Reinforced Flexible Pavement Layer Coefficients determined by Mechanistic-Empirical (M-E) Modeling

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1. Objective & Scope

- **Steps involved in a Mechanistic-Empirical (M-E) model for design and analysis of geogrid reinforced flexible pavements will be described**

- **A single pavement cross section and reinforcement type was used in a M-E model and further calibrated against a pavement test section**

- **Benefit values have been derived from M-E analysis (reinforced vs. unreinforced)**

- **Results obtained from the M-E analysis are compared to currently available empirically based proprietary methods**

2. Flexible Pavement Design Methodologies

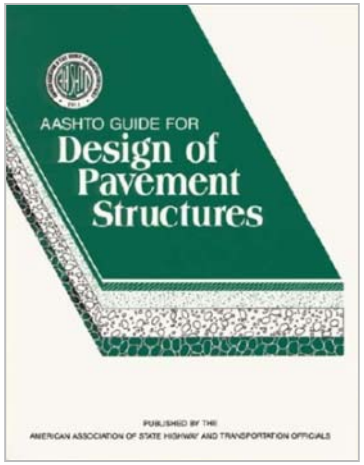
- **Experience**

- **Empirical**
  - Statistical Models derived from observation, measurement and data records from road tests

- **Mechanistic**
  - Calculation of pavement stresses / strains / deformations based on mechanistic-based performance models

- **Mechanistic-Empirical**
  - Combines empirical performance data obtained from the field with theoretical predictions based on the mechanics of materials used in Finite Element response models

3. Flexible Pavement Design Guideline



Basic Empirical Equation:

$$\log W_{18} = Z_R \times S_0 + 9.36 \log(SN+1) - 0.20 + \frac{\log\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \log(M_R) - 8.07$$

Input values:

- Z_R , S_0: Reliability of traffic prediction
- ΔPSI: Difference between the initial design serviceability index (p_o) and the design terminal serviceability index (p_t)
- M_R: Subgrade Support (Resilient Modulus)
- W_{18}: Predicted number of ESALs over pavement design life
- SN: Structural Number

Result:

TBR = Traffic Benefit Ratio

BCR = Base Course Reduction

SN = Structural Number

3. Flexible Pavement Design Guideline

Converted to a layer depth using coefficients:

$$SN = a_1 \cdot D_1 + a_2 \cdot D_2 \cdot m_2$$

Where: a_i = i^{th} layer coefficient (relative strength)

D_i = i^{th} layer thickness

m_i = i^{th} drainage coefficient

In case that a geogrid is used the design equation is altered slightly, as follows:

$$SN = a_1 \cdot D_1 + a_2 \cdot LCR \cdot D_2 \cdot m_2$$

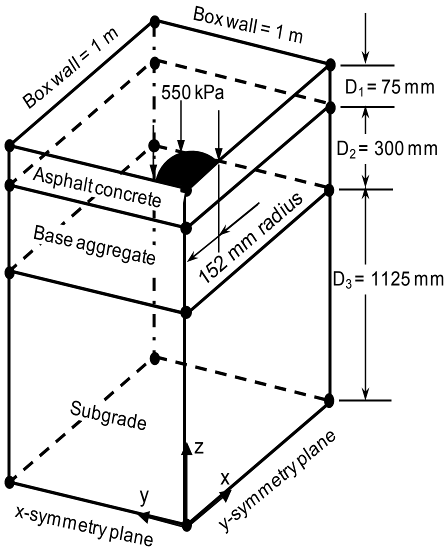
The LCR is calculated as follows:

$$LCR = \frac{SN - a_1 \cdot D_1}{a_2 \cdot D_2 \cdot m_2}$$

4. Mechanistic- Empirical Model (by Perkins & Edens 2002)

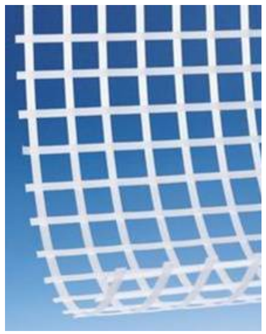
Input values for M-E model

Property	Value
Asphalt concrete thickness, D_1 (mm)	75
Asphalt concrete layer coefficient, a_1	0.40
Base thickness, D_2 (mm)	300
Base layer coefficient, a_2	0.14
Base layer drainage coefficient, m_2	1.0
Subgrade CBR	1%, 2%
Geosynthetic modulus, $G_{SM\text{-}2\%}$ (kN/m)	1140
Geosynthetic modulus ratio, G_{MR}	0.995
Reduction factor for interface shear	1.0
Reduction for Poisson's ratio	Checked
Reduction for shear modulus	Unchecked



