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Sensitivity analysis of steel frame considering uncertainty

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Abstract

One of the challenging issues in modern civil engineering analysis is the typically large number of random quantities defining the input and system parameters. One approach to making such problems tractable is to identify the most important sources of uncertainty. The influence of uncertainties of input and system parameters on the uncertainty of system response expressed by mathematical models is studied using sensitivity and uncertainty analyses. The stochastic sensitivity analysis will be carried out with the aim of assessing the relative sensitivity of the random variability of a monitored event to the random variability of individual input variables. The objective of the study is to assessment the influence of initial imperfections and excitation uncertainties on the response of a single storey steel plane frame. The influence of the variance of initial imperfections and excitation uncertainties on the variance of the response was calculated by Monte Carlo based procedure.

Keywords: Monte Carlo, sensitivity analysis, uncertainty, variance, frame.

1. INTRODUCTION

Uncertainty in Structural properties, design assumptions and earthquake-induced ground motion affect structural response. Strong ground motion and corresponding structural response appears random in space and time due to the inherent complexity of earthquake source, the path that seismically induced waves follow, and the soil layers that the waves go through to reach the foundation level of structures [1]. Also the properties of structures are influenced by a number of factors which are of random character. If a structure is to reliably fulfill its function during its service life, it is necessary to make provision for this during its design. In the general classification of initial structural imperfections, three fundamental categories of imperfection are considered [2]:

a. Geometrical imperfections: initial curvature of member axis, eccentricity of load action, deviation from the theoretical layout of the cross section (tolerance of dimensions and shape of the cross section), etc.

b. Material imperfections: dispersion of the mechanical properties of the material (non-homogeneousness of material characterized by the dispersion of the yield strength, ultimate strength, Young's modulus, etc.), initial stress state (residual stress as a consequence of rolling, welding, straightening and other technological manufacturing processes).

c. Structural imperfections: imperfections in the realization of joints, connections, welds, anchorage and other structural details which are apparent in comparison with the theoretical assumptions introduced in the solution of idealized system, in deviations of the effects of the actual structural system. Most initial imperfections arise due to inaccuracy during manufacturing process.

The Sensitivity Analysis is a study of how uncertainty in the model output can be apportioned to different sources of uncertainty in the model input factors [3]. The variance of the output in the variance-based sensitivity analysis is decomposed as a sum of contributions of each input variable. Variance-based sensitivity analysis methods are, by contrast, model-independent, in that, unlike methods based on regression or correlation analysis they yield accurate, unbiased results for non-linear, non-additive and non-monotonic models [3].

In the paper presented, the variance-based sensitivity analysis will be applied for study of the influence of input random quantities on the response of a single storey steel plane frame. The Sobol'