboratories when evaluating mixtures. Additionally, NCHRP is in the process of refining the recommendations originally suggested by the NCHRP 9-7 research team. This effort will result in a proposed AASHTO Standard Practice for the Development of a Quality Control / Quality Assurance Plan for HMA which when combined with the procedure currently used by the FHWA should address this concern. This issue will be discussed in detail at the next meeting of the Mixture and Aggregates ETG.

3. AASHTO MP-2 and PP-28 require mixtures be compacted to N-max as part of the Superpave design procedure. The need to continue this practice was questioned as little to no perceived benefits result from this additional effort. It was noted that compaction to N-max was a critical component of the N-SRmax screening procedure developed under NCHRP 9-16, which should
be considered before any change to the existing AASHTO standards are proposed. M. Anderson, G. Huber, and R. West will review this issue in more detail before developing a recommendation with supporting rationale for consideration by the ETG.

4. A proposal was made to reduce the Superpave gyratory specimen height from 115 mm to 75 mm to accommodate the AVK as well as reduce the size of specimens prepared in the laboratory. After discussion by the ETG it was agreed the work involved in evaluating this proposal further was excessive when compared to the possible benefits resulting from this effort. No additional action is planned at this time to further evaluate this proposal.

5. The FHWA explored the possibility of the D60/D15 ratio to define coarse and fine gradations in the absence of the restricted zone by looking at 87 different Superpave gradations from across the country. Based on the review of this substantial data set the D60/D15 ratio was not found to be a good method to define coarse vs. fine gradations.

6. Mixing and compaction temperatures of mixtures containing modified binders, specifically polymer modified binders, continue to be a concern for many states. Currently, binder suppliers provide the mixing and compaction temperatures for binders that cannot be appropriately characterized by MP-1. If inappropriate temperatures are used during the mix design process the resulting mixture air voids and VMA may not be correct, thereby compromising these mixtures. Guidance on this issue may be forthcoming from NCHRP 9-10. Additionally, it was noted that the Asphalt Institute has already published information that may be of assistance in this area. The ETG will review this document and determine if any changes to existing AASHTO standards are warranted to address this concern.

7. Current AASHTO specifications required the coarse aggregate angularity be 100/100 when the ESAL level exceeds 30 million for a 20 year design life. This stringent requirement precludes the use of highly crushed gravel aggregates on these roadways since most gravels are unable to achieve the 100/100 criteria. This has resulted in the transport of aggregate great distances in-lieu of using locally available aggregate, which would have been used prior to Superpave. No supporting data for a change to the existing criteria was presented, therefore no further action by the ETG is planned at this time.

**SGC Comparisons and Calibration Task Force**

Randy West (APAC) briefed the group on recent activities of the Task Team. At the last meeting, the following actions items for the task group were given:

1. Develop a work plan and calibration procedure for study of the SGC and DAV.
2. Solicit ETG members, State agencies and others to participate in a round robin study.
3. Analyze existing data.
4. Prepare standard practice in AASHTO format for the use of the DAV.
5. Recommend modifications to AASHTO T312.

Randy discussed results of the initial study evaluating NMAS, coarse and fine gradations, number of gyrations and different gyratory compactors. For the majority of the labs and mixtures tested, the variation among the means was less between compactors calibrated internally compared to compactors calibrated externally.

Studies have shown that the DAV is either non-invasive or only mildly invasive.

The extrapolation procedure works well. Twelve specimens and a full day of testing are required. Pre-compaction would reduce number of specimens but needs further study.

Conclusions/Recommendations:

1. DAV procedure works well but is time consuming.
2. DAV does not clearly eliminate bias between all compactors.
3. Extrapolation and invasiveness issues are settled.
4. Mix stiffness issue not settled. Best to use a standard mix such as a 9.5 mm fine graded mix gyrated to 100 gyrations at 4% air voids.
5. SGC’s must be well maintained. Molds must be clean with no scratches. Specification for maintenance and mold wear needs to be created.
6. Modify AASHTO T-312 to add option to use DAV.

Results of FHWA Evaluation of Mixes Using the AVK  

Chuck Paugh (FHWA) and Tom Harmon discussed the following issues related to gyratory compactor calibration:

Using current calibration procedures the between lab variability in terms of $G_{mb}$ is 0.043 and 1.8% in terms of air voids.

Analysis of 30 mixtures in 2000 showed that the means were significantly different between compactors but the variance is not.

Many issues related to $G_{mb}$ variability are attributable to material handling during the splitting and compaction process. However, some variability is definitely related to the differences in the angles of compaction between compactors.

During the SGC development, there was a 0.005 mean difference in $G_{mb}$ between the original Pine and Troxler compactors. Now during mass production of the equipment, the difference has increased to about 0.020.

During the internal angle target and tolerance study:

1. Target established by checking internal angles of original Pine and Troxler compactors used during Superpave development. Average internal angle was 1.16°.
2. Tolerance was identified as the amount of change in angle that would cause the effective design binder content to change by 0.1%. Tolerance was determined to be 0.022° but was rounded up to 0.03°.

