Summary Report on the State Pavement Technology Consortium

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16. ABSTRACT

This report documents the first year results of a pooled fund study among four states (California, Minnesota, Texas, and Washington State) and describes the structure and objectives. The planned continuation of this collaboration during the next two years is described.

The pooled fund project established a working relationship among the four State DOT organizations. Under this agreement, each state allocated funding to allow selected DOT personnel and university researchers to participate in a series of technical meetings. Washington acted as the lead state for this pooled fund project, and produced the minutes and other documentation.

Four technical meetings were held between July 1999 and January 2000, one in each of the four participating states. The general format for these meetings included presentations from the host DOT and associated research institutions, followed by specific topics of common interest to the four states. The four states quickly identified topics of mutual interest via this process. To provide the ability to study these topics and those identified in the future, the State DOT research managers agreed to establish a management framework to continue information sharing, to plan funding commitments and assure proper oversight and management of the collaborative studies.

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SUMMARY REPORT ON THE STATE PAVEMENT TECHNOLOGY CONSORTIUM

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DISCLAIMER

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EXECUTIVE SUMMARY

This report documents the first year results of a pavement-oriented pooled fund study among the State DOTs of California, Minnesota, Texas, and Washington State.

Four technical meetings were held between July 1999 and January 2000, one in each of the four participating states. The general format for these meetings included presentations from the host State DOT and associated research institutions, followed by specific topics of common interest to the four states. The four states quickly found that they share a common concern on numerous pavement issues and a mutual desire to act on these issues.

The initial effort to explore the potential of collaboration among four State DOTs and their associated research institutions has resulted in a number of positive actions, including funded studies, informal coordinated study efforts, international technology training and assessment, and a transfer of knowledge among the participants. It is clear that attending a few large technical conferences each year, and doing literature searches, does not provide the in-depth understanding of work done by others that focused discussions among a small group of knowledgeable and motivated individuals can provide.

As the participants continue with this effort, gain experience with administrative mechanisms and broaden the focus to emerging issues, adaptations will be necessary. The bottom line for those representing the four State DOTs is that the State Pavement Technology Consortium should continue.

SUMMARY REPORT ON THE STATE PAVEMENT TECHNOLOGY CONSORTIUM

INTRODUCTION

This report documents the first year results of a pooled fund study among four states, and describes the structure and objectives of the planned continuation of this collaboration during the next two years.

California, Texas, Minnesota and Washington are among the leading states in the research, development and deployment of advanced pavement technology. Each State Department of Transportation (DOT) has a continuing research and development program designed to improve its pavement design, rehabilitation, construction, and maintenance procedures. Each has long-standing research relationships with universities within that State, and all State DOTs have made substantial investments in research equipment and facilities. These programs have produced significant improvements in pavement technology resulting in improved pavement practices. Such practices aid all road owning public agencies in each state, and also benefits university education.

The sharing of information between researchers and practitioners in these states can be of substantial mutual benefit. These benefits include, but are not limited to: joint research and development programs of common interest; leveraging scarce funds and maximizing the use of existing expertise and research facilities; accelerated technology transfer of new knowledge among the participating states; identification of emerging critical issues; and educating transportation professionals on the latest technological advances.

A similar project, intended to address Intelligent Transportation Systems (ITS), had been executed among California, Minnesota, Texas, and Washington; the initial success of this ITS project helped to substantiate the potential benefits of a similar effort in pavement technology.

This pooled fund project established a working relationship among the four State DOT organizations. Under this agreement, each state allocated funding to allow DOT personnel and university researchers to participate in a series of technical meetings. Washington acted as the lead state for this pooled fund project, and produced the minutes and other related documentation.

The State Pavement Technology Consortium (SPTC) organization began as a discussion between the State DOT Research Directors at the Annual Meeting of the Transportation Research Board during January 1999 (represented by Wes Lum (California DOT), Bob Benke (Minnesota DOT), Paul Kruger (Texas DOT), and Marty Pietz (Washington State DOT)). It was agreed that four initial meetings would take place—one meeting in each state.

SUMMARY OF TECHNICAL MEETINGS

Four technical meetings were held between July 1999 and January 2000, one in each of the four participating states. The general format for these meetings included presentations from the host State DOT and associated research institutions, followed by specific topics of common interest to the four states.

These meetings were held at the following locations and dates:

- **California**: University of California at Berkeley, Berkeley—Richmond Field Station, California, July 12-13, 1999
- **Minnesota**: Minnesota DOT, Materials and Research Laboratory, Maplewood, Minnesota, September 9-10, 1999
- **Texas**: Texas DOT, Materials and Tests Division, Austin, Texas, November 17-18, 1999
- **Washington State**: Washington State DOT, Materials Laboratory, Tumwater, Washington, January 27-28, 2000.

Table 1 contains a list of all attendees (some attended one meeting, others all four). SPTC minutes (1999a, 1999b, 1999c, and 2000) were used to develop Tables 2 through 5.

At the first meeting in California, a total of 13 topics of interest were identified; these are shown in Table 2. A lead state was identified for each topic, and a one-page summary was subsequently prepared for discussion at the next meeting.

At that subsequent meeting in Minnesota, the group examined each problem, its elements (scope, extent), execution (method of conduct), and evolution (next steps). Table 3 provides a summary of decisions made with respect to each topic.

At the Texas meeting in November 1999, the topics of mutual interest continued to evolve. This is illustrated in Table 4, which shows topic titles and conclusions and/or actions needed. Importantly, by the time of this meeting, the group had established rapport and significant contact via telephone and email. This contact was occurring among the participants on the formally identified topics and action items, and on unrelated professional and technical issues. As a result, the group decided to continue the four-state collaboration beyond the initial exploratory meetings. The lead state (Washington) agreed to prepare a draft charter for continuing the four-state collaboration, including a proposed process to select researchers and to fund and manage studies of mutual interest. In addition, a decision was made to jointly sponsor the South African/US Pavement Technology Workshop in March 2000 at the Richmond Field Station in California.

The final meeting of the initially planned four occurred in Tumwater, Washington. The action items from that meeting are summarized in Table 5. At that meeting, the continuation and organization of the SPTC was formalized.

This collaboration to date has resulted in significant sharing of pavement technical information and development of specific, funded activities including:

- Development and offering of the South African/US Pavement Technology Workshop, held during March 20-23, 2000;

- Software enhancement to aid decisions concerning construction, duration, and logistics of urban pavement rehabilitation and reconstruction;

- Funding for a synthesis type of report on improved pavement field characterization, building on the recently published NCHRP Synthesis No. 278 (Measuring In Situ Mechanical Properties of Pavement Subgrade Soils);

- Analysis of longitudinal joint compaction in hot-mix asphalt pavement.

Decisions were made to fund or otherwise support in the near future a number of other actions including:

- A retrofitted dowel bar study to be conducted in California that includes the use of the Heavy Vehicle Simulator (HVS), complemented by the experience, field data, and research findings of the Minnesota and Washington DOTs;

- Development of a four state Superpave database, to examine the mix system and monitor field performance of Superpave mixes;

- Monitoring of selected paving projects in the four states during the year 2000 paving season, using an infrared camera and in situ density measurements, to exam hot mix segregation and possible mitigation techniques.

- Investigation of Internet-based training technology for possible application among the four states and associated universities, and for sharing experiences in the use of this technology with similar efforts underway by the Washington State DOT, National Asphalt Paving Association (NAPA), and TransNow (a USDOT funded center).

Informal collaboration among the participants has achieved benefits in a number of areas. For example, the Washington State DOT is using Minnesota's research on alkali-silica reactivity (ASR) to assess the potential impacts of changing from Type 2 to Type 1 portland cement. The WSDOT Research Office explored the Texas research implementation program and procedures, and adopted a modified version for use in its implementation efforts. The University of California at Berkeley received modified software developed at the University of Minnesota for use in determining asphalt concrete cooling times. Texas has shared the results of a paving remixing equipment rodeo with the other participants, as well as detailed specifications for calibration and use of lightweight profilers. Minnesota and Washington State have made available their pavement analysis and design software. All four states discussed and are collaborating on hot-mix temperature differentials, the implication on in situ mix quality, and the required data for development of logical mitigation measures.

COMPARISON OF STATE CLIMATES, PAVEMENT DESIGNS, MATERIALS, AND INTERNET ACCESS

A substantial effort was made during the first round of meetings to better understand each State DOT's pavement practices. This was further aided by information prepared for the South African/US Pavement Technology Workshop that is shown as Appendices A through D. Appendix A is a general comparison of the four states and South Africa. Appendix B provides a summary of typical pavement structures, and Appendix C provides related information for pavement materials. Appendix D is a summary of an media/Internet usage survey done for the four states.

The data in Appendix A reveals that in terms of area, population, and length of road systems, the following can be noted:

- The largest and the smallest states by area (Texas and Washington) differ by a factor of 3.8.
- The largest and smallest states by population (California and Minnesota) differ by a factor of 6.7.
- The largest and smallest road systems (Texas and Washington) differ by a factor of 3.7.
- The "combined" four states when compared to the U.S.
    - Cover 15 percent of the total U.S. area
    - Have 23 percent of the total U.S. population
    - Have 17 percent of the total U.S. road length.

In terms of climate data shown in Appendix A, the following similarities are observed (this includes South Africa since the four states have paid extra attention to some of their pavement practices):

- Temperatures
    - San Diego, Cape Town, and Johannesburg have similar summer and winter temperatures.
    - Seattle, Spokane, Cape Town, and Johannesburg have similar summer temperatures.
- Precipitation
    - Seattle, Houston, and Dallas have similar totals for annual precipitation.
    - Minneapolis and Johannesburg have similar totals for annual precipitation.
    - Spokane and Cape Town have similar totals for annual precipitation.
    - Dallas and Durban have about the same number of days of measurable precipitation.
    - Spokane and Minneapolis have about the same number of days of measurable precipitation.

Appendix B contains a summary of pavement structural design information for the four states and South Africa. This information came from two sources: a survey done in January 2000 to aid the South Africa/US Pavement Technology Workshop and NCHRP

1-32 (Jiang et al, 1996). In Appendix B, Tables B-1 and B-3 are summaries of related structural pavement information and from this information the following is noted:

- New or reconstructed flexible pavements: Three out of four states use state developed thickness design procedures.
- New or reconstructed rigid pavements: Three out of four states use AASHTO thickness design procedures (various versions).
- Design life: Ranges between 20 to 40 years.
- Traffic: Most use ESALs.
- Life cycle costing: The analysis period ranges between 35 to 40 years.
- Subgrade characterization: Various tests are employed to characterize the support for the pavement structure ranging from deflection analyses to material correlations.
- Portland cement concrete—jointed plain: The transverse joint spacing is typically about 15 feet with all states using dowel bars (currently or in the near future).

