

Performance-Based Design Guide for New and Rehabilitated Concrete

1.0 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.
4. Develop a functional design manual (noise, spray, aesthetics, friction, texture, illumination).
5. Design preservation and rehabilitation treatments and strategies using mechanistic-based designs.

2.0 TRACK BENEFITS

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.

3.0 ONGOING WORK RELATED TO THE DESIGN GUIDE TRACK

Fueled by the interest generated by the 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 4.1 - Incremental Improvements to Mechanistic-Empirical Pavement Design Guide Procedures
- DG 4.2 - New Mechanistic-Empirical Pavement Design Guide Procedures for Paradigm Shift Capabilities
- DG 5.1 - Implementation of the Mechanistic-Empirical Pavement Design Guide

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.

2. STAKEHOLDERS INVOLVED AND CORE GROUPS

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.

3. POTENTIAL TRACK LEADERS

The following track leads have been identified at this point:

- AASHTO Joint Technical Committee on Pavements (JTCP) – provides direct link to key decision makers in State agencies.
- TRB’s Design Section Representative and Committee Chair on Rigid Pavement Design – provides a ready link to practitioners and researchers.
- Consortium of State agencies who are large users of concrete pavements, e.g., Midwestern States, Texas, and California. The North-Central States ME PDG User Group will be a good start for this purpose—provides a link to active
- Industry—provides a link to contractors and consultants who deal with concrete pavements on a daily basis and know the practical issues related to cost, construction, performance, etc.
- Academia—provides a link to the community performing basic research.

It is recommended that representatives from each of these groups come together to 1) assess where we are and 2) define the next few projects that should be undertaken to meet the objectives of the Track. The key is to gain support from the JTCP first.

4. TRACK KICK-OFF MEETING SUGGESTIONS

It is proposed that the track team meetings be closely coordinated with the meetings of the AASHTO’s JTCP. The JTCP has been selected as a meeting venue because it involves 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. It would be beneficial to have the FHWA liaison to this meeting be made fully aware of the CP Road Map team’s requests for participation to ensure that a slot is made available to the team on the meeting agenda.

5. PRIORITIZED RESEARCH NEEDS

Two projects that might be offered from the track that are worth 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. 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.

Code: D7 (modified)

Title: 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, there 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

Code D9:

Title: 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.