Dynamic Nonlinear Finite Element Simulation of Light Falling Weight Deflectometer (LWD) Tests on Unsaturated Road Foundation Layers

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Introduction

pavement design procedures → empirical inputs → CBR, Hveem R-value → light falling weight deflectometer (LWD)

pavement design procedures → mechanistic structural analysis and design → resilient modulus (MR) → light falling weight deflectometer (LWD)

Introduction

light falling weight deflectometer (LWD) → models (backcalculating geomaterial moduli) → major drawbacks → variations of in-situ moisture levels; suction

The primary objective of this study was to address those drawbacks affecting moduli backcalculation of foundation layers from LWD tests.

Introduction

A two-dimensional (2D) axisymmetric finite element (FE) modeling approach

in-situ LWD measurements recorded

establish LWD deflection targets for road foundation layers at various moisture levels.

Modulus of Unsaturated Granular Materials

- First introduced for use by Siekmeier et al. (2009)
- The origins of the MR constitutive equation can be found elsewhere (NCHRP 2004)
- the plastic limit (PL) was used to estimate the volumetric moisture content at saturation
- Both PL and field moisture content were used to estimate LWD
- target : compacted fine-grained soils.

Modulus of Unsaturated Granular Materials

$$M_R = k_1 p_a \left(\frac{\sigma_{eb} + f_s \theta_w \psi}{p_a} \right)^{k_2} \left(\frac{\tau_{oct}}{p_a} + 1 \right)^{k_3}$$

$$k_1 = 800 \times \left(\frac{1}{5\theta_{sat}} \right)^{1.5} \left(\frac{1}{\log_{10}(\psi)} \right); k_2 = \log_{10}(\psi) - 1; k_3 = -8\theta_{sat}; f_s = \theta_w^{10\theta_{sat}^3}; \theta_w = \left[1 - \frac{\ln\left(1 + \frac{\psi}{\psi_r}\right)}{\ln\left(1 + \frac{10^6}{\psi_r}\right)} \right] \times \frac{\theta_{sat}}{\left[\ln\left[e + (\alpha\psi)^n\right]\right]^m}$$

$$\psi_r = 500\sqrt{\theta_r}; \theta_r = 1.6\theta_{sat}^2; \alpha = \frac{1}{(100\theta_r)^2}; \theta_{sat} = -0.000431PL^2 + 0.0336PL - 0.162; n = \frac{1}{(1-m)}; m = 0.8\theta_{sat}$$

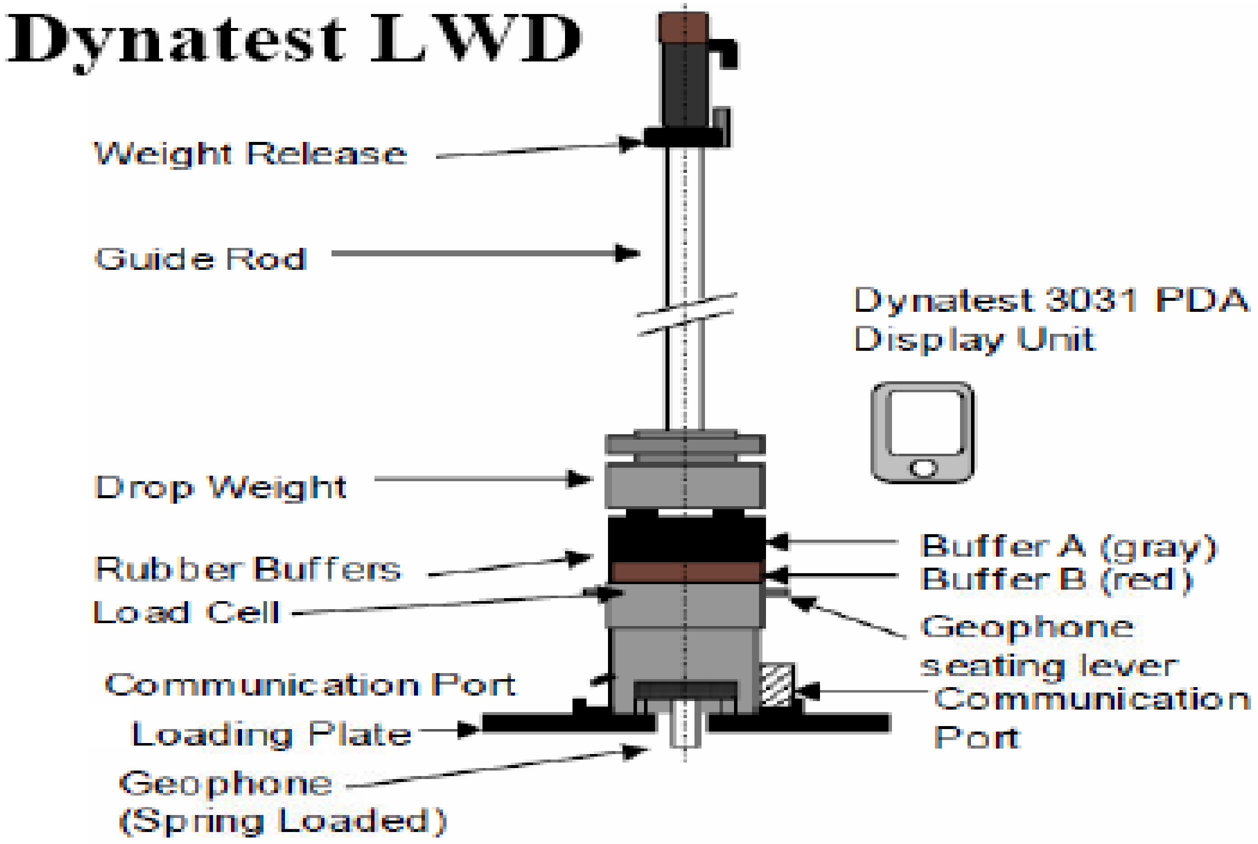
Finite Element Modeling of LWD Deflection Targets

