Task Order #02 Report

CONCRETE PAVEMENT ROAD MAP

for the period of

Prepared by the Road Map Operations Support Group
National Concrete Pavement Technology Center
Iowa State University
This report details the activities involved with Task Order #2 to initiate the CP Road Map. Task Order #2 provided for initial action steps in the Concrete Pavement Road Map through the formation and action by the priority track leadership groups. This report identifies the activities of the Executive Committee and the priority track leadership groups through meeting minutes and framework documents. The overall form of the report will follow the outline format of the Task Order.

Task A: Support Executive Committee

September 11, 2007
The fall meeting for Executive Committee was held in Chicago, Illinois. The administrative support team planned, scheduled, and arranged travel and facilitated the discussions for the meeting. The team prepared the agenda, presentations, and handouts for the meeting. These documents included the action plan and collaboration agreement which were discussed with the committee.

Major items of activity during the meeting included the following:
- Election of Kirk Steudle as Chair and Jim Duit as Vice Chair
- Development of an action plan
- Direction to proceed with a FHWA-led pooled fund for Road Map administrative funding
- Development of a separate track for the environmental/sustainability projects
- Continuing with overlays as a priority within Track #7, and not designating it as a separate track

The full minutes are included in the Appendix A.

July 9, 2008
Due to the difficulty of arranging a face-to-face meeting, a conference call was held to update the Executive Committee and to get their input. Major discussion items included the following:
- A report on the pooled fund solicitation indicating that only four states had committed at that time.
- Coordination work was underway to establish a workshop at TRB in January 2009.
- Input was received on the work elements that should be included in the next Task Order.
- The Committee directed an update to the Operations Manual that would provide for membership on the Committee by the participants in the pooled fund and also to indicate that the group would meet face-to-face one time per year with other meetings via conference call or webcast. See Appendix B.
- The committee recommended that FHWA tie the research requests they receive to the Road Map and that FALCON teams should use the Road Map to prioritize their projects.

The full minutes are included in the Appendix C.
Task B: Support Research Track Teams

The Task Order identified four priority tracks that were to be initiated. In addition, the Executive Committee was to review the Business Track. The four initial priority tracks included the following:

1. Performance-based concrete pavement mix design and analysis
2. Performance-based design guide for new and rehabilitated concrete pavements
3. High-speed nondestructive testing and intelligent construction systems
4. Optimized surface characteristics for safe, quiet, and smooth concrete pavements

Each track was to have a Leadership Group identified and the initial track meeting held to establish priority projects for research to recommend to the Executive Committee. The CP Tech Center was to facilitate the meeting and provide minutes.

The CP Tech Center was also charged with assembling a recommendation as to whether a new environmental/sustainability track should be added. As noted in the Executive Committee information above, a Sustainability Track was added by the Executive Committee in September of 2007.

In addition, the Executive Committee directed that the CP Tech Center place an emphasis on Concrete Pavement Overlays, which is a subtrack of Track #7: High-Speed Concrete Pavement Rehabilitation and Construction.

As a means of coordinating activities and work assignments, each priority track was assigned a coordinator and a subject matter expert. The table below identifies the team members’ assignments.

<table>
<thead>
<tr>
<th>Track</th>
<th>Subject Matter Expert</th>
<th>Coordinator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mix</td>
<td>Peter Taylor</td>
<td>Peter Taylor, Dale Harrington</td>
</tr>
<tr>
<td>2. Design</td>
<td>Jag Mallela</td>
<td>Ted Ferragut</td>
</tr>
<tr>
<td>3. NDT/ITS</td>
<td>Rob Rasmussen</td>
<td>Ted Ferragut</td>
</tr>
<tr>
<td>4. SC</td>
<td>Rob Rasmussen</td>
<td>Paul Wiegand</td>
</tr>
<tr>
<td>7. Overlays</td>
<td>Dale Harrington</td>
<td>Dale Harrington</td>
</tr>
<tr>
<td>11. Business</td>
<td>Ted Ferragut</td>
<td>Tom Cackler</td>
</tr>
<tr>
<td>13. Sustainability</td>
<td>Peter Taylor, Tom VanDam</td>
<td>Dale Harrington, Peter Taylor</td>
</tr>
</tbody>
</table>

The progress for each track is discussed separately below.

1. Track #1: Performance-Based Concrete Pavement Mix Design and Analysis. The Mix Track committee met on September 25–27, 2007, in Des Moines, Iowa. The sequence of work was rearranged so that developing a framework for work is to be done first. The second project is due to proceed under industry guidance and financing with input from a TAC set up through NCC. FHWA is continuing its activities toward the fourth subtrack on modeling.
Framework for Mixture Design System Development and Integration is as follows:

- Design and Control of Concrete Pavement Mixtures Manual
- Evaluation of Emerging Laboratory Equipment and Test Procedures
- Modeling – State of the Practice and Future Advancements
- Implementation and Outreach
- Mixture Test and Analysis Manual

The group was very supportive of the concepts behind the mix track. A work statement is being prepared for submission as a Pooled Fund request with Kansas agreeing to be the lead state.

A presentation was made at the Atlanta Concrete Pavement Technology Program (CPTP) conference in November 2007 on the software progress, software needs to be developed to link with testing. Feedback from participants in Atlanta indicated that there was a strong need for specifications that are tied with the goals of the track. A pooled fund work statement has been posted on the TPF website. To date, 5 states have committed $220,000.

A track Leadership Team meeting was held on June 4–5, 2008, in Ames, Iowa. The main focus of the meeting was to identify projects. Further discussions were held at the National Concrete Consortium (NCC) in Bloomington, MN, in September 2008. Specific emphasis was placed on calorimetry at that meeting.

Work has been started by PCA/ACPA on the publication, “Design and Control of Concrete Mixtures for Pavements.” It is planned to publish the volume in spring 2009.

The track framework document is included in the Appendix D.

2. Track #2: Performance-Based Design Guide for New and Rehabilitated Concrete Pavements. Work is currently ongoing related to rigid pavement design which falls under the various subtracks of the Performance-Based Design Track of the CP Road Map. Specifically, federal or state agency sponsored work is ongoing in 17 of the 21 subtracks of the Design Guide Track. This work is related to subtrack DG 5.1 on MEPDG implementation. Some of the projects go across multiple tracks, e.g., Mix Design. In addition, several industry-sponsored and FHWA-sponsored training activities related to the MEPDG are ongoing. The track Leadership Team was formed. A conference call was held with the Leadership Team on June 30, 2008, in which the priority activities for the track were discussed. The draft framework by staff (dated 6-12-08) was presented to the track committee for review and discussion. The participants agreed on forming the following subcommittees and on what emphasis they needed to place on the corresponding subject matter:

A. Concrete Overlays—This is considered a priority subject by the committee. Simplify the overlay design features where possible and identify research that addresses the interaction between underlining pavements, bond longevity, slab geometry effects, and fatigue damage to underlining pavements. Look for low-hanging fruit that can address immediate needs.
B. **ME Design Guide**—Look to advance ME Design in concrete pavement areas and start collecting major software needs.

C. **Performance Data**—Organize and understand what data are out beyond the LTPP and how to share quality performance data.

D. **CRCP Design**—FHWA and Concrete Reinforcing Steel Institute (CRSI) have developed a slate of CRCP research statements that will be reviewed by the committee.

E. **FHWA Software Integration**—This is an integration effort on ways to integrate PRS, ME Guide, HIPERPAV, and other software.

The participants also suggested that a new group—Non-Traditional Design Elements Subgroup—needed to be formed that would address technical and financial cooperation, challenges, and misconceptions.

The track Framework document is included in the Appendix E.

3. **Track #3: High-Speed Nondestructive Testing and Intelligent Construction Systems.** The CP Road Map has identified nine potential systems that could be developed and integrated into the paving operations:
   - Temperature/Moisture/Strength/Stiffness Changes and Development
   - Pavement Thickness
   - Dowel/Tie Bar/Reinforcement Alignment
   - Curing Effectiveness
   - Slab Support
   - Workability
   - Air Void Systems
   - Mix Density and Volumetrics
   - Smoothness/Texture/Skid Resistance and Splash/Spray

The track Leadership Team was formed and included individuals from the paving industry, equipment industry, DOTs, FHWA, and academia. At the track Leadership Team meeting in Austin, TX, in June 2008, the most critical parameters to monitor during construction were identified as fresh mix properties/variability, curing operations, and smoothness/texture. The Team also identified the corresponding technology that could be used to assess the most critical factors above.

The complete framework document is included in the Appendix F.

4. **Track #4: Optimized Surface Characteristics for Safe, Quiet, and Smooth Concrete Pavements.** ISU, FHWA, ACPA, and pooled fund states have developed a comprehensive program related to noise. An updated Strategic Plan was also developed under prior work. The track projects must address the logical connections between human experience and societal demands, pavement surface characteristics, pavement properties, and the physical factors of the pavement in hopes of optimizing the right solution for specific situations.
The Track Leadership Team was formed and the initial meeting was held in Dallas, TX, on April 23–24, 2008 (see meeting notes in Appendix G). The team felt that smoothness characteristics were a mature science and that tire–pavement noise was being pursued on a number of fronts. The primary focus on priority projects related to connecting societal demands to the pavements being produced. In addition, models should be developed to relate surface texture to noise, friction, splash and spray, and other surface characteristics. The full list of priority projects is shown in the framework document included in the Appendix H.

5. **Track #7: High-Speed Concrete Pavement Rehabilitation and Construction (Overlays).** Although the Executive Committee did not elevate overlays to track status, they felt that a significant emphasis should be placed on them as agencies look to maximize investments in existing pavements through rehabilitation techniques. The main focus of the Leadership Committee was the revisions to the initial edition of the Concrete Overlay Guide. The team, made up of academia, FHWA, DOTs, industry, and ACPA members, developed a 75-page manual entitled, “*Guide to Concrete Overlays – Sustainable Solutions for Resurfacing and Rehabilitating Existing Pavements.*” The manual has been completed and is in the printing process. See Appendix I for more information.

   Additional work will focus on the following:
   A. Develop a simplified and accurate approach for concrete overlay thickness determination using current design methodology.
   B. Complete research that would address the complex interaction between the concrete overlay and underlining pavement structures and interlayers.
   C. Complete field research that would help solve construction technique limitations for concrete overlays which would include paving machine control, locating longitudinal joints, appropriate opening strength, traffic management techniques for different lane roadways, and innovative overlay materials, particularly interlayers.

6. **Track #11: Concrete Pavement Business Systems and Economics.** The research in this track will clarify the relationship between concrete pavements and economic issues, capital availability, risk and risk transfer, and alternative contracting. The Executive Committee, with the help of the Road Map Operations Support Group, has focused most of its initial energy on the major administrative tasks aimed at establishing institutional framework for both the Committee and the Tracks.

   To that end, the Committee identified and supported the following initiatives:
   - Secure longer term funding for the CP Road Map Executive Committee and the Operations Support Team.
   - Prioritize the CP Road Map Tracks.
   - Establish a collaboration system among various DOTs and the FHWA.

   The framework for the track is shown in the Appendix J.

7. **Track #13: Sustainability.** Since the Executive Committee did not designate Sustainability as a separate track until after the contract for the project was underway, the work had to be integrated into the remaining activities. Thus, this track is not as far along
in its development as are the others. Work centered on identifying the appropriate organizations and people to be included on the leadership group and then to work out a course of action for the group. A track Leadership Team was assembled that included academia, natural resources organizations, FHWA, DOTs, industry, and suppliers. The first meeting was held on July 23rd, 2008, in Chicago, IL, with the leadership team separated into breakout groups to identify areas of interest and elements to be addressed in the framework. No specific priorities were established but the minutes from that meeting indicate common points of interest among the participants. See Appendix K.

**Task C: Initiate Communications and Outreach Activities**

An action plan and collaboration agreement were developed and presented to the Executive Committee at the fall meeting on September 11, 2007. The action plan has three main tasks: research database management, connection, and marketing and communication. A primary goal of these efforts is to provide up-to-date information about track priorities to potential sponsors and researchers and facilitate sponsors’ incorporation of track priorities into their programs.

Marketing and communication efforts focused on soliciting state DOTs participation in a new pooled fund to supplement FHWA funding for the operations support group to manage implementation of the Road Map. A marketing theme “It’s Your Move” was developed, and a brochure, letter, and package of information about the Road Map was sent to all state DOT chief engineers. Follow-up phone calls were made, and other personal follow-up contacts were made at the semiannual National Concrete Consortium meeting.

**Task D: Continue Ongoing Activities**

The administrative group continued the activities identified in Task Order 1.

1. **Continue updating and maintaining the CP Road Map Website.** Information about current priorities and team leadership activities has been added for each of the active tracks: (1) mix design, (2) design guide, (3) NDT, (4) surface characteristics, (7) overlays, (11) business systems, and (13) a new track on sustainability. A “news” section has been added to the homepage. A pointer to the new operations pooled fund has been added.

2. **Continue updating and maintaining the research database.** A national telephone survey was conducted to update current and recently completed research for each of the active tracks.

3. **Continue updating and maintaining the personnel directory.** The directory now contains information about all personnel involved with track leadership and facilitation.

4. **Continue updating and maintaining the project management tool developed to show the status of CP Road Map research studies and identify their input needs and anticipated outputs.** The database of current and recently completed research has been transitioned into a “back-end” resource that provides and configures information in various formats for website users. For example, users can link to a list (and then to individual details) of current or recently completed projects related to a specific problem statement without manually sorting the database. This provides a quick overview of gaps in research that are being addressed and gaps that still need to be filled.
5. **Continue updating and maintaining rules and procedures** for use during meetings and interactions associated with the CP Road Map program. The draft procedural manual has been updated.
APPENDIX A: CP ROAD MAP

EXECUTIVE COMMITTEE MEETING
CP Road Map
Executive Committee Meeting
September 11, 2007
Chicago, Illinois

AASHTO CLARIFICATION:
In 2005, the AASHTO Subcommittee of Materials (SOM) passed a resolution supporting the CP Road Map and recommended the Standing Committee on Highways support the CP Road Map. The recommendation from the SOM and the Standing Committee on Highways are attached.

Action items:
- Kirk Steudle, chair; Jim Duit, vice-chair of the Executive Committee (EC)
- CP Road Map website will be live with first electronic newsletter
- CP Tech Center will draft proposal for a federally led pooled fund for administrative funding
- Packet of information/Brochure on the Road Map (individual to states depending on their prior involvement and interest)
- Letter of support from FHWA
• Five DOT reps on the EC will be the pilot group. This group will try to get the collaboration agreement signed in their DOT and determine the level of buy-in to incorporating the Road Map into the research program.
• Environmental Track was established and is considered one of the priorities.
• Track 7 (High-Speed Concrete Pavement Rehabilitation and Construction) was not elevated to a full track priority, but “Overlays” was considered a subject priority.
• Next meeting March 2008 in Chicago

----------------------------------------------DETAILED MINUTES----------------------------------------------

1. Introduction
Peter Kopac outlined the CP Road Map management plan, consisting of the CP Tech Center for administrative organization, the executive committee for overall guidance, track leaders for direction, and sustaining organizations for funding. The first task order is nearing completion and the second task order is beginning. The first executive committee meeting concentrated on why and how of collaboration. This meeting is a call to action; a continuation of the plan for collaboration and a way to move it forward.

Tom Cackler indicated a shift to collaboration is the model of the future – a necessity to promote and succeed with a national research agenda. Collaboration is needed not only for funding, but also for implementation buy-in. Technology Transfer and training needs are a large part of making research successful and needs to play a larger role. The Road map is good, but not perfect – it needs to adjust as needs and opportunities change.

2. General Administration
• Approval of March Minutes: Randy Battey moved, Jim Duit seconded. Approved.
• Election of Officers: Steve Kosmatka and Gary Frederick were the nominating committee. They nominated Kirk Steudle as chair, and Jim Duit as vice-chair. Claude Bedard moved to accept both nominations, Julie Garbini seconded. Approved.

3. FHWA Task Order Reports
• Dale Harrington reported on the temporary research database in task order 1. This database is focused to looking for gaps in concrete pavement research and what is being done to fill these gaps, it is not designed to capture all the research being done. TRB, TRIS, RIP etc. are databases designed for the all inclusive efforts.
• Tracks 1-Mix Design; 2-Performance-based Design Guide for New and Rehabilitated Concrete; 3-High speed Nondestructive Testing and Intelligent Construction Systems; 4-Surface Characteristics; have been identified as high priority by the Executive Committee.
• Track 1 (Mix Design): Midwest Concrete Consortium has become the track leaders for Track 1 and their September 25th meeting will be second meeting of Track 1. After this meeting the CP Tech Center will develop a framework for moving with this track and will submit a framework to FHWA.
• Track 7 (High-speed Concrete Pavement Rehab and Construction) has had a great deal of interest by industry in the past 6-8 months. An Overlay “manual” has been produced and well received. A more complete overlay project is underway with demonstration projects and training.
• Track 11 (Concrete Pavement Business Systems and Economics): Executive Committee is the track leader for track 11. CP Tech Center has developed a brochure that shows a plan on how to get a fully functional system by 2015 through a systematic, collaborative plan.

4. Overview of Road Map Action Plan
Dale Harrington introduced the newly developed brochure (copy attached).
5. **Collaboration**
The CP Road Map is not tied to any single pot of money. It’s becoming very difficult to get large amounts of money for a specific agenda – pooled fund studies, collaboration have become necessary.

The action plan has three main tasks:

- **Database management**: what is all needed in a database and how should it be developed.
- **Connection**: We need to develop a proactive way of connecting research between agencies, between countries, between people. Technical expertise needs to be combined with funding.
- **Marketing and communication**: The priority tracks will get the most marketing and communication effort.

**Discussion:**
Over the next six months a collaboration plan needs to be developed and implemented. How to get DOTs and agencies informed and in agreement? How can we get states to use the Road Map when setting their research agenda; can local DOTs be influenced by a national agenda? Each state has different barriers, different mechanisms for coordinating research: a difficult task.

Marketing and outreach will be critical. Each track needs to have well defined subject matter and be communicated so that states can see their specific needs within that track, and can see how joining a pooled fund on a specific need will address their state’s needs as well as be part of the national agenda. States need help is seeing how their present research plan can and does fit into a national plan; that will encourage research committees to look at how to incorporate the Road Map into their long range research plan.

A Help Desk would be beneficial to encouraging states to become involved – a central place/person to go for finding out what else is being done, or whether research on a particular problem has been started; too much new research on topics already well documented.

Discussion on who are the benefactors of the collaboration center. Who are the customers; how can we get a coordinated sponsorship of research?

When everything is said and done, what will the structure look like? The vehicles available right now are known pooled funded programs that exist: AURORA, Crash Center – is the CP Tech Center going to be a pooled fund center to manage the Road Map? A regional center of excellence could be suggestion as a way to combine existing mechanisms (pooled funds, university research, consortiums, industry) to be developed as a way to continue funding.

6. **Project Management System**
The database that will be available on the CP Road Map will show what gap is being addressed, what is still a gap, and what should be done to fill it. It will have lots of information, but needs to have functionality for varying interest levels. The administrative group will be the primary users, but it will also be of use to stakeholders and researchers.

7. **Communications**
Clarification that references to the Road Map revising priorities actually refers to an updating of priorities, and an updating of funding, i.e. if a state indicates funding for a specific project within a track that project will move up the priority scale, not a change in research priorities. Agencies will have confidence the research they are funding as a priority will not be obsolete due to a revising priority list.
The CP Road Map site will be going live with the first electronic newsletter. There will be a way to signup for future newsletters and information updates.

8. Executive Committee Call to Action
Tom Cackler indicated the administration of the Road Map is about $750,000 per year (see slide 2 and 3 of item 8) and FHWA’s current funding level equals about 40%.

Gary Henderson indicated the FHWA plans to continue funding the administrative support group but likely will not continue the present level of support (approximately $300k per year) indefinitely. Some other mechanism of support needs to be considered. What are appropriate and equitable ways to continue to fund the administration support of this national initiative? A pooled fund seems to be a good mechanism; SP&R funds are then available.

Marketing will be HUGE! Obstacles:
- States are already facing shortage of research funds for their state projects and giving money to an administrative group will be a hard sell.
- What will state’s get for their money? Will they each get a “seat at the table”? Perhaps rotation on the executive committee, and technical committee involvement

The Midwest Concrete Consortium (MC2) is an example of a consortium where states have found value in getting states together. MC2 started out 12 years ago as a technical peer exchange on concrete pavements in the upper Midwest region with about 11 states. The MCO project, consisting of 17 states participating in a PFS, began meeting with the MC2 and resulted in more states involvement and tremendous growth for the MC2. The MCO PFS is having its final meeting on September 25th. MC2 has now initiated a new PFS to fund technology transfer that will allow states to continue to meet and discuss projects of mutual interest. Twelve states have signed up and more have expressed interest. Agenda item for September’s MC2 meeting will be to move from Midwest Concrete Consortium to a national concrete consortium, consisting of the states, FHWA, and industry representatives. One of the tasks this group will take on is the leadership for Track 1 (Mix Design and Analysis).

Comment made that due to the differences in mechanics of appropriating funds for pooled fund studies from different states, PFS solicitations need to stay open for a year to allow for each state’s individual approach.

INDUSTRY: Gordon Smith spoke on behalf of the ACPA as an industry representative. Industry, through ACPA and ICPA, has been funding the CP Tech Center @ 600K per year. This funding has been flexible, and the Center has been able to determine how to use the funding. Some of it has been used to fund personnel working on the Road Map. Industry is very supportive of collaboration and interested in talking to local DOTs regarding more collaboration. Industry funding generally has less restrictions on its usage so keeping it to plug holes in research projects, was suggested. Frequently it is difficult for a state DOT to fund research in a different state, so keeping it flexible is advantageous.

Industry reps commented it was refreshing to be proactive in organizing collaboration. Presenting a unified front with research dollars should show legislative entities that something is really getting done.

POOLED FUND DISCUSSION: Coordination of national research has been an ongoing problem. Having FHWA be the lead for the pooled fund gives credibility to the project and will make it easier for the DOTs to participate. Industry will not be part of the PFS, but will continue to fund individual projects. Other state chapters should be approached regarding administrative funding for the CP Tech Center using ICPA as an example.
Action item: Solicit for a federally led pooled fund for administrative funding. CP Tech Center will draft proposal for DOT reps review prior to MC2 September’s meeting.

