Application of Light Weight Deflectometer (LWD) for Use in Mechanistic Empirical Pavement Design in Other States

Agenda

- History of traditional pavement design – AASHTO 1993

- Background of the mechanistic-empirical pavement design

- Overview of light weight deflectometer (LWD) for roadways and pavements

- Movement to performance based design of pavement systems
History of Traditional Pavement Design

- 1993 AASHTO Pavement Design Guide
- Based on road test performed in late 1950s in Ottawa, Illinois

- Based on 18 kip equivalent single-axle loads (ESALs)
  - Flexible
  - Rigid

- Inputs:
  - Traffic data (AADT, \%T_{24})
  - Soil subgrade strength parameters
    - Flexible – CBR, M_R
    - Rigid – K
  - Rigid – Structural properties
History of Traditional Pavement Design

- Results:
  - Flexible – Structural number
  - Rigid – Direct thickness

- For flexible design – utilize structural coefficients of pavement layers (surface, intermediate, base, aggregate) to determine total buildup of pavement structure

- Typical design for 20 years plus
History of Traditional Pavement Design

- 1993 AASHTO provides reasonable design approach for evaluating structural capabilities of a given pavement structure

- Fails to include considerations for climate, non-uniformity of soil conditions, construction traffic
History of Traditional Pavement Design

- Subgrade parameters developed primarily from correlation to soil classification

- Construction acceptance of subbase and subgrade soils based on moisture and density
Background of ME Pavement Design

  - Developed by National Cooperative Highway Research Program (NCHRP)
- Utilizes $M_R$ for soil subgrade parameters
- Traffic data in terms of % trucks
Background of ME Pavement Design

- Layer analysis performed based on empirical data and mechanistic evaluation of properties
- Considerations given to climate, material type, traffic type and distribution over design life
- Provides a probabilistic model of pavement structure based on historic and predicted conditions
Background of ME Pavement Design

■ Benefits
  ■ Provides material cost savings
  ■ Fine tunes design of pavement structure

■ Drawbacks
  ■ Can require significant effort for implementation program
  ■ Considered overly complex by some agencies
The **Falling Weight Deflectometer (FWD)**, a nondestructive test method system, simulates the effect of a moving vehicle wheel load.

- The system applies a load as low as 1,000 lbs to 26,000 lbs for a pulse duration of approximately 25 to 30 msec. The pavement properties are "back-calculated" from the response to impulse load.

\[
M_R = 0.33 (0.24 P) / d_r r
\]

\[
M_R = 1500 \text{ CBR}
\]

Where
- \( P \) = applied load (lbs)
- \( d_r \) = deflection at a distance ‘r’
- \( R \) = distance from center of load (inches)
Overview of LWD
Overview of LWD

**Light Weight Deflectometer (LWD)**

- Developed in the 1970s; improved upon in the 1990s; becoming more widely used
- Primarily used for construction QA / QC
- Can be used for soil subgrade evaluation prior to pavement design (mechanistic approach) and design verification
- 22 lb (10 kg) standard weight lifted and dropped at adjustable height; additional weights can be added
- Force measured using built-in load cell
Overview of LWD

Light Weight Deflectometer (LWD)

- Loading plate sizes ranging from 4 inches (100 mm) to 12 inches (300 mm) to measure stress
- Integrated geophone to measure pulse wave and subgrade deflection
- Interfaces with a handheld PDA device outputting resilient modulus
- Procedure detailed in ASTM E2583
- Additional geophones can be used for spectrum response
Overview of LWD

Standard Assembly

- Weight catch / release
- Drop weight (22 lb shown)
- Buffer Stack
- Electronics unit
- 12 inch loading plate
- 6 inch loading plate
Results of LWD

- The LWD provides an accurate measure of the resilient modulus value, $M_R$, by creating a pulse similar to that of a vehicle loading.

- This can be correlated to a CBR value or used directly in pavement evaluation.
  - Provide a more representative picture of a pavement’s ability to handle traffic loads
  - Direct verification of the soil values used during pavement design
  - Quick results
The LWD is currently being used in Ohio to evaluate the chemically treated subgrade soils within the footprint of the mainline reconstruction.

No formalized reports yet; however results indicate that $M_R$ and CBR values exceed the design assumptions.
Design Verification

- LWD Testing – Ohio Turnpike
- Confirmed composite CBR values in excess of the design CBR

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Effective Subgrade CBR – Ohio Turnpike
Overview of LWD

Benefits of the LWD:

- Portable device
- Quick, simple, cost-effective
- Adjustable weight, drop height, impact area for simulation of traffic
- Direct measurement of subgrade $M_R$
- Can be used to measure natural subgrades, chemically stabilized subgrades and existing pavement systems

Along with ADCP, the LWD is becoming foremost method of acceptance for soil subgrade quality control / quality assurance. Used for acceptance in MN, IL, IN among others.
Performance Based Design

- Several states studying performance based design of pavement systems: MN, IN, IL, VA

- Reliance on structure performance and maintenance records
  - Distress development in flexible pavements
  - Crack formation in rigid pavements

- Performance of subgrade soils
  - In-situ resilient modulus based on LWD
Performance Based Design

- Current design methodologies based on worst case scenarios and empirical data alone

- Performance based design relates the input values to actual pavement response

- Requires more in-situ data and actual performance values of pavement structure

- Current software programs include:
  - DARWin-ME – Developed by AASHTO
  - MnPAVE – Developed by Minnesota Department of Transportation
Current Software Programs

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- MnPAVE – Inclusion of LWD
Current Software Programs

- MnPAVE – Inclusion of LWD
Conclusions

- Movement toward more mechanistic based design, determination of actual in-situ soil strength parameters is critical
- LWD is beneficial, providing a portable measuring device that can deliver accurate strength data
- Development of LWD provides another tool to evaluate in-situ soil subgrade data for use in pavement design
- With increased data collection, more precise models being developed for evaluation
Questions and Answers

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