Figures 1 and 2 provide an overview of flexible pavement thickness for the four states, the European Union (COST 333 (1999)), and South Africa. The thickness of asphalt concrete and the total pavement are similar for both the EU and the four states (for a given traffic level and subgrade support). Differences exist, in part, due to differing reliability levels. However, it must be noted that there are significant differences among the EU countries—only the mean values for the 20 countries noted in the COST 333 report are used here. Noticeable is the thickness of asphalt concrete used by South Africa, which is significantly less than either the four states or the EU countries.

Appendix C provides an overview of the four states and South African pavement material specifications. Specific emphasis is placed on asphalt concrete and unstabilized bases and subbases. Most of the information contained in Appendix C was obtained via a survey conducted during January 2000. Specific information was requested on gradation, compaction requirements, strength or stiffness, and other material properties.

For unstabilized bases and subbases, the materials summarized in Appendix C, Table C-1 are dense graded; thus, the gradation requirements are similar for the four states (there are differences in maximum aggregate size but the base types shown are only a partial list). A notable exception is South Africa that specifies more sieve sizes and tighter gradation bands.

In Appendix C, Table C-2, the compaction requirements for unstabilized bases are shown. Differences in compaction requirements are readily noted. The South African requirements for their high type G1 base are about 108 percent of AASHTO T-180. However, it must be noted that such high density requirements are part of the South African flexible pavement design philosophy that results in relatively thin surfacing layers (such as for asphalt concrete).

A comparison of asphalt concrete requirements is shown in Appendix C, Tables C-4 through C-7. In general, two of the states (California and Washington) with Hveem stability requirements use similar values. Marshall stability requirements (Minnesota and South Africa) differ. The required field densities vary among the four states and South

Africa (Appendix C, Table C-7); however, interpretation of compaction requirements can be uncertain. Actual field practices and compaction results would provide an improved comparison.

Appendix D provides media survey information completed by the four states during February 2000. The specific focus of the survey concerned Internet access and related media. The results of the survey can be summarized as follows:

- Video conferencing or media streaming via the Internet: This is not, at this time, widely used within the DOTs.
- Typically, the four states have T1 lines for Internet access (digital transmission link with a capacity of about 1.5 Mbps (megabits per second)).
- Streaming media is generally viewed via software such as RealPlayer, at least at the time the survey was done. The encoding of streaming media is not commonly done within the DOTs at this time.
- All four DOTs are PC-based and use the Windows operating system (mostly NT or 98).
- There are only limited constraints via in-house IT groups for changing software and hardware for conducting remote meetings and the use of streaming media.

MANAGEMENT COUNCIL AND ORGANIZATIONAL STRUCTURE

The State DOT managers agreed to establish a management framework to continue information sharing, to plan funding commitments and assure proper oversight and management of the collaborative studies. The following provides the associated objectives, a management structure, and level of continuation funding. It is assumed that the four states individually will continue their own pavement research and technology programs, and participate in national programs such as those sponsored by AASHTO, TRB and FHWA as they do currently: this activity complements those efforts and does not supplant them.

OBJECTIVES OF THE STATE PAVEMENT TECHNICAL CONSORTIUM (SPTC)

The objectives of the SPTC are:

- Establish a structure and funding for continuing discussion of pavement technology, technology sharing, research, and identification of emerging issues.

- Establish a mechanism for defining, funding, monitoring and completing studies of mutual interest which assure each state can participate effectively in project definition, monitoring of progress and review and acceptance of final results.

- Provide flexibility and responsiveness so that studies of interest to some, but not necessarily all of the partner states can be expeditiously defined, funded and conducted, while retaining appropriate project definition, management, and review of results.

- Provide maximum funding leverage for formal research studies by establishing a mechanism to accept funds and technical support from other agencies, including FHWA, other State DOT's, private sector associations and foundations, national laboratories and universities, in addition to contributions from two or more of the four participating State DOT's.

- Provide for participation by universities in each of the four states, and for national associations relevant to pavement technology, technology transfer and research.

- Limit membership in the consortium to the four states until July 1, 2002 in order to test the structure established, more fully develop the management and administrative processes, and build upon and solidify the professional and institutional relationships.

SPTC STRUCTURE

Management Council (MC). The Management Council will be comprised of a research representative and a materials/pavement representative from each of the four State DOT's. This body will decide upon funding levels, administrative issues, contracting procedures for formal studies of mutual interest, and sustaining funding for the SPTC. These eight individuals (two per state) represent the funding and technical decision-making managers regarding pavement research and technology in their respective agencies, and should therefore make those same decisions for the SPTC. Decision-making by this group will require consensus agreement of the eight members. The Management Council members are also members of the Technology Forum, and will meet as needed, usually twice per year in conjunction with the meetings of the Technology Forum.

To the extent that formal research studies are defined and sponsored by two or more of the four participating states, the MC will, in some cases, develop a statement of work, issue an RFP, evaluate proposals, and designate a "Lead State" (based on the home state of the selected research institution). In other cases the MC will simply designate a Lead State who will select the research team. The Lead State will administer the project as a Regional Pooled Fund project according to its specific authorities and procedures. The formation of Technical Advisory Committees with representatives from the each of the participating funding agencies is encouraged, however, and is discussed below.

Technology Forum. A Technology Forum will be comprised of research and technical staff from each of the four state DOT's, designated university faculty members, and invited technical/research representatives from national flexible and rigid pavement associations. This Forum will meet twice per year, rotating among the four states and other locations of specific interest, to share new developments, receive reports from on-going research activities sponsored by the SPTC and by individual agencies, and evaluate new opportunities and emerging issues. The technical discussions and evaluations, which take place during these meetings, form the basis for technology transfer, for development of funded studies of mutual interest, and for coordinated investigations of new technology.

Technical Advisory Committees (TAC). An individual TAC is comprised of technical experts from each State DOT that provides project funding, and invited university and/or industry representatives. These committees will function similarly to NCHRP panels and the technical committees usually created for Regional Pooled Fund projects. The committees will provide technical direction and oversight to the research/study teams, review findings and approve final reports and other project deliverables. Formation of TACs is encouraged, but not mandatory, for all studies under the purview of the SPTC.

Study Groups. Some issues of mutual interest may not require a formal research study, yet coordination among the states is thought to be of substantial value to the entire group. When issues such as this emerge from the four-state discussions, study teams would be appointed from each interested State DOT, with voluntary assistance from partner universities and national associations optional, to coordinate the efforts. One State DOT representative would be designated by the MC as Study Group leader. It is also not anticipated that any particular Study Group would continue indefinitely; these Study Groups would be formed to accomplish a particular task, and disbanded upon completion of that task.

Figure 3 illustrates the overall management structure.

Funding. To support the initial exploratory effort, each of the four State DOTs contributed $15,000 per year for two years. This funding has supported travel for site visits to each of the four states, the preparation of formal minutes, and minor coordinating costs incurred by the lead state (Washington).

Continuation of the existing Regional Pooled Fund study is supported by the four states, to continue the collaboration and to establish and sustain the SPTC, MC, Technology Forum, and Study Groups described above. It is anticipated that the MC and Technology Forum will meet twice per year, rotating among the four states and other locations of particular interest. In addition, the MC is establishing a web page at one of the participating DOTs, or at a designated university. An inexpensive, pc-based videoconferencing system to facilitate interaction among various participants is being tested to facilitate the work of councils, committees and study teams. Washington will continue as lead state for his coordinating study.

Formalization of Regional Cooperative Pavement Research Program. The MC will investigate establishment of a continuing Regional Cooperative Pavement Research Program, funded by contributions from each of the four states. Organizational considerations, funding levels, and procedures are yet to be developed.

SUMMARY AND CONCLUSIONS

An initial, intensive seven-month effort to explore the potential of collaboration among four State DOTs and their associated research institutions has resulted in a number of positive actions, including funded studies, informal coordinated study efforts, international technology training and assessment, and a transfer of knowledge among the participants. It is clear that attending a few large technical conferences each year, and doing literature searches, does not provide the in-depth understanding of work done by others that focused discussions among a small group of knowledgeable and motivated individuals can provide.

As the participants continue with this effort, gain experience with administrative mechanisms and broaden the focus to emerging issues, adaptations will be necessary. The evolution of interests, as can be seen by comparing the items in Tables 2 though 5, will almost certainly continue.

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State Pavement Technology Consortium (1999a), “Minutes of the Second Meeting of the Four State Pavement Pooled Fund Study—California Department of Transportation,” Berkeley, California, July 12-13, 1999.

State Pavement Technology Consortium (1999b), “Minutes of the Third Meeting of the Four State Pavement Pooled Fund Study—Minnesota Department of Transportation,” Maplewood, Minnesota, September 9-10, 1999.

State Pavement Technology Consortium (1999c), “Minutes of the Four State Pavement Pooled Fund Study—Texas Department of Transportation,” Austin, Texas, November 17-18, 1999.

State Pavement Technology Consortium (2000), “Minutes of the Fourth Meeting of the Four State Pavement Pooled Fund Study—Washington State Department of Transportation, “ Tumwater, Washington, January 27-28, 2000.

