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Global sensitivity analysis of unreinforced masonry structure using high dimensional model representation

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ABSTRACT

Sensitivity Analysis (SA) has very important implications in terms of model assessment. It is an important part of reliability studies as well. This paper presents global SA using High Dimensional Model Representation (HDMR) on a mesoscale model of unreinforced masonry shear wall. The mesoscale model contains both geometric as well as material nonlinearity. Prior to performing global SA: (a) mesh sensitivity study in order to determine the optimum mesh size; and (b) experimental validation of the finite element simulation using the data available in the literature, are conducted. The ability of two major variations of HDMR, namely RS (Random Sampling)-HDMR and Cut-HDMR, for conducting global SA is explored, first by solving analytical problem and later by analyzing the mesoscale model of unreinforced shear wall. From the study, recommendations are made to obtain the sensitive parameters of an unreinforced masonry structure with minimal computational effort.

1. Introduction

Very often we encounter physical or mathematical models which encompass a large number of input variables. Henceforth, an essential part of model evaluation should include some performance assessment of the model in prediction of response, in case insufficient data regarding input parameters is available. This is usually done through sensitivity analysis (SA) and uncertainty analysis. The main purpose of SA is to estimate effects of each model input, independently or through cooperative efforts, on the model response and to identify the primary contributors to the output uncertainty [1,2]. Whereas, uncertainty analysis looks into the uncertainty in the model response given uncertainty in input space [1]. SA can be broadly categorized into two groups depending on the type of analysis conducted. When SA is performed by varying each input parameter keeping other input parameters constant, it is called local SA [3]. Whereas, global SA is performed over whole input domain and the interaction between input parameters is taken into account. If the model is non-linear in nature results obtained by local SA are not representative [4].

Recently application of global SA to structural systems has caught the attention of the research community [5–7]. Very few works on local SA of masonry have been reported so far [8–12]. Lourenco [8] conducted local SA of an unreinforced shear wall using finite element analysis both on mesoscale and macro-scale levels. A total of nine parameters are taken in account for SA of the mesoscale model and the change in collapse load is monitored. Milani et al. [11] conducted local SA for different types of masonry vaults. The parameters taken in consideration are tensile strength of mortar and coefficient of friction of mortar. Reddy et al. [12] studied the influence of elastic properties of the constituents and joint thickness on the strength of soil-cement block masonry. Milani and Benasciutti [13] investigated the application of Response Surface (RS) models in Monte Carlo analysis of complex masonry buildings with random input parameters. The accuracy of the estimated RS approximation, as well as the good estimations of the collapse load cumulative distributions are evaluated through polynomial RS models. Interestingly, in most of the above-mentioned literature, conclusions are drawn based on finite difference approximation, which is simplest form of local SA. In addition, no works relating to global SA of masonry are reported so far, and the application of High Dimensional Model Representation (HDMR) for conducting global SA to solve structural engineering problems has not been explored either.

In the current work, global SA is carried out on a mesoscale model of an unreinforced masonry (URM) shear wall using HDMR. Often mesoscale models contain large number of input parameters. This limits the application of the models to wider range of problems since knowledge regarding all the input parameters might not be available. Identifying the important parameters by global SA can resolve this issue. Moreover, decisions regarding physical structural systems can be made. This paper addresses these issues and proposes a novel strategy to evaluate the global sensitivity of the parameters with the least computational effort.

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