Available online at www.sciencedirect.com
SCIENCE DIRECT®
Journal of Constructional Steel Research 61 (2005) 415–422
JOURNAL OF CONSTRUCTIONAL STEEL RESEARCH
www.elsevier.com/locate/jcsr

Sensitivity analysis of the stability problems of thin-walled structures

Zdeněk Kala*

Department of Structural Mechanics, Brno University of Technology, Faculty of Civil Engineering, Veveří 95, 602 00, Brno, Czech Republic

Received 20 April 2003; accepted 19 August 2004

Abstract

Analysing the system behaviour in relation to the input quantities it is often necessary to find out what quantities have the greatest effect on the studied output. The article shows the essential methods of applied sensitivity analysis. The objective of the paper is to analyse the influence of initial imperfections on the resistance of a member under axial compression. The analysis uses the Latin Hypercube Sampling simulation method (LHS) [Novák D, Teplý B, Shiraishi N. Sensitivity analysis of structures. In: Proc. of the fifth int. conference on civil and structural engineering computing. 1993. p. 201–07; Novák D, Lawanwisut W, Bucher C. Simulation of random fields based on orthogonal transformation of covariance matrix and Latin hypercube sampling. In: Proc. of int. conference on Monte Carlo simulation. 2000. p. 129–36] together with advanced models based on the nonlinear beam finite element method. The histograms of initial imperfections obtained by measurement [Melcher J, Kala Z, Holický M, Fajkus M, Rozlívka L. Design characteristics of structural steels based on statistical analysis of metallurgical products. Journal of Constructional Steel Research 2004;60:795–808] were considered.

Keywords: Sensitivity analysis; Simulation method; Imperfections; Yield strength; Buckling

* Tel.: +420 541147382; fax: +420 541240994.
E-mail address: kala.z@fce.vutbr.cz.

0143-974X/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jcsr.2004.08.005

1. Introduction

Solving the problems of stability, we are usually, besides the final result (stress and deformation, load-carrying capacity, failure probability, etc.), interested in the fact of how much the input parameters affect the result, or in other words what is the sensitivity of the response to the change of the input parameter. The use of the sensitivity analysis enables us to determine the dominant quantities that must be paid special attention. The sensitivity analysis can be generally divided into two fields:

The deterministic sensitivity analysis (or also the design sensitivity) is quite a well known and commonly used means for designing a structure. It is the component part of a design procedure, which uses a computational model enabling a successive change of values of one input quantity and uses parametric study to investigate the effect of the change on the output quantity. Even though these studies are very valuable and provide a quick overview on the model behaviour, they do not usually enable satisfactory conception of the whole spectrum of the possible cases that can occur on the real structure. In this connection we normally use a parametric study (sometimes called "what-if-study").

The stochastic sensitivity analysis provides more complex (and quantified!) information on the parameter's influence. The procedure of determining the sensitivity is to a certain extent similar to the deterministic sensitivity analysis. We also change the value parameter and observe how it is reflected in the output quantity. The change of the input quantity respects also the frequency of the occurrence, i.e. the realizations of the input random quantities are simulated as if they were received by measuring. The simulation usually indicates a phase of experimental work using a representation of a computational model. The objective of the simulation is to analyse the behaviour of the system in dependence on the input quantities and values of parameters.

In recent years, many various stochastic sensitivity analysis methods have been developed [12,13] and a number of possibilities for their practical applications has been presented [5,8]. Together with the development of new reliability analysis concepts (see, e.g., [6,9,17]), these methods can contribute to qualitative improvement of structure reliability analysis methods.

2. Basic sensitivity analysis methods

The sensitivity analysis is the analysis of the input quantity variability influence on the output quantity variability. In other words, it is the phenomenon of how the random variability of an input quantity influences (in comparison with the others) the structure response variability and how it takes part in the resulting failure probability. The sensitivity analysis answers thus the question of which quantities are dominant, and therefore they must be paid increased attention at (i) the preparation of input; (ii) the considerations and decision making concerning the improvement of technology procedures; (iii) the conception and organization of controlling activities. In cases (ii) and (iii), also economic criteria are usually included. Further on, it is possible to recognize by means of the sensitivity analysis which quantities show only little influence, and therefore they can be considered, as the case may be, only deterministically (as non-random ones) in further