If solicitation does not generate the needed interest, state’s feedback should provide some direction.

COLLABORATION AGREEMENT – Draft
Discussion as to appropriate signatory in each DOT for the collaboration document; effective signature may be specific to each state, however, the higher ranking of the officer lends more serious intent and action.

The intention is to supply documentation that would move from cooperation to collaboration, move from awareness of program to involvement. The draft agreement in the packet does not lock any state into any action; states’ are able to retain control by checking the areas of agreement.

ACTION ITEMS:
- Packet of information on the Road Map (individual to states depending on their prior involvement and interest)
- Brochure
- Letter of support from FHWA
- Executive committee members will look into level of commitment for their agency
- MCO states will need to champion the advantages of the pooled fund concept
- EC members can champion the pooled fund proposal at regional every other month teleconferences – and report on questions and concerns being expressed
- Five DOT reps on the EC will be the pilot group. This group will try to get the collaboration agreement signed in their DOT and determine the level of buy-in to incorporating the Road Map into the research program.

A draft Operations Manual was distributed. The committee is asked to read it, and send comments to the CP Tech Center. A final Operations Manual will be sent out and a vote via email will be solicited.

10. TRB Problem Statement (Fred Hejl)
Fred Hejl from TRB reiterated that coordination on a national level is difficult; the key to optimizing the Road Map research will be through standing committee research agendas.

11. Research Track Updates
- Environmental (recommendation to committee)
  Should environmental research needs become a separate track or stay part of each track? Discussion revolved around aggressive action being sought for environmental concerns, well over half of research proposals being submitted to funding agencies seem to have an environmental angle. Environmental research needs the higher visibility of being a separate track. Julie Garbini moved, Claude Bedard seconded, that the Environmental become a separate track. Approved.
- Should Track 7 (High-Speed Concrete Pavement Rehabilitation and Construction) be elevated to a full track priority, or should “Overlays” just be considered a subject priority within the track. Although no vote was taken the committee felt Track 7 should not be elevated to a priority track but “Overlays” be considered a subject priority in the track

Executive Committee members commented on the ease of air travel to Chicago. The next meeting will be March 2008 in Chicago.

Sept. 11, 2007
Road Map Executive Committee Meeting Minutes
APPENDIX B: NATIONAL CP ROAD MAP PROGRAM

(CP ROAD MAP) OPERATIONS HANDBOOK
National CP Road Map Program (CP Road Map)
Operations Handbook

The Executive Committee guides the overall accomplishment of the National Concrete Pavement Road Map Program (CP Road Map). This handbook outlines the Executive Committee’s operating principles, general responsibilities, and business procedures.

I. CP ROAD MAP GUIDING PRINCIPLES

The CP Road Map is a long-term research plan with a clear vision and goals and based on a philosophy of collaboration and partnership among stakeholders.

Goals/Objectives
The CP Road Map was developed to fulfill the following vision: By 2015, the highway community will have a comprehensive, integrated, and fully functional system of concrete pavement technologies that provides innovative solutions for customer-driven performance requirements. Towards this end, the CP Road Map prioritizes research that will
- Maximize public convenience.
- Improve the driving experience.
- Integrate design, mixtures and materials, and construction with pavement performance predictions.
- Improve pavement reliability.
- Identify new and innovative business relationships to focus on performance requirements.
- Constrain costs while improving pavement performance.
- Protect and improve the environment.
- Expand opportunities to use concrete pavement.

Philosophy of Collaboration and Partnership
The CP Road Map was developed through a collaborative process that actively collected input from all stakeholders: the Federal Highway Administration (FHWA), state and local departments of transportation, all sectors of the concrete pavement industry, and the transportation research community. The CP Road Map therefore reflects the needs and priorities of all stakeholders.

Such collaboration reflects and promotes the joint ownership of the CP Road Map and joint responsibility for ensuring its success. It also facilitates jointly adjusting priorities, leveraging investments, sharing findings regionally and nationally, and accelerating implementation.

II. CP ROAD MAP MANAGEMENT RESPONSIBILITIES

The CP Road Map will be collaboratively guided by the Executive Committee with participation and input from Sustaining Organizations, input from Research Track Leaders, and professional support services of the Operations Support Group (figure 1).
Executive Committee
The role of the Executive Committee is to provide overall guidance and coordination of the National CP Road Map Program. Responsibilities generally include the following:
- Obtaining executive-level buy-in of stakeholders to the Road Map.
- Fostering collaborative sponsorships, conduct, and technology transfer of research.
- Fostering research integration within and between the CP Road Map’s 13 tracks.
- Suggesting/promoting innovative technology transfer activities and training activities.
- Globally reviewing research and identifying new or developing research areas.
- Prioritizing tracks, determining track leaders, and advising track leaders.
- Leading conduct of Track 11 (Business Systems).
- Regularly evaluating progress of the CP Road Map.

Track Leadership Teams
The role of each track leadership team is to guide and coordinate the conduct of a specific research track in the CP Road Map. Responsibilities generally include the following:
- Validating and updating the track.
- Facilitating partnerships to get the research funded and accomplished.
- Establishing working groups as needed.
- Ensuring integration within and among tracks.
- Facilitating technology transfer and training.

Each track is unique, and so each leadership team will organize and administer the work in a unique way.

Sustaining Organizations
Sustaining organizations include all concrete pavement stakeholder organizations, public and private, that participate in and support the National CP Road Map Program at some level, especially those that participate in sustainable funding of operations support services (see section III). Responsibilities generally include the following:
- Participating in the Executive Committee as appropriate (see section VIII).
- Participating in the Track Leadership Teams as appropriate.
- Collaboratively funding administrative support services.
• Using the Road Map to guide internal organizational research priorities.
• Funding Road Map research (individually or pooled).
• Demonstrating commitment to the concept of collaboration for the good of the industry.
• Conducting Road Map research as appropriate.

Operations Support Group
The Operations Support Group is the hands of the Executive Committee and, to some extent, of the Track Team Leaders. It conducts day-to-day operations to fulfill the Executive Committee’s responsibilities. The group’s responsibilities generally include the following:
• Providing technical and administrative support to the Executive Committee in guiding conduct of the CP Road Map (e.g., research track and project management, communications activities, mechanisms for collaborative partnerships, general meeting support, etc.).
• Conducting background research and providing suggestions to the Executive Committee regarding the committee’s responsibilities.
• Implementing the Executive Committee’s decisions and policies.
• Generating CP Road Map progress and financial reports for the Executive Committee and FHWA.

III. COLLABORATION CENTER
To facilitate Executive Committee communications and the development of funding partnerships and other collaborative relationships, the Operations Support Group will develop and operate a “Collaboration Center.” The Collaboration Center will provide a framework for collaboration that combines web-based and human resources. The Collaboration Center will perform three general tasks:
  • Connecting people and organizations.
  • Managing data.
  • Communications and marketing.

Mechanisms and Processes for “Connecting”
Conduct of the Road Map requires that various stakeholders connect, cooperate, and collaborate on different tasks. For example, potential funders/sponsors of research need to connect with each other to develop funding partnerships; potential sponsors need to connect with potential researchers to conduct the work; researchers need to connect with potential organizations for demonstration projects and other technology transfer activities resulting from research; organizations with unsolved problems need to connect with potential research sponsors; etc.

The Operations Support Group will develop mechanisms and processes to facilitate these connections. The mechanisms and processes will be flexible enough to accommodate stakeholders’ varying involvement in the CP Road Map.

Managing Data
The Operations Support Group will develop a project management system supported by back-end database(s) of track and problem statement information and accessed via a web-based interface. This will be a flexible, expandable system. It will allow the Operations Support Group, Executive Committee, Track Team Leaders, and others (all with various accessibility rights) to access coordinated information about schedules, budgets, tasks, sponsors, researchers, products of research, current research needs and priorities, etc.

The primary purpose of the project management system is to demonstrate, as the Road Map proceeds, which gaps in research are being filled, which gaps remain, and how the remaining gaps are prioritized. It
will also be a tool for technology transfer of research products, for financial reporting, and for helping potential participants discover how they can participate in and/or contribute to conduct of the Road Map.

**Communications and Marketing**
The Operations Support Group will develop and implement a communications and marketing plan to serve a variety of audiences with varying informational needs. It will include, but will not be limited to, the following elements:

1. Website
2. Project management system to track budgets, sponsors, etc., of projects under the CP Road Map Program (content specialists will provide research project information and technical content)
3. Help desk
4. Executive Committee updates between biannual meetings
5. Project reports, summaries, technical briefs, manuals, and other technology transfer publications

**IV. WORKING WITH TRACKS AND TRACK TEAM LEADERS**

The Executive Committee will prioritize research tracks and adjust priorities as appropriate.

Working through the Operations Support Group, the Executive Committee will organize Track Team Leaders, then work with and advise teams to achieve the following goals:

- Facilitate the organization and launch of priority tracks.
- Ensure cross-track integration of research and technology transfer and cross-track compatibility of products like software.
- Identify new research areas or revised priorities as appropriate within each track.
- Suggest and promote technology transfer and training activities.

**V. MANAGEMENT OF TRACK 11**

As indicated in Section II, CP Road Map Management, the Executive Committee is responsible for leading track 11, Business Systems and Economics. Subtracks outline the following responsibilities:

1. Plan and fund Operations Support Group’s support services for the Executive Committee and Track Team Leaders (this activity is being handled through initial FHWA support contract and succeeding FHWA-led pooled fund; see section III).
2. Advance concrete pavement economics and life-cycle costs.
3. Advance innovative contracting procedures and incentive programs for concrete pavements.
4. Provide technology transfer and publication support services to Track Team Leaders (this activity is covered through the communications and marketing effort, as part of the Collaboration Center; see section III).

Following the general approach outlined in section V, the Executive Committee/Track 11 Leadership Team will conduct the following activities with the support of the Operations Support Group:

1. Draft the framework for track 11.
2. Identify existing innovative practices in contracting, incentive programs, and life-cycle cost analyses and conduct early technology transfer activities related to these practices.
3. Develop and implement plan for additional research into innovative contracting practices, incentive programs, and life-cycle cost analyses.
4. Conduct technology transfer related to completed research.
VI. CP ROAD MAP PROGRAM EVALUATION

The Operations Support Group will submit regular reports as required by the Executive Committee and the FHWA pooled fund. The reports will cover financial issues, research gaps being filled, progress-to-date on each track, impacts of progress to date, and other reports as requested.

VII. EXECUTIVE COMMITTEE BUSINESS MEETING PROCEDURES

This section outlines issues related to committee membership, officers, and meeting procedures.

Committee Membership
In general, the Executive Committee will be composed of executive-level decision makers representing State agencies, industry, academia, and FHWA. Specifically, these groups will be invited to participate as follows:

<table>
<thead>
<tr>
<th>No. of Reps</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>1</td>
<td>research university</td>
</tr>
<tr>
<td>7</td>
<td>state DOT</td>
</tr>
<tr>
<td>1</td>
<td>American Concrete Pavement Association</td>
</tr>
<tr>
<td>1</td>
<td>Portland Cement Association</td>
</tr>
<tr>
<td>1</td>
<td>RMC Research Foundation</td>
</tr>
<tr>
<td>3</td>
<td>contractors</td>
</tr>
<tr>
<td>1</td>
<td>materials suppliers</td>
</tr>
<tr>
<td>1</td>
<td>fly ash association</td>
</tr>
<tr>
<td>1</td>
<td>slag association</td>
</tr>
<tr>
<td>1</td>
<td>aggregate/rock associations</td>
</tr>
<tr>
<td>2</td>
<td>OSG pooled fund states</td>
</tr>
</tbody>
</table>

One of the three FHWA representatives will be the technical monitor of the CP Road Map Program.

A representative of the Transportation Research Board will be a standing invited guest (non-voting).

Terms of Membership
Each member organization will select its representative(s) to the Executive Committee. They will serve at the pleasure of the member organization.

Member Duties and Responsibilities
All members on the Executive Committee will attend or send a substitute to act on their behalf at meetings.

All members (not including the standing invited TRB representative) or their substitutes will have a vote on any issues coming up for a vote.

Representatives will conscientiously participate in the conduct of all Executive Committee responsibilities listed in Section II.
APPENDIX C: CP ROAD MAP

EXECUTIVE COMMITTEE CONFERENCE CALL
Instead of the face-to-face meeting scheduled, a conference call was held when it was discovered that many members had conflicts and could not make it to the meeting.

**Pooled fund states/funding update**

The pooled fund solicitation and follow-up marketing packet from the Center has resulted in four states making a commitment. It is hoped that additional states will join as SPR funds are allocated in the future.

States would like to have a list of research priorities to use as they look to fund research within their state. The Road Map (Task 15) identified problem statements that could be the basis for initial work. As track committees are formed, a framework is developed and research priorities are identified. These frameworks and priority projects are posted on the website following TAC meetings.

NCHRP has mid-September deadline for problem statements. It appears that SHRP may get additional funding also and national research RFPs will be the likely result. Information on the priorities should be sent to the AASHTO meeting August 3-8, or the TRB subcommittee on Materials.

**Program process flowchart**

The draft flowchart that describes the steps in the Operations Support activities was discussed; modifications will be made to make it more understandable. What is needed:
- Timeline for each track
- Existing research
- Gaps
DOT Collaborative Agreements
Although DOTs were willing to verbally support the Road Map, many were hesitant to sign the collaborative agreement. DOTs may have been concerned about a long-term commitment when they were uncertain about the funding. It appears the collaboration agreement has value as a working document to explain the Road Map but probably will not work as an indication of commitment.

TRB workshop – 2009/annual
Tom Cackler has been in contact with Fred Hejl (TRB staff person that originates concrete related workshops) regarding a commitment to a Standing Workshop on the Sunday of TRB week. The technical content has not been finalized but it will involve concrete sustainability. The plan is to provide proposed problem statement needs that would lead to a set of priority projects and be sent forward through TRB.

Task Order #3 Draft Work Activities
- Travel for committees will be addressed
- Additional work for the future
- Develop recommendations for evaluating the success of the program
- Develop TAC to identify Sustainability track

Peter Kopac reiterated the federal governments plan for the Road Map to be a unified effort with the government paying for public agency involvement (travel) and industry paying for their own involvement in the formation of the TACs. The Center will continue to try to combine meetings as much as possible to minimize travel expense.

Update Operations Handbook
- Collaboration document stipulated any state supporting the pooled fund study will be a member of the Road Map Executive Committee. However, it is being recommended that the states signing up as full commitment pooled fund study participants will vote to seat two members. Agreed.
  - Establish protocol for meetings
    - One physical meeting (not during TRB, either October or Feb/March)
    - Two, or more if needed, meetings via conference call/webcast

Additional comments:
- Surface Characteristics track should be the model for other tracks
- Recommend that FHWA tie research solicitations to Road Map. FALCON research teams need to point to Road Map tracks.
APPENDIX D: FRAMING REPORT FOR TRACK 1 OF THE CP ROAD MAP
MIX DESIGN AND ANALYSIS
Background
The FHWA, in cooperation with Iowa State University (ISU) and the American Concrete Pavement Association (ACPA), developed the Concrete Pavement Road Map, which outlines a collaborative approach to strategic concrete pavement research and technology transfer for the future. The CP Road Map development process relied heavily on input from the stakeholder community. The CP Road Map Operations Group, a team assembled by Iowa State University’s National Concrete Pavement Technology Center (CP Tech Center) under contract to the FHWA, is working with industry and government partners to get the CP Road Map off the ground.

Mix Design and Analysis (MDA), the first of 12 research tracks defined under the CP Road Map, has been identified as one of four initial priority tracks by the CP Road Map Executive Committee. Several initial priority projects have been identified, and a scope of work developed, to meet the early objectives of the MDA Track. Specifically, these initial projects will quickly move the state of the art of mix design into the state of the practice.

This framing document briefly describes the purpose and history of the MDA Track and the impact of recent events and accomplishments on the research and priorities outlined in the track. This will be a living document, revised regularly by the Operations Group as research gaps are filled, priorities readjusted, and new needs identified.

The MDA Track is critical for several reasons. Concrete is a complex material. A decision by the design engineer may require changes to the materials specification. Selection of a particular material may change the maintenance needs of the pavement. All parties in the mix design process need to understand how their actions will affect the whole system, and by how much.

Another issue is that development of materials and mixture specifications is currently based on failure. Something goes wrong with a project, so the engineer tweaks the spec to prevent a repeat of the problem. This approach often attacks the symptom, not the cause of the problem, and can actually initiate or exacerbate other problems.

Another reason that this topic requires attention is that sustainability can no longer be ignored. The need to develop sustainable pavement systems is forcing us to change our approaches to some decisions. When considering project optimization, we have to include not only financial cost but environmental load. We can no longer insist on the best possible materials; we are running out of them. Instead we have to decide the limits of acceptability for locally available and recycled materials.

The complexity of the problem is compounded by the fact that many ingredients in concrete are changing as cost or environmental constraints are imposed on the manufacturers. As a result, some commonly used rules of thumbs may no longer be valid.
MDA Track Mission Statement

The aim of the Mix Design and Analysis Track of the CP Road Map is to develop and deliver integrated tools and techniques that will make it possible to specify, proportion, and construct concrete mixtures that meet the combined needs of owners and contractors for constructible, long lasting, sustainable, cost efficient, and verifiable concrete mixtures for pavements.

Current Gaps in Mix Design and Analysis

In October 2006, more than fifty representatives of agency, industry, and university members of the concrete pavement construction industry met for a day and a half at Turner-Fairbank Highway Research Center (TFHRC). Anticipating the startup of the CP Road Map MDA Track, participants discussed the needs of the industry with respect to mix design and proportioning. They validated the research needs, or gaps, outlined in the MDA Track. The wide variety of opinions expressed at that meeting can be summarized in four categories:

- **Tests.** There is an over-arching need for cost effective, fast, reliable tests that measure the properties we are really interested in, both for incoming materials and for the mix itself. Some are for QC (contractor internal work) and some are for QA (client acceptance) as discussed below. We therefore have to establish the parameters that define acceptable performance, and develop tests to measure them.
  - The first family of tests needed includes those that assess the acceptability of a given material. Many of these are currently used based on existing ASTM and AASHTO methods. However, some parameters are still not resolved such as methods to assess alkali reactivity of aggregates, in which the most reliable test takes up to 2 years to run, while the rapid 2 week test is reportedly unreliable about half of the time.
  - Tests are needed to monitor the variability of materials coming into a mixture, so that adjustments can be made on the fly to ensure that the delivered mixture is uniform and appropriate for the conditions in which it is being used.
  - The other tests required are those that assess the quality and / or performance of the mixture as it is placed. Tied to this is the need for appropriate limits that allow unambiguous decisions to be made regarding the acceptability of a given material or mixture. Without these tests, it is impossible to develop good performance based specifications, because it is impossible to measure the concrete performance.

Other points to note include:
  - Critical, high priority parameters needing attention include verification of materials or mixtures, workability, durability and shrinkage.
  - Such parameters and tests should be appropriate for adoption in incentive payment systems.
  - Measurements must be able to be conducted in real time so that contractors can make adjustments on the fly.
  - Specifications must allow some flexibility to ensure that the needed adjustments are not forbidden.
  - Approaches are needed to measure and allow for variability in the mix ingredients. Definitions are needed that define when a variation is significant enough to require re-approval.
  - A better understanding is needed about limitations and applications of recycled materials including concrete as aggregate and recycled water.
Approaches that should be considered include:

- Embedded sensors that can track system chemistry
- Embedded sensors that can assess the quality of the air-void system
- An instrumented vibrator that reports the rheological properties of a mix

**Models.** Tied to the needs for tests is a need to correlate test results with long term performance of a concrete system. At present we lack the tools to be able to predict the potential life of a pavement based on accelerated or early age performance data.

- Other models needed include development of more robust predications of fresh concrete properties based on the properties, proportions and interactions of the ingredients. This is especially evidenced in the current approaches taken to addressing interactions between ingredients. It is known that class F fly ash may improve alkali silica reaction expansion, but this can only be quantified using slow or imprecise tests. At the same time the use of the ash will likely retard setting and early strength gain, thereby increasing the risk of plastic cracking. The decision then of “how much fly ash” is based on empirical estimates.
- Specifiers and plant operators need effective guidelines on the effects and side effects that may be expected if they change the source, type or dosage of a given material.

**Specifications.** Current contracts are built around lowest cost, therefore innovations impose high risk to the specifier and to the contractor. It is more conservative to continue with business as usual.

- Prescriptive practices also allow little flexibility to accommodate variation in materials or environment, potentially leading to distress or unacceptable variation in the finished pavement.
- The aim of a good specification is to ensure that the owner is given the highest probability of getting what they pay for, while affording suppliers and contractors a reasonable opportunity to optimize their decisions.
- As specifications become more performance based, there is a need for a guidelines addressing who should make what decisions – for instance, should designers specify slump when they do not know what equipment the contractor will use, and what slumps will be optimum for that equipment?

**Communication.** When changing the rules, we have to prove that they work and teach the people involved what the new rules are and how to use them.

- The need for education is growing because cement based systems are becoming increasingly complex with multiple admixtures and supplementary cementitious materials in most concrete mixtures made today. This is coupled with increasingly stringent demands being placed on the mixtures as budgets and time constraints become tighter.
- The potential for problems is exacerbated as staffing levels are being reduced, leaving relatively inexperienced personnel being required to make decisions beyond their experience or training.

This meeting helped identify initial priority activities for the MDA Track, while clarifying the need for the MDA Track to be updated and “reframed” in light of newly completed and current research. See figure 1. It also led to the development of a track administrative structure.
Recently Completed Work
Several significant research projects have been completed since the TFHRC meeting. These include the following:

- Material and Construction Optimization for Prevention of Premature Pavement Distress in PCC Pavements (MCO). This Iowa DOT led Pooled Fund project has developed a Testing Guide that recommends a graduated series of tests based on the type of road being constructed. The tests are intended to be used by contractors to monitor materials and reduce variability in the concrete mixture.

- Identifying Incompatible Combinations of Concrete Materials. The project funded by FHWA developed a protocol on tools to identify whether materials within a given mixture were likely to interact causing unacceptable performance of the mixture.

