Colorado’s Development of the MEPDG

Jay Goldbaum
Pavement Design Program Manager

Arizona Pavement / Materials Conference
November 16th, 2011
Pavement Design Timeline and MEPDG Implementation in Colorado

1999: NCHRP 1-37A Launches
2001: CDOT Prepares Implementation Roadmaps
2004: NCHRP Develops MEPDG
2007: CDOT Updates Roadmaps
2009: CDOT Begins Calibration/Validation Efforts with ARA
2012: CDOT Adopts DARWin - ME

Late 1950's
AASHO Road Test
1972, 1986, 1993 AASHTO Guides
2008: MEPDG is an AASHTO Standard
2012: CDOT Adopts DARWin - ME

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Objectives of CDOT’s MEPDG Implementation Project

- Identify resources needed to implement the MEPDG
- Confirm or adjust default values
- Confirm or adjust the calibration coefficients
- Recommend any changes in policy and procedure that will be needed
- Provide design document that can be used by CDOT designers
HMA Rut Depth in Colorado

- 08-1029, Craig
- 08-1053, Montrose
- 08-2008, La Junta
- 08-0502, RAP
- 08-0506, Virgin

- Age, years
- Rut Depth, inches
Colorado’s MEPDG—The Plan

- 2009 to 2010: Data collection and input determination, 121 test sections
  - Materials Testing and Characterization
  - Traffic Analyses
  - Performance Analyses

- 2010 to 2011: Data analysis and calibration/validation
  - Create Input libraries
  - Determine local calibration values

- 2011: Documentation and Design Manual

- 2012: Adopt MEPDG for use on all CDOT Projects

- Continuous Training
## MEPDG Traffic Analysis

<table>
<thead>
<tr>
<th>MEPDG Traffic Input Parameter</th>
<th>Need to Compute CDOT Defaults?</th>
<th>MEPDG Default Available?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly adjustment factors</td>
<td>Needed</td>
<td>Yes</td>
</tr>
<tr>
<td>Hourly distribution factors</td>
<td>Needed</td>
<td>Yes</td>
</tr>
<tr>
<td>Vehicle class distribution</td>
<td>Needed</td>
<td>Yes</td>
</tr>
<tr>
<td>Axle load distribution factors</td>
<td>Needed</td>
<td>Yes</td>
</tr>
<tr>
<td>Number of axles per truck</td>
<td>Needed</td>
<td>Yes</td>
</tr>
<tr>
<td>Mean wheel load location and lateral traffic wander</td>
<td>Needed</td>
<td>Yes</td>
</tr>
<tr>
<td>Axle configuration</td>
<td>Needed</td>
<td>Yes</td>
</tr>
<tr>
<td>Wheelbase</td>
<td>Needed</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Traffic Data

![Traffic Data Chart]

- **X-axis:** Hour
- **Y-axis:** Percentage of Trucks
- **Legend:**
  - Blue line: 0200
  - Red line: MEPDG
Axle Load Spectra

Class 5 Trucks

Class 9 Trucks
Climate Data

= Cooperative Weather Station  = MEPDG Station
HMA Experimental Factorials:

1. Conventional (HMA over ABC) Pavements
2. Full-Depth HMA Pavements
3. HMA Overlay
   - Straight overlay
   - Mill and fill
   - Full depth reclamation
   - Hot in-place recycled
   - Cold in-place recycled
   - SMA
4. HMA Overlay of PCC Pavements
   - Intact
   - Fractured
A. HMA Thickness
- Less than 4 inches
- 4 to 8 inches
- Greater than 8 inches

B. Base Course
- Class 6
- Class 7

C. Soil Foundation
- Stabilized
- Non-expansive
  - Course grained
  - Fine grained

D. Climate Based on Elevation
- Less than 6,500 feet
- 6,500 to 8,000 feet
- Greater than 8,000 feet

LTPP test sections, pavement management sections, adjacent DOTs.

Secondary Factors:
- Neat and PMA mixes; with and w/o RAP; etc.
PCC Experimental Factorials:

1. Conventional (PCC over ABC) Pavements
2. Full-Depth PCC Pavements
3. PCC Overlay of PCC Pavements
   • Intact
   • Fractured
4. PCC Overlay of HMA Pavements
   • 5 to 7 inch thickness
   • Less than 8 inches
   • Greater than 8 inches
PCC Experimental Factorials (Continued):

A. PCC Thickness
   • Less than 9 inches
   • 9 to 11 inches
   • Greater than 11 inches

B. Aggregate Base Course
   • Class 6
   • Class 7
   • Asphalt Treated

C. Soil Foundation
   • Cement or Lime Stabilized
   • Non-expansive

LTPP test sections, pavement management sections, adjacent DOTs.

Secondary Factors:
Dowels and Nondoweled
Standard and Widened Slabs
AC and PCC Shoulders
Populating the Experimental Factorials

Long-Term Pavement Performance Data
- 60 sections in CO, 10 sections outside CO; 30 GPS and 40 SPS
- New Flexible and Rigid Pavements
- HMA or PCC overlay of Flexible and Rigid Pavements

CDOT PMS Section Selection Criteria
- Representative roadway sections
- Availability of 3 condition surveys within 7-10 yr period (min)
- Consistency of distress measurements
- Availability of construction history data
- Availability of well-defined traffic data
- Availability of material properties from construction/project records
CDOT Sections

- **40 Hot Mix Asphalt Sections**
  - 11 New Pavements
  - 19 Simple AC Overlays of HMA Pavements
  - 6 AC Overlays with Hot In-Place Recycling
  - 2 AC Overlays with Cold In-Place Recycling
  - 2 AC Overlays of Rigid Pavements