- Abaqus®
- The Dynatest LWD was modeled, as shown in Figure 1(a).
- Soil, LWD loading plate , the 200-mm diameter LWD loading plate.
- The example FE model results of vertical stress distribution and LWD deflection targets at varying moisture levels are shown in Figure 2(b) and Figure 2(c).
- LWD deflection targets.

THANKS FOR LISTENING

Finite Element Modeling of LWD Deflection Targets

- Figure 1: (a) Schematic views of LWD device



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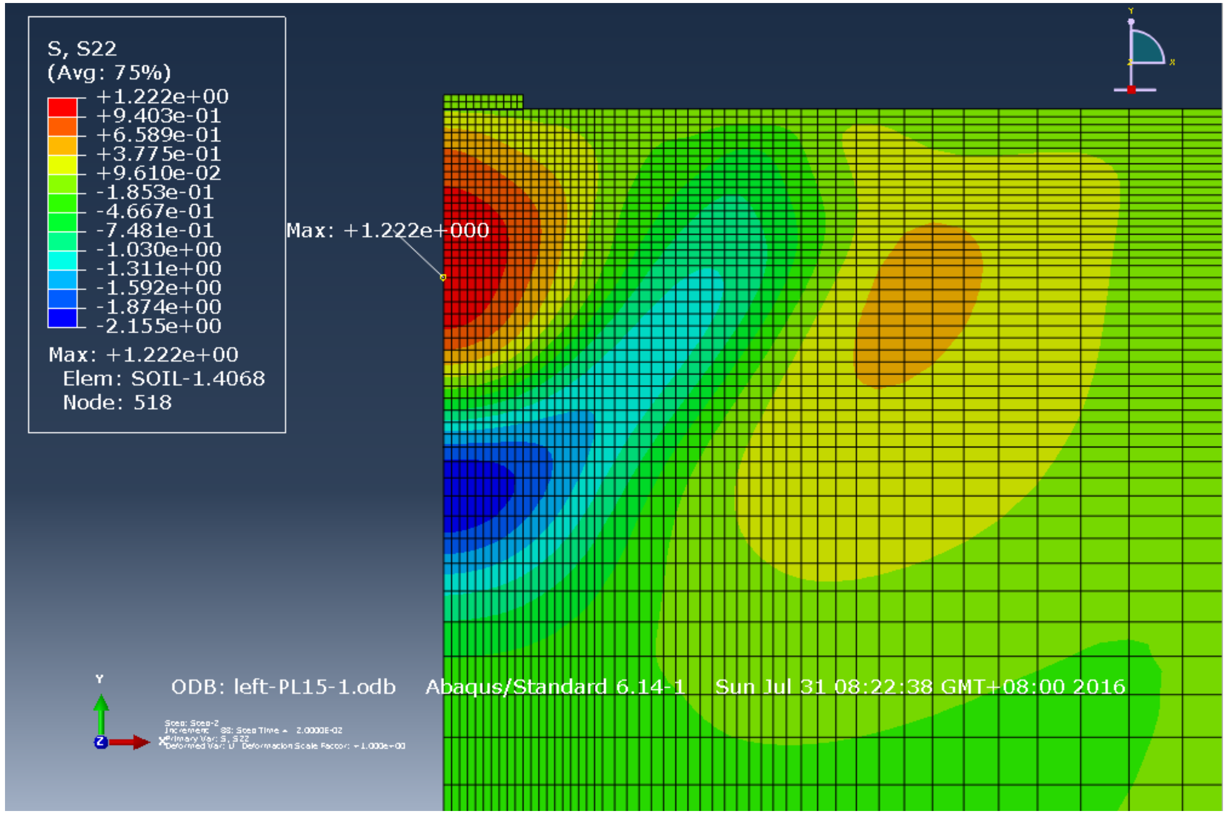
Finite Element Modeling of LWD Deflection Targets