Table 1. Attendees of the Four Initial SPTC Meetings

Name	Organization
State DOTs	
Kevin Herritt	Caltrans
Jim Wilson	Caltrans
Tom Hoover	Caltrans
Wes Lum	Caltrans
Bob Doty	Caltrans
Karl Frick	Caltrans
Alfredo Rodriguez	Caltrans
Susan Massey	Caltrans
Lance Brown	Caltrans
Gerry Rohrbach	MnDOT
Glenn Engstrom	MnDOT
Lisa Bilotta	MnDOT
Tom Burnham	MnDOT
Ben Worel	MnDOT
Eric Embacher	MnDOT
Julie Vandenbossche	MnDOT
Atenea Salomon	MnDOT
Dave Johnson	MnDOT
Jerry Geib	MnDOT
Tom Nordstrom	MnDOT
Bruce Irish	MnDOT
John Siekmeier	MnDOT
Prasad Rangaraja	MnDOT
John Garrity	MnDOT
Duane Young	MnDOT
Jim McGraw	MnDOT
Joe Meade	MnDOT
Dave Van Deusen	MnDOT
Paul Krugler	TxDOT
Ken Fults	TxDOT
Carl Utley	TxDOT
Magdy Mikhail	TxDOT
Mike Murphy	TxDOT
Maghsoud Tahmoressi	TxDOT
Tom Baker	WSDOT
Marty Pietz	WSDOT
Linda Pierce	WSDOT
Keith Anderson	WSDOT
Jim Spaid	WSDOT
Rudy Malfabon	WSDOT
John Conrad	WSDOT
Jeff Uhlmeyer	WSDOT

Table 1. Continued

Name	Organization
Universities	
Carl Monismith	University of California-Berkeley
John Harvey	University of California-Berkeley
Jeff Roesler	University of California-Berkeley
Manuel Bejarano	University of California-Berkeley
Dave Newcomb	University of Minnesota
Ken Stokoe	University of Texas-Austin
Soheil Nazarian	University of Texas-El Paso
Tom Scullion	Texas A&M/TTI
Amy Epps	Texas A&M/TTI
Joe Button	Texas A&M/TTI
Cindy Estakhri	Texas A&M/TTI
Joe Mahoney	University of Washington
George Turkiyyah	University of Washington
Eyad Masad	Washington State University
Counties	
Michael Sheehan	Olmsted Co/Minnesota
Other Related Organizations	
Nick Coetzee	Dynatest
Other Organizations	
Fuming Wang	ZUT-China

Table 2. Initial Topics of Mutual Interest—California Meeting—July 1999

Topic No.	Topic	Number of Interested State DOTs	Lead State for Write-Up
1	**Temperature Differentials**	4	Washington
2	**Construction Duration and Logistics**	4	California
3	**Longitudinal Joints**	4	Texas
4	**Improved In-Situ Characterization (can include GPR, DCP, RWD, SASW, Deflection Analyses, Seasonal Variations)**	4	California and Washington
5	**Longer Life Pavement (can include Heavy Duty Pavement, AASHTO 2002 "Gaps," New Materials, Improved Characterization, Reflective Cracking)**	4	California
6	**Training**	4	California
7	**Retrofit of Dowel Bars**	2 (CA,WA)	California
8	**Pavement Smoothness**	4	Texas
9	**AC Moisture Sensitivity**	4	Minnesota
10	**Aggregate Soundness**	3 (CA,MN,TX)	Texas
11	**Superpave Performance (PG grading (including bumping) and Production; Performance Testing)**	4	Minnesota
12	**Alternative Materials for Dowel Bars and PCC Reinforcement**	4	Washington
13	**Implementation at the Policy Level (relates to No.6 Training)**	4	California

Table 3. Initial Topics of Mutual Interest—Decisions Made—Minnesota Meeting
September 1999

Topic	Decisions
Temperature Differentials in Asphalt Concrete Pavement	Linda Pierce and Joe Mahoney will develop a draft template for data collection by the four states and a draft model specification. This information will be provided to the four states prior to the Austin meeting in November. Additionally, they will develop a work plan beyond the template and model specification for discussion at the Austin meeting.
Construction, Duration, and Logistics of Urban Pavement Rehabilitation and Reconstruction	UCB will present a detailed work plan at the Austin meeting. Action item for John Harvey.
Improved HMAC Longitudinal Joint Construction	Paul Krugler will send a copy of the Texas DOT SP&R study proposal to the other three states.
Improved Pavement Field Characterization	Develop a study scope not to exceed $25,000. Joe Mahoney noted that other work agreed to (such as the RSA short course planned for March 2000) might reduce the need for this topic; however, he will prepare the draft study scope as requested.
Longer Performing (Service Life) Rehabilitation Strategies for Pavements	Send thoughts concerning long life pavements to Kevin Herritt. He will assimilate the comments and report to the group at the Austin meeting. Joe Mahoney will prepare an executive summary on the superior performing pavements study so that it can be sent to the four states.
State Pavement Program Training and Implementation Survey	John Harvey will synthesize the results from the four states and then transmit to all parties that attended the meeting.
Dowel Bar Retrofit Quantification	At the Austin meeting, the following will be done • The Texas DOT will demonstrate or otherwise illustrate their accelerated testing device. Action item to Ken Fults. • Mn/DOT will provide information on their dowel bar study at the Austin meeting. Action item to Gerry Rohrbach. • Caltrans and UCB will update the group on their dowel testing plans. Action item to Tom Hoover and John Harvey.
Improved Pavement Smoothness	Each state will come to the Austin meeting prepared to present where their DOT is on smoothness specifications. WSDOT will distribute their research plan for the smoothness survey, if complete.
Improved Method of Determining Moisture Susceptibility of Hot Mix Asphalt	Prepare a draft Request for Proposals to be presented and discussed at the Austin meeting. Mn/DOT will take the lead. All four states are welcome to submit their ideas to Gerry Rohrbach.
Toughness and Durability of Aggregates for ACP	A status report will be made on the topic at the Austin meeting. This information may lead to a four state study decision. Paul Krugler will take the lead on this topic.
Cost Effectiveness of Superpave	A template will be drafted, presented, and discussed at the Austin meeting. The lead for this will be Ken Fults.
Alternative Materials for Dowel Bars	Do a search for state experience, reports, and consult with Mark Synder (Univ of Minn.). Action item for Linda Pierce. Wes Lum will consult with the Caltrans corrosion lab concerning related corrosion studies and coordinate the information with Linda Pierce.
Implementation at the Policy Level	Additional discussion will occur at the Austin meeting following John Harvey's survey results.

Table 4. Evolution of Topics of Mutual Interest—Texas Meeting—October 1999

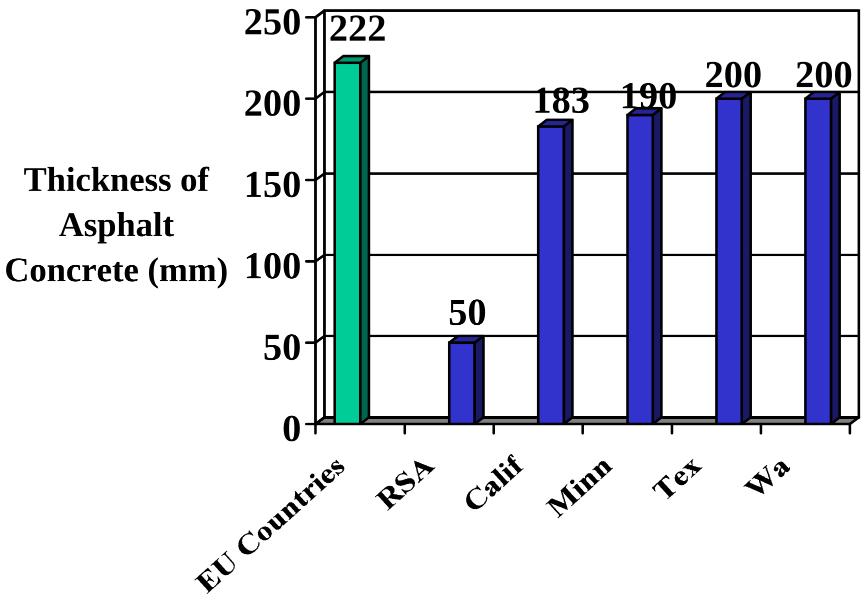
Topic	Decisions
Four State Charter/Research Guidelines	This activity will include, at a minimum, the following: a more formalized (but not too formal) draft charter for continuing the four state collaboration, a process for selecting researchers to conduct studies, and how such studies will be managed. The draft will be circulated to the states prior to the Seattle meeting. This will be the primary topic for discussion among the State DOTs scheduled for the afternoon of January 26, 2000. **Action item** to Marty Pietz to develop a draft charter.
Preventive Maintenance	The four states appear to have a mutual interest in a collection of "best practices." It was agreed that this topic merits additional discussion at the January 2000 Seattle meeting. No specific action item.
Pavement Smoothness	Three action items resulted from the discussion on pavement smoothness. These are: Priority 1: A framework for a four-state smoothness specification including profiler details (calibration, etc.) will be prepared for the January 2000 meeting in Seattle. Action item to Ken Fults and Linda Pierce. Priority 2: A process for how individual state data relating to pavement smoothness can be shared will be presented in Seattle (specific reference was made to TxDOT and WSDOT data sets—there may be others). Action item to Linda Pierce/Jim Spaid/Marty Pietz. Priority 3: If necessary, a proposal/problem statement will be sent to the Joint Task Force on Pavements to consider for submittal to AASHTO SCOR relating to pavement smoothness specifications. No action needed on this for now.
Improved Pavement Field Characterization	It was agreed that a synthesis type of report would be developed. Final action for funding and selection of researcher slated for the Seattle meeting. Action item to Joe Mahoney for an updated RFP to be sent to the states prior to that meeting.
Micro-Deval and Magnesium Sulfate Soundness Tests	The four states will continue to share information on the Micro-Deval test. No specific action item.
Hot Mix Moisture Susceptibility	Given the discussion at the Austin meeting, no major action item is required at this time. However, Marty Pietz will contact Bob Reilly at NCHRP to obtain the current version of the moisture susceptibility problem statement.
Longitudinal Joint Research	The states (California, Minnesota, and Washington State that is) could submit cores to for inclusion in the TxDOT/TTI study. The three states need to confirm whether they want to participate in the existing TxDOT/TTI study. To be included would possibly require the states to provide cores to the TTI research team. It might involve funding the TTI research team (or a team member) to their state or TxDOT might be able to support that type of travel. It was agreed that scoping the extent of low compaction at longitudinal joints is a good idea for all four states. **Action items are:** **Action item**. Each state comes to the Seattle meeting with a decision as to whether they intend to participate in the existing TxDOT/TTI study. **Action item to State DOT research directors.** Decision must be made as to submitting cores to TTI or all testing done by the individual states and submitted to the researchers. Final decision on this will be made at Seattle meeting. Action item to Paul Krugler to provide recommended approach.

Table 4. (Continued) Evolution of Topics of Mutual Interest—Texas Meeting—October 1999

Temperature Differential Study, Model Segregation Specification, and Controlled Experiment	**Action item:** Ken Fults and Joe Mahoney will prepare a revised model draft segregation specification for discussion and action at the upcoming January 2000 four-state meeting in Seattle. **Action item:** Joe Mahoney will prepare a conceptual framework for a single experimental design with replicates in the four states. This will be presented at the January 2000 four-state meeting. **Action item:** In the spirit of inviting industry participation in the overall activity, David Newcomb, NAPA, will be invited to the Seattle meeting. The invitation was extended and accepted following the Austin meeting.
Superpave Template	**Action item**: Send Rita Leahy's recent WSDOT Superpave report to the three states (availability will be December 1999). Action: Marty Pietz. **Action item:** Comment on TxDOT Excel/Access items as a possible Superpave template. Action: State DOTs be prepared to discuss at Seattle meeting.
Pavement Software	It was agreed that the development of an "approved pavement software" list—analogous to an approved products list—is of interest to the four states. Action item: Joe Mahoney will prepare a more detailed framework—to be presented at the Seattle meeting.
Long Life Pavement .	**Action item:** States provide ideas for areas of common interest to Kevin Herritt. He will collect and summarize. **Action item:** Joe Mahoney/WSDOT submits superior performing pavement executive summary to the four states
Precast Pavements	**Action item:** TxDOT, Caltrans, and UT-Austin (Frank McCullough) will discuss areas of mutual interest. **Action item**: John Harvey will consider sending key UC-Berkeley personnel to upcoming Texas meeting on the topic.
Dowel Bar Study	**Action item:** Tom Hoover agreed to prepare and present at the Seattle meeting a plan for evaluating dowel bars via HVS testing. Further, the plan will include a way in which Mn/DOT and WSDOT can partner on that type of effort.
Training	**Action item:** The individual states will prepare a list of the types of training items they seek—this includes format (video, CD, Internet based, etc.), topics, and application (which would include duration of training and the types of persons to receive the training). Discussion item for the Seattle meeting. Their lists will be submitted to John Harvey. John will summarize and present at the Seattle meeting.

