

Input Parameters for M-E PDG Design

The M-E PDG design procedure is based on the process of adjusting factors that can be controlled in order to accommodate factors that cannot be controlled to achieve the desired pavement parameters and performance.

1. What do we want?

- All of the following are modeled, based on experience and experimentation, to predict the state of each parameter at the end of the selected design life. The model uses inputs from items 2 and 3 below. If the results are unacceptable, then the parameters that can be changed are adjusted and the model recalculated.
 - Acceptable surface roughness at the end of the life.
 - Acceptable cracking at the end of the life.
 - Acceptable faulting at the end of the life.

2. What do we have to accommodate?

These are parameters that vary from location to location and cannot be changed, but must be accounted for in the modeling.

- Expected traffic loading.
 - Type of traffic (classes).
 - Growth of traffic density with time.
- The climate in which the pavement is built.
- Water table depth.

3. What can we adjust?

These are the parameters that can be adjusted in the design process in order to achieve the properties and performance required in item 1.

- Pavement type (JPCP, JRCP, or CRCP).
- Joint details (load transfer, spacing, sealant).
- Edge support (if any).
- Drainage.
- Layer 1: Concrete properties.
 - Thickness.
 - Strength and modulus of elasticity.
 - Thermal properties (coefficient of thermal expansion, conductivity, heat capacity).
 - Shrinkage.
 - Unit weight.
- Layer 2: Stabilized layer properties.
 - Material type.
 - Thickness.
 - Strength.
 - Thermal properties.
- Layer 3: Crushed stone properties.
 - Strength.
 - Gradation.
- Layer 4: Soil properties.
 - Type (soils classification).
 - Strength.
 - Gradation.



Technical Summary

A summary of chapter 2 (pages 7–26) of the *IMCP Manual* (reference information on page 4)

Concrete Pavement Design

This document is one of a set of technical summaries of chapters 1 through 10 of the *Integrated Materials and Construction Practices for Concrete Pavements: A State-of-the-Practice Manual* (IMCP manual). Together, these summaries provide a general overview of information in the manual and introduce its important concepts. To be useful as training documents, the technical summaries should be used in conjunction with the manual.

This summary covers chapter 2, aspects of concrete pavement design that are critical for optimizing pavement performance. Desired performance is uniquely defined for each pavement. It includes the level of structural and functional performance, service life, and pavement properties like ability to carry specific traffic loads. In addition, chapter 2 briefly describes the effect of site factors

on performance, basic concrete pavement types, and commonly used pavement design procedures.

What is Pavement Design?

Pavement design consists of determining slab thickness, joint dimensions, reinforcement and load transfer requirements, and other pavement features (figure 1).

What Do We Want in a Pavement?

The primary goal of pavement design is to provide a pavement with the following characteristics:

- Safe.
- Cost effective.
- Constructible.
- Low maintenance.
- Long-lasting and durable.

