A Machine Learning Model for the Determination of Macro-Scale Masonry Properties based on a Virtual Laboratory at Micro-Scale

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ABSTRACT

Cutting-edge methods in the computational analysis of structures have been developed over the last decades. Such modern tools are helpful to assess the safety of existing buildings. Multi-scale techniques have been proposed to combine the accuracy of micro-modelling and the computational efficiency of macro-modelling [1]. Machine learning tools have been utilized successfully to train specific models by feeding big source data from different fields, e.g. autonomous driving, face recognition, etc.

This research proposes a multi-scale numerical modelling technique to describe the nonlinear material behaviour of masonry structures. The proposed method is based on a machine-learning tool that links the two scales of the analysis by training the macro-model smeared damage constitutive law [2] through benchmark data from numerical tests derived from micro-models.

The first part of the research consists in building up a computational experimental campaign in a virtual laboratory. A variety of strain states, increasing monotonically, is applied to the boundary of a micro-modelled wall in order to activate different stress states. A great number of results arise and serve as the input training data for the machine-learning model.

The second part of the research consists in training the linear and nonlinear variables of an advanced constitutive law for masonry materials by applying gradient descent optimization [3]. The input learning data are the strains and stresses from the virtual laboratory. The input strains feed the model and the input stresses are used to compute a loss of the actual variable configuration. If the loss exceeds a user predefined criterion, the variables of the constitutive law are optimized by a gradient descent operator.

The optimized constitutive law is validated by applying it to a macro-model of the same masonry wall used for the calibration of the micro-model of the virtual laboratory.

REFERENCES

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