- Concrete Mixture Performance Analysis System (COMPASS) is a Windows-based application aimed at optimized paving mixtures based on materials characteristics selected to achieve desired mixture performance.

![Figure 1. Updated Framework of MDA Track Research Needs](image-url)
• The Integrated Materials and Construction Practices for Concrete Pavement (IMCP) Manual provides broad information on the effects of materials properties and proportions on concrete performance.

• A Guide Specification for airfield pavements has been prepared in a project funded by IPRF.

Ongoing Work
Several projects are currently underway that address some of the needs described above:

• FHWA is currently funding a significant, multi-year project with the aim of implementing best practices with respect to preventing and mitigating alkali silica reaction.

• FHWA has also recently released a request for proposals for innovative methods to analyze and test for alkali reactivity of concrete mixtures and to develop mitigation methods.

• Indiana DOT is leading a new Pooled Fund that is aimed at finding a reliable method of assessing the permeability of pavement concrete.

• NCHRP is funding a project aimed at better understanding the effects of currently available fly ash on concrete mixtures, including improved tools to characterize and specify the material.

• IPRF is funding work on investigating the effects of deicing salts on concrete pavements for airfields.

• South Dakota is the lead state in a Pooled Fund project investigating the effects of magnesium chloride on concrete. This project is nearing completion.

• A project is underway aimed at developing guidelines for using ternary mixtures in concrete. Phase 1 work based on tests on pastes and mortars is complete, and was funded by a Pooled Fund led by Iowa. Phase 2 is starting under the sponsorship of FHWA.

• A project funded by an Iowa led Pooled Fund is investigating field temperature monitoring devices for assessing setting times and potential incompatibility/variability is nearing completion.

Planned Work
From the updated framework of research needs (figure 1), a number of specifically defined, high-priority tasks have been identified for immediate action. Some of the work will be conducted under a pooled fund currently being established. Other work is being conducted by agencies using their own funding sources. As additional organizations collaborate with the Track Leadership Team, their projects and the gaps they fill can be identified. The priority projects include the following:
**Pooled Fund**

An FHWA pooled fund led by Iowa is being set up to address specific needs within each of the four categories described above that summarize ideas from several Technology Transfer Concrete Consortium (TTCC) meetings:

- **Tests.** The following tests may be considered to be in three different states of development:
  1) Nearing implementation, 2) Under development, and 3) Conceptual. The actions needed for each test will vary and are described as appropriate for each test.
    - Rheology test. The slump test is currently the standard approach to determining workability of a mixture. However it is not always valid for use in mixtures needed for slipform paving, and it does not describe the parameters needed to be known by paver operators. There is a need to develop a simple field test for measuring how much a paving mixture will move when vibrated (viscosity) and whether it will be prone to edge slump (yield stress). Some work has been conducted in this field in the past with limited success. A pilot investigation into alternative approaches to this issue is needed. It is planned that the results of the test will allow for a more definitive description of the workability of a mixture.
    - AVA. The air void analyzer is a device intended to provide on-site evaluation of the air void system in fresh concrete. Work is being conducted by a number of researchers to evaluate the device and to develop guidelines on its use. The findings of these researchers need to be gathered and interpreted, and a formal method statement needs to be developed for submission to AASHTO and ASTM.
    - If performance based specifications are to become more acceptable, there is a need to be able to verify that a mixture delivered to a given site contains the correct materials in the given proportions used in the verification testing during design stage. At present there is no good way to do this, but the topic is worth investigating.
    - If the AVA does not prove to be useful, consideration should be given to investigating alternative methods of assessing the air void system in fresh concrete.
    - Foam index test. Several versions of this test are used by fly ash producers and purchasers as a quality control tool. There is a need for this test to be standardized and submitted to AASHTO and ASTM.

Other tests that need to be further investigated include:

- Coefficient of Thermal Expansion (CTE), is a measure of the change in dimension of a concrete sample due to changes in temperature. The parameter has a direct impact on the risk of temperature related cracking in newly placed concrete pavements. A test has been developed at FHWA and needs to be field tested and validated, and a formal method statement needs to be developed for submission to AASHTO and ASTM.
- Field Temperature Monitoring. Monitoring the rise in temperature due to hydration of a fresh mixture provides a tool to assess the uniformity between material and concrete batches, as well as indicating setting times useful for saw-cutting operations. A project is nearing completion investigating the various devices available including some field tests. A formal method statement needs to be developed for submission to AASHTO and ASTM.
- Permeability. European specifications are using a permeability test developed by Torrent. There is a need to investigate the applicability of this test to US pavement construction.
Recommendations have also been made to use the ASTM C 642 boiled water test as a simple measure of potential durability. This test has been the subject of a brief investigation in Minnesota. The test warrants further investigation. Work under this task will be coordinated with the Indiana Pooled Fund Permeability work.

- **Models.** The models discussed below include tools or methods to correlate different parameters, and to help users select appropriate materials and proportions.
  - Seminal work conducted by Klieger in the 50’s on which we base our current limits on air content and air void system parameters was conducted using no supplementary cementitious systems and a single type of air entraining admixture. Some of the recommendations of this work need to be verified as still appropriate for current cements, SCM’s and air entraining admixtures, all of which have changed significantly over time.
  - There is a need to correlate paste content with mixture shrinkage and cracking risk, for all types of binders
  - There is a need to set out standard information to be recorded and stored at the time of construction so that in later years, the performance of pavements can be compared with the construction data, thus allowing development of durability models based on field performance rather than extrapolation of laboratory data.

Other models that need to be further investigated include:
  - Interaction Hyperdoc – it is planned to develop an interactive electronic document based on the IMCP that will enable users to observe the effects that their decisions on materials type and dosage will have on properties of the concrete.
  - Current specifications impose limits on minimum working temperatures for concrete pavements. The validity of these limits needs to be verified.
  - Current tools used to assess the combined aggregate grading are empirical in nature, and are difficult to impose specified requirements around. It is accepted that while a good combined grading increases the probability of an acceptable mixture, it is still possible to make good concrete pavement with a poor grading and bad pavement with good grading. This topic needs further investigation.

- **Specifications.** Changes and innovations to the way we do things can only be achieved within the context of specifications. It is therefore critical that appropriate specifications be developed and implemented.
  - A guide specification and commentary will be prepared that lays out current state of the art thinking with respect to materials and mixture selection, proportioning and acceptance. This document will take into account the different environments, practices and materials in use across the US, and will allow optional inputs for local application. The specification will be developed based on existing documents including the recent IPRF Draft P501.
  - As a supplement to the IMCP Manual, it is planned to develop check-sheets for different parties involved in the development of a mix design. They will help inexperienced practitioners make appropriate selections for the tasks they are conducting (e.g. preparing a specification or selecting aggregates). It is also intended that decisions are made at the correct location (e.g. slump is selected by the contractor rather than the specifier).
• **Communication.** An integral part of any significant change to the methods or process of mix design is education. Users from all parties have to be made familiar with what has changed, why it was necessary, and how it affects they way they do things.
  o Field trials to demonstrate and validate new tests
  o Field trials to demonstrate and validate new models
  o Field trials to demonstrate and validate new specifications
  o Training materials as needed

**Other Planned Projects**
Two other projects are currently planned as early activities under the MDA Track:

One is the development of a publication entitled *Design and Control of Concrete Pavement Mixtures*” This will be prepared by PCA and ACPA staff using their own funding. It will be based on current state of the practice technology and will be similar in style and content to the PCA’s “Design and Control of Concrete Mixtures”. It will be reviewed by a panel of representatives from owners, engineers, materials suppliers, and contractors.

A project is one being conducted by FHWA to coordinate the various software packages that they already have had developed. These include COMPASS, HIPERPAV, and COST.

**Stakeholders and Partners**
At present, the following organizations have expressed interest in committing to the activities of this track:

• Several states have indicated that they will contribute to the Iowa-led pooled fund described above. A work statement is in the last stages of preparation for this fund.
• Cement industry through PCA
• ACPA
• FHWA

**MDA Track Administration**

• A Track Leadership Team has been established comprising the following:
  o Richard Meininger – FHWA
  o John Staton – MI DOT
  o Leif Wathne – ACPA

• A Technical Advisory Committee for the MDA Track was selected. The committee is comprised of 15 people representing federal, state, and industry interests as noted below:

  **Contractors:**
  Hamad, Farid  
  Capon, Pete  
  Brown, Mark  
  Descheneaux,  
  Barry

  **Suppliers:**
  Taubert, Don  
  Lobo, Colin

  FKHamad@laneconstruct.com  
  PCapon@Rieth-Riley.com  
  brownm@zachry.com  
  barry.descheneaux@holcim.com  
  dtaubert@capitolcement.com  
  clobo@nrmca.org
• The Iowa-led Pooled Fund will also appoint its own TAC representing those states that contribute to the fund.

The goal of the Track Leadership Team is to provide an environment that fosters
• Collaboration between
  o Funding agencies to ensure that research money is leveraged to deliver as much useful information as possible at minimum cost
  o Researchers to unite their resources and abilities to the same end
• Coordination, so that
  o Work is not repeated unnecessarily
  o Efforts are focused appropriately
• Implementation so that
  o The results of the work can be made public
  o Opportunities are provided to test developments in the field
  o Acceptance in regulatory bodies is facilitated
  o Effective use of new, proven, tools is encouraged into the future.
APPENDIX E: PERFORMANCE-BASED DESIGN GUIDE

FOR NEW AND REHABILITATED CONCRETE
Performance-based Design Guide for New and Rehabilitated Concrete

Implementing the CP Road Map Design Track

BACKGROUND

Prior to the Mechanistic Empirical Pavement Design Guide (MEPDG), empirical and very limited mechanistic approaches to concrete pavement design were the standard practice. Empirical approaches are effective when all of the site and design feature conditions basically remain the same, which rarely occurs. The focus is on serviceability (or smoothness) only and not on understanding and managing specific distress or failure modes which create loss of smoothness and maintenance needs.

The primary source of much of today’s pavement design is still the AASHTO road test of the 1950s. This one subgrade, one base, one climate, limited traffic design guide was constructed using better-than-normal construction practices. Data analysis techniques were also fairly basic and design reliability was not included. Moreover, the AASHTO road test did not incorporate many of the concepts and products used in concrete pavement practice today, including concrete overlays, non-doweled joints, longer joint spacing, tied concrete shoulders, CRCP, permeable bases, different cements, dowel bar retrofits, and other necessary repairs.

Under this track, the concrete pavement research community aims to continue the development of the next generation of mechanistic approaches to pavement design, but also to assure better integration with materials, construction, and environmental inputs. Because many materials properties are important to design success, it is critical that the research conducted under this track be closely coordinated with that done in Track 1 (Performance-Based Concrete Pavement Mix Design System).

The state-of-the-practice today is moving rapidly toward mechanistic-empirical approaches, particularly with the release of the M-E pavement design guide and the expressed interest of many States. These mechanistic-empirical approaches will allow the designer to account for new design features and characteristics, many materials properties, changing traffic characteristics, and differing construction procedures (such as curing and day/night construction). The designer can also now consider additional design features and focus more on pavement performance, including limiting key distress types.
In addition, the design reliability approach does not have the significant limitations of the current AASHTO empirical guide for heavy traffic.

This track builds off and continues the improvement of the excellent comprehensive work done under NCHRP 1-37A and recently approved by AASHTO as the Interim M-E Pavement Design Guide. This track requires a detailed understanding the AASHTO Interim M-E pavement design guide, committing researchers to improving the accuracy and comprehensiveness of performance modeling and prediction.

However, the CP Road Map also identifies the need for simplified design procedures for cities and counties, as well as a design catalog approach.

The pavement design practice of today is basically empirical with AASHTO, though the state-of-the-practice is moving toward mechanistic approaches.

In continuing this work, this track not only looks to the next generation of modeling improvements, but seriously considers the integration of design with materials, construction, presentation, and surface characteristics.

This track also explores the development of new high-speed computer analysis tools for optimizing pavement design that can address changes to multiple inputs and thus offer better data on potential life-cycle costs and reliability.

**TRACK OBJECTIVES**

1. Develop viable (e.g., reliable, economical, constructible, and maintainable) concrete pavement options for all classes of streets, low-volume roads, highways, and special applications.
2. Improve concrete pavement design by maximizing the use of fundamental mechanistic relationships.
3. Integrate pavement designs with materials, construction, traffic loading, and climate.
5. Design preservation and rehabilitation treatments and strategies using mechanistic-based designs.
6. Develop and evaluate new and innovative designs for specific needs – high traffic; residential; and parkways.

**Design Track Goal**

Mechanistic-based concrete pavement designs will be reliable, economical, constructible, and maintainable throughout their design life and meet or exceed the multiple needs of the traveling public, taxpayers, and the owning highway agencies. The advanced technology developed under this track will increase concrete pavement reliability and durability (with fewer early failures and lane closures) and help develop cost-effective pavement design and rehabilitation.
STAKEHOLDERS INVOLVED AND CORE GROUPS

There are many groups organized to deal with concrete pavement design issues.

The State DOTs, through AASHTO’s Joint Technical Committee on Pavements (JTCP) has historically led the country in identifying, funding (through NCHRP) and implementing design-related research.

The Federal Highway Administration also has been key to identifying long term research needs in concrete pavement design, especially the development of models, best practices, and training and implementation efforts.

The concrete pavement industry through the American Concrete Pavement Association, have been actively involved in many design-related efforts. They include the concrete overlays, simplified software development, professor training seminars, tie-bar design, and applications for cities and counties, for example. They also are the voice of the industry, giving input to AASHTO, FHWA, and the individual states.

Several national and regional consortia/groups have formed to evaluate and/or advance the MEPDG implementation. A search of TRB’s Research In Progress website suggests that nearly two dozen states have active project related to the MEPDG in particular and the Design Track in general.

Examples include the FHWA Lead States (includes 19 states), State Pavement Technology Consortium (SPTC) comprising of Minnesota, Texas, California, and Washington, Northeast States, Rocky Mountain States, and North Central States.

The National Center for Concrete Pavement Technology is currently developing a national effort to better implement concrete overlays. Included in this effort is the recognition of the need for a more integrated and simplified way to design overlays supplementing the procedure included in the ME pavement design guide. The National Center is also coordinating regional programs across the country to set up MEPDG discussions.

State DOTs have come together regionally through groups such as the Midwest Concrete Consortium (now the National Concrete Consortium). The North Central States MEPDG User Group is another example.

The Concrete Reinforcing Steel Institute, in partnership with the FHWA, has organized an Expert Task Group that is looking at issues related to continuously reinforced concrete pavements, with a focus on the M-E Guide.

There are many other groups, formal and ad-hoc that are looking into specific elements of concrete pavement design.
ONGOING WORK RELATED TO THE DESIGN GUIDE TRACK

Fueled by the interest generated by the AASHTO Interim Mechanistic Empirical Pavement Design Guide (MEPDG), a tremendous amount of work is currently ongoing related to rigid pavement design which meets several of the Track Objectives noted above; especially, objectives 1, 2, and 3, and 5. Objective 4 of the Design Track is partially addressed by the recently completed NCHRP 1-43 project (Pavement Friction Guide) and the ongoing work sponsored by ISU-FHWA-ACPA consortium (Concrete Pavement Surface Characteristics Field Experiments).

Specifically, federal, state, and industry sponsored work is ongoing in 17 of the 21 subtracks of the Design Guide Track. These include:

- DG 1.1 - Development of Benchmark Problems for Concrete Pavement Structural Models Verification
- DG 1.2 - Improvement of 2D and/or 3D Structural Models for JPCP & CRCP Used for Reconstruction and Overlays
- DG 1.4 - Improvements to Dynamic Modeling of Concrete Pavement Systems for Use in Design and Analysis
- DG 1.5 - Structural Models for Special New Types of Concrete Pavements and Overlays
- DG 2.1 - Enhancement and Validation of Enhanced Integrated Climatic Models for Temperature, Moisture, and Moduli
- DG 2.2 - Development and Enhancement of Concrete Materials Models and Improved Pavement Design
- DG 2.3 - Enhancement and Validation of Traffic Loading Models Unique to Concrete Pavements
- DG 2.4 - Improved JPCP Deterioration Models
- DG 2.5 - Improved CRCP Cracking and Punchout Prediction Models
- DG 2.6 - Improved Consideration of Foundation and Subdrainage Models
- DG 3.1 - Concrete Pavement Design Aspects Related to Multiple/Additional Lanes
- DG 3.3 - Improvements to Concrete Overlay Design Procedures
- DG 3.4 - Improvements to Concrete Pavement Restoration (CPR)/Preservation Procedures
- DG 3.5 - Development of New and Innovative Concrete Pavement Type Designs
- DG 4.2 - New Mechanistic-Empirical Pavement Design Guide Procedures for Paradigm Shift Capabilities

Not surprisingly, spurred by the recent positive ballot received by the MEPDG from the AASHTO subcommittees on Materials and Design to make it an AASHTO Interim Pavement Design Guide, there has been a wealth of activity related to the MEPDG. This
work is related to Subtrack DG 5.1 on MEPDG implementation. Some of the projects go across multiple tracks, e.g., Mix Design. In addition, several industry and FHWA sponsored training activities related to the MEPDG are ongoing.

Specific projects are shown in Appendix 1.

**TRACK LEADERSHIP MISSION**

The CP Road Map supports organizational mechanisms that will lead to
1) Improved coordination, cooperation, and collaboration of research and implementation;
2) Identification and promotion of research that is currently unfunded but needed;
3) Integration of the design track with Track 1 Mix Design and Track 3 NDT for Construction; and
4) Implementation and training efforts.

The CP Road Map is being administered by the National Center for Concrete Pavement Technology through funding from both the FHWA and the State DOTs. For the Design Track to proceed in an orderly fashion and to assure that the above four mechanisms are addressed.

It is proposed that a group of leaders knowledgeable with design issues, understand the work going on, and are committed to the long term goals of the Design Track.

**TRACK LEADERSHIP MEMBERS**

**State DOTs**
Andy Gisi, KS
John Donahue, MO
Mohamed Elfino, VA
Danny Dawood, PA
Jeff Uhlmeyer, WA

**Industry**
Randy Riley, IL ACPA
Matt Zeller, MN ACPA
Todd LaTorella, MO-KS ACPA

**Design Track Leadership Scope**

It is recommended that representatives from the AASHTO JTCP, the industry, and FHWA begin to formally discuss ways to promote the overall goals of the Track and undertake the following activities

1) Identify and support a slate of design research
2) Develop a framework for cooperation and sharing of work underway in design research and implementation
3) Organize implementation and training efforts
4) Work with other tracks to assure proper integration.
11/3/2008

Jim Powell, ACPA-NW
Mike Ayers, ACPA National

FHWA
Tom Harman
Angel Corera
Gary Crawford

Academia
Julie Vandenbossche
Jeff Roesler

TRACK KICK-OFF INITIATION

On June 30, 2008, a conference was held with all the track leaders to discuss the potential missions. It is intended for the next year that conference calls and webinars be the vehicle for communication. The minutes of that meeting are included as Appendix 1.

SUGGESTED SHORT-RANGE RESEARCH AND IMPLEMENTATION PROJECTS

Concrete Overlays

Guidance for concrete overlay design has been published by ACI, AASHTO, FHWA, PIARC, NCHRP, ACPA, PCA, the U.S. Army Corps of Engineers, Federal Aviation Administration, and various state departments of transportation. These procedures use a variety of underlying assumptions and design strategies. No single document exists now to design the various concrete overlay solutions – bonded, unbonded, whitetopping, CRCP, overlays, etc.

It is suggested that a comprehensive review of the design procedures lead to two efforts:

1) Building off the current Concrete Overlay Project (ISU and FHWA), pull together a comprehensive design manual that is heavy on case studies developed under that initiative and shows how to use the various design tools in specific situations.
2) Develop a more comprehensive strategy on pulling together one design practice, by integrating existing procedures and continuing research on some of the key weaknesses. (See Appendix 2.)
3) Continued training and outreach on overlay design and construction efforts.

This effort should be presented as part of the Concrete Overlay Initiative to see if support can be gathered for this initiative.

Cost Range: $600,000 - $700,000
Concrete Tie Bars

On the recent Scan of Long Life Pavements, the Scan Team noted that the Europeans use less tie bars than is customary here in the U.S. As part of the implementation of that Scan, the ACPA has research underway to look at how tie bars are actually designed and see if there is a way to reduce the number and spacing.

The Minnesota DOT and the National Concrete Pavement technology Center, with cooperation of FHWA, are working to develop a project at MnROAD to install various diameters and lengths of tie bars at different spacing. The slabs will be instrumented to compare the field results to the theoretical results from the MEPDG.

It is suggested that their research be examined and evaluated, with technology transfer and implementation efforts promoted, as a continuation of this work.

Cost Range: $350,000 – $400,000

SUGGESTED LONGER RANGE RESEARCH PROJECTS

Two projects that might be offered from the track that are worthy of consideration are noted below. These projects have been selected since they (1) are considered as high priority items for the stakeholder design community and (2) they have good synergy with other Track work. They also promote the performance goals of the track.

The overall funding needed to accomplish these projects is also noted. This work could be further prioritized and segmented so that it can be accomplished incrementally in stages under multiple funding mechanisms. The incremental deliverables could be designed to be modular in nature to facilitate further enhancement and integration under future research products.

Develop an Integrated Concrete Materials Modeling and Design/analysis Tool

Background: Concrete materials properties have a great effect on the short- and long-term performance of concrete pavements. While tools currently exist for early age performance prediction (e.g., HIPERPAV) and long-term performance prediction (MEPDG), they have not been fully integrated from a materials modeling standpoint. Several materials inputs are common to both these tools making the integration a relatively easy process, however, more work needs to be done to integrate and optimize the materials, climate, traffic, and other inputs. Such an integrated tool would have tremendous obvious benefits to all the stakeholders involved with designing, constructing, and building concrete roadways.

Tasks: Key aspects of this improvement of PCC materials and construction to be addressed are as follows.
1. Several concrete material properties vary over time which must be considered in design. These properties include strength, modulus, shrinkage, creep, and others. Provide further data on these properties on how they vary over time as a function of mix design and exposure conditions.

