Guide for Mechanistic-Empirical Design

New and Rehabilitated Pavement Structures

Introduction
Objectives of the Workshop:

- Introduce the NCHRP 1-37A M-E Guide
- Discuss status
- Describe key elements
- Highlight capabilities
- Provide an opportunity to discuss evaluation and implementation
Introduction Outline

- Current pavement design procedures
- Need for change
- Capabilities of M-E design systems
- NCHRP 1-37A project – Background & Highlights
- FHWA’s role in the implementation process
Design Methodologies

• Experience

• Empirical
  ▪ Statistical models from road tests

• Mechanistic-empirical
  ▪ Calculation of pavement responses, i.e., stresses, strains, deformations
  ▪ Empirical pavement performance models

• Mechanistic
AASHO Road Test

Test Loop

test tangent
• Serviceability concept - PSI
• Traffic damage factors – ESALs
• Structural number concept – Sn
• Empirical Process
• Simplified Pavement Design
## What’s Being Used in 2003

<table>
<thead>
<tr>
<th>Design Procedures</th>
<th>DOTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972 AASHTO Guide</td>
<td>3</td>
</tr>
<tr>
<td>1986 AASHTO Guide</td>
<td>2</td>
</tr>
<tr>
<td>1993 AASHTO Guide</td>
<td>26</td>
</tr>
<tr>
<td>Agency’s own pavement design guide or combination of AASHTO/Agency design procedures</td>
<td>17</td>
</tr>
</tbody>
</table>
Limitations of the AASHO Road Test Based Procedures

- One climate – Ottawa, Illinois
- Limited Span – two years
- Limited Traffic – generally < 2 million
- 1950 vehicles
- 1950’s materials and construction
- Only new construction
What Is Wrong With The Present System?

Current design traffic is far beyond road test limits

Current Design Traffic
<2 million

Data Limits (AASHO Road Test)

Axle Load Repetitions

Projection A

Projection B

Projection C

Current Designs
>100 million

<2 million

Projection A

Projection B

Projection C
AASHO Serviceability

**Initial PSI**

**Terminal PSI**

**Time (Applications)**

**Initial PSI**

**Terminal PSI**

**Time (Applications)**
Structural Number

- Flexible Pavements
  - Not fundamental properties
  - Cannot be measured in laboratory
  - Cannot be established for new materials
- Rigid Pavements
  - “K” value
  - Bumping to account for stabilized layers
- No fundamental load carrying capacity
A coordinated and cooperative effort to develop a pavement design system to improve state of practice by incorporating advances in pavement design

Empirical Procedures
to
Mechanistic-Empirical Procedures
Mechanistic - Empirical Principles

M-E Principles = Engineering Fundamentals
M-E Pavement Design Process

- Climate
- Materials
- Structure
- Traffic
- Response
- Damage Accumulation
- Distress

Iterations
Terminology

- NCHRP 1-37A Guide
- 2002 Design Guide
- New Design Guide
- Guide for M-E Design
- M-E Design Guide

ALL THE SAME THING!
Not AASHTO Design Guide
How will I benefit from the M-E Design Guide?

It Ties Together:
- Structural Design
- Materials Selection
- Construction

Making sure that the design criteria have been met or exceeded.

Agency/Owner and Contractor/Supplier
NCHRP 1-37A Capabilities

• Integrated effects:
  ▪ Each current and future loadings
  ▪ Site specific climate (ICM)
  ▪ Material changes over time
NCHRP 1-37A Capabilities

- Predicts specific distresses based upon analysis on fundamental materials properties and M-E principles
- Tool for forensic analysis
NCHRP 1-37A Capabilities

- Allow design of:
  - Composite pavement designs
  - Rehabilitation and overlays
- Evaluates effects of specification changes
NCHRP 1-37A Design Guide Basics
## NCHRP 1-37A Guide – Basics

- Proven theories
- M-E based
- Modular design
- One computer program with same interface
- Hierarchical inputs
- AC – elastic layer basis
- PCC – finite element basis
- National (LTPP) & local calibration
- All documentation accessible
Why are so Many Details Needed?

- Materials properties change with time and environment
- Calculates incremental damage for each load
- Damaged dependent upon stress strain and material properties at time of loading
Pavement Design Variables

Each load application

CTB Modulus

PCC Modulus

Traffic

AC Modulus

Granular Base Modulus

Subgrade Modulus

Time, years

0 2 4 6 8
Why is Incremental Damage Important?

- Allows for incremental performance predictions during performance period
- Adjustments of scheduled rehab(s) based on as-constructed and actual performance data
- Basis for performance measures for long term warranties 5, 10, 15 years
AASHTO Guide Development

AASHTO Joint Task Force on Pavements (JTF)

NCHRP 1-37A

AASHTO JTF  All SHAs, FHWA

AASHTO Subcommittee on Design

AASHTO Standing Committee on Highways
NCHRP 1-37A Timeline

- Project Deliverables
  - Hard Copy
  - CD Version
  - Web Based

News Flash!!!
Design Guide Available!

- Concerns
  
http://WWW.trb.org/mepdg/

- Enhancement
Enhancements Underway

- **Design Models:**
  - Top Down cracking-NCHRP 1-42
  - Reflective cracking-NCHRP 1-41

- **Traffic Interface-NCHRP 1-39**

- **Implementation-NCHRP 1-40**

- **Data collection for calibration of HMA models – NCHRP 9-30A**
NCHRP 1-37A DESIGN GUIDE
SOFTWARE

This software is furnished only for review by members of the NCHRP 1-37A project panel and is regarded as fully privileged. Dissemination of this software must be approved by the NCHRP.
Convenient Input Layout

General Information

Status and Summary

View Results and Outputs

Inputs

Run Analysis
Typical Range Tool Tip

Range from 125 to 200

Move cursor to input box for typical input range to appear
Input and Output Summaries

Each summary may be opened in a Microsoft Excel file by clicking the desired file.
Graph Example Output–Rutting

Permanent Deformation: Total Rutting in Pavement Layers (Inch)

AC Rutting Design Value = 0.25"

Verify against design criterion specified by agency
FHWA’s Role in Design Guide Implementation

How does this program fit into the FHWA’s national program?
“Pavements that meet our customers’ needs and are safe, cost effective, long lasting and can be effectively maintained”
FHWA Pavement Program

- Encompasses all pavement elements
- Integrated throughout FHWA
- Multi-faceted activities
- Supports AASHTO initiatives
- Created a Design Guide Implementation Team (DGIT)
DGIT PURPOSE

To assist State highway agencies and industry in development and implementation of the new Pavement Design Guide
Elements of the DGIT Plan

- Workshops
- Training
- Technical Assistance
- Refinements

www.fhwa.dot.gov/pavement/dgitdata.htm
Questions?

www.fhwa.dot.gov/pavement/

Email: DGIT@fhwa.dot.gov