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EQUIVALENCE OF A FE NUMERICAL MODEL AND A REDUCED MODEL OF SOIL-STRUCTURE INTERACTION, DEFINED NUMERICALLY USING ARTIFICIAL NEURAL NETWORKS

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Despite the enormous progress in modelling the soil-structure interaction problems by discretization of a structure and a real domain of soil, using FEM, DEM, or MFD, the reduced models are still very popular in engineering practice. In reduced models, the action of the soil on the structure is replaced by the action of a linear or non-linear elastic layer (e.g. Winkler's model) or a layer with other properties, described by a number of parameters. The main difficulty here is finding values of the parameters required by these reduced theories. These values are obviously functions of the engineering properties of the soil. The subject of this paper is to find the dependence of the parameters of the reduced model on the parameters of the full model, involving realistic behavior of the soil, in order to ensure the equivalence of both models. To obtain the equivalence of the two approaches (the full FE model and the reduced one) we propose to analyze any of the classical engineering test the soil-structure interaction. We show the potentiality of the method presenting two examples: non-linear Winkler's springs for the model of static test of bearing capacity of piles and the Pasternak model of a slab on the soil, subjected to Falling Weight Deflectometer (FWD) test. We assume that the two models are equivalent if they give identical results (displacements) in finite number of observation points. In the analyzed examples these are: the results of measurements of pile settlement during the static loading test and nine vertical deflections of the slab surface measured in the classical FWD test. An Artificial Neural Network (ANN) is built to record the dependence of the parameters of the reduced model (at the network output) on the parameters of the full model (given at the network input). The scheme of the procedure is the following:
We train first a simple feed-forward ANN with hidden layers to approximate a "direct" FEM solution. In the training, the realistic, geotechnical parameters of the soil (used before in the FEM model) presented at the input of the ANN_1 and observable data computed by this model are put at the output. The second ANN is trained to approximate "inverse" problem related to the reduced model: the values of the displacements in the observation points obtained as a solution of the reduced theory are presented at the input of the ANN_2 and the trial parameters of the reduced model are obtained at its output. The complex network ANN_1@ANN_2 acts as a formula that attributes the parameters of the reduced model to the realistic soil-structure description that is used for FE modelling. The formalism we propose is quite general, applicable for many engineering problems. It is also automatic in engineering applications because of its numerical character.