- Figure 1:(b)example finite element model results of vertical stress distribution



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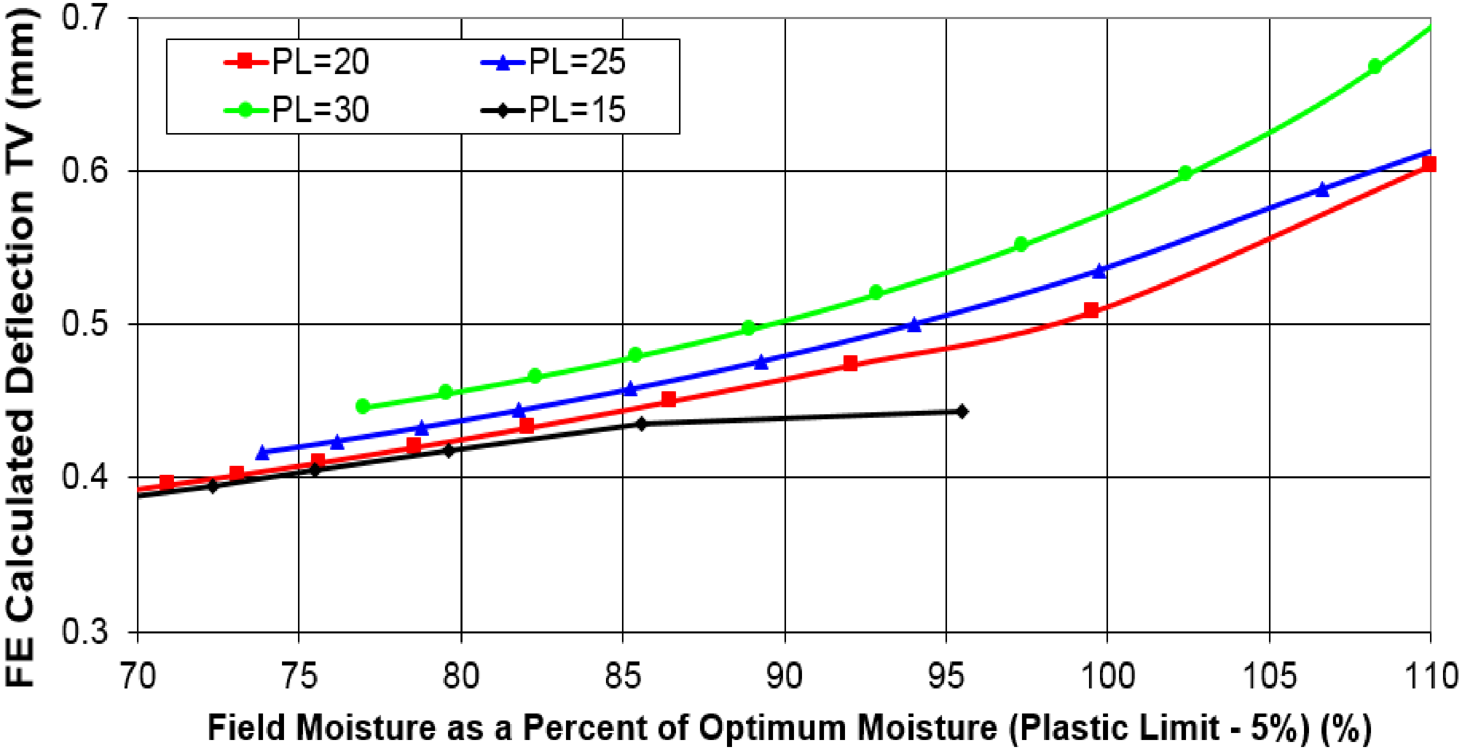
Finite Element Modeling of LWD Deflection Targets

- Figure 1:(c) LWD deflection targets at varying moisture levels



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