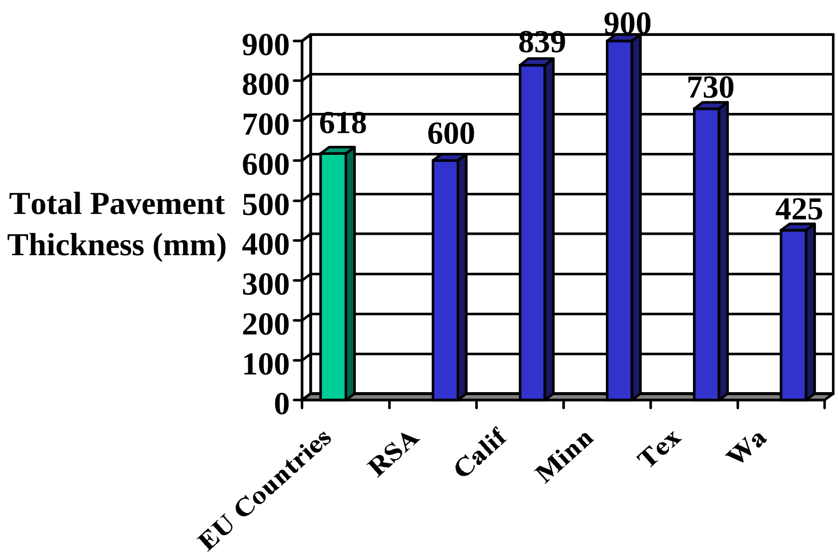
Table 5. Evolution of Topics of Mutual Interest—Washington State Meeting—January 2000

Topic	Decision
Internet Media Capabilities	A set of questions on Internet media capabilities in the four state DOTs will be prepared and sent to the state research directors. Joe Mahoney will prepare the questions in conjunction with John Harvey. The responses will be sent to Joe for summarization. Action item to Joe Mahoney and four state research directors (Marty, Tom, Paul, Gerry).
NAPA Training	David Newcomb will keep the four states in the loop with respect to NAPA training. Action item to David Newcomb.
University Overhead Rates	Each university will summarize its overhead rates and submit to Marty Pietz. Action item to Marty Pietz (for UW and WSU), John Harvey (UCB), Paul Krugler (TAMU/TTI and UTA), and Gerry Rohrbach (for UM).
Lightweight Profilers	Each state is to review the lightweight profiler information provided during the meeting. Comments are to be sent to Ken Fults. Action item to Jim Spaid (WSDOT), Gerry Rohrbach (Mn/DOT), and Kevin Herritt (Caltrans).
Smoothness Specification	Smoothness specification information. The four states will continue to share information on this topic.
Hot Mix Segregation	Draft specification for hot mix segregation. Joe Mahoney will provide the specification to Minnesota (Gerry Rohrbach and Glenn Engstrom), Texas (Ken Fults), and California (Kevin Herritt) following revisions. A meeting is set for February 14 with WSDOT representatives to hash out the final version. Additionally, Joe will provide the four states with a template that can be used to obtain data on segregation from paving projects. Action item to Joe Mahoney for the final version of the specification and the data template. Action item to Ken Fults, Kevin Herritt, and Gerry Rohrbach/Glenn Engstrom as to how their State DOTs might further collect data on segregation and use of the specification.
Superpave Template	TxDOT will an updated template based on Mn/DOT Superpave data. Following the update, the template will be sent to WSDOT and Mn/DOT. Action item to Maghsoud Tahmoressi.
Preventative Maintenance	Mn/DOT will share information with the other three states on their evolving Preventive Maintenance program. Action item to Glenn Engstrom.
Retrofitted Dowel Bars	WSDOT and Mn/DOT will provide relevant reports, specifications and data to Tom Hoover on their experience with retrofitted dowel bars. Action item to Linda Pierce and Glenn Engstrom.
Long Life Pavements	Provide input to Kevin Herritt on long-life pavement studies underway by Caltrans. Action item to Linda Pierce, Ken Fults, and Glenn Engstrom (Mn/DOT will share specific information on their long-life project being built Summer 2000).
RSA Short Course	RSA short course. Action items include: • Attendees need to return application forms (provided earlier at the meeting) to UCB prior to February 28, 2000. • The four states need to provide pavement design and specification data to Joe Mahoney no later than February 18, 2000. • Base course samples will be sent to John Harvey at UCB for transshipment to CSIR as soon as possible. • John Harvey will invite other state attendees (Pennsylvania, Florida, and Georgia), and Roger Larson (FHWA).
Management Council	Action items to the MC include • UCB urban freeway reconstruction proposal(s) • Final action on funding for RSA short course at UCB • Selection of PI for Pavement Field Characterization study



Comments:
- EU: Average for 20 countries
- E80s: 10,000,000
- Subgrade support: CBR = 5 to 6 (or equivalent test value)

Figure 1. Comparison of Asphalt Concrete Thicknesses—The Four States, EU Countries, and South Africa



Comments
- EU: Average for 20 countries
- E80s: 10,000,000
- Subgrade support: CBR = 5 to 6 (or equivalent test value)
- Differing reliability levels
- Tx thickness reduced by 200 mm if lime treated subgrade not included

Figure 2. Comparison of Total Pavement Thickness—The Four States, EU Countries, and South Africa

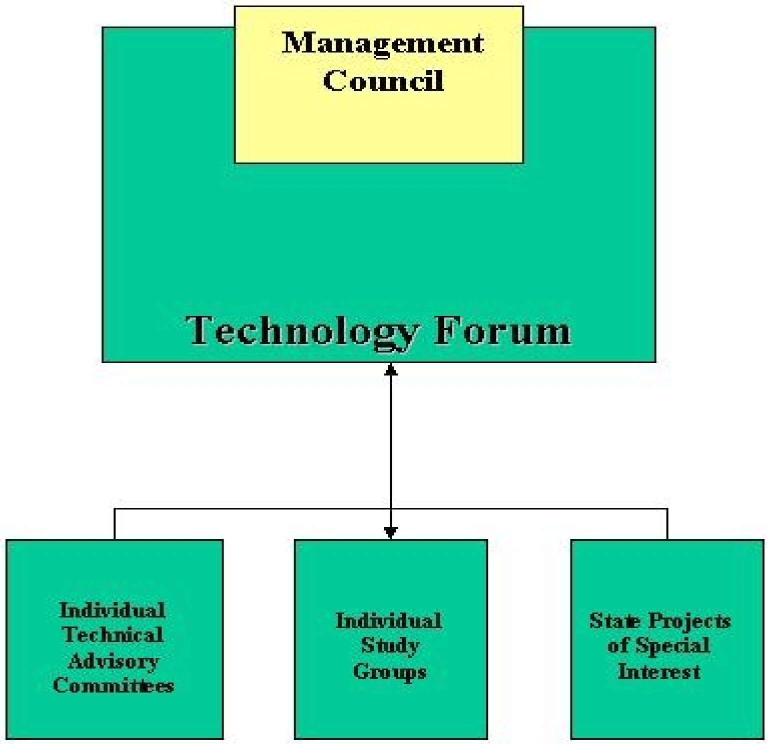


Figure 3. Organization of the State Pavement Technology Consortium

Appendix A
A General Introduction to the Four States and South Africa

LAND AREA

Country or State	Area, km^2 (mi^2)	South Africa is Larger By
South Africa	1,220,902 (471,009)	
California	411,804 (158,869)	3.0X
Minnesota	225,365 (86,943)	5.4X
Texas	692,809 (267,277)	1.8X
Washington State	183,098 (70,637)	6.7X

Source: The World Almanac 2000

POPULATION

Country or State	Population (as of 1998)	South Africa is Larger By
South Africa	43,426,386	
California	32,666,550	1.3X
Minnesota	4,725,419	9.2X
Texas	19,759,614	2.2X
Washington State	5,689,263	7.6X

Source: The World Almanac 2000

ROADWAY EXTENT

Country or State	Paved Length (km)	Unpaved Length (km)	Total Length (km)	Percent Paved (%)
South Africa	137,000	194,000	331,000	41
California	230,000	37,000	267,000	86
Minnesota	84,000	127,000	211,000	40
Texas	277,000	200,000	477,000	58
Washington State	81,000	48,000	129,000	63
United States	3,897,000	2,461,000	6,358,000	61

Sources: For South Africa www.uniontrans.com. For the four State DOTs: Highway Statistics, 1998, FHWA.

CLIMATE STATISTICS

Country or State	Temperatures			Precipitation mm (in.)	No. of Days of Measurable Precipitation
	January Mean °C (°F)	July Mean °C (°F)	Yearly Mean °C (°F)		
South Africa					
Durban	**24 (75)**	**17 (62)**	21 (69)	1016 (40)	84
Johannesburg	**20 (68)**	**11 (51)**	16 (61)	711 (28)	70
Cape Town	**21 (69)**	**12 (54)**	17 (62)	508 (20)	69
California					
San Diego	**13 (55)**	**20 (68)**	17 (62)	254 (10)	44
San Francisco	**10 (50)**	**15 (59)**	14 (57)	559 (22)	67
Minnesota					
Minneapolis	**-10 (14)**	**23 (73)**	7 (45)	737 (29)	108
Texas					
Dallas	**8 (46)**	**29 (84)**	19 (66)	940 (37)	85
Houston	**12 (53)**	**28 (83)**	21 (69)	1168 (46)	98
Washington					
Seattle	**4 (40)**	**18 (64)**	11 (52)	991 (39)	150
Spokane	**-2 (28)**	**21 (70)**	9 (49)	381 (15)	113

Source: Miscellaneous environmental atlases.

