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SURROGATE MODEL BASED RELIABILITY ANALYSIS FOR FUZZY CROSS-CORRELATED RANDOM FIELD MATERIAL DESCRIPTION

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Realistic analyses require appropriate models of uncertain input data. Polymorphic uncertainty approaches combine basic uncertainty models into one parameter, like a fuzzy random variable describing a material parameter [1].

Heterogeneous materials can be described by random fields (RF), which dependent on an auto-correlation function. Material interdependencies can be taken into account using cross-correlated RFs [2]. Usually, these RF parameters (auto- and cross-correlations) are only vaguely known. Therefore, in the presented paper, they are described by convex fuzzy sets. For the suggested polymorphic material description, an appropriate reliability analysis scheme is introduced comprising two main blocks: A surrogate model, approximating the failure probability of the system and an α-level optimization performed on the surrogate model, where the RF parameter fuzzy sets are used as an input and failure probability fuzzy sets are estimated as the results.

A hydro-mechanical coupled system of a masonry gravity dam cross-section, implemented as a 2D plain strain finite element model, serves an an application example [3]. Different surrogate model configurations are investigated using varying numbers of support points. The resulting fuzzy sets obtained using the surrogate model are compared to re-calculated failure probabilities estimated with the finite element model itself. They are found to be in good agreement. The computational costs using the surrogate model are reduced by a factor of several tens. The consideration of material cross-correlation, even as a wide fuzzy description, implies significant differences in the resulting failure probabilities and should not be neglected in a reliability analysis of such multi-field systems. For large finite element models using a polymorphic uncertain material description, a possible domain decomposition approach is briefly introduced.

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