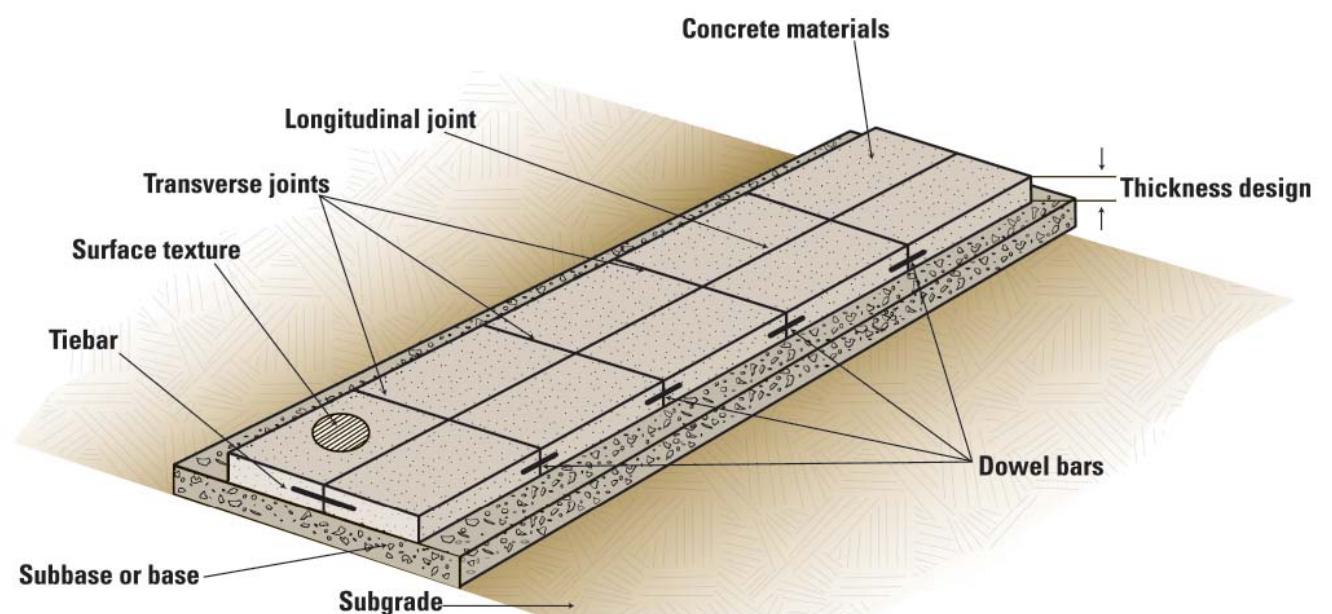


Figure 1. Pavement design features

National Concrete Pavement Technology Center



August 2007

This technical summary is based on chapter 2 of the IMCP Manual (Taylor, P.C., et al. 2006. *Integrated Materials and Construction Practices for Concrete Pavement: A State-of-the-Practice Manual*, Ames, Iowa, Iowa State University [FHWA HIF-07-004] [www.cptechcenter.org/publications/imcp/]) and was sponsored by the Federal Highway Administration. (References for any citations in this summary are at the end of the chapter.)

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the view of Federal Highway Administration or Iowa State University.

CP Tech Center Mission

The mission of the National Concrete Pavement Technology Center is to unite key transportation stakeholders around the central goal of advancing concrete pavement technology through research, tech transfer, and technology implementation.



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Poorly designed pavements (even if they are well constructed) will likely experience accelerated deterioration and not meet the stated objectives.

To select the appropriate concrete pavement type and design features, the designer must define the following parameters:

- Level of desired structural and functional performance.
- Design life (target service life).
- Appropriate specifications required to achieve pavement durability for the design life.

Pavement Performance

The goal of all pavement design methods is to provide a pavement that performs well. Performance is generally described in terms of structural and functional performance:

- Structural performance—A pavement's ability to carry the imposed traffic loads.
- Functional performance—A pavement's ability to provide a safe and comfortable ride.

Structural performance

The most important design-related variables for ensuring a certain level of structural performance are as follows:

- Coefficient of thermal expansion (CTE).
- Slab thickness.
- Reinforcement or load transfer.
- Flexural strength typically 3,800 to 4,500 kPa (550 to 650 lb/in.²) or compressive strength about 30 MPa (4,000 lb/in.²).
- Modulus of elasticity (stiffness) typically 20–40 gigapascal (GPa) (3,000–6,000 ksi).
- Support conditions.

The most common structural distress is load-related cracking (figure 2).

Functional performance

Usually thought of as ride quality and surface friction, functional performance also includes other factors, such as noise and geometry.

Functional distress is not always distinguishable from structural distress and often may have the same root cause. Structural distress will almost always result in a reduction of functional performance because structural distresses often reduce ride quality and can affect other functional performance measures.

Design Life

Concrete pavements can be designed for virtually any service life, either in years of service or traffic loadings. The primary factors affecting design life are the materials, construction quality, and slab dimensions (including thickness and jointing details).

Concrete Properties

Concrete properties must conform to the design assumptions in terms of strength properties. Of equal or greater importance in long-term pavement performance is the durability of the materials in the concrete.

How Does the Site Affect Design?

Site factors are those factors unique to the location of a paving project that significantly affect its design and performance:

- Subgrade support and drainage—must be uniform for long-term performance, so design methods assume that support is relatively constant throughout a pavement over its design life.
- Environmental factors—while not considered in many design procedures, NCHRP's mechanistic-empirical pavement design guide (M-E PDG) incorporates some important environmental factors into the design process.
- Traffic considerations—the anticipated traffic types and loadings over a road's design life are a major factor in pavement design.

