Mechanistic-Empirical Pavement Design Workshop

State Perspective

Linda M. Pierce, PE
State Pavement Engineer
Washington State Department of Transportation

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Presentation Outline

- Washington State details
- WSDOT previous design procedure
- ME Design
  - Reasons for developing
  - Challenges
  - Implementation efforts
  - Benefits
- Thoughts on implementation
Washington State Details

- Pavement network
  - Chip Seal: 4,365 ln-mi (23.7 percent)
  - HMA: 11,624 ln-mi (63.3 percent)
  - PCC: 2,384 ln-mi (13.0 percent)
  - Total: 18,373 ln-mi

- Climate
  - Western Washington: primarily wet non-freeze
  - Eastern Washington: dry freeze

- Traffic
  - Primarily heavily populated in western Washington
  - Primarily farming communities in eastern Washington
WSDOT Previous Design Procedure

- Gravel equivalency process
- Based on work conducted by Hveem and Carmany and modified by WSDOT to better match actual pavement performance
- Subgrade characterization
  - Originally based on CBR
  - Problems with some clean sands and clayey gravels along the Washington coast, a switch was made to R-value (modifications – primarily confining pressure).
WSDOT Gravel Equivalency Design Chart

- Traffic Index
  - Used by WSDOT from 1956-1991
  - Process for converting mixed truck repetitions to 5,000 lb equivalent loads

- Relationship between gravel equivalent and HMA, ATB and CTB were developed
  - Empirically based from test track data and Washington State in-service pavements
AASHTO Design of Pavement Structures

- WSDOT fully adopted in 1995
  - Primarily for new construction
- Developed WSDOT specific input values
  - Design catalogs
  - Project specific design
Reasons for Moving to ME Design

- Accommodate changing load types
- Better utilization of available materials
- Accommodate new materials
- Improved reliability of performance predication
- Better definition of the role of construction
- Material properties which relate better to actual pavement behavior and performance
- Improved definition of existing pavement layer properties
- Accommodation of environmental and aging effects on materials
WSDOT Motivation for Moving to ME (HMA overlay thickness design)

- Increasing emphasis
  - Maintenance
  - Rehabilitation
- Need for a more rational and cost effective HMA overlay design procedure
- Multilayered elastic analysis was determined to provide reasonable and effective solutions
WSDOT HMA ME Overlay Design

- **Everpave**
  - Developed by University of Washington and WSDOT
  - Requires the use of
    - Layer moduli (backcalculated from FWD testing and adjusted for seasonal effects)
    - Calculation of strains
  - Necessary to preclude
    - Fatigue and rutting failures
  - HMA layer moduli are corrected for temperature typical for WSDOT mixtures
  - Iterative process to determine overlay thickness
Everpave (continued…)

- Unstabilized base course and subgrade characterized

\[ E = K_1(\theta)^{K_2} \quad \text{or} \quad E = K_3(\theta)^{K_4} \]

- Failure criteria (Chevron’s method)
  
  - Rutting (subgrade)
    \[ N_f = 1.077 \times 10^{18} \left( \frac{1}{\varepsilon_v} \right)^{4.4843} \]
  
  - Fatigue (Finn, Monismith, Newcomb)
    \[ N_f = (N_{lab})(SF) \]
    \[ SF = 10^{14.82 - 3.291 \log \left( \frac{\varepsilon_t}{10^{-6}} \right) - 0.854 \log \left( \frac{E_{AC}}{10^3} \right)} \]
Efforts for Implementing ME Design

- Need to characterize (most significant factors)
  - Materials (includes seasonal variation)
  - Truck classification and volumes
  - Failure criteria (rutting and fatigue cracking)

- Field testing and evaluation
  - Coring
  - Trenching
  - FWD testing
  - Pavement performance
Efforts for Implementing ME Design

- Need to train personnel
  - Layered elastic theory
  - Material testing
  - FWD testing and analysis
  - Seasonal changes and impacts on materials
  - Characterization of traffic
Thoughts on Implementation

- This may take time…
  - WSDOT ME development to implementation took 8 – 10 years (at least three PhD’s and several Master’s studies)

- ME overlay designs
  - 1980’s
    - Evaluated 600-800 lane miles per year
  - Today
    - Evaluate less than 100 lane miles per year
    - Mill and fill is standard treatment
    - Pavement management practice
    - Effective rehabilitation treatment
Thoughts on Implementation

- Determine necessary level of effort
  - What is the level of material variation (or any other variable)?
    - Subgrade (can be huge in any given state, but can this be segmented by area)
    - Base layers (treated or untreated)
    - HMA or PCC
  - What is the impact of variation on thickness design?
  - Is this significant to require the need for extensive testing or could a material catalog be developed for the majority of work?
Questions