The re-adjusted machines compared very well for field mixtures tested.

It is recommended that the angle tolerance be rounded down to 0.02°. Repeatability and reproducibility are good using the DAV.

Effect of angle change: a 0.1° change in internal angle is equivalent to a 0.016 change in $G_{mb}$ and a 0.1% change in air voids.

Two out of three SGC owners are not getting annual checkup from manufacturer. Less than 40% have had the manufacturer’s check up at all.

It is imperative that the gyratory compactor and molds be clean.

The $N_{design}$ table was established using a SGC that had a 1.15° internal angle.
Recommendations:

AASHTO T-312 should be modified to have a non-binding option for internal angle calibration. It should also maintain procedures and mold wear checks.

**Progress of NCHRP 9-26**

Tom Harmon discussed preliminary findings of this study, specifically as it relates to the precision found between different compactors evaluated as part of this study.

NCHRP 09-26 entitled, “Development of Precision Statement for the AASHTO Provisional Standard T312-01 on Compaction of Mixes Using Superpave® Gyatory Compactor,” is being conducted by the AASHTO Materials Reference Laboratory (AMRL) funded by NCHRP. Preliminary findings are as follows:

<table>
<thead>
<tr>
<th>Single Operator Precision:</th>
<th>1s limit Relative Density (%)</th>
<th>d2s limit Relative Density (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5-mm nominal max. agg</td>
<td>0.3</td>
<td>0.9</td>
</tr>
<tr>
<td>19.0-mm nominal max. agg.</td>
<td>0.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Multilaboratory Precision:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.5-mm nominal max. agg</td>
<td>0.6</td>
<td>1.7</td>
</tr>
<tr>
<td>19.0-mm nominal max. agg.</td>
<td>0.6</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Data indicates a bias between gyratory compactor type, which resulted in the relativity high 2ds values. The project is being expanded by NCHRP under the revised title of “Develop Precision and Bias Statements Using Existing Proficiency Sample Data (Data Mining).” An additional $300k has been supplied for this effort.

**ETG Recommendations Regarding the AVK**

The ETG members strongly agreed that this is a critical issue. Consequently the data generated by the FHWA and the DAV Task Team will be forwarded to the AASHTO Subcommittee on Materials (SOM) for their information and consideration. Specifically, a recommendation will be included regarding modifications to AASHTO T-312 (Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyatory Compactor) to allow the angle to be set either internally or externally, as well as a draft Standard Practice on the use of the DAV.

**4.75 mm Mixture Task Force Activities**

At previous meetings, the ETG had identified a need for a 4.75 mm Superpave mix, for use as a leveling or a thin surfacing mix. A Task Team led by Jimmy Brumfield (Mississippi DOT) met and developed: (1) modifications to AASHTO MP-2 (Standard Specification for Superpave Volumetric Mix Design); and (2) documentation of the complete rationale for the development of these changes. These changes were reviewed in detail by the ETG and there was full agreement to adopt these modifications. They will be forwarded to the SOM for their consideration.

**Results of Pooled Fund Study #176**

Discussion of results and recommendations of the now completed Purdue study that focused on aggregate properties in Superpave.
Lee Gallivan (FHWA) reported on the final efforts regarding the National Pooled Study No. 176 "Validation of SHRP Asphalt Mixture Specifications Using Accelerated Testing". Funding for the project is provided by twenty-seven States and the Federal Highway Administration for specific laboratory and accelerated pavement testing on various asphalt mixtures. The study was designed to evaluate Superpave volumetric criteria for developing and evaluating simulated long-term pavement performance results.

A work plan developed by the participating States, wanted the study to evaluate the following components of the Superpave system: 1) the effect of voids in the mineral aggregate (VMA) on pavement performance; 2) the effect of fine aggregate angularity (FAA) on pavement performance, and; 3) the effect on pavement performance of hot mix asphalt mixture gradations that are designed to pass through the restricted zone.

The draft final report is nearly complete and includes the following general conclusions.

- Minimum VMA alone does not adequately define the threshold between stable and unstable mixes
- VMA Threshold depends on NMAS
- VMA should not exceed 1.5 to 1.8% of requirements
- Critical VMA for higher FAA is greater than for mixes with lower FAA
- Gradation through the RZ had minimal impact on design VMA
- Increase of FAA was found to improve performance but no enhancements in the mixtures in very high FAA (50+) (AC%, difficult to compact, and problems with volumetrics)
- RZ was found not be significant on rutting performance with APT mixes, with the volumetrics otherwise correct
- Mixes through the RZ performed better in the PurWheel
- VMA could not be correlated with performance
- Asphalt film thickness was a robust parameter that reflected performance (7-9 microns)
- Higher as build VMA increases rutting in the APT
- Mixes compacted to 6-8% AV performed better in the APT

The Draft final report is expected this summer and will be distributed to the States first then will be available to all.

Follow up: The Draft Final Report was released in July to the participating states.