Summer

Winter

Appendix B
Typical Pavement Designs

INTRODUCTION

A request was sent to the four states and South Africa during January 2000 to provide flexible pavement structural designs for three ESAL levels (E80s):

- 40,000,000 ESALs: High traffic loading case
- 10,000,000 ESALs: Medium traffic loading case
- 500,000 ESALs: Low traffic loading case

They were asked to use a subgrade resilient modulus of 9,000 psi (62 MPa). [Note: This was interpreted as a CBR of approximately 5 to 7% for the South African design procedure.] This is the same subgrade resilient modulus value as used for NCHRP 1-32. Further, it was requested that the reliability level be clearly stated for each design. Additionally, if possible, they were also asked to design the pavement sections at normal agency reliability levels and with 50% reliability.

The selection of layer materials should be conventional in that unusual materials will complicate the job of comparing US and South African practices.

A summary of the results provided by the four state DOTs and South Africa follow in Tables B-1 and B-2.

An earlier summary based mostly on NCHRP 1-32 results for the four states was developed during July 1999. Those results include information on PCC pavements and are shown as Tables B-3, B-4, and B-5.

TABLE SUMMARIES

Tables B-1 through B-5 follow. Briefly, these are:

- Table B-1: Summary of flexible pavement structural designs prepared specifically for the RSA/US course (summarized February/March 2000).
- Table B-2: Summary of related flexible pavement design information prepared specifically for the RSA/US course (summarized February/March 2000).
- Table B-3: Major pavement design features from NCHRP 1-32 and survey of the four State DOTs (originally prepared July 1999).
- Table B-4: Typical rigid pavement designs from NCHRP 1-32 and survey of the four State DOTs (originally prepared July 1999).
- Table B-5: Typical flexible pavement designs from NCHRP 1-32 and survey of the four State DOTs (originally prepared July 1999).

Table B-1. Summary of Flexible Pavement Structural Designs.

Agency	Equivalent Axle Loads (80 kN)					
	500,000 E80s		10,000,000 E80s		40,000,000 E80s	
	Material Type and Specification	Thick. (mm)	Material Type and Specification	Thick. (mm)	Material Type and Specification	Thick. (mm)
California (No ATPB)	**AC** **Base** (AB, Class 2) **SB** (ASB, Class 2)	122 183 <u>213</u> 518	**AC** **Base** (AB, Class 2) **SB** (ASB, Class 2)	183 305 <u>351</u> 839	**AC** **Base** (AB, Class 2) **SB** (ASB, Class 2)	213 351 <u>427</u> 991
California (with ATPB)	**AC** **ATPB** **Base** (AB, Class 2) **SB** (ASB, Class 2)	107 46 152 <u>213</u> 518	**AC** **ATPB** **Base** (AB, Class 2) **SB** (ASB, Class 2)	183 46 244 <u>351</u> 824	**AC** **ATPB** **Base** (AB, Class 2) **SB** (ASB, Class 2)	198 46 320 <u>427</u> 991
Minnesota (Aggregate Base)	**AC** (LVWE35030C) **AC** (LVWE35030C) **Base** (Class 6 (3138)) **SB** (Class 3 (3138))	40 65 150 <u>410</u> 665	**AC** (SPWEB440F) **AC** (SPWEB440F) **AC** (SPNWB430B) **Base** (Class 6 (3138)) **SB** (Class 4 (3138)) **SB** (Class 3 (3138))	50 50 90 150 150 <u>410</u> 900	**AC** (SPWEB640F) **AC** (SPWEB640F) **AC** (SPNWB630B) **Base** (Class 6 (3138)) **SB** (Class 4 (3138)) **SB** (Class 3 (3138))	50 50 140 150 150 <u>360</u> 900
Minnesota (Deep Strength)	**AC** (LVWE35030C) **AC** (LVNW35030C) **AC** (LVNW35030B) **Base** (Class 5 (3138)) **SB** (SG (3149.2B2))	40 65 150 75 <u>150</u> 480	**AC** (SPWEB440F) **AC** (SPWEB440F) **AC** (SPNWB430B) **Base** (Class 5 (3138)) **SB** (SG (3149.2B2))	50 50 165 75 <u>560</u> 900	**AC** (SPWEB640F) **AC** (SPWEB640F) **AC** (SPNWB630B) **Base** (Class 5 (3138)) **SB** (SG (3149.2B2))	50 50 255 75 <u>470</u> 900
Texas	R = 90% **BST** (2 Course Surface Treatment, Item 316) **Base** (Flexible Base, Item 247) R = 80% **BST** (2 Course Surface Treatment, Item 316) **Base** (Flexible Base, Item 247)	 15 <u>300</u> 315 15 <u>250</u> 265	R = 95% **AC** (Type C Surface HMAC, Item 340) **AC** (Type B HMAC Base, Item 340) **Base** (Flexible Base, Item 247) **SB** (Lime Stabilized Subgrade, Item 260) R = 80% **AC** (Type C Surface HMAC, Item 340) **AC** (Type B HMAC Base, Item 340) **Base** (Flexible Base, Item 247) **SB** (Lime Stabilized Subgrade, Item 260)	 50 150 330 <u>200</u> 730 50 100 300 <u>200</u> 650	R = 95% **AC** (Type C Surface HMAC, Item 340) **AC** (Type B HMAC Base, Item 340) **CTB** (Cement Stab. Base, Item 276) **SB** (Lime Stabilized Subgrade, Item 260) R = 80% **AC** (Type C Surface HMAC, Item 340) **AC** (Type B HMAC Base, Item 340) **CTB** (Cement Stab. Base, Item 276) **SB** (Lime Stabilized Subgrade, Item 260)	 65 300 300 <u>200</u> 865 50 125 300 <u>200</u> 675
Washington	R = 50% **AC** **Base** (CSBC) R = 75% **AC** **Base** (CSBC)	75 <u>150</u> 225 100 <u>175</u> 275	R = 50% **AC** **Base** (CSTC) R = 85% **AC** **AC** (Base) **Base** (CSTC)	150 <u>250</u> 400 100 100 <u>225</u> 425	R = 50% **AC** **AC** (Base) **Base** (CSBC) R = 95% **AC** **AC** (Base) **Base** (CSBC)	100 125 <u>225</u> 450 100 175 <u>250</u> 525

Table B-1. Continued

Agency	Equivalent Axle Loads (80 kN)					
	500,000 E80s		10,000,000 E80s		40,000,000 E80s	
	Material Type and Specification	Thick. (mm)	Material Type and Specification	Thick. (mm)	Material Type and Specification	Thick. (mm)
South Africa	R = 80% **DBST** **Base** (G4) **SB** (G5) **Layers needed for minimum support** (G7)	≈15 125 150 <u>150</u> 440	R = 95% **AC** **Base** (G1) **SB** (C3) **Layers for minimum support** (G7)	50 150 250 <u>150</u> 600	R = 95% **AC** **Base** (G1) **SB** (C3) **Layers for minimum support** (G7)	50 150 300 <u>150</u> 650

Notes for Table B-1:

- General material type abbreviations
  - AC: Asphalt Concrete
  - BST: Bituminous Surface Treatment
  - Base: Unstabilized Granular Base Course
  - CTB: Cement Stabilized Base
  - SB: Unstabilized Granular Subbase Course
- California abbreviations
  - AB: Aggregate Base, Class 2
  - ASB: Aggregate Subbase, Class 2
  - ATPB: Asphalt Treated Permeable Base
- Minnesota abbreviations for Specification 2360
  - SP = Superpave
  - WE = Wearing Courses
  - NW = Non Wearing Courses
  - B = Max aggregate size 19.0 mm, 12.5 mm nominal
  - 6 = Traffic level 30 to 100 million E80s
  - 4 = Traffic level 3 to 10 million E80s
  - 30 = 3.0 % air voids
  - 40 = 4.0 % air voids
  - F = Binder PG 64-34
  - B = Binder PG 58-28
- Minnesota abbreviations for Specification 2350
  - LV = Low Volume
  - WE = Wearing Courses
  - NW = Non Wearing Courses
  - C = Max aggregate size 19.0 mm
  - 50 = Number of blows (Marshall)
  - 30 = 3.0 % air voids
  - C = Binder PG 58-34
  - B = Binder PG 58-28
- TxDOT: It is unclear whether the lime treated clay subgrade should be classified as a subbase. In Table B-1, it is described as a subbase layer.
- Washington State abbreviations
  - AC = Class A or Superpave 12.5 or 19.0 mm wearing course
  - AC (Base) = Class E hot mix
  - Base (CSBC) = Crushed Surfacing Base Course
- South Africa abbreviations
  - DBST: Double Bituminous Surface Treatment
  - **Layers needed for minimum support**:

Selected layer(s) used to increase in situ subgrade CBR to a minimum of 15%. For these designs, it is assumed that the in situ subgrade CBR is some 5 to 7%. If it can be reworked (ripped and compacted) to give a 150 mm layer of minimum CBR 15%, no other layers would be used. If this is not feasible, a 150 mm lower selected layer of minimum CBR 15% would be added after reworking the in situ subgrade.

  - **AC**: normally a continuously graded asphalt surfacing;
  - **G1**: graded crushed stone, max size 37.5 mm, achieving at least 86% of solid (bulk relative) density in situ;
  - **G2**: graded crushed stone (similar to G1) but to a slightly lower in situ density of at least 85% of solid (bulk relative) density or 100 to 102% mod. AASHTO;
  - **G4**: crushed or natural gravel, max size 37.5 mm, at least 80% CBR at 98% mod. AASHTO density;
  - **G5**: natural gravel, max size 63 mm or 2/3 of layer thickness, at least 45% CBR at 95% mod. AASHTO density;
  - **G7**: gravel or soil, , max size 2/3 of layer thickness, at least 15% CBR at 93% mod. AASHTO density;
  - **C3**: cemented natural gravel with a UCS in the range 1 to 3.5 MPa (145 to 508 psi) at 100% mod. AASHTO;
  - **C4**: cemented natural gravel with a UCS in the range 0.75 to 1.5 MPa (109 to 218 psi) at 100% mod. AASHTO.