2. Determine the effect of construction factors on concrete materials properties in the slab. This would include the following as a minimum:
   - slab curing
   - slab zero-stress temperature
   - built-in curling (thermal gradient through slab as it solidifies)
   - differential slab shrinkage

3. Development of new tests for characterizing concrete strength and modulus that reflects field behavior better than those used today.

4. Achieve early-age and long-range performance predictions.

Cost Range: $1,000,000

Implementation: Implemented into the MEPDG

Development of Improved JPCP Deterioration Models

Background: JPCP is by far the most popular type of concrete built in the world. This is due to its relative cost effectiveness and its reliability. The design of JPCP has greatly improved through increased knowledge over the past several decades.

Tasks: There remain some important aspects of improvement as listed below.

1. Improve on the top down & bottom up transverse cracking models for new & rehab developed under NCHRP 1-37A.

2. Longitudinal cracking (fatigue related). There has been longitudinal cracking in JPCP that could not be explained by traditional fatigue cracking calculations. A major study is needed to determine under what circumstances longitudinal cracking could occur that is fatigue based. The effect of widened slabs will be investigated.

3. Improved joint and crack faulting & spalling models for new and overlays. The existing models will be considered and improved upon to model faulting for all kinds of design and rehabilitation situations needed for design. An improved joint opening/closing model may be needed.

The end product of all this research would be greatly improved and more comprehensive distress and smoothness prediction models for JPCP. The key benefit will be a reduced prediction uncertainty which results in a more cost-effective design for a given level of reliability for JPCP.

Cost Range: $1,000,000 – 1,500,000
Implementation: Implemented into design procedure.

Design of new and Innovative Concrete Pavement Type Design

JPCP is the world’s most widely constructed concrete pavement. Historically, rectangular sections have been used extensively for this type of pavement.

Tasks:
1. Conduct a literature study to explore many new and innovative shapes for concrete pavement designs. This study will involve both performing a literature search and contacting as many agencies as possible around the world to investigate the latest innovative designs.
2. Identify key design innovations that could optimize the structural and material design of these pavements, examining trapezoidal cross sections for example.
3. Complete an analytical analysis of these various sections, identifying possible strengths and weaknesses of the new shapes.
4. From the most promising, develop an experimental project that builds and monitors several of these sections.

Cost Range: $400,000 - $600,000

Implementation: Implemented into design and construction procedures.
APPENDIX 1  MINUTES FROM THE DESIGN TRACK CONFERENCE CALL; JUNE 30

Participants

John Donahue, MO  Jim Powell, ACPA-NW
Mohamed Elfino, VA  Mike Ayers, ACPA National
Jeff Uhlmeyer, WA  Tom Harman, FHWA
Randy Riley, IL ACPA  Julie Vandenbossche, U of Pitt
Matt Zeller, MN ACPA  Jeff Roesler, U of IL
Todd LaTorella, MO-KS ACPA

Absent

Angel Corera, FHWA
Gary Crawford, FHWA
Andy Gisi, KS
Danny Dawood, PA

The Performance-Based Design Guide for New and Rehabilitated Concrete Track Committee (20 members) held its first meeting via conference call. The draft framework by staff (dated 6-12-08) was presented to the track committee for review and discussion. The participants agreed on forming the following subcommittees and what emphasis they needed to place on the corresponding subject matter:

1. **Concrete Overlays** – this is considered a priority subject by the committee. Simplify the overlay design features where possible and identify research that addresses the interaction between underlining pavements, bond longevity, slab geometry effects and fatigue damage to underlining pavements. Look for low hanging fruit that can address immediate needs.

2. **ME Design Guide** – look to advance ME Design in concrete pavement areas and start collecting major software needs.

3. **Performance Data** – organize and understand what data is out beyond the LTPP and how to share quality performance data.

4. **CRCP Design** – FHWA and CRSI have developed a slate of CRCP research statements that will be reviewed by the committee.

5. **FHWA Software Integration** – This is an integration effort on ways to integrate PRS, ME Guide, HIPERPAV, and other software.

The participants also suggested that a new group: Non Traditional Design Elements Subgroup needed to be formed that would address technical and financial cooperation, challenges and misconceptions.

Future Meetings

Downstream, the participants agreed that a face-to-face meeting would be necessary. They also agreed that work in this track be closely coordinated with the meetings of the AASHTO’s Joint Technical Committee on Pavement (JTCP). The JTCP has been selected as a meeting venue.
because it brings all the key agency decision makers to one forum and their agenda allows outside presentations of the nature the CP Road Map team plans.

There was agreement that many of the research projects related to the MEPDG would be routed through AASHTO and NCHRP. It was also agreed that the FHWA is the best place for the software integration project.

The participants also supported the concept of FHWA address the software integration and update of the key projects identified above.

Assignments and Subcommittee Preferences (as of September 28, 2008)

ME Design Guide:  John Donahue, Jeff Roesler, Gary Crawford
Concrete Overlays:  John Donahue, Todd Latorella, Jeff Roesler, Randy Riley
Performance Data:  John Donahue
CRCP Design: Jeff Roesler, Angel Corera,
FHWA Software Integration:
Non-Traditional Design Elements:  Todd Latorella, Jeff Roesler

Overlays

- The work under this Track should focus on Overlays first, developing a simple, straightforward overlay design. Paving engineers are used to designing asphalt overlays anywhere from 2" to 6" without a robust design and assigned a life expectancy based on experience and empirical data.
- Most felt that the concrete industry is many times was held to a higher standard.
- An implementation statement that captures this concept should be developed as the first order of business for the Track Team

MEPDG

- The MEPDG has a lot of great information. But it is almost too detailed for lack of a better term. There are so many inputs many of which could great affect on the pass or failure of the design. Some of the failure criteria in the Guide just don't seem to materialize in the field: marginal strength, joint spacing, etc. While the guide is based on LTPP data, some of the participants rarely see a failure due to anything other than materials.
- Gary Crawford probably has the most up-to-date understanding of what is being done now and in the future on the Guide as AASHTO works on the software issues. It is noted that some minor research is included in the software work and that the Track Team might want to work more closely with AASHTO on the concrete portion.

Performance Data

- Historically, the concrete industry always tried to make concrete pavements last longer. Through the design track, we need to focus on hitting the performance target. If the customer wants a 20 year pavement, the design procedure should allow for its design and construction, not constantly give out a 30 year or longer pavement. In this situation, dowels, aggregate, cement, strength thickness all come into play. Why not use a lower
quality aggregate if the performance period is only a 20 years. A "catalog" with minimum required for what is being requested?

**Design Catalog or PC Web-based Design**

- The need for a PC or web-based design features catalog, a "living" catalog. One would start out with a blank typical and build your pavement section for the project conditions and application. If the user adds features the cost of these features plus the impact on performance is tabulated (i.e. 10 dowels vs. 12 dowels).
- This would help designers and owners see the cost ramifications of specific design features during the design process they might make different (more educated) decisions.
- This would put the "design" back in pavement design.

**Post Call Activities**

- On September 9, 2008, the CP Tech Center developed a statement of work to address deficiencies in overlay thickness design and presented the concept to the CP Tech Center’s Overlay Committee. The Committee will interface with the Track Team.
- On September 11, 2008, the Design Track draft objectives, benefits, on-going work and potential track leaders were presented to the CP Road Map Executive Committee. The committee felt that when the track leadership was brought together they needed to select priority projects that were high on stakeholder’s radar and had good synergy with other track work.

**Next Steps**

- Under Task Order 3, it is suggested that the Design Track finish setting up the subgroups and begin work on identifying work under each subtrack.
- The Overlay Design implementation work should be further structured, with clear statements of work developed. The Track Team should oversee this work and support ways to get the work funded.
- The Track Team should also formally reach out to the AASHTO JTCP and develop a common slate of research projects, working towards developing and introducing NCHRP statements.
### Appendix 2. List of Active M-E Guide Projects

<table>
<thead>
<tr>
<th>Study No.</th>
<th>Topic Area</th>
<th>Title</th>
<th>Author</th>
<th>State</th>
<th>Year</th>
<th>Agencies involved</th>
<th>Abstract</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>PCC Materials</td>
<td>Engineering Properties of Florida Concrete Mixes for Implementing the New Mechanistic-Empirical Rigid Pavement Design Guide</td>
<td>Ping, Virgil (PI), Uwaibi, Emmanuel (PM)</td>
<td>Florida</td>
<td>Start date: 2006/5/3, End date: 2008/1/28</td>
<td>Florida Department of Transportation, Florida State University, Tallahassee</td>
<td>The primary objective of the proposed study is to evaluate thermal engineering properties of typical Florida PCC mixes for satisfying the concrete materials inputs. The new M-E rigid pavement design guide will be reviewed and evaluated for requirements of PCC materials inputs. Three major input levels will be reviewed to evaluate the requirements of PCC materials inputs. An experiment design will be developed to conduct laboratory testing of three basis types of Florida PCC mixes for the thermal engineering properties. The determination of the coefficient of thermal expansion will be conducted using AASHTO TP 60 Standard Test Method for the Coefficient of Thermal Expansion of Hydraulic Cement Concrete. Analyses of test results will be performed to evaluate the thermal engineering properties of the Florida PCC mixes. Correlation relationships will be proposed to estimate some of the pertinent properties through simple strength tests or other related tests. An implementation plan will be proposed in coordination with the pavement design office for use of Florida specific concrete inputs to the MEPDG rigid pavement design procedures in Florida.</td>
</tr>
<tr>
<td>2</td>
<td>PCC Materials</td>
<td>Evaluation of Portland Cement Concrete Pavement Materials, US 27, Pendleton County</td>
<td>Graves, R. Clark (PI), Mathews, Marcie (PM)</td>
<td>Kentucky</td>
<td>Start date: 2005/12/1, End date: 2007/11/30</td>
<td>Kentucky Transportation Cabinet, University of Kentucky, Lexington</td>
<td>Kentucky’s rigid pavement utilizes a catalog of rigid pavements designs developed by evaluating both the Kentucky rigid pavement design procedure and the 1986 AASHTO procedure at varying levels of traffic and subgrade strength. As Kentucky anticipates moving toward the use of the proposed NCHRP 1-37A Pavement Design Guide, new design procedures will be required for concrete material parameters which have not been previously routinely tested in Kentucky. This project will evaluate parameters for Modulus of Rupture (flexural strength), Modulus of Elasticity, and Coefficient of Thermal Expansion using a construction site at US 27 in Pendleton County.</td>
</tr>
<tr>
<td>3</td>
<td>PCC Materials</td>
<td>Evaluation of Portland Cement Concrete Pavement Materials, I-265, Jefferson County</td>
<td>Graves, R. Clark (PI), Mathews, Marcie (PM)</td>
<td>Kentucky</td>
<td>Start date: 2005/12/1, End date: 2007/11/30</td>
<td>Kentucky Transportation Cabinet, University of Kentucky, Lexington</td>
<td>Kentucky’s rigid pavement utilizes a catalog of rigid pavements designs developed by evaluating both the Kentucky rigid pavement design procedure and the 1986 AASHTO procedure at varying levels of traffic and subgrade strength. As Kentucky anticipates moving toward the use of the proposed NCHRP 1-37A Pavement Design Guide, this project will be required for concrete material parameters which have not been previously routinely tested in Kentucky. Using construction site on I-265 in Jefferson County, this project will evaluate parameters for Modulus of Rupture (flexural strength), Modulus of Elasticity, and Coefficient of Thermal Expansion.</td>
</tr>
<tr>
<td>4</td>
<td>PCC Materials</td>
<td>Inputs of Portland Cement Concrete Parameters Needed for the Design of New and Rehabilitated Pavements in Mississippi</td>
<td>Al-Ostaz, Ahmed (PI), Barsta, William F. (PM)</td>
<td>Mississippi</td>
<td>Start date: 2004/10/1, End date: 2006/8/30</td>
<td>Mississippi Department of Transportation, FHWA, University of Mississippi, University</td>
<td>Mississippi Department of Transportation MDOT is implementing the mechanistic-empirical pavement design methodology developed under NCHRP 1-37A. This pavement design method characterizes the pavement materials by fundamental properties such as modulus and Poisson’s Ratio. For rigid pavement design the Portland Cement Concrete (PCC) is characterized by: (1) modulus of rupture; (2) compressive strength; (3) modulus of elasticity; (4) tensile strength; (5) coefficient of thermal expansion; (6) concrete shrinkage; (7) unit weight; and (8) Poisson’s ratio. In this study PCC mixes encompassing a range of aggregate types with various blends of Type I cement, Class F or C fly ash and slag that are typically encountered in Mississippi will be evaluated for these parameters.</td>
</tr>
<tr>
<td>1</td>
<td>Rigid Pavements</td>
<td>Project Level Performance Database for Rigid Pavements in Texas</td>
<td>Chen, Hua (PI), Won, Moon (PM)</td>
<td>Texas</td>
<td>Start date: 2005/9/1, End date: 2008/8/31</td>
<td>Texas Department of Transportation, University of Texas, Austin</td>
<td>The Texas Department of Transportation (TxDOT) is the leader in the use of portland cement concrete (PCC) pavements in the US. They also developed a strong research program in the area of PCC pavement, making TxDOT one of the most innovative and proactive organizations when it comes to improving PCC pavement design and construction practices. One of TxDOT’s achievements in the PCC pavement research area is the development of a comprehensive rigid pavement database. PCC pavements provide long-term performance with minimum maintenance required, if designed and built properly. It takes a long time for PCC pavements to show true behavior and how they eventually fail. Understanding how PCC pavements behave and eventually fail will enable engineers to improve the design, materials, and construction aspects of the PCC pavements. A long-term database is the best way to achieve this goal. The objective of this research study is to continue and improve previous work done for the current TxDOT Rigid Pavement Database (RPDB). A great effort has been conducted for over 30 years in the previous projects to collect and update rigid pavement data in Texas.</td>
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<tr>
<td>2</td>
<td>Rigid Pavements</td>
<td>Composite Pavement Systems</td>
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<td>Topic Area</td>
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<tr>
<td>General Pavement /MEPDG</td>
<td>1</td>
<td>Layer Moduli of Nebraska Pavements for the New Mechanistic-Empirical Pavement Design Guide (MEPDG)</td>
<td>Kim, Yong-Rak (PI), Syslo, Mick (PM)</td>
<td>Nebraska</td>
<td>2007/7/1, End date: 2010/6/30</td>
<td>Federal Highway Administration, University of Nebraska, Lincoln</td>
<td></td>
</tr>
<tr>
<td>General Pavement /MEPDG</td>
<td>2</td>
<td>Using Falling Weight Deflectometer Data with Mechanistic-Empirical Design and Analysis</td>
<td>Smith, Kurt D. (PI), Sivaneswaran, Nadarajah (PM)</td>
<td></td>
<td>Start date: 2006/9/15</td>
<td>Federal Highway Administration, Applied Pavement Technology, Incorporated</td>
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<tr>
<td>General Pavement /MEPDG</td>
<td>3</td>
<td>Develop Test Procedures to Characterize Material Response Behavior, and Transfer Functions for TxDOT M-E Design</td>
<td>Scullion, Tom (PI), Leidy, Joseph (PM)</td>
<td>Texas</td>
<td>Start date: 2006/9/1, End date: 2009/8/31</td>
<td>Texas Department of Transportation, Texas A&amp;M University, College Station, Texas Transportation Institute</td>
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<tr>
<td>General Pavement /MEPDG</td>
<td>4</td>
<td>Development of a Master Plan for Calibration and Implementation of the M-E Design Guide</td>
<td>Hall, Kevin D. (PI), Pearce, David (PM)</td>
<td>Arkansas</td>
<td>Start date: 2005/7/1</td>
<td>Federal Highway Administration, University of Arkansas, Fayetteville</td>
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</table>

**Layer Moduli of Nebraska Pavements for the New MEPDG**

The primary objective of this research is to develop a database of dynamic (and Resilient) modulus values of various materials used in Nebraska using the UTM-25kN testing facilities. In addition to the direct laboratory testing of the representative Nebraska pavement materials for Level 1 design inputs, surrogate methods such as the use of Witzczak's predictive equations and the use of default resilient moduli based on Nebraska soil classification data (Level 2 and for Level 3 design inputs) will be evaluated to investigate their applicability for the design of pavements that are normally subject to low traffic volume. The experience and database obtained from this research will help the Nebraska Department of Roads (NDOR) Materials, Pavement and Maintenance (MPM) Unit implement the moduli testing in their laboratory.

**Using Falling Weight Deflectometer Data with MEPDG**

In spite of the rapid advances in computing technology and power during last decade, the procedures for routine backcalculation and interpretation of Falling Weight Deflectometer data has seen little change. A significant percentage of most State Highway Agencies (SHA) pavement activities relate to rehabilitation of existing pavements and the effective use of nondestructive field testing, such as FWD testing, for the evaluation of in-service pavements will be key to an efficient approach. One of the objectives of this project is to review the current state of the practice and art in routine backcalculation of FWD data and develop recommendations for advancing FWD data analysis and interpretation, particularly in relevance to the rehabilitation procedures in the Mechanistic-Empirical Pavement Design Guide (MEPDG) developed under NCHRP 1-37A project. This project will also develop best practices guideline for analyzing and interpreting FWD data for project level analyses with particular emphasis on the effective and efficient use of FWD data with the MEPDG.