Laid & welded Geogrid properties

Polymer	Unit weight [g/m²]	Tensile Strength		
		2% [kN/m] MD/CMD	at 5% [kN/m] MD/CMD	Ultimate [kN/m] MD/CMD
PP	200	12/12	24/24	30/30



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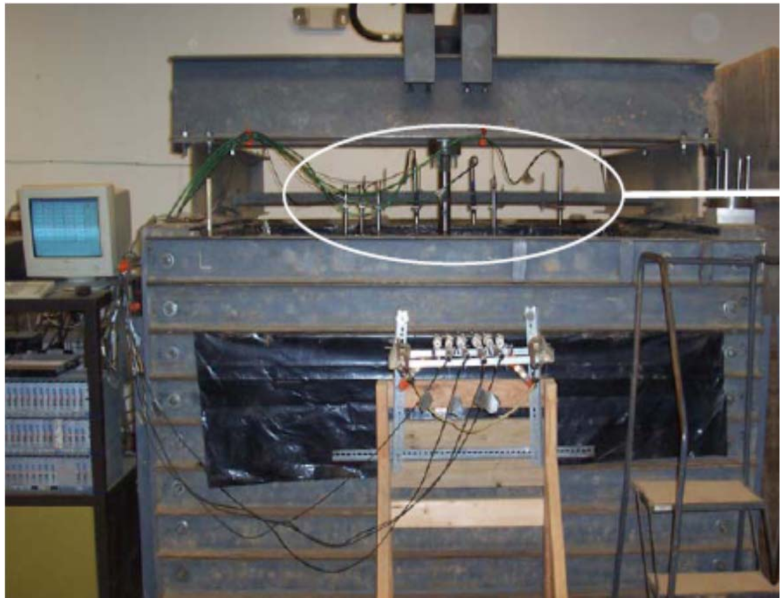
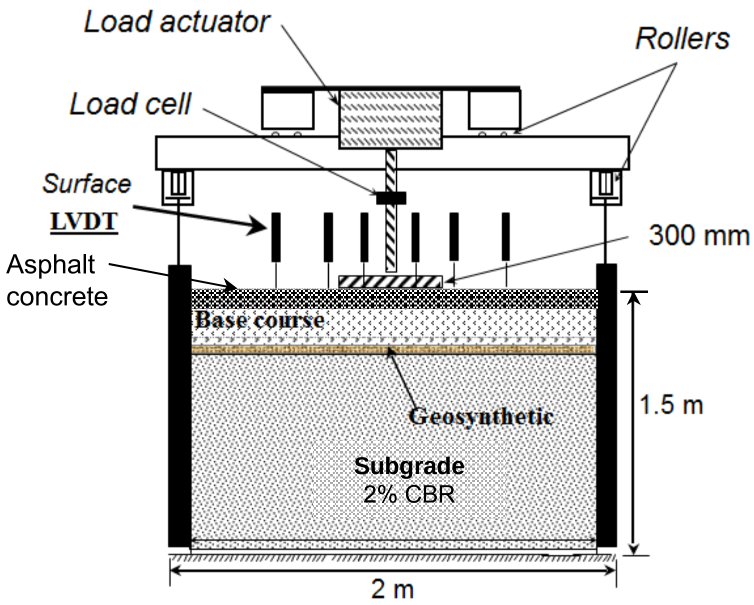
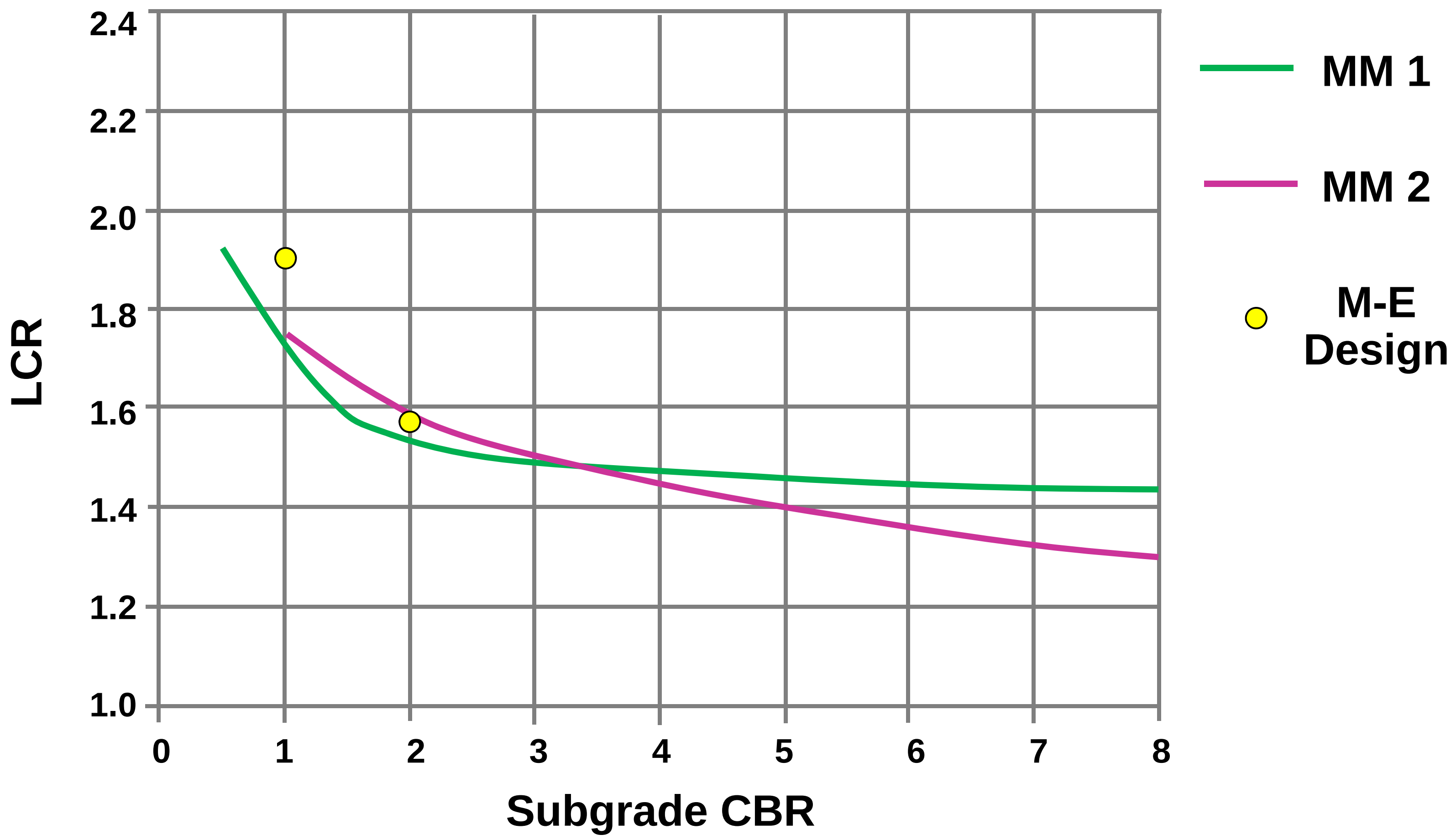
4. Mechanistic- Empirical Model (by Perkins & Edens 2002)





Empirical Pavement Performance Model

5. Results of M-E Analysis



6. Conclusions

- **The improvement of a reinforced base course layer in a flexible pavement was determined using the Mechanistic-Empirical (M-E) design method**

- **Results of the carried out analysis are expressed in terms of an improvement in the structural layer coefficient (LCR) of the base course layer, which is within the context of the AASHTO '93 *"Pavement Design Guide"***

- **The obtained benefit values (LCR) from the carried out M-E design predict an increase of benefit as the subgrade CBR decreases.**

- **The obtained benefit values produce reasonable results and appear to be in line with the general trend shown in available empirically based models**

- **LCR values for different conditions (pavement /base course thickness, subgrade strength, reinforcement type, etc.) have to be determined and validated by a separate empirical and mechanistic design.**

Thank you for your kind attention!