Table B-2. Summary of Related Pavement Structural Design Data Submitted by the Four States and South Africa

Agency	Comments
California	• Design procedure: NEWCON90 (based on design by gravel equivalency) • Input values – Traffic Index (TI) = 8 (500,000 E80s), 12 (10,000,000 E80s), 14 (40,000,000 E80s) – R-value = 15 (subgrade soil) – R-value = 50 (Aggregate Subbase, Class 2) – R-value = 78 (Aggregate Base, Class 2)
Minnesota	• For 20 year E80s in the design lane greater than 7 million, the structure would be designed as a rigid pavement. • For 20 year E80s greater than 7 million, a partial frost-free design is required. This requires a minimum structural thickness of 900 mm. • For 20 year E80s less than 1 million, deep strength designs require 75 mm of Class 5, Aggregate Base, and a minimum of 150 mm of select granular material or better type of material. • Superpave AC mixes (Specification 2360) are used on all projects for which the 20-year design lane E80s exceed 3 million. • Mn/DOTs present flexible aggregate and deep strength pavement design procedures do not permit direct assessment of reliability levels. When compared to AASHTO 1993, the reliability levels are about 95% or greater.
Texas	• R = 80% is the lowest allowable flexible pavement reliability for the Texas Flexible Pavement Design System. • It is unlikely that a “flexible” structure would be built to accommodate 40 million E80s in Texas.
Washington State	• If the pavement is in a freeze-thaw location, the total pavement thickness should be increased to a minimum of ½ the expected depth of freeze. • By policy, the reliability levels for the three E80 levels are: – 500,000: 75% – 10,000,000: 85% – 40,000,000: 95%

South Africa	• Designs shown in Table 1 were obtained from TRH 4 (1996 version). • For “wet” conditions, which in South Africa is defined by a climatic index (Weinert N value) and broadly covers the eastern side encompassing KwaZulu Natal extending down to Port Elizabeth and up through parts of Mpumalanga, the following should be noted: – For the lightest pavement, the minimum base quality would be increased from G4 to G2, with a thickness increase from 125 to 150 mm. – For the 10 million E80 design, the cemented subbase would be increased from 250 mm to 300 or 400 mm, depending on how well protected the base is from water ingress (a judgment call). • In the TRH4 catalogue, there is no design for a granular base pavement design for wet regions for traffic loading above 30 million E80s. The only other design suggestion for this traffic class would use a hot-mix asphalt base (50 mm AC: 180 mm asphalt base: 450 mm C3 cemented subbase, with subgrade preparation/selected layers as indicated above) • For the design traffic loading calculation, the recommended damage exponent for these pavements is 3 not 4. For most practical cases this will convert a real axle load spectrum to a lower E80 value than using AASHO road test derived factors/n=4 or 4.2.

Table B-3. Major Pavement Design Features (Source: NCHRP 1-32)

Feature	State			
	California	Minnesota	Texas	Washington
Flexible				
Thickness Design	State Procedure (Gravel Equiv)	State Procedure	State Procedure (FPS)	AASHTO 93
Design Process	Manual	Manual	Computer Software	DARWin/State Computer Software
Design Period	20 years	20 years	20-30 years	40 years if ESALs > 100000/year; 20 years if less
Life Cycle Cost Analysis Period	35 years	35 years	Same as Design Period	40 years
Traffic	Traffic Index	ESALs	ESALs	ESALs
Subgrade Strength Design Parameter	R-value (Lab)	R-value (Correlation)	Triaxial Class, Deflections (Lab, Field)	M_R (Lab, FWD Deflections)
Rigid				
Thickness Design	State Procedure	AASHTO 72	AASHTO 93	AASHTO 93
Design Process	Manual	Typical Sections	DARWin	DARWin
Design Period	20 years	35 years	30 years	40 years
Life Cycle Cost Analysis Period	35 years	35 years	Same as Design Period	40 years
Types of PCC Pavement	JPCP	JPCP/JRCP	JPCP/JRCP/ CRCP (80%+)	JPCP
Subgrade Strength Design Parameter	R-value (Lab)	k-value (Correlation with other tests)	k-value	k-value (Correlation)
PCC Base Types (Current)	ATPB, CTPB, LCB, ACB	AGG, AGGPB	ACB or ACB/CSB (Non-erodible)	ACB, ATPB
Contraction Joint Design	12’-15’-13’-14’ No Dowels (Practice changing)	13’-16’-14’-17’ or 20’ Dowel Dia 1.00”-1.25”, Grade 40, 60	15’ Dowel Dia = $D_{slab}/8$ Grade 60	15’ Dowel Dia 1.5” Grade 60

Table B-4. Typical Rigid Pavement Designs (Source: NCHRP 1-32)

Feature	State			
	California	Minnesota	Texas	Washington
Slab Thickness				
2.5 million ESALs	8.4”	7.0”	8.0”	8.0”
7.5 million ESALs	9.0”	7.5”	10.0”	8.5”
30.0 million ESALs	10.2”	10.0”	15.0”@ R=99.9 13.0”@ R=95.0	10.5”

Notes

- **California**: Several base options available including ATPB/AGG, CTPB/AGG, and LCB/ACB. The contraction joints have no dowels (aggregate interlock). The k-value is 300 pci. The contraction joint spacing is 12’-15’-13’-14’
- **Minnesota**: Slab thicknesses assume a k = 300 pci and includes either a widened lane (14’) or tied PCC shoulders. Contraction joints include dowels (1.0” diameter for the 7.0 to 7.5” thick slabs; 1.25” diameter dowels for the 10.0” thick slab). The joint spacing is 13’-16’-14’-17’
- **Texas**: The joint transfer value is J = 3.2 (AASHTO), rainfall 30”-38”, Shoulder Type II (not tied). The stated reliabilities are 95% for the 8.0” and 10.0” thick slabs and 99.9% for the 15.0” thick slab. The k-value is 300 pci. The contraction joint spacing is 15’
- **Washington**: The slab thicknesses shown are for a reliability level of 95%. The composite k-value is 400 pci (the only value listed for Washington in NCHRP 1-32 and the WSDOT Pavement Guide). All contraction joints spaced at 15’ with 1.5” diameter dowels.

Table B-5. Typical Flexible Pavement Designs (Source: NCHRP 1-32)

Feature	State			
	California	Minnesota	Texas	Washington
Layer Thicknesses				
1.7 million ESALs	5.4"AC/6.6" Agg Base/ 13.8" Subbase	9.0"AC/3.0" Agg Base/ 18.0" Subbase	7.3"AC/6.0" Improved Subgrade	8.0"AC/3.5" Agg Base
5.0 million ESALs	6.6"AC/7.2" Agg Base/ 16.8" Subbase	10.5"AC/3.0" Agg Base/ 17.0" Subbase	9.1"AC/6.0" Improved Subgrade	10.0"AC/3.5" Agg Base
20.0 million ESALs	7.8"AC/8.4" Agg Base/ 19.8" Subbase	12.0"AC/3.0" Agg Base/ 15.0" Subbase	18.5"AC/6.0" Improved Subgrade	11.0"AC/5.5" Agg Base

Notes

- All states used a subgrade resilient modulus of 9,000 psi.
- Several types of designs were summarized in NCHRP 1-32 but used asphalt stabilized (hot-mix) bases to extent possible in generating Table B-5. **California** did not present that specific type of base course design option. For California, used design with aggregate base (unstabilized).
- **Minnesota**: Includes additional subbase thickness for frost design.
- **Texas**: Reliability levels stated to be 95% for ESAL levels 1.7 and 5.0 million and 99.9% for ESALs of 20 million.
- **Washington**: Reliability levels stated to be 75% for 1.7 million ESALs, 85% for 5.0 million ESALs, and 95% for 20 million ESALs.

Appendix C
Pavement Material Comparisons

INTRODUCTION

This module will be used to illustrate some of the similarities and differences associated with materials used in the four states and South Africa. The first comparison will be for unstabilized base courses. Separate tables are presented for gradation, compaction, and miscellaneous requirements.

The specific request to the four states was as follows:

“Please list the following items relating to flexible pavement materials specifications (a typical, widely used class or type will be fine—no need to list all types or classes of a material type):

- Material type
  - Asphalt Concrete (AC)
  - Bituminous Surface Treatment (BST)
  - Asphalt Treated Base (ATB)
  - Cement Treated Base (CTB)
  - Unstabilized base course material
  - Unstabilized subbase course material
- Gradation bands and a typical gradation
- Compaction requirement and the standard test method used to measure density (such as AASHTO T-180 or AASHTO T-99 for unstabilized materials)
- Strength or stiffness requirement
- If a stabilized material, please provide a typical binder content or binder content range (percent by weight of total mix). This is important for AC, ATB, and CTB. For AC, please note the current mix design method and target field air void range.
- As appropriate for a specific material
  - Los Angeles Wear
  - Percent crushed aggregate in the unstabilized base or subbase materials.
- Other significant requirements used by a State DOT.”

SPECIFICATION SECTION SUMMARY

CALTRANS

Material Type	Caltrans Standard Specification Section
Asphalt Concrete – Type A – Type B	39
Seal Coats – Coarse – Medium – Medium Fine – Fine	37
Treated Permeable Base – Asphalt TPB – Cement TPB	29
Cement Treated Bases – Class A – Class B	27
Aggregate Bases – Class 2 – Class 3	26
Aggregate Subbases – Class 1 – Class 2 – Class 3	25

TxDOT

Material Type	Specification Identifier
Asphalt Concrete – Type C Surface Course – Type B HMAC Base	Special Specification 3117 Item 340
Bituminous Surface Treatment – Two Course	Item 316
Cement Stabilized Base (Plant Mixed)	Item 276
Flexible Base Grade 1, Type A	Item 247
Lime Stabilized Subgrade (Road Mixed)	Item 260

WSDOT

The WSDOT Standard Specifications and Materials Manual (for testing) can be located at the Online Publications in the WSDOT web site:

(http://www.wsdot.wa.gov/fasc/EngineeringPublications/)

Material Type	WSDOT Standard Specification Section
Asphalt Concrete, Class A	5-04, 9-02, 9-03
Asphalt Concrete, Superpave	See attached
Asphalt Concrete Base (Class E)	5-04, 9-02, 9-04
Bituminous Surface Treatment	5-02, 9-02, 9-03
Asphalt Treated Base	4-06, 9-02, 9-04
Cement Treated Base	N/A
Unstabilized base course	4-04, 9-03
Unstabilized subbase course	N/A

TxDOT CEMENT STABILIZED BASE

Material Type	Strength Requirements
Cement Stabilized Base (Plant Mixed), Item 276	Strength categories: • L: 5170 kPa (750 psi); 4-9% cement • M: 3450 kPa (500 psi); 3-9% cement • N: As shown on project plans

SUMMARY FOR UNSTABILIZED BASE MATERIALS

Tables C-1 through C-3 are used to summarize the results received from the four states and South Africa with respect to various specification requirements for unstabilized base material.