- **11 Portland Cement Concrete Pavements**
  - 5 New Pavements
  - 4 Conventional Overlays of HMA
  - 2 Thin Whitetopping Overlays of HMA
Data Collection – Forensic Investigations
1975 Original Construction Project

2000 Resurfacing Project
Site Specific Data
Other Testing as Needed
### HMA Material Properties Needed for the MEPDG Procedure

<table>
<thead>
<tr>
<th>Material Property</th>
<th>Input Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>HMA Dynamic Modulus</td>
<td>✓</td>
</tr>
<tr>
<td>HMA Repeated Load Permanent Deformation</td>
<td>✓</td>
</tr>
<tr>
<td>HMA Indirect Tensile Creep Compliance</td>
<td>✓</td>
</tr>
<tr>
<td>HMA Indirect Tensile Strength</td>
<td>✓</td>
</tr>
<tr>
<td>HMA Maximum Specific Gravity</td>
<td>✓</td>
</tr>
<tr>
<td>Bulk Specific Gravity of Cores</td>
<td>✓</td>
</tr>
<tr>
<td>HMA Mixture Design Sheets</td>
<td>-</td>
</tr>
<tr>
<td>Asphalt Specific Gravity</td>
<td>✓</td>
</tr>
<tr>
<td>Asphalt Content of HMA Mixture</td>
<td>✓</td>
</tr>
<tr>
<td>Asphalt Performance Grade</td>
<td>-</td>
</tr>
<tr>
<td>Asphalt Penetration @ 25 °C</td>
<td>✓</td>
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<tr>
<td>Asphalt Viscosity @ 140 °C</td>
<td>✓</td>
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<tr>
<td>Asphalt Viscosity @ 275 °C</td>
<td>✓</td>
</tr>
<tr>
<td>Asphalt Viscosity</td>
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</tr>
<tr>
<td>Asphalt Softening Point</td>
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<tr>
<td>Fine aggregate specific gravity &amp; absorption</td>
<td>✓</td>
</tr>
<tr>
<td>Coarse aggregate specific gravity &amp; absorption</td>
<td>✓</td>
</tr>
<tr>
<td>Sieve analysis of fine &amp; coarse aggregate</td>
<td>-</td>
</tr>
</tbody>
</table>
# PCC Material Properties Needed for the MEPDG Procedure

<table>
<thead>
<tr>
<th>Material Property</th>
<th>Input Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastic Modulus</td>
<td>✓</td>
</tr>
<tr>
<td>Poisson’s Ratio</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Flexural Strength</td>
<td>✓ -</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>- ✓ ✓</td>
</tr>
<tr>
<td>Unit Weight</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Heat Capacity</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Surface Shortwave Absorptivity</td>
<td>- - -</td>
</tr>
<tr>
<td>PCC Zero-Stress Temperature</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Cement Type</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Cementitious Material Content</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Water to Cement Ratio</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Aggregate Type</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Curing Method</td>
<td>✓ - -</td>
</tr>
<tr>
<td>Ultimate Shrinkage</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Reversible Shrinkage</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td>Time to Develop 50 % of Ultimate Shrinkage</td>
<td>✓ ✓ ✓</td>
</tr>
</tbody>
</table>
Framework for Model Validation and Recalibration

- **Statistical Approach for Model Validation**
  - Determine Model Prediction Capability
    - Using coefficient of Variation, $R^2$
  - Estimate Model Accuracy
    - Using standard error estimate (SEE)
  - Determine Bias
    - Hypothesis testing of model intercept and slope for linear model fitting predicted and measured data
      - Slope = 1; Intercept = 0
    - Paired t-test for measured and predicted distress/IRI

- **Non-Statistical Approach for Model Validation**
  - Used when measured distress/IRI was mostly zero
  - Computation of diagnostic statistics not possible or meaningless
Current Status

- Task 0: Project Kick-Off Meeting and Coordination
- Task 1: Database Development
- Task 2: Field Investigations and Lab Materials Testing
- Task 3: Verification of Current MEPDG
- Task 4: Local Calibration & Validation of MEPDG Models
- Task 5: Development of CDOT MEPDG Design Manual
- Task 6: Deployment of Concurrent Designs
- Task 7: Development of Default Input Libraries
- Task 8: Training Program Delivery
- Task 9: Preparation and Submittal of Reports
User Friendly Software

DARWin

Mechanistic Empirical Pavement Design

This software is for review only and should not be used for design. This software was developed under NCHRP 1-57A and 1-40D. Distribution of this software must be approved by NCHRP.

developed by

APPLIED RESEARCH ASSOCIATES, INC
TRANSPORTATION

ASU
Oh, by the Way.....

- $930,000 – Consultant Contract
- $150,000 – Resilient Modulus for Soils
- $100,000 – Asphalt Mix Performance Tester, Pine Compactor, Incubators and Saws
- $24,000 – Upgrade to FWD
- $15,000 – Coefficient of Thermal Expansion Device
- $15,000 – Flexural Strength Tester
- $40,000 – DARWin ME Annual License fee to AASHTO
Benefit to Colorado

Estimated savings is about 9% of our resurfacing budget = $14 million per year

✓ Cost effective typical sections
✓ Higher reliability in designs
✓ Improved accuracy of long-term budget
✓ Increased ability to model distresses
✓ Better assessment of contractor materials
Summary: Colorado’s MEPDG

- Comprehensive tool for pavement design and analyses.
- Excellent forensic tool!
- Optimize on design features – not just increase pavement thickness!
- Accuracy can be quantified.
QUESTIONS?