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STUDY ON SENSITIVITY OF ENHANCED FWD TESTING DATA TO PAVEMENT MODEL PARAMETERS

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In order to economically maintain roads and highways the fast and robust identification procedure, capable to detect an amount of deterioration of pavement structure, is required. The inverse procedure usually employed for such investigation is often based on falling weight deflectometer (FWD) test [1], which is well established and widely used for pavement characterization. The measurable quantities from FWD test, namely force induced by the falling weight and deflections recorded by a group of geophones are later interpreted as a static ones, neglecting its purely dynamic nature. Such interpretation despite an explicit residual discrepancy between computed and measured data [2] is still a norm among practicing engineers. In the literature the number of publications deal with static interpretation of dynamic FWD data can be found, (e.g. [3, 4]), however the problem still remains unsolved. Another, even more serious problem is generated through various approximation methods applied to pavement modeling, which serve as a counterpart of experimentally measured quantities in an inverse analysis.

Nowadays many numerical and/or analytical models are used in backcalculation procedure, which for the engineering applications are usually simplified and not always adequate to ambient situations and conditions. The analytical models very often exploit a linear elastic theory (LET) of layered half-space or equivalent thickness theory (MET) based on the Odemark‘s transformation method. Numerical models, on the other hand, use following assumptions: (a) the materials are continuous and homogeneous; (b) the interlayer connections are chosen as perfectly bounded or totally free, and (c) the relationship between strain and stress follows linear elasticity. All these assumptions simplify the computations but in the same time introduce an error which very often should not be neglected. Therefore, optimally would be to use simplified and accurate models which will produce results sensitive to all model parameters while being insensitive to all neglected variables (i.e. applied simplifications).

For the purpose of study on sensitivity of FWD measurements with respect to pavement model parameters the numerous of static and dynamic analytical-numerical models, consisting of all important ingredients (i.e. contact properties, inter-layer cohesion behavior and enhanced nonlinear visco-elasto-plastic constitutive models for all pavement layers) is considered here. By limiting all model parameters (inputs), gathered in vector $\mathbf{p}$, in their feasible domain one can perform a 'random walk' in this space perturbing each parameter independently ($\Delta p_k = \delta p_k$, where δ can be chosen as e.g. 0.01) and check the effect of each perturbation to the computed quantities - here displacements (outputs). As an objective measure of sensitivity an elementary effect method (EEM) [5] is selected which through a stochastic scan of input space provides averaged amount of output changes. Because the measured output is a set of displacements recorded in various moment of time and different locations, the proper scalar-measure of output should be selected. Here the output is represented by a $M \times N$ matrix u_{ij} where i-th row contains displacement recorded in time t_i for $i = 1, \ldots, M$, and j-th column contains displacements recorded in j-th geophone for $j = 1, \ldots, N$. One of the simplest method to transform matrix $\mathbf{U}$ into a scalar is to compute an Euclidean norm $\bar{u} = \|\mathbf{U}\|_2^2$. Average sensitivity of L random walks for k-th model parameter is computed here by a formula:

$$s_k = \frac{1}{L} \sum_{l=1}^{L} \frac{\bar{u}_k - \bar{u}_0}{\Delta p_k} \frac{p_k}{\bar{u}_0} = \frac{1}{L} \sum_{l=1}^{L} \frac{\bar{u}_k / \bar{u}_0 - 1}{\delta} \tag{1}$$

and serve later as an important factor used in assessing the correctness of model(s) simplification. Such approach gives mathematically based method of smart model reduction which can be further use in backcalculation analysis for more realistic pavement characterization.

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