Table C-1. Gradation Requirements for Unstabilized Base Course Materials

Sieve Size (mm)	California Class 2		Minnesota		Texas Flexible Base Grade 1 Type A	Washington State		South Africa/CSRA	
	37.5 mm	19.0 mm	Class 6	Class 5		CSTC	CSBC	Nominal Size 37.5 mm	Nominal Size 26.5 mm
50.0	100								
45.0					100				
37.5	90-100							100	100
31.5							100		
26.5								84-94	100
25.0		100	100	100					
22.4					65-90				
19.0	50-85	90-100	90-100	90-100		100		71-84	85-95
16.0							50-80		
13.2								59-75	71-84
9.5			50-85	50-90	50-70				
6.3						55-75	30-50		
4.75	25-45	35-60	35-70	35-80	35-55			36-53	42-60
2.00			20-55	20-65				23-40	27-45
0.600	10-25	10-30							
0.425			10-30	10-35	15-30	8-24	3-18	11-24	13-27
0.075	2-9	2-9	3-7	3-10		10.0 max	7.5 max	4-12	5-12

Notes

- Reference to specific specification
  - California DOT: Section 26, Aggregate Bases
  - Minnesota DOT: Specification 3138
  - Texas DOT:
  - Washington State DOT: Standard Specifications, Section 9-03.9(3)
  - South Africa/CSRA: Specification 3600.
- WSDOT CSTC: Crushed Surfacing Top Course
- WSDOT CSBC: Crushed Surfacing Base Course
- CSRA materials are for crushed stone only.

Table C-2. Compaction Requirements for Unstabilized Base Course Materials

Agency	Compaction Requirement
California	≥ 95% of California Test Method No. 216 (the compaction energy for that test falls between AASHTO T-99 and AASHTO T-180; see Appendix A)
Minnesota	Compacted in accordance with AASHTO T-99
Texas	Compaction: Density control, 100%
Washington State	≥ 95% of WSDOT Test Method No. 606 or AASHTO T-180
South Africa/CSRA	G1Base: 86 or 88% of apparent density (88% of apparent density ≅ 108% of AASHTO T-180) G2 Base: 100 or 102% of AASHTO T-180

Notes: Reference to specific specification

- California DOT: Refer to Appendix A for additional information on California Test Method No. 216.
- Minnesota DOT: Specification 3138
- Texas DOT: Item 247, Grade 1, Type A
- Washington State DOT: Standard Specifications, Section 4-04.3(5)

Table C-3. Other Requirements for Unstabilized Base Course Materials

Agency	Atterberg Limits			LA Abrasion	% Fracture	Sand Equivalent
	Liquid Limit	Plasticity Index	Linear Shrinkage			
California						
Class 2						25 min
Minnesota						
Class 6						
Class5				40% max		
Texas						
	35 max	10 max				
Washington State						
CSTC				35% max	75% min	32 min
CSBC				35% max	75% min	32 min
SA/CSRA						
G1	25 max	4 max	2% max			
G2	25 max	6 max	3% max			

Note: All agencies have various specification requirements. Those shown in Table C-3 are only a selection of the more recognizable ones.

California

- Minimum R-value = 78
- Durability Index = 35 min

Texas

- Wet Ball Mill = 40 max
- Minimum compressive strengths specified (310 kPa at 0 kPa lateral pressure and 1206kPa at 103 kPa lateral pressure).

SUMMARY FOR ASPHALT CONCRETE MATERIALS

Tables C-4 through C-7 are used to summarize the results received from the four states and South Africa with respect to various specification requirements for asphalt concrete materials.

Table C-4. Gradation Requirements for Asphalt Concrete Materials—California, Minnesota, and South Africa/CSRA

Sieve Size (mm)	California		Minnesota		Minnesota		South Africa/CSRA	
	A	B	2360 (Superpave)	Typical Gradation	Spec 2350	Typical Gradation	37.5 mm max	26.5 mm max
37.5							100	
31.5								
26.5							84-94	100
25.0	100	100		100				
19.0	90-100	95-100	100 min	100	100	100	71-84	85-95
16.0								
13.2								71-86
12.5			90-100	97	90-100	95		
9.5	60-75	65-80	90 max	85	35-90	80	50-67	62-78
6.3								
4.75	45-50	49-54		59	20-80	60	36-53	42-60
2.36	32-36	36-40	28-58	42	15-65	50	25-42	30-48
1.180							17-34	22-38
0.600	15-18	18-21						16-28
0.425								
0.300							10-22	12-20
0.150								8-15
0.075	3-7	3-8	2-8	5	2-7	3	5-12	5-10

Notes: Reference to specific specifications

- California DOT
  - Type A: 19.0 mm max, coarse grading
  - Type B: 19.0 mm max, medium grading
  - Other max aggregate sizes for Types A and B (however, 19.0 mm is most commonly used)
    - 12.5 mm
    - 9.5 mm
    - 4.75 mm
- Minnesota DOT: Specifications 2360 and 2350
- South African/CSRA: Specification 4200. Continuously graded AC.

Table C-5. Gradation Requirements for Asphalt Concrete Materials—Texas and South Africa/CSRA

Sieve Size (mm)	Texas		Texas		South Africa/CSRA	
	Type C Surface Course	Typical Gradation	Type B HMAC Base	Typical Gradation	37.5 mm max	26.5 mm max
37.5					100	
31.5						
26.5					84-94	100
25.0	100		98-100			
22.4	98-100		95-100			
19.0					71-84	85-95
16.0	95-100		75-95			
13.2						71-86
12.5						
9.5	70-85		60-80		50-67	62-78
6.3						
4.75	43-63		40-60		36-53	42-60
2.36					25-42	30-48
2.00	30-40		27-40			
1.180					17-34	22-38
0.600						16-28
0.425	10-25		10-25			
0.300					10-22	12-20
0.180	3-13		3-13			
0.150						8-15
0.075	1-6		1-6		5-12	5-10

Notes: Reference to specific specifications

- Texas DOT: Item 340.
- South African/CSRA: Specification 4200. Continuously graded AC.

Table C-6. Gradation Requirements for Asphalt Concrete Materials—Washington State, South Africa/CSRA

Sieve Size (mm)	Washington State		Washington State		Washington State		South Africa/CSRA	
	Class A	Typical Gradation	19.0 mm Superpave	Typical Gradation	12.5 mm Superpave	Typical Gradation	37.5 mm max	26.5 mm max
37.5							100	
31.5								
26.5							84-94	100
25.0			100					
19.0	100		90-100		100		71-84	85-95
16.0								
13.2								71-86
12.5	90-100		90 max		90-100			
9.5	75-90				90 max		50-67	62-78
6.3	55-75							
4.75							36-53	42-60
2.36			23-49		28-58		25-42	30-48
2.00	30-42							
1.180							17-34	22-38
0.600								16-28
0.425	11-24							
0.300							10-22	12-20
0.150								8-15
0.075	3-7		2-7		2-7		5-12	5-10

Notes: Reference to specific specifications

- Washington State DOT: Standard Specifications, Section 9-03.8 and General Special Provision for Superpave contained in Appendix B. Superpave gradations termed "control points."
- South African/CSRA: Specification 4200. Continuously graded AC.

Table C-7. Other Requirements for Asphalt Concrete Materials

Agency	Required Field Density %Gmm	Stability or Stab. Value	Percent Design Air Voids	LA Abrasion	% Fracture	Sand Equivalent
California						
Types A and B	89 to 91% (See Note 3)	A: 37 min B: 35 min	4.0	A: ≤ 45% B: ≤ 50%	A: 90% min B: 25% min (for particles retained on 4.75 mm)	A: 47 min B: 42 min
Minnesota						
2360	92% if < 100 mm from surface			< 40%	One fractured face on 85 to 100%[1]	45-60[1]
2350	91%	5 kN min		< 40%		
Texas						
Type C and Type B (See Note 4)	Target field air void content 5-6%		4.0%			
Washington State						
Class A	91-92%	37 min	2-4.5	≤ 30%	One fractured face on 90% of matl retained on 2.00 mm and above.	37 min
Superpave 12.5 & 19.0 mm	91-92%	-	4.0	≤ 30%	Same as Class A	37 min
SA/CSRA						
37.5 mm	≥ 97 – voids in approved production mix (Note 5)	8-12 kN	4.0	Note 2	Note 2	35 min
26.5 mm	≥ 97 – voids in approved production mix (Note 5)	8-12 kN	4.0	Note 2	Note 2	35 min

- General Note: All agencies have various specification requirements. Those shown in Table C-7 are only a selection of the more recognizable ones.
- Note 1: Minnesota Fractured Faces and Sand Equivalent values depend on traffic level.
- Note 2: The South African/CSRA specification has requirements for Resistance to Crushing, Shape of Aggregate, Polishing, and Absorption.
- Note 3: Specification requirement for compaction is 95 to 96% of LTMD (density under standard kneading compaction at the design asphalt content). This translates to about 89 to 91% of Gmm (or 11 to 9% air voids).
- Note 4: Type C requires %VMA = 13 (min). Type B requires %VMA = 12 (min).
- Note 5: Determined as a percentage of theoretical maximum density in accordance with the Rice method.

APPENDIX C.1
CALIFORNIA STANDARD TEST METHOD NO. 216

The California compaction specification for untreated and treated soils and aggregates is described in the Standard Test Method No. 216. The test method described in Cal 216 is a laboratory compaction test based on wet density rather than dry density as in the AASTHO compaction methods. Field compaction is controlled by monitoring the relative compaction. Relative compaction is defined as "the ratio of the in-place wet density of a soil or aggregate to the test maximum wet density of the same soil or aggregate when compacted by a specific test method."

The test method used to determine the maximum wet density in the laboratory uses the California Impact Compaction Apparatus, which is different from the AASHTO compaction apparatus. The California Compaction Apparatus is composed of a split cylindrical mold (91.5 cm (36in.) high), and a 4.54 kg (10lb) tamper composed of a metal piston and a graduated handling rod. About 2300 to 2700 grams of wet soil are compacted in the mold in five layers. Each layer is compacted with 20 blows of the tamper dropping free from a height of 45.7 cm (18in.). After compacting the fifth layer, the graduated tamper shaft is read at a point level with the top of the mold. With the tamper reading and the weight of the wet soil compacted, wet density in grams per cubic centimeter is determined from Table 1 in the California Test Method No. 216. Note that the California compaction test method does not required trimming of the compacted soil to a specific volume like in the AASHTO Test Methods.

The following table summarizes compaction characteristics to compute the compaction energy of California 216 and AASHTO methods.

Characteristic	CAL 216	AASHTO T-99	AASHTO T-180
Hammer Wt (N)	44.5	24.5	44.5
Drop Height (m)	0.457	0.305	0.457
No. Layers	5	3	5
Blows/Layer	20	25	25
Mold Volume (m^3)	$10.54x10^{-4}$ $12.64x10^{-4}$ Varies depending on amount of soil compacted and type of soil.	$9.4x10^{-4}$	$9.4x10^{-4}$
Compaction Energy ($kN\text{-}m/m^3$)	1929 1608	596	2704

Compaction Energy is determined as:

$$CE = \frac{HammerWeight \times DropHeight \times \# Layers \times Blows / Layer}{MoldVolume}$$

Note that the compaction effort of California Test No. 216 is between AASHTO Test Methods T-99 and T-180.