Selecting Pavement Type

Three types of concrete pavements are commonly designed and constructed in the United States (figure 3):



Figure 2. A longitudinal crack representing structural distress
(photo by American Concrete Pavement Association)

- Jointed plain concrete pavements (JPCP).
- Continuously reinforced concrete pavements (CRCP); reinforcement includes welded wire fabric, deformed steel bars, etc.
- Jointed reinforced concrete pavements (JRCP).

The type of pavement selected is generally based on economics, level of traffic, ability or inability to close the roadway for routine maintenance activities, and numerous other factors.

Jointed Plain Concrete Pavements (JPCP)

Most concrete pavements constructed today are JPCP designs, which are characterized as follows:

- No reinforcement.
- May contain dowel bars across the transverse joints for load transfer.
- May contain tiebars across longitudinal joints to hold slabs together.

Continuously Reinforced Concrete Pavements (CRCP)

CRCP designs are used for some high-traffic routes. Reinforcement is not included in the structural design of pavement thickness. CRCPs have the following characteristics:

- No transverse joints.
- Contain significant reinforcement (influences crack spacing and holds cracks tightly together).

Jointed Reinforced Concrete Pavements (JRCP)

These designs contain both joints and reinforcement. JRCPs are not as commonly used on State highways as they once were but are used to some extent in municipalities.

Selecting a Design Procedure

The most commonly used pavement design procedure is the AASHTO 1993 Pavement Design Guide.

NCHRP's *Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavements* (M-E PDG) will be balloted by AASHTO as an Interim Design Procedure and has many benefits over the 1993 Guide.

AASHTO 1993

Construction/materials inputs for the AASHTO 1993 procedure include the following:

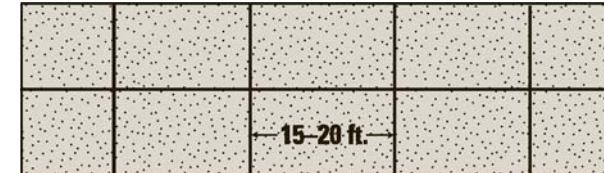
- Slab thickness.
- Concrete strength parameters.
- Support (subgrade and base).
- Ride quality.

NCHRP's M-E PDG

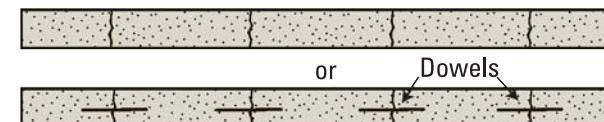
The M-E PDG design procedure offers a more integrated approach to pavement design in the following ways:

- Combines a mechanistic approach with observed pavement performance (empirical).
- Incorporates many new materials-related variables, some of which are controlled by field operations.
- Predicts distress types (specific to design type) as a function of time or traffic.
- Must be calibrated for local conditions.

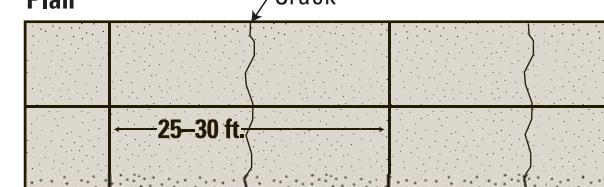
JPCP - Jointed plain Plan



Profile



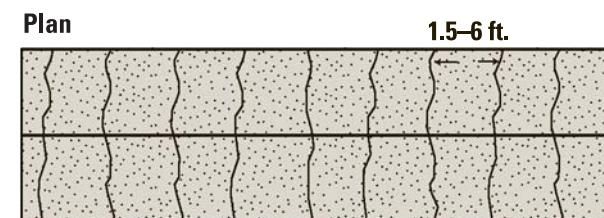
JRCP - Jointed reinforced Plan



Profile Dowel Mesh Dowel



CRCP - Continuously reinforced Plan



Profile



About 0.7% steel by area
(No joints except at ends)

Not to scale

Figure 3. Common pavement types are JPCP, JRCP, and CRCP.