**Develop Test Procedures to Characterize Material Response Behavior, and Transfer Functions for TxDOT M-E Design**

This project will develop the framework for the development and implementation of the next level of MEPDG (Mechanistic-Empirical Pavement Design guide) for TxDOT. As specified in the Project Statement this initial study will focus in the following areas: (1.) To identify and evaluate test procedures that characterize material properties needed to predict pavement response, (2.) To assemble existing performance prediction models (transfer functions) and evaluate their feasibility of being implemented in Texas. Key considerations will be the models' performance in basic sensitivity analysis, the practicality of the data input requirements and their performance at simulating results from accelerated pavements tests (APT), and (3.) To calibrate the selected transfer functions with available performance data from the LTTP data bases, various test track studies and whatever performance data is available from the data bases being assembled in Texas. The Project Statement states that the current version of the NCHRP's MEPDG guide will "not be implementable for at least 8 - 10 years." However the research team feels that there are several excellent features in the new proposed...
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<tr>
<th>Study No.</th>
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<th>Abstract</th>
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<tbody>
<tr>
<td>General Pavement /MEPDG 6</td>
<td>Monitoring and Modeling of Pavement Response and Performance</td>
<td>Sargand, Shad (PI), Green, Roger (PM)</td>
<td>Ohio</td>
<td>Start date: 2006/5/1, End date: 2011/5/1</td>
<td>Federal Highway Administration, University of Ohio, Athens</td>
<td>Mechanistic-empirical (ME) based pavement design procedures are being used by some DOTs to determine the adequacy of layer thicknesses in new and existing AC and PCC pavements and to verify pavement designs with expected material properties, traffic loading, and climatic conditions. Similarly, the influences of weather related factors and construction practices on pavement response and performance have not been sufficiently examined. Harsh weather conditions and/or improper construction techniques may lead to the development of premature functional and structural types of distress that may ultimately affect pavement serviceability. Thus, the need exists to review and verify ME design methods, along with accompanying climatic models, and to document construction processes for perpetual AC pavements, long-lasting PCC pavements, as well as for several types of rehabilitation applied to existing rigid pavement. This includes an investigation of the influence of the mechanical properties of individual material layers on pavement response and performance. The primary objectives of the proposed research are to: (1) Monitor the new perpetual AC and</td>
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<td>11</td>
<td>General Pavement /MEPDG</td>
<td>Technical Assistance to NCHRP and NCHRP Project 1-40A: Version 0.9 AND 1.0 of the M-E Pavement Design Software</td>
<td>Witczak, Matthew W. (PI), Harrigan, Edward T. (PM)</td>
<td></td>
<td></td>
<td>NCHRP, TRB, AASHTO, AQSU</td>
</tr>
<tr>
<td>12</td>
<td>General Pavement /MEPDG</td>
<td>Technical Assistance to NCHRP and NCHRP Project 1-40A: Version 0.9 of the M-E Pavement Design Software</td>
<td>Darter, Michael (PI), Harrigan, Edward T. (PM)</td>
<td></td>
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<td>NCHRP, TRB, AASHTO, ARA</td>
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<tr>
<td>14</td>
<td>General Pavement /MEPDG</td>
<td>Evaluations and Applications of Mechanistic Performance Prediction Modeling Tools</td>
<td>Basheer, Imad (PM)</td>
<td></td>
<td></td>
<td>NYDOT, ODOT, TxDOT, FHWA</td>
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<tr>
<td>15</td>
<td>General Pavement /MEPDG</td>
<td>AASHTO Mechanistic Empirical Pavement Design Guide Implementation in MO</td>
<td>John Donahue, Missouri Department of Transportation</td>
<td>Missouri</td>
<td>2004/7/15, End date: 2006/9/31 Missouri Department of Transportation</td>
<td>This project will result in the specific application for Missouri of the new AASHTO Mechanistic-Empirical design guide. The purpose of NCHRP 1-40A is to conduct an independent review of the M-E Design Guide design methodology and software. Preliminary results from this project were presented to NCHRP on March 1-2, 2005, and members of our project team, as well as the Missouri DOT, were in attendance at the meeting. At this meeting, no fatal errors within the software were reported, but the panel has suggested some changes to the design methodology that could affect the calibration process in Missouri. In addition, the independent panel has yet to complete their review. As such, work on some of the latter tasks was ceased. At the same NCHRP panel meeting, results from NCHRP 9-30(2001) and 1-40B were presented. Based on these findings, NCHRP authorized recalibration of the M-E Design Guide distress prediction models using an independent data source than was used during the NCHRP 1-37A calibration study. Results from the 1-40B recalibration will be available at the end of June 2005. The preliminary results, however, have shown that there are no fatal errors.</td>
</tr>
<tr>
<td>Study No.</td>
<td>Title</td>
<td>Author</td>
<td>State</td>
<td>Year</td>
<td>Agencies involved</td>
<td>Abstract</td>
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<td>16</td>
<td>Facilitating the Implementation of the Guide for the Design of New and Rehabilitated Pavement Structures</td>
<td>Hanna, Amir N. (PM)</td>
<td>Mississippi</td>
<td>2004/7/1</td>
<td>NCHRP, TRB, AASHTO</td>
<td>The objective of this research is to facilitate the implementation and adoption of the recommended Mechanistic-Empirical pavement design guide developed in NCHRP Project 1-37A through the performance of activities identified by the project panel and the AASHTO JTTF. ERES Consultants Division of Applied Research Associates, Inc. is finalizing the development of the 2002 Guide for Design of New and Rehabilitated Structures through NCHRP Project 1-37A. The 2002 Guide incorporates mechanistic-empirical pavement design principles and allows highway agencies to develop cost-effective and reliable designs by systematically considering climate, material properties, construction variability, and traffic to predict pavement performance. This design process is a total departure from the process utilized in the current AASHTO design procedure, requiring the designer to make trial selection of materials and layer thicknesses and evaluating their performance under projected loadings over the design life of the pavement. The objective of this study is to implement the 2002 Design Guide for Mississippi Department of Transportation (MDOT). The following issues will be addressed in this study: (1) provide for training of Design Guide users and other stakeholders; (2) develop and execute a plan for securing the appropriate design input data on material and traffic characterization, and other design inputs; (3) conduct sensitivity analysis.</td>
</tr>
<tr>
<td>17</td>
<td>Implement the AASHTO 2002 Design Guide for MDOT</td>
<td>Saeed, Atfar (PI), Barstis, William F. (PM)</td>
<td>Mississippi</td>
<td>2004/3/1, 2004/7/1</td>
<td>Mississippi Department of Transportation, FHWA, ERES</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Adaptation of Mechanistic-Empirical 2003 Guide for Design of MN Low-Volume PCC Pavement Design Guide in New York State</td>
<td>Khazanovich, Lev (PI), Rindels, Alan (PM)</td>
<td>Minnesota</td>
<td>2007/5/31</td>
<td>Minnesota, Minneapolis</td>
<td>The objective of this research project is to adapt the mechanistic-based design procedure being developed under the NCHRP Study 1-37A for the design of low-volume portland cement concrete roads for Minnesota conditions. As a result of NCHRP Project 1-37A, a new NCHRP 2002 Pavement Design Guide is to be released by either the end of 2002 or early 2003. AASHTO will be going through a process to review, comment, and adopt the NCHRP 2002 Guide as its Pavement Design guide. A project is needed to implement this AASHTO 2003 Pavement Design Guide. The new guide provides state-of-the-art procedures for new and rehabilitated pavements. The objectives of this project are to review the Guide and its associated software, to comment on the Guide/software, to coordinate the Department’s AASHTO review processes, to develop an implementation plan, and ultimately to adopt the new AASHTO Pavement Design Guide in New York State.</td>
</tr>
<tr>
<td>19</td>
<td>Calibration of the NCHRP 1-37A Design Guide (Pavement Analysis and Design System)</td>
<td>Anderson, Keith W. (PM)</td>
<td>Washington</td>
<td>2003/7/1</td>
<td>Washington State Department of Transportation</td>
<td>AASHTO will soon release its new Pavement Design Guide. The prediction equations in the new guide need to be calibrated to fit the states climates, materials, and traffic characteristics. This project will use WSPMS data to calibrate the prediction models. The benefits will be a calibrated pavement design process that not only produces rational pavement designs (namely layer thickness) but also predicted performance for the design period.</td>
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</table>
| 20       | Development of Traffic Data Input Resources for the Mechanistic Empirical Pavement Design Process | Stone, John (PI), Pipkin, George Dennis (PM) | North Carolina          | 2009/6/30 | North Carolina Department of Transportation, North Carolina State University, Raleigh | The objectives of this research are to develop a North Carolina database for Levels 1, 2, and 3 Mechanistic-Empirical Pavement Design Guide (MEPDG) traffic data and procedures, and to identify the resources needed to collect the data, including: traffic count sites, equipment, regional highway cluster sampling plans, seasonal analysis methods, and traffic forecasting methods. The Mechanistic-Empirical Pavement Design Guide for New and Rehabilitated Pavement Structures uses nationally based data traffic inputs and recommends that state departments of transportation develop their own site-specific and regional values. The North Carolina Department of Transportation (NCDOT) recently completed an implementation plan for adopting the MEPDG, and two of the critical implementation recommendations addressed new data collection requirements for site-specific truck classification counts, truck axle load spectra, regional average seasonal adjustment factors, and forecasting methods for axle loads, as well as truck class volumes. We anticipate that the NCDOT will most consistently use Level 2 data inputs and Level 2 procedures and that the most difficult ;
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<tr>
<th>Topic Area</th>
<th>Study No.</th>
<th>Title</th>
<th>Author</th>
<th>State</th>
<th>Agency involved</th>
<th>Abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>2</td>
<td>Development of MDOT's Advanced Traffic Loading Analysis System (MS-ATLAS) to Support Mechanistic Empirical Pavement Design Guide Implementation</td>
<td>Saeed, Athar (PI), Barstis, William F. (PM)</td>
<td>Mississippi</td>
<td>Mississippi Department of Transportation, Federal Highway Administration, ARA (ERES) Consultants</td>
<td>The current Mississippi Department of Transportation (MDOT) flexible pavement design method utilizes 4 input values: AADT, % Trucks, ESALS for 10 or 20 year, and Flexible factor. The new Mechanistic-Empirical Pavement Design Guide utilizes a significant amount of additional traffic information in the form of load spectra to support a given pavement design. SS No. 165 “Traffic Load Spectra Development for the 2002 AASHTO Design Guide” included the following recommendation: “Use of automated software that processes, checks, analyzes and prepares traffic data in the format required for input into the design guide would greatly reduce time and result in more accurate and efficient use of the guide. Manual processing of the large volume of traffic data can be accomplished, but will be labor intensive and subject to increased mistakes.” The objective of the current proposed study is to utilize the existing ATLAS prototype software to develop and implement an automated custom software system for processing and analysis of MDOT traffic data in support of the MEPDG implementation effort. In addition to the software, ARA will provide support in the form of technical documentation and training.</td>
</tr>
<tr>
<td>General</td>
<td>3</td>
<td>Evaluation of Daily and Seasonal Climatic Effects on Pavements: The Minnesota Test Road (MNROAD) Contract and Pooled Fund Studies</td>
<td>Dempsey, Barry J (PI), Sherwood, James (PM)</td>
<td>Minnesota</td>
<td>Minnesota Department of Transportation, University of Minnesota, Minneapolis, University of Illinois, Chicago, Minnesota Department of Transportation</td>
<td>The objective of this project is to develop the Integrated Climate Model. Based on the products of this research, the ICM was integrated into the NCHRP 1-37A Mechanistic-Empirical Pavement Design Guide. To develop traffic load equivalency factors. The load tests of the MNROAD instrumented pavements, provided data for over 100 on-line reports. The project will develop low temperature cracking models, based on field data.</td>
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APPENDIX F: HIGH-SPEED NONDESTRUCTIVE TESTING
AND INTELLIGENT CONSTRUCTION SYSTEMS
HIGH-SPEED NONDESTRUCTIVE TESTING AND INTELLIGENT CONSTRUCTION SYSTEMS

Implementing the CP Road Map ND Track

Framework, dated 02 July 2008

Administrative Contact: Paul Wiegand
Technical Contact: Dennis Turner
CP Road Map Facilitator: Ted Ferragut

Background

Over the past 20+ years, society has experienced a wide array of technological advances, from the personal computer to the cell phone. During this time, the research community has refined a number of NDT technologies. However, these tools have largely been confined to pavement management uses and have not been applied extensively to the concrete paving process.

Advances in technology could benefit both the construction and inspection teams in several key ways. DOTs have expressed interest in the benefits of ND testing. The equipment industry, however, faces both a technical challenge and an investment challenge of investing without having any certainty of a market. Establishing a working group that properly frames the issues, agrees on the technologies, and prioritizes the work efforts is critical for overcoming this investment challenge.

The CP Road Map has identified nine potentials systems that could be developed and integrated into the paving operations:

- Temperature/Moisture/Strength/Stiffness Changes and Development
- Pavement Thickness
- Dowel/Tie Bar/Reinforcement Alignment
- Curing Effectiveness
- Slab Support
- Workability
- Air Void Systems
- Mix Density and Volumetrics
- Smoothness/Texture (Skid Resistance & Splash/Spray)

With wireless and telecommunication systems, information can be shared all over the country, with specialists working to improve the operation without even being on site.

Background information on the CP Road Map and other corresponding research tracks can be downloaded from the FHWA website at: http://www.fhwa.dot.gov/pavement/pccp/pubs/05047/.
Benefits of ND Testing Integrating with the Paving Operation

Both industry and government will benefit from these tools by reducing reliance on slow and sometimes poorly managed small-sample testing programs. The technologies targeted in this research track are intended to form the basis of an Intelligent Construction System (ICS) that could sense and adjust the paving process automatically while informing contractors and inspectors of changes and/or deficiencies in construction. Continuous and real-time sampling could be configured to detect changes to the approved mix design and the preprogrammed line and grade values. These technologies would also allow industry and government to use the data for long-term pavement management and evaluation. In this regard, this research track is interdependent with multiple tracks within the CP Road Map.

This document further describes the framework of the ND Track of the Long-Term Plan for Concrete Pavement Research and Technology – The Concrete Pavement Road Map published in September 2005.

Mission Statement for the ND Track

Under the ND Track, the concrete pavement industry will work together to develop an integrated set of technologies that can rapidly assess and track construction parameters related to pavement construction and performance.

The ND Track Research Team will identify, promote, and coordinate the research and technology that is necessary to achieve this goal. It will promote collaboration among partners, and ensure that duplication is minimized.

Identifying the Gaps

In developing the CP Road Map, and with the ND Track Goal in mind, a thorough review of the state of the practice was made. During this process, gaps were identified with respect to testing methods commonly used to monitor the paving operation. These gaps have both short and long term effects on the industry. In the short term, gaps exist from the practice of manual data collection of a limited number of parameters and locations during construction. The inability to collect the correct data in the proper amounts also effectively limits our industry from fully implementing mechanistic pavement design procedures and performance based specifications.

To move forward, we must first look at the various components of the paving process and determine where technology and practice are lacking. To address the gaps in current practice, the ND Track will address field control issues and ongoing efforts with existing technologies. Another goal focuses solely on the technological gaps that must be closed to move towards a fully automated construction monitoring process. The final goal of the ND Track is to integrate field control practices with technological advances to form a fully integrated ICS.

An idealized ICS for concrete paving is shown in Figure 1. In this figure, we see a member of the construction or inspection team with access to multiple data streams tracking the paving process.
These continuous streams of data will allow the paving process to be managed much more effectively and efficiently.

Figure 1. Idealized Intelligent Construction System for Concrete Paving

The ND Track: a Plan to Bring Technologies Together

A structured outline for the ND Track was presented in the original CP Road Map. The Track was divided into subtracks, and then again into tasks that describe individual “compartments” of research and technology. Collectively, the work program will meet the goal of the Track, but only if collaboration is realized. Although some related work has been ongoing since the publication of the CP Road Map in 2005, it has not been directly focused towards the goals of the ND Track. This demonstrates the need to formally manage the ND Track to realize these goals.

The ND Track currently identifies 22 problem statements. The proposed research is organized into three subtracks and presented in a recommended sequence:

✓ Subtrack ND.1: Field Control
✓ Subtrack ND.2: Nondestructive Testing Methods
✓ Subtrack ND.3: Nondestructive Testing and Intelligent Construction Systems Evaluation and Implementation

Problem statements contained in the plan may correspond to one or more individual projects. Over the course of the ND Track, each problem statement will be developed into research project statements that will contain detailed descriptions of the research to be accomplished, specific budgets, and definite timelines. Detailed problem statements for the ND Track are not included here for brevity, but can be found in the National CP Tech Center Publication, Long-Term Plan for Concrete Pavement Research and Technology – The Concrete Pavement Road Map: Volume II, Tracks, published September 2005.

Foundational, Recent, and Ongoing Work

The following is a summary of some of the more relevant work that is foundational in nature, recently completed, and/or ongoing. While categorized under the Subtrack headings, no attempt is made here to prioritize their relevance. Collaboration with the sponsors and researchers of these projects will be important to the success of the ND Track.
Subtrack ND.1: Field Control

- Stringless Paving – Multiple Equipment Manufacturers
- Advanced Quality Systems – FHWA/ARA/Fugro/Transtec
- Reflective Ultrasonic Technique for Early Age Strength Determination – Northwestern University
- Maturity Testing for Highway and Airfield Concrete – IPRF/ Multiple State DOTs/Vendors
- Nondestructive Evaluation of Iowa Pavements: Phase I – Iowa DOT/Iowa State
- Implementation of TEMP System – FHWA CPTP Task 7 – Transtec
- Performance Specifications for Rapid Highway Renewal – SHRP II R-07 – Traumer

Subtrack ND.2: Nondestructive Testing Methods

- Thermochron and Hygro Button Innovation – Texas DOT/Univ. of Texas
- Scanning Lasers for Real-Time Pavement Thickness Measurement – Iowa DOT/Iowa State
- Integrating Deflection and Ground Penetrating Radar – Texas DOT/Texas A&M
- Accuracy of Ground Penetrating Radar for Pavement Layer Thickness – Univ. of Kentucky
- Demonstration of Seismic and Maturity Testing Technologies – Univ. of Texas-El Paso/AP Tech
- Magnetic Tomography for Dowel Bar Location – FHWA CPTP Task 7 – ARA
- Demonstration of SmartCure to Monitor Curing Operations – FHWA/Transtec
- Accelerated Implementation of Intelligent Compaction – FHWA/Pooled Fund/Transtec
- Examining the Benefits and Adoptability of Intelligent Soil Compaction – NCHRP 21-09
- Measuring Pavement Profile at the Slip-Form Paver – Ames Engineering/GOMACO
- Concrete Pavement Surface Characteristics Program – FHWA/Iowa State

Subtrack ND.3: Nondestructive Testing and Intelligent Construction Systems Evaluation and Implementation

- Nondestructive and Innovative Testing Workshop – FHWA CPTP Task 59 - Transtec
- Leveraging Technology to Improve Construction Productivity – FIATECH

Stakeholders and Partners

Successful collaboration under the ND Track will require participation from a number of diverse groups, many of which are listed below.

- Active Stakeholders and Partners
  - AASHTO
  - ACPA Chapters
  - ACPA National
  - FIATECH
  - FHWA
  - NRMCA
  - PCC Paving Equipment Manufacturers
  - PCC Paving Contractors
  - Sensor and Nondestructive Testing Vendors
  - State DOTs
  - TRB Committee AFH50
Inaugural ND Track Forum

An ND Track Forum was held in Austin, Texas in June 2008 to address the issues raised in this paper. As with the Mix Track and Surface Characteristics Track, the strategic forums proved very beneficial to organize and kick off work under this track.

Objectives

- To achieve consensus on the ultimate objectives of the ND Track.
- To validate what knowledge gaps exist today.
- To identify how we as an industry can work to fill these gaps.
- To identify early projects and their funding mechanisms.
- To help advance the CP Road Map ND Track to a dynamically managed program.

Agenda

- Introduction to CP Road Map
  - Brief History of Program
  - Current CP Tech Center Role in Implementation and Administrative Support
  - The Definition and Importance of Collaboration.
- Presentation of Draft ND Track Framework
- Summary of ND Work
  - Foundational
  - Recently Completed
  - Ongoing
- Discussion with goal of Consensus
  - Overall Objective
  - Gaps
  - Short-Term Projects and Products
  - Long-term Project and Products
- Identification of Funding Partners for Short-Term Projects
- ND Track Communications, Coordination, and Collaboration Plan
- What Happens Next?

Participant List

- FHWA/USDOT
  - Gary Crawford, Office of Pavement Technology
- State DOT
  - Shannon Swietzer, North Carolina Turnpike Authority (APH50)
  - Hua Chen, Texas DOT
  - Bryce Simons, New Mexico DOT
  - Doug Schwartz, Minnesota DOT
- Pavement Industry
  - Kevin Klein, GOMACO
  - John Eisenhour, Terex Roadbuilding
  - John Maurer, Ames Engineering
  - Dennis Warren, Texas Concrete Paving Association
- Academia and Other Industry
  - John Daniewicz, Rhino Analytics
  - Randall Jean, Baylor University
Ranking Parameters

A brainstorming exercise at the forum was conducted to rank measurement parameters according to importance and ease of implementation in a real-time monitoring system. The results are summarized below:

Importance (highest to lowest)                      Ease of Implementation (easiest to most difficult)
✓ Fresh Mix Properties/Variations                      ✓ Curing
✓ Curing                                           ✓ Surface Characteristics
✓ Surface Characteristics (smoothness/texture)        ✓ Fresh Mix Properties/Variations

Action Plan

In order to effectively build off of the work to date, a number of early products are recommended under the ND Track. These early products should include:

1. Identify most critical parameters to monitor during construction:
   a. Fresh mix properties/variability
   b. Curing operations
   c. Smoothness/texture
2. Identify corresponding technologies to assess most critical parameters to monitor during construction.
   a. Framework study that shows system integration of all potential devices, their location, their interrelationship, the wireless communication system, and the availability of information at various locations on the paving train, plant, or test laboratory.
   b. Complete and detailed study of sensor technologies
   c. Detailed study of types and protocols for wireless network tools to transmit and record sensor readings in an integrated communication system. This would include considerations to develop robust equipment and sensors needed to withstand equipment vibrations, weather, and other potential problems from the construction environment
3. Identify long-term research needs:
   a. Assess real-time measurement needs and techniques for concrete mix properties and variability
      i. Systems approach that would link data from plant, transport vehicles, and paving equipment.
   b. Develop causality links between paving operations and mix properties/variations on changes to pavement smoothness and texture.
c. Identify techniques and technologies to properly measure air void system in the appropriate location on the paving operation.

4. Identify short-term implementation needs:
   a. Develop equipment performance specifications for curing monitoring system similar to SmartCure
      i. Provide model specification to National Concrete Consortium.
   b. Search for funding mechanisms or incentives to further implement available real-time smoothness and/or texture monitoring systems.

5. Organize symposium of 40-50 attendees from concrete paving and sensing industries to discuss technologies to address identified measurement needs.
   a. Present engineering parameters of concrete paving that would benefit from new and improved sensing technologies.
   b. Present sensing technologies that directly address identified needs for concrete paving.

6. Further study of stringless paving operations, including superelevated, horizontal, and vertical curves.

Contacts
✓ Administrative Contact: Paul Wiegand, 515-294-7082, pwiegand@iastate.edu
✓ Technical Contact: Dennis Turner, 512-451-6233, dennis@thetransstecgroup.com
✓ CP Road Map Facilitator: Ted Ferragut, 202-744-4275, tferragut@tdcpartners.com
✓ Meeting Logistics: Denise Wagner, 515-294-5798, dfwagner@iastate.edu
APPENDIX G: CP ROADMAP SC TRACK

TASK FORCE MEETING #1
Participants

- FHWA/USDOT
  - Mark Swanlund (MS)
  - Larry Wiser (LW)
- State DOT
  - Bernard Izevbekhai (BI)
  - Brian Schleppi (BS)
  - Jeff Seiders (JS)
- Pavement Industry
  - Larry Scofield (LS)
  - Ron Guntert (RG)
- Academia
  - Steve Karamihas (SK)
  - Kevin McGhee (KM)
- National CP Tech Center
  - Paul Wiegand (PW)
  - Rob Rasmussen (RR)
  - George Chang (GC)
  - Gary Fick (GF)

Day 1: April 23, 1:00pm to 5:00pm

Introduction (PW)

- (see slide handouts)
- The goal of this meeting is to help point where research in concrete PSC should go.
- Brief history of the CP roadmap.
- Current CP Tech Center role is implementation and admin – demonstrated the proposed admin organization chart, track leadership groups for each track, etc.
- Stress the definition and importance of collaboration.

Draft SC Track Framework (RR)

- (see slide handouts)

On the overall Pyramid vision:

- BS: “Plowing” might be replaced by more general winter maintenance techniques including chemical treatments.
- KM: “winter maintenance” may be a better term.
PW: Make it “maintenance” to be more general.
JS: Expand the top “Users & society” to things such LCC.
SK: Suggest targeting this to DOT or even Congress!
JS: Communicate with the public on the potential impacts (better human experience, less maintenance).
BI: Metrics are important: how we measure and monetize the PSC and its impacts.
JS: For example, “reduction in accidents” has a real money index.
SK: “keep you alive but at what expense” … as a demonstration of alternative solution/problems. Human experience is when you get the phone calls or complaints.

Connection between PSC and Human response/social benefits
JS: Add LCC.
SK: Green, friction, safety.
MS/GF: “Rolling resistance for fuel savings”.
SK: No credible research on the benefits/effects from rolling resistance – need “objective” study.
RR: Europe has experience on rolling resistance researching – “green” is driving this.
RG: where should “material uniformity” be positioned (RR: at the bottom of the pyramid) texturing on plastic and solid state of concrete. Applying European techniques directly to the US without knowing the effects of material (e.g. Europe has well-graded, better aggregates).
BI: Cost aspects of general pavement characteristics (e.g., built-in curl/warp is expensive to grind).

Connection between pavement properties and factors
PW: add “foundation support” (citing a 2-year-old failed pavement).

Connection 5: Measurement/analysis techniques
PW: same metrics for various applications (e.g., use of IRI).
JS/RR: weather is an important factor for measurement and PSC selection.