REFERENCES

Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates, California Test 216, Standard Test Methods, Volume 1: Testing and Control Procedures, Third Edition, State of California, Department of Transportation, 1978.

The summary of the California test method contained in the Appendix was provided by Manuel Bajarano, Pavement Research Center, University of California at Berkeley.

Appendix D
State DOT Media Questions
Summary of Responses/February 2000

INTRODUCTION

Questions concerning State DOT media capabilities and Internet access were sent to the California, Minnesota, Texas, and Washington State DOTs following the Four State Pavement Consortium meeting held on January 26-28, 2000. The purpose is to better understand communication and streaming media potential for the four states. Responses were submitted by Christopher Colon (Caltrans), Gerry Rohrbach (Mn/DOT), Mark Filip (TxDOT), and Marty Pietz (WSDOT). Some of the abbreviations used in the responses are defined at the end of this document.

1. Do you do currently conduct remote meetings?
   - Satellite-based video conferencing?
   - Internet-based video conferencing?
   - Other type of video conferencing?

State DOT	Response
California	• **Satellite-based video conferencing?** Caltrans has satellite-based video conferencing with dedicated video conferencing rooms. • **Internet-based video conferencing?** Caltrans is currently testing Internet-based video conferencing for the desktop using the H323 IP network protocol. Caltrans was testing an intranet-based video-conferencing product but the manufacturer removed the product from the market. • **Other type of video conferencing?** Caltrans has a dedicated T1 line wired to approximately twenty rooms using H320 protocol. Caltrans also has three sites using the ISDN protocol.
Minnesota	• The Office of Materials and Road Research does conduct remote meetings via Internet-based video conferencing
Texas	• No
Washington State	• **Satellite-based video conferencing**: Yes, but long lead-times required to schedule, and significant marginal cost is involved. • **Internet-based video conferencing**. WSDOT is using NetMeeting for internet-based videoconferencing on a very small scale in a few offices; some of these existing uses do not use the video features.

2. Please describe the type of Internet connection available at your DOT.
   - Browser? Do you have to use a specific browser and version? Is the choice up to the individual user?
   - Internet connection speed? Alternatively, how is the DOT connected to the Internet (56K modem, T1 line, DSL, cable, other)?
   - Firewalls? Do they exist and will they be a problem for applications such as streaming media? [Note: Firewalls are generally assumed an issue but technology exists to deal with them.]
   - Connection hardware. Do you typically use PC or Apple computers?

State DOT	Response
California	**Browser? Do you have to use a specific browser and version? Is the choice up to the individual user?** Caltrans has a mixture of Netscape Navigator and Internet Explorer as per individual users preferences. Internet connection speed? Alternatively, how is the DOT connected to the **Internet (56K modem, T1 line, DSL, cable, other)?** Caltrans is predominately connected to the internet through a T1 line at a speed of 384Kbps. There is also some ISDN connections at speeds of 64Kbps, 128Kbps, and 264Kbps. **Firewalls? Do they exist and will they be a problem for applications such as streaming media? [Note: Firewalls are generally assumed an issue but technology exists to deal with them.]** Firewalls do exist at Caltrans but will not present a problem for streaming media applications. **Connection hardware. Do you typically use PC or Apple computers?** Caltrans has a computer hardware complement consisting of approximately 90% PC and 10% Apple.
Minnesota	The Office of Materials and Road Research video conferencing equipment is connected to the Internet via MN/DOT's Wide Area Network (WAN). The connection is an ATM based network with dedicated routers and switches to handle the streaming audio and video. • The users have the choice of either Microsoft Internet Explorer or Netscape Navigator – the IT staff recommends Microsoft Internet Explorer. • The video conferencing connection is a dedicated T1 line. • MN/DOT has a Firewall in place. Ports can be opened to allow streaming audio and video. • The Office of Materials and Road Research uses PC based computers.
Texas	• Browser: Netscape 4.61 • Internet speed: T1 most locations • Firewalls: Yes, TxDOT employs firewalls • We are a PC based organization.
Washington State	• Netscape 4.x and Explorer 4.x are standard browsers; the WSDOT network is primarily a T1 backbone. Internet access is then via the Washington State Department of Information Services (DIS), and WSDOT has a 10 Mb fiber connection to DIS. • WSDOT has its own firewall, there are no know problems associated with streaming video through the firewall. • Connection hardware. WSDOT is nearly all PC; the few remaining Apples are being phased out.

3. To do streaming media, a downloadable player is required. Typically, there are three format types—RealNetworks media (RealAudio and/or RealVideo), Microsoft Media Player, or Apple QuickTime. Do you use a specific format or is the choice optional within the DOT?

State DOT	Response
California	Caltrans predominately uses RealNetworks G2 for streaming media with some use of IP TV (Internet MPEG based).
Minnesota	The Office of Materials and Road Research uses RealNetworks.
Texas	No specific streaming media player has been chosen by TxDOT.
Washington State	WSDOT uses the RealMedia player. Exceptions are possible.

4. This question is directed at the operating system typically used within the DOT. Is the operation system Windows 95, Windows 98, Windows NT, or Windows 2000? If the typical hardware is Apple, then some version of OS is used. If so, which one?

State DOT	Response
California	Caltrans has a smorgasbord of all the above stated operating systems and many varying versions of the same.
Minnesota	The Office of Materials and Road Research uses Windows NT.
Texas	TxDOT uses Windows NT 4.0, Windows 95 and a few Windows 98 OS's.
Washington State	WSDOT uses Windows NT, in all workstations. Laptops have either Windows 95 or 98 installed. Plans are to move the workstations to Windows 2000.

5. Does your DOT currently have a group that encodes streaming media (encoding is the process of compressing the files for use on a server)? If yes, where are they located with the DOT organization?

State DOT	Response
California	Caltrans encodes streaming media using a G2 codec and the personnel are located at headquarters.
Minnesota	The Office of Materials and Road Research does not have a group that currently encodes streaming media.
Texas	TxDOT currently does not use streaming media, so the question is not applicable.
Washington State	WSDOT HQ Design Office has done some (very little to date) of this, using RealMedia.

6. What limitations or approvals are needed to change software/hardware in order to conduct remote meetings and use streaming media?

State DOT	Response
California	Information Systems and Service Center (ISSC) is the focal point to put anything on the Caltrans network.
Minnesota	The IT staff at The Office of Materials and Road Research will assist/approve any software/hardware upgrades to PCs or network equipment.
Texas	Approval would need to be made through our Information Services Department (ISD), which would be a major undertaking.
Washington State	Network impact is a concern and is evaluated. Budget issues can be a limitation. Workstation requirements and impact is also an issue. WSDOT has an ITB (Information Technology Board) consisting of WSDOT executive staff and an ITC (Information Technology Committee) consisting of representatives from throughout the department. These committees address IT issues and set IT direction and standards at a departmental level.

7. Are there specific groups within your DOT that are champions for using technology for conducting remote meetings or Internet-based conferencing and training? If yes, what parts of the organization are they located?

State DOT	Response
California	The ISSC group performs all networked technology and is located at Caltrans headquarters.
Minnesota	The IT group, including the Office of Materials and Road Research's IT division, strongly believes in technology for conducting remote meetings.
Texas	The respondent was unaware of such groups within TxDOT, although they may exist.
Washington State	WSDOT Traffic Systems Management Center (TSMC) would like to stream traffic camera images (an improvement over their current static images) via their web page to the Public. WSDOT Design and CAE Offices also want to use the technology. WSDOT's Staff Development Office offers some Internet-based training, and could make use of this technology. The LTAP Center, under Dan Sunde in the Roadways and Local Programs Service Center are also interested, not to mention the Materials Office and the Research Office.

8. Other comments that would be useful to the consortium concerning Internet-based media applications in your DOT.

State DOT	Response
California	None
Minnesota	None
Texas	TxDOT has occasionally had users express interest in streaming video for conferencing but ISD has not been enthusiastic about the additional bandwidth required.
Washington State	• TCP/IP: All new internet-based applications need to be compliant with this protocol. • Use only those applications that are reputable in industry standards or best of industry leaders. • The limitations of the existing infrastructure would be the only prohibitive factors. Fiber optics will be here in a couple of years, and then will provide many new opportunities.

DEFINITIONS OF SELECTED TERMS

Definitions for a selection of terms used in the state responses was obtained from http://www.mminternet.com/dsl/glossary.htm and "The Whole Internet—The Next Generation" by Conner-Sax and Krol, O'Reilly and Co, 1999.

- **ATM**. Asynchronous Transfer Mode. A protocol that packs digital information into 53-byte cells (5-byte header and 48-byte payload) that are switched throughout a network over virtual circuits.
- **Bandwidth**. This is a reflection of the size or the capacity of a given transmission channel. In digital transmission, bandwidth is normally described in bits per second.
- **DSL**. Digital Subscriber Line. A general term for any local network loop that is digital in nature.
- **H323**. An international standard that allows for seamless electronic conferencing (desktop conferencing and collaboration). Software conforming to this standard should be able to communicate with any other so configured software.
- **HTTP**. Hypertext Transfer Protocol. This protocol allows for the transfer of web pages between a web server and a PC browser.
- **Integrated Services Digital Network** (ISDN). ISDN provides standard interfaces for digital communications networks and is capable of carrying data, voice, and video over digital circuits.
- **Kbps, Gbps, Mbps**
    - **Kilobits per second** (Kbps). A measure of bandwidth capacity or transmission speed. It represents a thousand bits per second.
    - **Gigabits per second** (Gbps). A measure of bandwidth capacity or transmission speed. It represents a billion bits per second.
    - **Megabits per second** (Mbps). A measure of bandwidth capacity or transmission speed. It stands for a million bits per second.

- **Local Area Network** (LAN). A data communications network covering a small area, usually within the confines of a building or floors within a building; a relatively high-speed computer communications network for in-building data transfer and applications.
- **T1**. A digital transmission link with a capacity of 1.544 Mbps. T1 uses two pairs of normal twisted wires, the same as found in most residences. T1 normally handles 24 voice conversations, each one digitized at 64 Kbps. However, with more advanced digital voice encoding techniques, it can handle more voice channels. T1 is a standard for digital transmission in the United States. T1 lines are used to connect networks across remote distances. There are faster services available.
- **Transmission Control Protocol/Internet Protocol** (TCP/IP). The TCP/IP protocol is a networking protocol that provides communication across interconnected networks, between computers with diverse hardware architectures and various operating systems. TCP (Transmission Control Protocol) and IP (Internet Protocol) are only two protocols in the family of Internet protocols. Over time, however, "TCP/IP" has been used in industry to denote the family of common Internet protocols.