Computational Sensitivity Analysis for Construction Stage Models

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Abstract

This paper is about sensitivity analysis and discusses how computational approaches like adjoint sensitivity analysis can be adopted for structural analysis models which consider the construction stage process. It is also shown how the sensitivities can be visualized by sensitivity maps and how these can significantly support the use of sensitivity analysis in structural engineering practice. In addition to the methodological developments, the paper also focuses on demonstrating the application of the approach. By means of an example, sensitivity distributions based on a holistic building model and a construction stage model are computed and compared. In that regard, the paper discusses how sensitivity analysis can provide information about the properties of the used models and how sensitivity data can assist the model assessment.

Keywords: sensitivity analysis; construction stage analysis; advanced models of structures; advanced structural analysis

1 Introduction

Sensitivity analysis deals with studying the effects of varied input parameters to the variation of output parameters of any kind of model or system. In the field of structural engineering output quantities of interest are for example stresses or deflections. Possible input parameters are stiffness values, load intensities, geometrical parameters or variables of boundary conditions. Although there is research on the topic since the 1980s (e.g., Haug et al. [1]), sensitivity analysis has not been implemented into everyday structural engineering.

Sensitivity analysis is no unique procedure, instead it is the collective term for different methods with various informative value and computational effort. Saltelli et al. [2] provides an overview about different methods and separates between local and global approaches. Global methods are typically used as part of uncertainty analysis to investigate which of the uncertain model parameters have a low respectively high contribution to the uncertainty of the output quantity. To perform global sensitivity analysis probabilistic properties of the parameters (i.e., their probability density function) are required. Local methods typically describe the relationship between input parameters s and a system response R as derivative dR/ds. Local approaches suffer from their dependency on the employed parameter values in the model on which basis the derivatives are computed and are not able to describe interactions between different parameters. In this paper the focus will be on local sensitivity analysis as (i) they require no probabilistic properties of the parameters, (ii) their computational effort is significantly lower and (iii) they are suitable to determine the properties of different models, e.g., to compare models that take the construction process into account with those that do not.

Similar to sensitivity analysis, also construction stage analysis is rarely considered up to now, although the topic is discussed since the 1980s, see