ACPA Research (LS)
NGCS – next generation of concrete surfaces.
REMELS being developed for modern PCC surfaces.
Eight concrete pavements (one of them is 40-year-old, all have unknown surfaces) in the current REMEL database, and thus in the TNM model.
MS: Volpe is just a contractor for FHWA on TNM. Volpe is not the policy maker.
Nomograph from Purdue study on effects of joint faulting/opening width/sealant.
(LS will provide this)
Most of the field validation is not done.
Innovative surfaces – to establish limits.
LS/MS/JS: explain/discuss how ARFC can be built and issues associated with it.
As a “topping” – an open graded friction course.
RG/MS: European practices of cleaning porous asphalt show that it may be detrimental to pavement.
PW: what’s the grinding depth? LS: 1mm
Diamond shaped grooves on Caltrans roadway might be worth trying. 1969 report.
Trade off between cost and benefit.
GF: Casting texture into a mold can be used to produce surface pattern.
MS: parking lot in Universal Studio, Orlando – fan-pattern surface would be an interesting one to measure.
FHWA Research (MS)

♦ Pavement smoothness is considered relatively mature technology. Will be in all AASHTO provisional specs.
♦ Six FALCON teams were formed since 2007: ID gaps, proposed activities, get inputs from others.
♦ FY08 work areas were described (ULIP, ProVAL, specs).
  o Smoothness ETG: Sept will meet to push specs to be full standards.
  o Functional performance indicator.
  o ProVAL 3.0 will be based on .NET framework, due in Oct. 2008.
  o Potential revisions on the “skid crash reduction technical advisory” (last updated in 1980).
  o CTM/DFT/Griptester loan program (shipping has been an issue).
  o High friction surface demo using alternative materials on high crash locations. So far, several states (KS, TX, FL, WA) are interested. Calcined Bauxite is relatively cheap.
  o LS: Italgrip used to be called “ShellGrip”.
  o Pavement noise: TNM pavement effects study. OBSI test method updated. Pooled fund study on quieter PCC and HMA, and grinding. Close-spaced transverse tining (4-6 mm) will be tested.
  o Complementary studies with NCAT.
  o Splash-and-spray: feasibility study (done by Transtec) demonstrates that existing tests not suitable for roadway application. Recommended approach is modeling for now.
  o Integrated texture-noise model.
  o Pooled fund projects.
♦ Suggested FY09 new activities (starting Oct 1, 2008).
  o Smoothness QA – may modify the provisional specs.
  o PSC vs. crashes.
    ▪ JS: TxDOT has similar studies – suggest to include risk analysis (e.g., on positive texture)
    ▪ SK: mention the past IPRF studies that didn’t even mention pavement types. Confounding factors should be considered. Threshold values will be expected from this research.
    ▪ BI: Did similar studies at MnDOT and presented in TRB 2008. Weather records/information associated accidents are available in database.
  o Texture measurement using stereo vision – ultimately at high speed.
  o Definition of quiet pavements. (next step: measurement and thresholds)
  o Task 16 - How smooth is smooth enough for PCC (also a similar study on HMA).
♦ FHWA and collaboration
  o LW: FHWA would collaborate in national level.
  o MS: Any research-need statement to show products and benefits. FY09 activities will be on “softer” side as opposed to “gadgets”.
  o LW: there is a relationship between the FALCON focuses and the pyramid. This meeting is to get inputs from state and industry.
  o JS: Implementation would need collaboration with industry and equipment manufacturers.
  o RG: FHWA and states should allow innovation. E.g. smoothness spec is tighter – driving innovation to achieve, uniformity based on statistical specs.
  o JS: Design-build encourages changes/innovation in construction and equipment.

Future goals of TRB AFD90 Work (KM)

♦ The AFD90 future works/philosophy is in line with the CP Roadmap.
♦ BS: Profile pooled fund has enough parties involved to avoid effort duplication.
Summary of SC Work Conducted to Date (RR)

♦ A test section with two-lift JCP will be constructed in KS.
♦ RG: Two-lift is currently used in Western Europe and moving to eastern.
♦ JS: stress two-lift’s importance to address future needs.
♦ RR: Sustainability is the driven force in Europe to use two-lift.
♦ RG: Two-lift on CRCP is more challenging – need conveyor belts.
♦ RG: new vs. new vs. old for the splash-&-spray study is very important.
♦ MS/RR: transverse profile and cross-slope will be factored in the study.
♦ On the FWHA/Profile Pooled fund:
  o MS: Footprint, single-accelerometer, and reference profiler.
  o SK: Measurement issues will be resolved soon. Next is to resolve the threshold.
♦ On real-time profilers:
  o JS: It’s more a QC device.
  o SK: Effects from stringline, dowel-basket rebound, etc can be easily identified.
  o RG: System errors in paving process can be sorted out at early stages.
  o BS: Effects of maintenance treatment (such as chemical for ice removal) on PSC may need to be captured in northern states.
  o RG: Emphasis on tining techniques.
  o RR: We will be involved in construction to identify as-built texture variability.
  o SK: Longitudinal tining can be highly variable based on what has been seen.

Day 2: April 24, 8:00am to 12:00pm

Round Table Discussion (All)

GF

♦ Drag textures may be an improvement over what we are currently doing – what can we do to assure the industry that these can work long term. Do the results of “old research” still apply today?
♦ Short-term: get buy-in from past texture research. Fundamental research in splash and spray is important. Iowa Highway 30 experiences show that variability increases with different materials (e.g., aggregates). We shouldn’t sacrifice dense-graded mixture if we can.
♦ JS: Limestone fine aggregate has been problematic in TX for friction. Addressed friction through increased macrotexture by tining and an acid insolubility test to weed out calcareous materials. Running out of high quality siliceous sands though, so need to find alternatives. Possibly two lift is an alternative. Concerned with drag due to lack of macrotexture. How water drains will be a consideration though.
♦ Splash & Spray – is there a way to look at this in the field to compare to “typical” conventional textures?
♦ It is important to continue to do fundamental research, but maybe drag textures can be a short-term solution in some instances.
♦ SK: this may just be project-specific depending on materials, traffic, etc. Find out where and when we can use it now. We may have “Superpave-type” of research on PSC in the future, but we shouldn’t just wait for the fundamental research to be done.
♦ JS: can be similar to mix design – a “step by step” process to define texture. Also, we should use a blank tire as this may decouple the factors of texture on friction.
♦ The variability in the tined texturing seems to be closely related to the mortar, especially when aggregates begin to be picked up that are near the surface. How does this affect the as-constructed texture (deviation from nominal) and the variability in wear? Another reason why drag textures might be of benefit.
RG: A project he has seen spalled badly because of the need to meet a tine depth spec. Forced the contractor to work a lot of mortar to the surface.
JS: Want to get away from tining in order to improve durability (go to a more well-graded mix).
RG: One of the benefits of longitudinal tining is that curing can be done quickly, but maybe a t/c cart can be outfitted to do this without “backing up”. Well-graded mixtures are needed for smoothness; hard to do this with most gap-graded mixtures. The mix designs should drive, not the tining.

**BI**

Mix design as it pertains to texture and texture durability. It may be just part of the mix design that is important: gradation, for example. Admixture incompatibility may lead to problems with the concrete retaining texture.
Loss of texture does not necessarily imply loss of friction. Hysteresis effects can actually increase with wear. Need to look at the various friction-texture relationships independently, and not take too simple of an approach.
There may be a point in engineering texture beyond which friction is not significantly improved.
Selection of the tire for skid testing differentiates the various friction mechanisms to some degree.
If there are any textures that appear to show promise, these could possibly be added to Mn/ROAD, but the window is short.
JS: we should track 10-67 test section textures. The simplified model of a wheel displacing water as it rolls is in some ways keeping Texas from moving away from tining, since it shows the benefit of tining to minimize the potential of hydroplaning.
CPAM requested that a transverse drag texture be tried – maybe to help hydroplaning.
The surfaces being planned now include trans. Tined, turf drag (normal, light, and heavy). 1 mm minimum texture depth (with sand patch). Exposed aggregate (as part of a two-lift pavement) done next year, transverse drag. There is no longitudinal tining.
Looking at texture durability/degradation.
Characterizing texture – comparing MTD of different nominal textures can be deceiving in terms of their relevance to pavement surface characteristics. Spectral content is another measure – but does this have the same issues when comparing between varying nominal texture types.
There should be a better understanding of the hysteresis component of friction – how it changes over time, traffic, environmental exposure.
Seasonal variation – how do we account for this in comparing measurements? Spectral content may be a good diagnostic.
At MnDOT, transverse drag is being attempted. Heavy- and light- turf drag is also being planned.
SK: Profile study will involve longitudinal tining.

**RG**

Do we need a spec for consistency in grooves in longitudinal tining – will this help noise? Should check with Woodstrum where they have slipped longitudinal lines under the pan.
Type 1 Wisconsin will look at subtle variations in mix, texturing that lead to variability.
JS: looking at grooving – negative texture should be of benefit. Curing and protection quickly after placement seems key. This is the reason they’ve gone to grooving on bridge decks.
Cost is a consideration when looking at extensive grinding.
GF: has built prototypes of a heavy mat that can (when dragged) impart grooves. The success is probably mix dependent.
Manual finishing behind the paver might be problematic if texturing is done at the pan.
“Green grooving” might be a consideration.
What is best depth for friction – 0.7 mm or more (MTD) seems to be a reasonable in terms of relevance to crashes – this is not a clear boundary though and shouldn’t be used as a rule.
JS

♦ Understanding of Mix Design using Concrete Works – materials properties – something that can possibly tie back to effects on texture.
♦ Concrete surfaces are needed that are safe, durable, comfortable, and sustainable. But cost issues are a real consideration.
♦ Maybe we need to use different textures in different locations depending on the demands. Traffic, geometric requirements, trucks.
♦ Most DOTs are moving to almost exclusively maintenance operations due to a lack of funding. Funding streams for capital projects will be coming from other sources – PPP, bonds, etc. The projects that result will be more performance based.
♦ SK: Interactive Highway Design Module was developed with the goal of visualizing the behavior and performance of traffic. Is it possible that a site-specific tool could be developed that will consider the numerous factors, but with an emphasis on surface design.

SK

♦ Need a relevant figure of merit (with a direct link to serving the public) – in smoothness we have something (good, not perfect), but do we have it in friction?
♦ Need a reproducible (time stable) and inexpensive (used for both QC and QA) measurement system – stability of texture too with time, sorting out changes in the measurement.
♦ Need a system of auditing field measurements (certification against a reference measurement, spot checks).
♦ Need a defensible set of thresholds (what is unacceptable, what is good enough, what would you pay for an increment of improvement).
♦ What exists now for friction is really a way to identify “problem pavements”, but is not necessarily what is right for a fundamental approach to link texture ultimately to safety. Skid trailers rarely if ever simulate the condition of emergency braking. Electronic stability control systems will soon be mandated, making locked-wheel even less relevant. We should not “optimize” texture to meet locked wheel skid numbers.

BS

♦ Recognizes that the locked wheel test is not measuring what we need to. Moving to smooth tire is at least a step in the right direction. Texture depth seems to be a good measurement, while some sensors have shortcomings with certain concrete textures (esp. longitudinal). Need to look more at macrotexture as an indicator that might be more relevant to safety.
♦ We have no control over the tires and brake systems. We need to focus on what we can control: the pavement surface.
♦ Should a contractor be allowed to use extensive grinding to achieve smoothness?
♦ Will noise dictate when we grind?
♦ We have not been able to effectively communicate PSC with folks that are closer to the bottom of the pyramid – those designing and building and maintaining the pavements.
♦ Better practices for building smoother concrete pavements are needed.
♦ RG: mix design is one of the key factors in this. It took a season to make the transition to zero blanking band in Iowa – the contractors used that season to learn their processes that affected smoothness the most.

MS

♦ What makes good pavement surfaces good, and what makes bad ones bad – noise, friction. Hope is that this leads to real-time diagnostics.
♦ How do we select the most appropriate surface for the particular application?
♦ Need measurement methods that are deployable for QC/QA/IA.
♦ We can grab short-term items now and implement today – other items can be scheduled out medium- to long-term. A lot of this can help organize these items.
KM
♦ We are maintaining the system a lot more than building new.
♦ Functional performance expectations for repair and maintenance work. What can we reasonably expect for this kind of work? Grinding contractors are educating themselves, but what targets should/can a DOT establish? Not just smoothness either.
♦ Is it possible that a concrete surface isn’t necessarily the best option – are there “composite” options with a different type of wearing surface.
♦ JS: with good curing and structure – only the surface remains to be engineered in such a way to achieve a “100 year” pavement.
♦ Durability of pavement markings is becoming an increasing issue.
♦ AFD90 items.
♦ BI: we should pick surface rehab on projects that they are needed. We cannot quantify the benefits that are received unless the baseline is appropriate.

RG
♦ We should measure the fundamental aspects of the pavement that can be used to help optimize for multiple PSC. With the texture aspects selected that should be controlled, the contractors can be asked to control them. The equipment can then be designed to help the contractors meet these specs.
♦ What drives innovation is when a need exists. Things like RoboTex help to quantify the fundamental aspect needed to identify the other aspects that require control.
♦ BS: there is still too adversarial of a relationship between DOT and industry that seems to be stifling progress.
♦ JS: with the new funding relationships and performance requirements, these relationships will change.
♦ GF: a lot of the issues can be traced to methods specs – performance specs can make it more complicated for the contractor, but ease relations.
♦ Two issues that hinder improvement in concrete: 1) not a consistent program in concrete each year. Contractors cannot justify large investments and will fight changes in spec that require investment; 2) fear of bonus specifications (by DOT) – not recognizing that the competitive environment will not increase bid prices overall. Smart contractors find the things that need to be done to get to the bonus; improving quality without costing more.

LW
♦ How do you design for improved surface characteristics?
♦ Link back to materials – how can these affect improvements to PSC?
♦ Maintenance and preservation techniques/activities to improve PSC.
♦ What about a connection to the tire and vehicle industry?
♦ Trade-offs between all PSC and how these related to economics, safety, fuel consumption, environment
♦ Standardizing how PSC are measured – calibration, validation, standardizing techniques, output format, etc. – also, quantifying what is being measured in a way that relates back to a reference
♦ Specs can then be implemented on designing and constructing, and back to maintenance and preservation standards.
♦ PPP and warranties (long-term maintenance contracts/agreements) – bonding capacity of contractors.
♦ SK: has been talking to tire people, and has expressed interest (recently retired people that “can talk now”). John Ferris is another contact.
♦ Vehicle and tire changes can affect how we “optimize” pavements.

LS (notes)
♦ Smoothness repeatability.
How best to measure safety.
Rolling resistance.
Changes in properties over time.
Diurnal changes.
Pervious concrete.
Minimum amount of time for noise measurement

**Presentation of proposed short-term projects (RR)**
(see slide handouts)

**Discussion on projects and funding (All)**

- **JS:** we had a good model on profiling – with working groups, and the products being fed to AASHTO. A similar approach is being approached with noise. Could this same model be used for friction, where we could bring in the experts in the auto/tire industry, for example. The noise is now in a pooled fund, to keep the expertise together.
- **MS:** the ETG had specific tasks – mostly to develop specifications. Those task groups “worked for” SOM. These ETGs will continue to be supported. There isn’t a problem per se with a friction ETG, but the tasks need to be identified.
- **KM:** what might come from the TA for friction that would lead to a mission for an ETG? **Mark:** friction management might be one topic for discussion. TA’s are policy, not consensus documents.
- **JS:** what we should be measurement and how to measure it can be tasks.
- **NCHRP 1-43** can be used as a starting point – this might lead to a need for measurement standards.
- **KM:** what about the need for a friction workshop?
- **SK:** what is discussed in tire courses would be a key part of that (friction workshop).
- **JS:** should we start the track on friction that noise and smoothness have had?
- **SK:** a broader heading of “safety”.
- **MS:** FHWA, NCHRP, and Pooled Fund are options for funding.
- Not a lot of “hard side” statements have worked their way through SCOR.
- This topic would cover design, construction, and materials.
- **JS:** NCHRP process takes a long time. This is the advantage of the ETG – tasks can be completed quicker – more efficient mechanism. Especially for standards.
- The less urgent projects can be fed through more conventional “research” mechanisms.
- If more control is needed, a “pooled fund” could work. FHWA-managed pooled funds work well.
- **JS:** propose using Washington State for pooled fund – TX, MN, WA, CA “four state” pavement construction consortium. This has worked well in getting things on the street quickly.
- **MS:** Pooled fund in VA is covering PSC – idea is to serve local states with equipment rodeos, etc. – is it possible to leverage this with the tire-pavement noise pooled fund being managed by WSDOT.
- **KM:** measuring and characterizing texture would be a fit with the VA pooled fund.
- **JS:** where do the industry groups come in? Are there funding mechanisms through them?
- **ACPA, NRMCA (RMC foundation)** have participated in the past. Assuming with the appropriate approach, this could continue.
- **IGGA** has been instrumental in the diamond grinding pooled fund at Mn/ROAD.
- **MS:** industry participation at Mn/ROAD has been a good example – much of it is “in kind” contributions of services.
- **JS:** should consider interfacing with the SPTC. Part of the meetings is to discuss work ongoing and gaps. We should participate.
- Meet again in fall. Links to the mission of SPTC – mechanistic approaches, foundation issues, etc.
GC: statistical based specification for uniformity is a goal of IC, can that be adopted in this issue.

RG: executive committee of CP Road Map is attended by stakeholders. This collaboration can extrapolate to pooled funding.

JS: when pooled, can take advantage of the resources that each state has to offer.

RG: Consortium leaders (NCC, SPTC) should be brought together. All too often there are meetings like this that mention the same problems. RoboTex was a way to visualize – making it easier to understand the mechanisms at play. We need to link our common gaps, and see if we can work together to address them.

BI: the PI might not be the most technical person – might be others more appropriate on the project.

JS: if the FHWA is developing a TA on friction management, there are going to be reactions. It seems that friction is the next logical area.

Say “safety”, not “friction”.

JS: it seems that the ETG mechanism should be in place to develop the information before approaching JTCP or SOM.

SK: pooled funds can sometimes start with a need, as a forum to discuss… and then lead to the products of most value.

BI: the first meetings are usually just to discuss the issues to better understand. A lot of times the results of the pooled fund doesn’t match the original scope.

MS: the initial solicitation of VA pooled fund was vague, and it has since been narrowed down.

LW: the FWD UG proposed a pooled fund for calibration centers, but the scope evolved to where broader interest was gained.

JS: there needs to be motivation sometimes to bring groups together to address these issues. Friction may be one of those because of the upcoming TA.

BS: what is the next step in terms of collaboration? We should quantify what it is that we need to know about texture, and then identify how to measure that. This has to work among all material types. This will likely address half of the friction issue.

JS: closely related is if we are addressing safety with skid alone.
APPENDIX H: UNDERSTANDING AND OPTIMIZING
CONCRETE PAVEMENT SURFACE CHARACTERISTICS
Background

What is a pavement surface characteristic (PSC)? Said simply, it is a way to describe a pavement surface that directly or indirectly connects to a human response or societal need. It includes things such as smoothness, friction, noise, splash & spray, surface drainage, and rolling resistance. Other characteristics include tire wear, vehicle wear, and reflectivity & illuminance. Affecting these surface characteristics are numerous pavement properties, with the most important being surface texture. These “bumps and dips” in the road range in size from long rolling undulations to asperities that cannot be seen with the naked eye. Other important pavement properties include the degree of permeability and porosity, cross-slope, and mechanical impedance (stiffness). Even the color of the surface will also affect some surface characteristics both directly and indirectly.

In July 2006, the National Concrete Pavement Technology Center (CP Tech Center) published a Strategic Plan for Improved Concrete Pavement Surface Characteristics. The plan included an update to the Surface Characteristics (SC) Track of the Long-Term Plan for Concrete Pavement Research and Technology – The Concrete Pavement Road Map published in September 2005.

Meanwhile, a coordinated three-part effort has been underway since early 2005 termed the Concrete Pavement Surface Characteristics Program. Managed by the CP Tech Center, this effort has pooled funding and experience from within the FHWA, the concrete paving industry including ACPA, and numerous State DOTs. In early 2007, the third part of this program was launched under Pooled Fund TPF-5(135).

The purpose of this document is to consolidate both ongoing and proposed activities related to concrete pavement surface characteristics. It is intended to be a technical framework document, developed as part of the CP Road Map SC Track implementation. The framework effort will, in turn, update and validate a prioritized, productive, coordinated, and non-duplicative research plan for addressing knowledge gaps and advancing improvements in concrete pavement surface characteristics.
Mission Statement for the SC Track

Under the SC Track, the concrete pavement industry will work together to develop specifications and guidelines to design, construct, and maintain concrete pavements that are safe, comfortable, durable, and cost effective. The goal is concrete pavements that invoke a pleasant human experience and address an array of societal needs. The SC Track will coordinate the research and technology that is necessary to achieve this goal. It will promote collaboration among partners, and ensure that duplication is minimized.

Identifying the Gaps using an Integrated Perspective

In developing the CP Road Map, and with the SC Track Goal in mind, a thorough review of the state of the practice was made. From this, numerous gaps were identified with respect to concrete pavement surface characteristics research and technology. The idea was that in order to fill these gaps, a workplan of activities would be developed.

Since that time, we have learned a lot, and while most of the gaps identified in the CP Road Map remain, they can now be presented more concisely. However, before presenting the gaps, we must first identify how PSC fit within the decision-making framework. With an integrated perspective, we can begin to understand how to more optimally direct the proposed research program.

Figure 1 illustrates this integrated perspective. As highway practitioners, our mission has always been to serve the public with a safe, comfortable, and cost effective highway system. What the pyramid shows are the logical connections between the human factors at the top and the technical factors at the bottom.

Figure 1. An Integrated Perspective of Pavement Surface Characteristics.
THE LEVELS OF THE PYRAMID REPRESENT COMPONENTS OF THIS SYSTEM. WE COULD CLIMB THE PYRAMID BY STARTING WITH THE MOST BASIC FACTORS AT THE BOTTOM – SOME ARE UNDER OUR CONTROL, OTHERS WE NEED TO RECOGNIZE THEIR INFLUENCE AND MITIGATE THEIR EFFECTS IF/AS NEEDED. PAVEMENT PROPERTIES ARE AFFECTED BY THESE FACTORS, INCLUDING BOTH AS-CONSTRUCTED VALUES AND HOW THEY CHANGE OVER TIME. THE PROPERTIES, IN TURN, AFFECT THE PSC IN VARIOUS WAYS. FUNCTIONAL PERFORMANCE IS ANOTHER WAY TO DESCRIBE PSC, AS IT IS THE ABILITY TO DESCRIBE THE NATURE OF THE PAVEMENT SURFACE AS IT SERVES ITS INTENDED FUNCTION. THIS LEADS TO THE LAST CONNECTION WHERE THE PSC ULTIMATELY DETERMINE HOW THE PUBLIC IS SERVED.