**Progress of NCHRP 9-25**  

Christensen

Dr. D. Christensen of Advance Asphalt Technologies provided an update on NCHRP 9-25, Requirements for Voids in the Mineral Aggregates for Superpave Mixtures. The objective of this research is to develop recommended mix design criteria for VMA, VFA, or calculated binder film thickness, as appropriate, to ensure adequate HMA durability and resistance to permanent deformation and fatigue cracking for coarse and fine, dense-graded mixes in the context of the Superpave mix design method.

Ternary property maps are a useful tool for evaluating the complex relationships between the composition of asphalt concrete and various performance-related properties. Based upon an initial set of such property maps, several preliminary conclusions can be made concerning such relationships: fatigue resistance tends to increase with either increasing binder content or VMA, and/or increasing VFA; rut resistance tends to increase with decreasing VMA; and resistance to age hardening should increase with decreasing air voids and/or increasing VFA.
The Hirsch model, a relatively simple and rational model for predicting the modulus of asphalt concrete was developed during Phase I of NCHRP Project 9-25 and has been further refined and verified as part of NCHRP Project 9-31. This model uses only volumetric composition and binder modulus as input parameters. It is well suited for use in analyzing the relationship among volumetric composition and pavement performance since it relies on testing conducted as part of routine mixture design.

Laboratory data collected to date indicate that optimum mixture strengths, and potentially maximum rut resistance, are obtained at compositions close to the volumetric optimum of 75 % VFA or 3.4 % air voids. However, it might be possible to achieve improved rut resistance by designing mixtures somewhat leaner than is currently the practice, though this would potentially reduce durability and fatigue resistance.

Additionally it was noted current standard Superpave volumetric specifications, and the many variations being implemented throughout the country, contain many confusing and potentially conflicting implied limitations which result from the complex relationships among air voids, VFA, and VMA. In future modifications of Superpave, such conflicting implied limitations should be avoided.

**Superpave 2005 – Long Range Plan**

Ted Ferragut provided an update of the current long-range plan developed as a requirement of AASHTO resolution AR-5-98 and future research topics.
Action Items

1. All presenters should forward an electronic copy of their presentation to ETG Secretary.

2. Graphically (flow chart?) show the interaction of the various 9 series NCHRP projects, attach to minutes JohnB

3. Add to the overall role of ETG: identify short and long term research needs. Next TRB Committee mtg. JohnB

4. Prepare a summary of Binder ETG concerns as related to mix stiffness for Mix ETG consideration?? Agenda next meeting. JohnD

5. Provide information on specific mixes in use to NCHRP 9-25 contractor on concerns by a number of States (VA/NJ/PA) that some mixes are under asphalted with current criteria. By end of week Fee

6. Concerning consideration of reducing SGC sample size to 75 mm, sample height data from initial studies will be provided for inclusion in minutes. JohnD

7. Nmax requirement: provide recommendation to keep or delete along with rationale, prior to end of July, and will be forwarded to all members. (Solicit input from Prowell) - Huber, West, Anderson

8. For next meeting provide ETG with a summary of the 9-7 proposed changes/report Add to agenda for next mtg Gerry

9. Make available to ETG members information in current AI /NAPA ES 101) publication on variation of modified asphalt compaction temperatures, range, and effects. Anderson

10. Review the Bailey Method in the Circular ALL ETG and forward to the TRB A2D00 Committee the draft Circular. Huber

11. Task Group on SGC get with individual equipment manufacturers and include input on annual maintenance and general equip upkeep. Propose a note on importance of proper maintenance (and rationale) be added to T-312. Sent to ETG Chair and forward to SOM by April 1, 2002? - West

12. SGC Task Group: prepare procedure for DAV and appropriate detailed rationale, forward to ETG Chair and all members for review by March 7, 2002 (TRB Superpave Committee members will be provided a complete copy of the proposed procedure and detailed rationale). Comments will be forwarded to Task Force by March 21 and final document sent to ETG Chair for subsequently forwarding to SOM by April 8, 2002 for their consideration as an alternative/option to T312. West/Musselman

13. ETG issue a guidance statement on the SGC/DAV. Update previously developed guidance document. Distribute a draft to ETG members prior to next meeting by end of
July. Harman/West

14. 4.75 mm Task Force document proposed changes to MP-2 and rationale for inclusion of 4.75 mm into specification. Forward to TRB Superpave Committee for consideration to SOM - Musselman

15. Attach to minutes, document of 4.75 mm various mixes evaluated and associated binder content – Sines

16. Obtain from ICAR and provide for next meeting current information on FAA rationale. – Merrick/Jahn

17. Comments on Long Range Plan and Status of Research to Ted Ferragut. Open issue forum for next meeting, members provide brief description of items and sent to all members prior to next meeting. Also identify issues for future research. - Sines – All

18. Prepare a problem statement for a NCHRP synthesis study of various aggregate blending methods, send to ETG Chair prior to next meeting. - Huber

19. Send to all CO DOT etc a CD with minutes and all presentations. JohnB