REVERSING THIS PROCESS ALSO HELPS ILLUSTRATE IT. CLIMBING DOWN THE PYRAMID BEGINS WITH THE DEMANDS PLACED ON THE HIGHWAY INDUSTRY BY THE USERS AND SOCIETY. THESE COULD BE LEGISLATIVE DEMANDS DRIVEN BY PUBLIC OUTCRY. THESE DEMANDS WOULD, IN TURN, TRANSLATE INTO VARIOUS THRESHOLDS OR TARGETS OF PSC. TO ACCOMPLISH THESE LEVELS OF PSC, CERTAIN PAVEMENT PROPERTIES AND COMBINATIONS THEREOF MUST BE PRESENT. AND IN ORDER TO ACHIEVE THESE PAVEMENT PROPERTIES, THE VARIOUS FACTORS MUST BE SELECTED AND CONTROLLED, IDEALLY IN A COST-EFFECTIVE MANNER.

THE LINKAGES (SHOWN AS THE VARIOUS ARROWS ON THE RIGHT) ARE KEY TO THE WORK PROPOSED UNDER THE SC TRACK. THE GAPS IN RESEARCH AND TECHNOLOGY ARE LARGELY BORNE FROM A NEED TO UNDERSTAND THESE LINKS. IT IS NOT ENOUGH TO UNDERSTAND THE LINK BETWEEN JUST TWO OF THESE LEVELS; ALL OF THE LEVELS MUST BE CONNECTED IF THE SC TRACK IS TO ACHIEVE ITS ULTIMATE GOAL.

WITH THIS INTEGRATED PERSPECTIVE, THE GAPS AS THEY STAND TODAY CAN BE PRESENTED IN TERMS OF FIVE SIMPLE QUESTIONS. EACH QUESTION IS CROSS-REFERENCED BACK TO THE PYRAMID WITH THE QUESTION NUMBER. THE FIRST THREE QUESTIONS ADDRESS THE LINKS BETWEEN LEVELS. THE LAST TWO IDENTIFY GAPS THAT RELATE TO THE PROBLEM MORE GLOBALLY.

1. **What are the links between PSC, human response, and societal benefit?**

   Affected by our highways are the drivers, those that live and work alongside these roads, and society as a whole. As highway engineers, we can measure PSC, but difficulty lies in relating these back to specific human perceptions and societal impacts. For example, how does friction (a measurable characteristic) relate to safety – or even more specifically, to wet-weather accident rates? With respect to smoothness, indicators such as the International Roughness Index (IRI) are mathematical transformations of physical measurements. But how does this relate to comfort or possibly the effect it might have on cargo? Finally, noise is measured in terms of level, but this should also be connected to annoyance.

   The need exists to relate the physical measurements of PSC to the human responses that they trigger. A determination must also be made about how societal needs are being fulfilled. To understand this link will require tools such as life cycle analysis that not only account for tangible costs, but also indirect factors such as safety and comfort. Only then can rational threshold or target values for PSC be derived.

2. **What are the relationships between pavement properties and PSC?**

   Pavement surface characteristics describe a pavement in a number of unique ways. While some PSC are fundamental physical characteristics, others are the result of a response between the pavement and a vehicle and/or tire. As a result, the problem can be quite complex due to the sheer variety of vehicles that exist.

   Pavement texture is arguably the most important pavement property affecting PSC. There are other important properties, however, including stiffness, cross-slope, color, and in some cases, porosity. Predicting PSC requires an understanding of the physical pavement properties as they interact with the vehicles, and compounded by other factors including weather. Identifying these relationships will fill a
gap, since only then can optimization of a pavement surface truly occur. To the greatest degree possible, models are needed that are mechanistic in nature so that current experience can be more confidently extrapolated to more innovative pavement materials and textures.

3 How do design, materials, construction, maintenance, climate, and traffic factors affect pavement properties, both initially and over time?

In the previous question, we identified the need to understand what pavement properties affect PSC. However, we must also determine what degree of control we have over the factors affecting those properties. For example, pavement texture can be specified during design in terms of nominal dimensions. The same is true of other relevant properties including cross-slope, stiffness, etc. However, how these properties are constructed and how they change over time will depend on the equipment used, properties of the concrete, and the weather conditions during placement and over time. Other contributing factors will also be at play including accumulated traffic and maintenance, especially snow plowing. How all of these factors affect both the pavement properties and the changes over time remain as critical gaps. Linked with this should be a keen understanding of the impacts to the material and structural performance of the pavement.

4 Can concrete pavement surfaces be optimized and/or innovation introduced to meet site-specific conditions?

Optimization of a pavement surface must consider the demand placed on that surface by the users and society. The demands will be, of course, site specific. From these demands, unique target and threshold values for PSC can be derived that, in turn, point to various combinations of pavement texture and materials. While it is believed that the vast majority of the highway system will continue to utilize “conventional” texturing techniques, each should be described in terms of what it can provide on a consistent and predictable basis. To complement this, innovative materials and techniques should also be explored, including exposed aggregate surfaces, porous concrete, and non-conventional textures, materials, and construction methods.

5 Are today’s measurement and analysis techniques satisfactory in characterizing pavement properties and PSC?

In order to collaborate effectively, standard techniques to measure and characterize the pavement surface must be established early in the SC Track. These techniques should attempt to measure pavement properties and PSC in as fundamental a way as possible. In contrast, many of the techniques in use today measure a system response, which in turn is a function of the test equipment. While separating the pavement effect from that of the equipment is difficult in some cases, it should be strived for. To fill this gap, measurement and analysis techniques are needed that are relevant, accurate, portable, and ideally performed both efficiently and with minimal training demands. Practical considerations must also be effectively addressed including things such as the effect of weather conditions during measurement.
The SC Track: a Plan to Fill the Gaps

Within the original CP Road Map, a structured outline for the SC Track was presented. The Track was divided into subtracks, and then again into tasks that describe individual “compartments” of research and technology. Collectively, the work program will meet the goal of the Track, but only if collaboration is realized.

Since 2005, work under the SC Track has been informally launched through the efforts of the FHWA, CP Tech Center, and others. However, the need now exists more than ever to more formally manage the SC Track to make it a success.

The SC Track currently identifies 40 problem statements representing an investment of between $27 and $56 million in research. The proposed research is organized into seven subtracks and presented in a recommended sequence:

- Subtrack SC.1: Innovative and Improved Concrete Pavement Surfaces
- Subtrack SC.2: Tire-Pavement Noise
- Subtrack SC.3: Concrete Pavement Texture and Friction
- Subtrack SC.4: Safety and Other Concrete Pavement Surface Characteristics
- Subtrack SC.5: Concrete Pavement Profile Smoothness
- Subtrack SC.6: Synthesis and Integration of Concrete Pavement Surface Characteristics
- Subtrack SC.7: Technology Transfer and Implementation of Concrete Pavement Surface Characteristics Research

Problem statements contained in the plan may correspond to one or more individual projects. Over the course of the SC Track, each problem statement will be developed into research project statements that will contain detailed descriptions of the research to be accomplished, specific budgets, and definite timelines. Detailed problem statements for the SC Track are not included here for brevity, but can be found in the National CP Tech Center Publication, Strategic Plan for Improved Concrete Pavement Surface Characteristics, published July 2006.

In order to effectively build off of the work to date, a number of early products are recommended under the SC Track. Most of these are proposed as syntheses given the fragmented reporting of the work to date. These early products should include:

1. A description of highway user (functional) requirements for all classes of roads (streets, low-volume, highways, special applications); identification of PSC levels that fulfill these requirements.
2. Relationships between pavement texture and other pavement properties as they affect all PSC.
3. Concrete pavement designs, materials, and construction methods that produce predictable levels of PSC.
4. Documentation of changes in PSC over time as a function of design, materials, and construction, along with traffic, climate, and maintenance.
5. Advancements in equipment and standardization for continuous and efficient measurement of PSC in an accurate and relevant manner.
6. Preliminary design, construction, and measurement guidelines including technology transfer products that serve to convey the lessons learned to date.

The research plan as organized under the SC Track should be used as a guide. Obviously, beyond these early products are numerous other tasks that seek to fulfill the ultimate goal of the Track.
Foundational, Recent, and Ongoing Work

The following is a summary of some of the more relevant work that is foundational in nature, recently completed, and/or ongoing. While categorized under the Subtrack headings, no attempt is made here to prioritize their relevance. Collaboration with the sponsors and researchers of these projects will be important to the success of the SC Track.

Subtrack SC.1: Innovative and Improved Concrete Pavement Surfaces

- Concrete Pavement Surface Characteristics Program, Part 3 – CP Tech Center / FHWA / Pooled Fund TPF-5(139)
- Two-Lift Concrete Paving Program – National CP Tech Center / Kansas DOT / FHWA
- Third-Generation Road Surfaces (Modieslab) – IPG Noise Innovation Program (Netherlands)
- Optimized Diamond Grinding and Innovative Texturing – ACPA
- PCC Surface Characteristics – Rehabilitation (Mn/ROAD Study) – Pooled Fund TPF-5(134)
- Innovative Methods for Creating Texture on Pavements, Conceptual Papers and Field Trials – FHWA
- Texturing of Concrete Pavements – NCHRP 10-67
- Concrete Mixtures with Inclusions to Improve the Sound Absorbing Capacity of PCC Pavements – Recycled Materials Resource Center / FHWA
- Use of Lightweight Aggregates for Tire-Pavement Noise Reduction – FHWA

Subtrack SC.2: Tire-Pavement Noise

- State DOT Quiet Pavements Research Programs – Caltrans, Washington State, Colorado, Texas, Florida, Arizona (QPPP)
- Tire-Pavement Noise Research Consortium – Pooled Fund TPF-5(135)
- Traffic Noise Model (TNM) 3.0 Software Development – FHWA / Pooled Fund TPF-5(158)
- Pavement Effects Study for TNM – FHWA
- Measuring Tire-Pavement Noise at the Source – NCHRP 1-44
- Truck Noise Source Mapping – NCHRP 8-56
- Methodologies for Evaluating Pavement Strategies and Barriers for Noise Mitigation – NCHRP 10-76
- Noise Intensity Testing in Europe (NITE) – Caltrans
- Sustainable Road Surfaces for Traffic Noise Control (SILVIA) – FEHRL (Europe)
- Standardization of On-Board Sound Intensity – AASHTO / ASTM / SAE

Subtrack SC.3: Texture and Friction

- Texture and Friction Measurement Equipment Loan Program – FHWA
- Guide for Pavement Friction – NCHRP 1-43
- Harmonization of Texture and Skid Resistance Measurements – Florida DOT
- Assessment of Alternate PCPP Texturing Methods in Colorado – Colorado DOT
- Harmonization of European Routine and Research Measuring Equipment for Skid Resistance (HERMES) – FEHRL (Europe)
**Subtrack SC.4: Safety and Other PSC**
- Relationship between SN with Ribbed and Smooth Tire and Wet Accident Location – Ohio DOT
- Wet Pavements Crash Study of Longitudinal and Transverse Tined PCC Pavements – Wisconsin DOT
- Review of UK Skid Resistance Policy – Highways Agency / TRL (UK)
- Relationship between Macrotexture and Crash Occurrence – ARRB (Australia)
- Characterizing the Splash and Spray Potential of Pavements – FHWA
- Cool Pavements Initiative – EPA / Arizona State Univ.
- Rolling Resistance of Tires on Road Surfaces – BAST (Germany)
- Effect of Pavement Surface Type on Fuel Consumption – NRC (Canada)

**Subtrack SC.5: Smoothness**
- Development of a “Golden Tire Footprint” for Improvement of Profiler Reference – FHWA
- Improving the Quality of Pavement Profiler Measurement – FHWA / Pooled Fund TPF-5(063)
  - ProVAL Software
  - Reference Profilers
  - Benchmark Profiler
  - Single Accelerometer Study
- Smoothness Criteria for PCC Pavements – FHWA
- Ultra-Light Inertial Profiler Prototype – FHWA
- Smoothness Specification Implementation and Support – FHWA
- Measuring Pavement Profile at the Slipform Paver – Iowa HRB / FHWA

**Subtrack SC.6: Synthesis and Integration of PSC**
- Pavement Surface Properties Consortium – Pooled Fund TPF-5(141)
- Concrete Pavement Surface Characteristics Program, Part 1 – CP Tech Center / FHWA
- Concrete Pavement Surface Characteristics Program, Part 2 – CP Tech Center / FHWA / ACPA
- Synthesis of Performance-Based Surface Condition Measurements for Acceptance – FHWA

**Subtrack SC.7: Tech Transfer and Implementation**
- Little Book of Quieter Pavements and Listening Experiences – FHWA
- Tire-Pavement Noise 101 Workshops – FHWA
- Pavement Smoothness Workshops – FHWA
**Proposed Short-Term Projects**

With past and ongoing work summarized, gaps in research and technology identified, and a vision formed for the early products, a specific program of short-term work can now be laid out. The following is a list of five projects that would help fill the early gaps, and work within the timeline for the track:

<table>
<thead>
<tr>
<th>Subtrack / Link to Integrated Perspective (see Figure 1)</th>
<th>Project Title</th>
<th>Project Scope</th>
<th>Cost Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC.6 1</td>
<td>Development of an Integrated Functional Classification System for Concrete Pavement Surface Characteristics</td>
<td>In this project, the links between societal/human factors and the various pavement surface characteristics will be identified. Using current measures/metrics for the various PSC, both target and threshold values will be identified that meet the demands for various types of roads. A classification system should be developed that is rational, simple to understand, and can be readily localized by State DOTs. The resulting system should be peer reviewed, and evaluated using network data from 3-5 States.</td>
<td>$500,000 to $750,000</td>
</tr>
<tr>
<td>SC.2 SC.3 SC.4 SC.6 2</td>
<td>Refinement of Models to relate Pavement Texture to Noise, Friction, Splash &amp; Spray, and other Concrete Pavement Surface Characteristics</td>
<td>To date, there has been some effort to link pavement texture to tire-pavement noise, friction, and other PSC. However, little has been done with respect to concrete pavement textures, and furthermore, little has been done to approach this problem with an ultimate goal of a unified model that links texture to all PSC. A number of individual projects will be undertaken with the goal of developing new or revising existing models with specific application to concrete pavement textures. Existing texture data can be used for model development, and validated with new data as necessary – both from in the field and under controlled conditions in the laboratory.</td>
<td>3 to 5 projects of $100,000 to $250,000 each</td>
</tr>
</tbody>
</table>
Some effort has been undertaken to date to identify the potential effects that design, materials, construction, and climate can have on a concrete pavement surface. Specific properties include slab curvature, texture depth, and surface wear potential. This project will seek a more complete and coherent understanding of these relationships, along with the necessary links to material and structural performance.

A robust analysis of available data should be conducted including that from LTPP SPS2 sites and sites previously evaluated under the CPSCP. Furthermore, new concrete pavement sections should be evaluated both during and subsequent to construction in order to identify those characteristics that can be attributed to specific construction activities and equipment.

<table>
<thead>
<tr>
<th>Subtrack / Link to Integrated Perspective (see Figure 1)</th>
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<th>Cost Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC.3 SC.5 3</td>
<td>Characterizing Design and Construction Artifacts in Concrete Pavement Surfaces</td>
<td>Some effort has been undertaken to date to identify the potential effects that design, materials, construction, and climate can have on a concrete pavement surface. Specific properties include slab curvature, texture depth, and surface wear potential. This project will seek a more complete and coherent understanding of these relationships, along with the necessary links to material and structural performance.</td>
<td>2 to 3 projects of $500,000 each</td>
</tr>
<tr>
<td>Subtrack / Link to Integrated Perspective (see Figure 1)</td>
<td>Project Title</td>
<td>Project Scope</td>
<td>Cost Estimate</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>---------------</td>
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</tr>
<tr>
<td>SC.7</td>
<td>Training for Improved Surface Characteristics through Better Practices in Concrete Pavement Design, Constriction, and Maintenance</td>
<td>A lot of knowledge is amassing with respect to how concrete pavements can be designed, constructed, and maintained in order to make them safer and more comfortable without compromising durability or cost. Building off of the success of previous outreach efforts including the Tire-Pavement Noise 101 and Improved Pavement Smoothness Workshop series’, the proposed training program will consist of up-to-date workshop series’ that broaden the scope to include all PSC. While the training will include requisite sections on fundamentals, better practices will be the emphasis. The participants in the training should walk away with a skill set that can be immediately applied to daily practice. Follow-up support will also be provided, allowing participants of the training to have access to the experts that can assist them with specification development and related procedural changes.</td>
<td>1 to 2 projects of $250,000 to $500,000 each</td>
</tr>
</tbody>
</table>
## Improved Concrete Pavement Texture Evaluation

Work under the SC Track will place a much higher demand for accurate texture data that is relevant to all PSC. Current measurement technologies fall short of these demands, and therefore a series of projects is proposed to address this. Ideally, three projects will be undertaken that 1) will specify the newer requirements for texture measurements; 2) develop equipment; and 3) evaluate the new equipment in terms of its ability to meet the more stringent demands.

The first project would establish the criteria that can subsequently be used to evaluate the desirability of texture measurement systems. Possible criteria include measurement accuracy and representativity/relevance for texture of various sizes, cost, proprietary nature, and production (measurement) rate.

Development of equipment can then proceed, which can be funded publicly (an open architecture prototype), privately (with response left to the free market), or a combination that might use seed (grant) money to spur development.

The final step will include an evaluation of the equipment against the new criteria, and furthermore demonstrating the capabilities of the equipment on a variety of concrete pavement surfaces.

<table>
<thead>
<tr>
<th>Subtrack / Link to Integrated Perspective (see Figure 1)</th>
<th>Project Title</th>
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</tr>
</thead>
</table>
| SC.3                                                    | Improved Concrete Pavement Texture Evaluation | Work under the SC Track will place a much higher demand for accurate texture data that is relevant to all PSC. Current measurement technologies fall short of these demands, and therefore a series of projects is proposed to address this. Ideally, three projects will be undertaken that 1) will specify the newer requirements for texture measurements; 2) develop equipment; and 3) evaluate the new equipment in terms of its ability to meet the more stringent demands. 

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Development of equipment can then proceed, which can be funded publicly (an open architecture prototype), privately (with response left to the free market), or a combination that might use seed (grant) money to spur development.

The final step will include an evaluation of the equipment against the new criteria, and furthermore demonstrating the capabilities of the equipment on a variety of concrete pavement surfaces. | 2 to 3 projects of $250,000 to $500,000 each – industry match and/or public/private partnerships |
Stakeholders and Partners

Successful collaboration under the SC Track will require participation from a number of diverse groups. The following includes a summary of stakeholders and partners divided into two tiers. The first includes organizations that have already demonstrated active roles in this area, primarily through sponsorship of work items previously described. Tier II includes groups that logically have a stake in the outcome of the research, but whose participation may need to be sought when the timing is deemed appropriate.

- **Tier I – Active Stakeholders and Partners**
  - FHWA
  - State DOTs / NCHRP
  - ACPA Chapters
  - ACPA National
  - IGGA
  - PCA
  - Concrete Paving Contractors
  - Diamond Grinding Contractors
  - Construction/Texturing Equipment Manufacturers

- **Tier II – Reserve Stakeholders and Partners**
  - AASHTO
  - City and County Governments
  - Public and Private Tollway Authorities/Concessionaires
  - ACI
  - Measurement Equipment and Sensor Vendors
  - Pavement Evaluation Firms
  - NRMCA
  - TRB
  - Concrete Paving Industry Consortiums (e.g., NCC, SCAN, ISCP)
  - RPUG
  - Vehicle and Tire Industries

Inaugural SC Track Meeting

**Date/Location**

- Date: 23-24 April 2008
- Location: Grapevine, TX

**Objectives**

- To achieve consensus on the ultimate objectives of the SC Track.
- To validate what knowledge gaps exist today.
- To identify how we as an industry can work to fill these gaps.
- To identify early projects and their funding mechanisms.
- To help advance the CP Road Map SC Track to a dynamically managed program.
**Final Agenda**

23 April 2008 (Wednesday) – 1:00 pm to 5:00 pm

- Introduction to CP Road Map (Wiegand)
  - History, CP Tech Center Role, Definition and Importance of Collaboration
- Presentation of Draft SC Track Framework (Rasmussen)
- Introduction to FHWA and ACPA Research Programs (Wiser and Scofield)
- Connection to TRB AFD90 (McGhee)
- Summary of SC Work (Rasmussen)
  - Foundational, Recently Completed, Ongoing
- Open Discussion of Track to Build Consensus (Wiegand and Rasmussen)
  - Overall Objective of Session
  - Individual Recommendations of Needs and Research/Implementation Tasks
  - Gaps
  - Short-Term Projects and Products
  - Long-term Project and Products

24 April 2008 (Thursday) – 8:00 am to 11:00 am

- SC Track Communications, Coordination, and Collaboration Plan (Wiegand)
- Identification of Funding Partners for Short-Term Projects (Wiegand)
- What Happens Next? (All)

**Participant List**

- FHWA/USDOT
  - Mark Swanlund, Office of Pavement Technology
  - Larry Wiser, TFHRC
  - Bob Orthmeyer, Pavement and Materials TST **
- State DOT
  - Bernard Izevbékhai, Minnesota DOT
  - Brian Schleppi, Ohio DOT
  - Jeff Seiders, Texas DOT
- Pavement Industry
  - Larry Scofield, ACPA
  - John Roberts, IGGA **
  - Ron Guntert, Guntert & Zimmerman
- Academia and Other Industry
  - Kevin McGhee, VTRC
  - John Ferris, Virginia Tech University **
- National CP Tech Center
  - Paul Wiegand, National CP Tech Center
  - Ted Ferragut, TDC Partners, Ltd. **
  - Rob Rasmussen, The Transtec Group, Inc.
  - Tom Cackler, National CP Tech Center **
  - George Chang, The Transtec Group, Inc.
  - Gary Fick, Trinity Materials

**Note:** could not attend meeting.
APPENDIX I: SUMMARY OF CP ROAD MAP TRACK 7

HIGH SPEED CONCRETE PAVEMENT REHABILITATION AND CONSTRUCTION
(CONCRETE OVERLAYS)
Summary of CP Road Map Track 7  
High Speed Concrete Pavement Rehabilitation and Construction  
(Concrete Overlays)  
10-10-08

The CP Tech Center Advisory Board meeting of April 6, 2006 outlined an overall program for concrete overlays to address the need of rehabilitating aging concrete and asphalt pavements in the United States. The initial program included the development of a 30 +/- page user friendly concrete overlay guide to be completed as soon as possible. The second phase was to develop a technical assistance program for selected states throughout the country that provided expert teams to the states to help guide them through the concrete overlay selection, design and construction process. The third and final phase was to develop a 150 +/- page technical concrete overlay manual. For the rest of 2006 the CP Tech Center along with a national selected overlay committee developed the initial Guide to Concrete Overlay Solutions which was published in January 2007. A total number of prints distributed of the Guide was approximately 10,000 copies.

The CP Road Map Executive Committee concurred with the CP Tech Center Advisory Board that innovative approaches for concrete overlays could move concrete overlays into a position as one of the cornerstones for the new generation of concrete pavements. On March 27, 2007 the Executive Committee concurred with the following goals and objectives of the overlay sub-track.

**Goal** – To increase the awareness, knowledge and benefits of concrete overlay applications among state and local agencies and contractors.

**Objectives:**

1. Update the current 2007 Guide to Concrete Overlay Solutions that would include accelerated construction, work zone management, traffic staging, evaluations and items to consider in specification development.

2. Initiate a cooperative 8 state field application program in regional DOTs throughout the country who would be guided by the Center through the process of selection, design and construction of concrete overlays.

3. Develop a concrete overlay manual that would go into the details of the selection, design and construction of concrete overlays. This manual would be considered long term and needed only when the updated Guide needed to be expanded to provide additional technical detail.

4. Develop a simplified and accurate approach for concrete overlay thickness determination using current design methodology.

5. Complete research that would address the complex interaction between concrete overlay and underlining pavement structures and interlayers. This research should include development of new overlay design methods that take into account the effects of underlining pavement cracking, optimum interlayer properties, bond longevity, slab geometry effects and fatigue damage of the underlining pavement over time.
6. Complete field research that would help solve construction technique limitations for concrete overlays which would include paving machine control, locating longitudinal joints, appropriate opening strength, traffic management techniques for different lane roadways and innovative overlay materials, particularly interlayers.

Overlay Committee Members:
- Andy Bennett, Michigan Department of Transportation
- Jim Cable, P.E., Iowa State University
- Dan DeGraaf, Michigan Concrete Paving Association
- Jim Duit, Duit Construction Co., Inc., Oklahoma
- Todd Hanson, Iowa Department of Transportation
- Randell Riley, Illinois Chapter ACPA
- Matt Ross, Missouri/Kansas Chapter ACPA
- Jim Shea, New York State Chapter ACPA
- Gordon Smith, Iowa Concrete Paving Association
- Sam Tyson, Federal Highway Administration
- Leif Wathne, American Concrete Pavement Association
- Jim Grove, CP Tech Center
- Matt Zeller, Concrete Paving Association of Minnesota
- Jeff Uhlmeyer, Washington State DOT
- Kevin Maillard, OHM Advisors
- Robert Rodden, American Concrete Paving Association
- Shannon Sweitzer, North Carolina Turnpike Authority

Concrete Overlay Milestones:
2. April 2008 started 2 ½ year Concrete Overlay Field Application Program. To date five states have requested technical support as outlined in the field application program.
3. August 2008 Guide to Concrete Overlay Solutions 2nd Edition was completed and sent to printing.

Future Emphasis for the Concrete Overlay Program:
1. The CP Road Map Performance Based Design Track Leadership Committee concurred with the Concrete Overlay Committee for the development of a two phase program that would address overlay design issues.
   a. Development of concrete overlay design catalogue based on existing design procedures. Proposed funding by CP Tech Center/FHWA.
   b. Development of a new concrete overlay thickness design procedures (long-term).
2. Complete concrete overlay field research that would help solve construction technique limitations. Proposed funding by FHWA/Iowa Highway Research Board. The proposed research is listed as follows:
   a. Reduce quantity overrun concerns with GPS mapping of the proposed project. Reduce construction survey time with GPS mapping and evaluate GPS and 3-D construction equipment control (milling machine, slipform paver and cure cart). Development of ways to establish the profile grades and machine control before or immediately after the contract letting by the highway agency so that construction is not impacted.
b. Evaluate the use of GPS to control longitudinal joint sawing. Develop innovative ways to guide the longitudinal joint forming operation to match the underlying joint alignment.

c. Evaluate milling by the standard practice of string line control and by GPS control. Determine the best way to establish the level of need and timing of milling for existing asphalt surface preparation.

d. Evaluate use of innovative bond breaker materials.

e. Determine innovative ways of handling traffic control for the construction of single lane overlays as part of a two lane or multilane overlay. Evaluate impact of haul road selection on road opening time.

f. Investigate potential ways using both existing and new paving train components so that the length of the paving operation is minimized.

g. Evaluate pavement strength versus opening time and completion of project time. Determine the appropriate opening strength that is required of the concrete for use by local traffic, through trucks and construction traffic, for depths of concrete of 6 inches or less.
APPENDIX J: CONCRETE PAVEMENT BUSINESS SYSTEMS AND ECONOMICS

IMPLEMENTING BUSINESS TRACK 11
Concrete Pavement Business Systems and Economics

Implementing Business Track 11

Administrative Contact: Paul Wiegand
Technical Contact: Ted Ferragut

Background

This track addresses business and economics issues in concrete paving. It has two main goals: 1) to address the management and financing of the Executive Committee functions, including innovative management systems and 2) to address concrete pavement economics.

The Executive Committee has been operational since 2006. Funding for the Committee, along with Operating Procedures have been developed and implemented. The Executive Committee is an advisory board that identifies and suggests to the concrete pavement community the priority areas for research and technology. It supports the establishment of Track Research Leadership Groups that look to actually promote, implement, and evaluate the research and technology areas, with the Committee assuring that there is cross-cutting coordination among the Tracks.

Additionally, the Committee looks at ways that collaboration strategies can be identified and implemented so as foster more cooperation and accelerate the accomplishment of the goals identified in the Road Map. Finally, the Committee also concerns itself with identifying systems that would accelerate the exchange of knowledge and education on concrete pavements to the broader highway community.

The second major mission of the Executive Committee is to promote the quantification, value and benefits of concrete pavements and ensure that adequate delivery mechanisms are in place to supplement and complement the conventional low-bid system. With the price of asphalt-based products at an all time high, the interest in concrete pavements has never been higher in traditionally non-concrete areas. This track calls for the examination of the impact of this new economic reality, including ways to bring concrete pavement to new customers in a faster way. Related to the economics is the emerging use of alternative bidding, design-build, build-maintain, warranties, performance specifications, public-private partnerships, and other mechanisms that are both creating opportunities, capital, and risk transfer to the concrete industry.
Subtracks

The Track 11 Business Subtracks in the CP Road Map include:

1. Concrete Pavement Research and Technology Management and Implementation
2. Concrete Pavement Economics and Life-Cycle Costs
3. Contracting and Incentives for Concrete Pavement Work
4. Technology Transfer and Publications for Concrete Pavement Best Practices
5. Concrete Pavement Decisions with Environmental Impact

Business Track Activities To Date

The Executive Committee, with the help of the CP Administrative Team has focused most of its initial energy on the major administrative tasks aimed at establishing institutional framework for both the Committee and the Tracks.

To that end, the Committee identified and supported the following initiatives:

1. Secure longer term funding for the CP Road Map Executive Committee and the Operations Support Team.
   - A DOT pooled fund study was established that provides reasonable resources for the administration of the Road Map through 2011.
   - FHWA continues to support the CP Road Map with funds placed into the pooled fund study.

2. Prioritize the CP Road Map Tracks.
   - Tracks related to Mix, Design, NDT/ICS, Surface Characterisitics and Sustainability have been established as priorities.
   - The Sustainability Track is of particluar importance. It was originally designated as a cross-cutting issue, but with global attention to the environment, it was elevated to full track status.
   - Additionally, the Committee endorsed the acceleration of the Concrete Overlay Subtrack and elevated it to priority status as well.

3. Established Track Teams for each of the priority tracks.
   - All priority tracks are up and running with key members from across the concrete pavement community.

Track Goal

The research in this track will clarify the relationship between concrete pavements and economic issues, capital availability, risk and risk transfer, and alternative contracting.
Several of the Tracks will be managed via conference calling, such as the Design Track, in order to minimize travel resources.

4. Established a collaboration system among various DOTs and the FHWA.
   - The Executive Committee approved a process for linking DOTs together in a collaborative fashion.
   - One state has signed the collaboration paper.

5. Establish a comprehensive website and communication mechanism.
   - Significant discussions was held on this subject with ideas ready for implementation.
   - They included blog testing on the SC Track.

**Business Track Activities for Future Consideration**

This promises to be an imporant transition period for the CP Road Map and the Executive Committee. Several issues relate to the need to more strongly formalize the Executive Committee as a voice for the concrete pavement industry as it relates to reasearch and technology transfer.

**Management and Administrative Issues: Short Range Plan**

The following seven initiatives are offered to help focus on critical Management and Administrative Issues related to the Road Map. They are organized as a possible foundation plan for 2009-2010.

1. Administrative Funding: The funding for the management and administrative program is relatively minimal. Research Track committees do not have the funds to do all the work they need to in order to assure progression of the work.

2. Research and Technology Funding: Reauthorization of the Transportation Program will involve action to promote the accomplishments under the Road Map, but also to identify the benefits of its continuation.

3. Road Map Status Report: To that end, the Executive Committee should prepare a Road Map Status Report for both FHWA, the DOTs, and ACPA.

4. Strategic Direction: The Executive Committee should revisit the entire CP Road Map strategic approach and determine if the priorities and processes should be adjusted or stay the same.

5. Outreach: The Committee should examine the outreach mechanisms available to both promote ongoing research sharing, research findings, and education programs. Webinars, blogs, and other webbased methodolgies should be examined, espacially in light of limited transportation funding to go to conventional conferences and workshops.

6. Collaboration: The Executive Committee and the Research Track Leaders should continue to
focus on encouraging collaboration for both research and for education programs despite differences in institutional priorities or goals. To get the collaboration process underway, it is proposed to work with state DOTs to identify priority research they are interested in funding at their in-state university. From there the research will be brought to groups such as the National Concrete Consortium for presentation and determination of interest on the part of other DOT agencies.

7. Integration: The Committee should examine how the tracks are proceeding with integration efforts to assure cross-track issues are addressed. Communication between Track Leaders is essential to ensure the overall goal of the Road Map is pursued without duplication.

In addition to the Management and Administrative Issues, the Committee should help establish studies in the following economic areas:

**Economic Issues: Short Range**

1. Economics Study: What does the cost of asphalt products really mean to the concrete industry? A strategic and thorough examination of initial costs and whole costing should be examined to determine the long range impact on research, technology, and education.
   - Estimated Cost: $50,000  8 months

2. Alternative Pavement Bidding: The DOTs have been using alternate bidding for asphalt-concrete solutions. The results to date should be synthesized with best practices highlighted. The effort should examine FHWA and DOT policies, procedures as they relate to both bidding and value engineering practices.
   - Estimated Cost: $100,000  12 months

3. Innovative Contracting Practices: A study of design-build, best value, design-build-maintain, and public-private partnerships should be considered to determine the best ways to address specifics related to concrete pavements.
   - Estimated Cost: $75,000  12 months

4. Incentives: Incentives for smoothness, strength, and sometimes air have been used in the industry since the late 80's. The paving industry believes they have a positive impact on their operations. There appears to be a lack of interest in continuing incentives and to learn from previous accomplishments. It is suggested that a full evaluation of existing programs be examined, including changes in DOT practices. Additionally, the study should examine new ways to provide incentives for both quality and timeliness attributes. A similar study was also suggested to SHRP II under their rapid renewal program and can be used as a framework for this study.
   - Estimated Cost: $150,000  12 months

5. Technology Transfer: an accelerated technology transfer and rapid education programs for the future concrete paving workforce is paramount to getting the word out on both conventional
and emerging knowledge of concrete pavements. This has taken on a new urgency with the relative equality of concrete-asphalt prices and the interest this has generated in new markets.

- Estimated Cost $75,000  12 months

The Executive Committee should discuss the merits of each of these six ideas and suggest a priority slate of work. The Administrative Support Group will then develop a more complete scope of work and look to find the funding to conduct the studies.

**Conclusion**

This is a critical year for the CP Road Map. Executive Committee support of the concepts, tracks and the focus of the future research are critical. It is especially important that the upcoming Transportation Reauthorization Bill and FHWA initiatives support the overall goals of the concrete pavement research and technology identified in the plan.
APPENDIX K: MINUTES

FIRST MEETING OF THE CONCRETE PAVEMENT SUSTAINABILITY TRACK LEADERSHIP GROUP
MINUTES
First Meeting of the Concrete Pavement Sustainability Track
Leadership Group

July 23, 2008 – Chicago IL

Leadership Group Members Present:

| Gina Ahlstrom | FHWA |
| George Crombie | VT-Natural Res |
| Jennifer Distlehorst | Kansas DOT |
| Ben Franklin | ACAA -Headwaters |
| Joep Meijer | The Right Environment |
| Tom Pyle | CALTRANS |
| Tim Smith | Cement Assn of Canada |
| Leif Wathne | ACPA |
| Kevin Cail | Lafarge |
| Barry Descheneaux | Holcim Inc. |
| Jim Duit | Duit Construction |
| Kevin Gardner | Univ of NH |
| Kevin McMullen | WI CPA |
| Doug Schwartz | MN DOT |
| Michael Sprinkel | VA Trans Res Council |
| David Weber | Slag Cement Association |

Operations Support Group Members Present:

| Dale Harrington | Snyder & Assoc. |
| Tom Van Dam | APTech Inc |
| Michael | Sprinkel |
| David Weber | Slag Cement Association |

Leadership Group Members Not Present:

| Erin Ashley | NRMCA |
| Steve Kosmatka | PCA |
| Ken Kobetsky | AASHTO |
| Ronald Landy | EPA |

Introductions

Dale Harrington went over the CP Road Map’s background and discussed the definition of sustainability. He laid out what the Operations Support Group (OSG) is proposing for the Sustainability Leadership Group to consider and modify. He explained what the track is not.

Leif W We need to be able to quantify sustainability to the point of being able to compare. We need to include all pavements in the program and apply the same techniques to all. Fill in the gaps in research.

Kevin M We need information to make decisions on which measures to prioritize. We need to get information to compare measures to address economics and quality of life. Kevin addressed coordination of our work with other CP Road Map Tracks.

Barry D We need to further define our mission. Is it a tool or a method? Current practices manual as opposed to Best Practices.

Jennifer D Credible comparisons need to be made. Let’s get back to the Road Map discussion. Coordination & leadership (education) should be included. Societal instead of society. Discussion on how to address the risk involved with innovations. Expand the list of areas to quantify benefits.

Tom V Explained Green Roads rating system. We must use universally accepted standards like ISO 9001. Tom explained the draft framing document (discussion items). The Mission Statement–should we add “operations” for such things as fuel usage, lighting, heat, etc. Moving engineering forward to the next level to address sustainable factors.

Mike S We need to address congestion/volumes related to construction related lane closures &
traffic control delays.

Tim S  We need rules on how to use the standards, not to pick and choose as they see that helps their case.

Joep M  This group could establish standards that should be used. We need broader scope. Let people know we are here and keep our name and activities out there in front of people by newsletter or website.

Tom P  We need to include a tool. A tool must identify what we want. Industry has no understanding of what sustainability for concrete pavements involves or the need to coordinate activities with all agencies. If possible, do not follow California’s route of creating sustainable activities through legislative and regulatory enforcement.

Gina A  We need more than one tool.

George C  Let’s get as far as we can to understand how concrete pavements will impact climate & water.

Jim D  Include gaps in the briefing document, such as re-use steel as opposed to re-processing.

Goal/Vision/Mission - Tom Van Dam went over the draft information. Initial thoughts were given and the Administrative Group will rewrite and send out. Low-hanging fruit was discussed based on the need to get the track underway. The initial decision was to proceed with a briefing document - 10 to 12 pages on what is known and agreed upon.

Framework – Peter Taylor led the framework discussion based on the printed packet information. The group went through a brainstorming exercise to identify ideas or concepts that are critical to the concrete pavement sustainability subject. The list, without prioritization, is summarized below:

<table>
<thead>
<tr>
<th>1. Carbon Dioxide</th>
<th>21. Life Cycle Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Energy</td>
<td>22. Social Factors</td>
</tr>
<tr>
<td>3. Safety</td>
<td>23. Diverging Intent</td>
</tr>
<tr>
<td>5. Materials</td>
<td>25. Funding</td>
</tr>
<tr>
<td>7. Tradition</td>
<td>27. International Agreement</td>
</tr>
<tr>
<td>8. Innovation</td>
<td>28. SCM’s-(alternative materials including waste products)</td>
</tr>
<tr>
<td>9. Education</td>
<td>29. Mercury (contaminants)</td>
</tr>
<tr>
<td>10. Leadership</td>
<td>30. Smoothness/Noise/Acoustics</td>
</tr>
<tr>
<td>11. Construction Practices</td>
<td>31. Use of Non-Renewable Resources</td>
</tr>
<tr>
<td>12. Life Cycle</td>
<td>32. Land Transformation &amp; Land use</td>
</tr>
<tr>
<td>14. Standards</td>
<td>34. Lack of Government Leadership</td>
</tr>
<tr>
<td>15. Regulatory Policy</td>
<td>35. Environmental Justice (lawsuits)</td>
</tr>
<tr>
<td>17. Specifications</td>
<td>37. Shoulders/Pavement System</td>
</tr>
<tr>
<td>18. Language (jargon)</td>
<td>38. Traffic Congestion</td>
</tr>
<tr>
<td>20. Water Quality</td>
<td>40. Rehabilitation</td>
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<td>41. The Future</td>
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<td>42. Longevity</td>
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<td>43. Cement Content</td>
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<td>44. Local Materials - Transforming Logistics</td>
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<td>45. Heat Island Effects</td>
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<td>46. Energy Harvesting</td>
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<td>47. Self Healing</td>
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<td>48. Smart Infrastructure</td>
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<td>49. Construction Waste</td>
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<td>50. Multi Modal - Vehicle Type</td>
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<td>51. Fuel Savings/Operations</td>
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<td>52. Design-Joint Spacing/Thickness-Two Lift</td>
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<td>53. Composite Pavements</td>
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<td>54. Equipment (zero clearance paver on two sides)</td>
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<td>55. Information Dissemination</td>
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<td>56. Quality Control</td>
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</table>
The Leadership Group was then broken into four working groups to prioritize the topics into short-term (3-5 years) and long-term (>5 years) issues. The groups were as follows:

**Group 1**
Gina Ahlstrom  
Kevin Cail  
Michael Sprinkel  
Joep Meijer

**Group 2**
Barry Descheneaux  
Tim Smith  
Tom Pyle  
George Crombie

**Group 3**
Jennifer Distlehorst  
Leif Wathne  
Ben Franklin  
Jim Duit

**Group 4**
David Weber  
Doug Schwartz  
Kevin Gardner  
Kevin McMullen

The results from each group are as follows:

**Group 1:**
- Research: develop a methodology to measure the impact on sustainability
  - prioritized topics: pick some, finish them, pick new ones
  - first environment then social
  - within environment
    - CO2
    - Energy
    - ...
    - Later
- Showcases:
  - recycling
  - clinker content reduction
- Tech transfer: apply to the other tracks; advice / services to the other tracks; evaluate options
- Evaluate best practices to guide long term prioritizing
- National average 80:20 database
- Knowledge transfer: elaborate on stakeholders for concrete and sustainability and their interests / needs, it is not just the technical community, outside the scope of the tracks
- Communication: showing leadership / being out there - language/education/promotion: for example; 4 times per year newsletter/website/blog; include other tracks

**Group 2:**
Triangle graphic-economics; societal; environmental:
- CO2 & energy are critical elements
- Must deal with specs/standards-life cycle assessment (LCA), all documents must include
- Don’t forget mercury “pollution”-cement production being fined.
Group 3:
(3 to 5 years)
• What’s out there right now? Defined & measured.
• Develop tools and best solution for a particular project, set criteria.
• Carbon economy calculation on concrete to get ahead of the carbon credit proposals, lead the involvement.
• Optimize use of energy from existing pavements.
• Develop measurement system.
• Priority placed on in-place recycling (paradigm system).
• Get information out about concrete pavement sustainability.
  ▪ US scan
  ▪ Feature green projects at NC²
  ▪ Web site
• >5 - Fill the gaps in knowledge.

Group 4:
Short-term
• Robust life cycle analysis for roadway systems. Develop briefing document for LCA on roads – collect published literature and tools that exist. Enable.
• Develop framework for incorporating benefits (in cost-benefit), social impacts, user costs in decision making. Moving toward LCC with explicit incorporation of LCIA, social impacts, etc.
• To expand the usage of SCMs in concrete mixtures through education – better properties, recycling, replacing higher impact material. Part of this is quantifying benefits associated with this practice.
• Quantification of heat island? Or critical synthesis of heat island studies/data. Maybe add lighting evaluation to this objective.
• Develop a current practices document.
• Reduce cementitious content in mixes. Move to performance spec., can quickly move to lower cementitious content. Needs to move to specs and standards. (Mix design track?)

Long-term
• Identifying/developing/evaluating alternative cementitious materials for more durable, cost-effective pavement.
• Evaluation of larger limestone additions – cost, process complication,
• Constructability, effect on mixture.
• Environmental impact of design changes – M-E design guide, lane widths, any other design changes.
• Fast-setting cements and continuous paving for improving constructability of CP. Process simplification in general.
• Water demand issue?

Wrap-Up
Peter Taylor then presented the following list of common points from the individual groups.
• Measurement including tools, evaluation, LCA, …
• Education
  o Define terms and jargon
  o Current practices document
  o Best practices recommendations
  o Specifications (must get technical people involved vs. politicians)
• Get more efficient with materials (cut emissions, energy, non-renewable materials)
• Other environmental elements (lighting/heat/noise/etc)
Final Comments
Include LCA in briefing document. Send out email on requesting bibliographies of resources, dealing with sustainability in transportation and sustainability studies.

Piggyback with ACI meeting in November for the Leadership Group’s next meeting.

The track work team will deal with the following items:

1. Revised vision and mission statement – week to 10 days
2. Outline the framework - 1st part of October
3. Face to face meeting - 1st part of November