8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

SENSITIVITY ANALYSIS OF MULTIPARAMETER MODEL SYSTEMS IN CIVIL ENGINEERING

***Z. Kala[1] and L. Puklický[2]**

[1] Brno University of Technology
Faculty of Civil Engineering
Department of Structural Mechanics
Veveří Str.95
Zip Code: 602 00
Brno, CZECH REPUBLIC
E-mail: ka1a.z@fce.vutbr.cz

[2] Brno University of Technology
Faculty of Civil Engineering
Department of Structural Mechanics
Veveří Str.95
Zip Code: 602 00
Brno, CZECH REPUBLIC
E-mail: 1.puk1icky@centrum.cz

Key Words: *Sensitivity, Frame, Imperfections, Steel, Resistance, Interaction effects.*

ABSTRACT

The objective of the present paper is the sensitivity analysis of the steel plane frame load-carrying capacity. Steel plane frame is a system which contains three members: two columns and cross beam, see Fig. 1. Sensitivity analysis is used to analyze how sensitive a system resistance is with respect to change of initial imperfections.

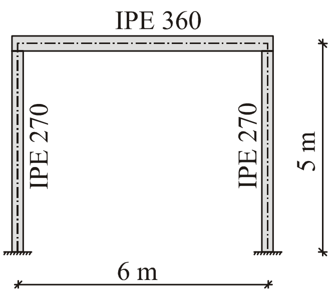

Fig. 1: Frame Geometry

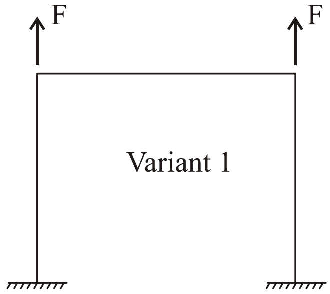

Fig. 2: Load action 1

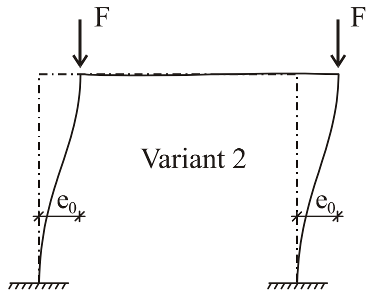

Fig. 3: Load action 2

Statistical information on initial imperfections of cross-section geometry and material characteristic were published in [4]. Input quantities X_i of left column are yield strength f_{y1}, cross-sectional height h_1, cross-sectional width b_1, web thickness t_{w1}, flange thickness t_{f1} and Young modulus E_1. Input quantities of right column are f_{y2}, h_2, b_2, t_{w2}, t_{f2}, E_2. Input quantities of cross beam are f_{y0}, h_0, b_0, t_{w0}, t_{f0}, E_0. Statistical characteristics were considered as histograms according to the results of experimental research [4]. The system imperfection e_0 considered according to the first buckling mode was the last random input characteristic, see Fig. 3. The Gauss density function with mean value μ_{e0}=0 mm, and standard deviation, σ_{e0}=5 mm were assumed for system imperfection e_0.

The load-carrying capacity of variant 2 was solved by the nonlinear Euler incremental method and combined with the Newton-Raphson method [3]. The frame geometry was meshed by beam elements with initial curvature in form of a parabola of the 3rd degree.

The Sobol's variance decomposition is used for investigation of first-order effects and second-order effects due to interactions [2, 1]. In our study, the sensitivity analysis of load-carrying capacity Y (output quantity) to statistically independent input imperfections X_i was evaluated according to:

$$S_i = \frac{V\left(E\left(Y \middle| X_i\right)\right)}{V(Y)} \qquad (1) \qquad\qquad S_{ij} = \frac{V\left(E\left(Y \middle| X_i, X_j\right)\right)}{V(Y)} - S_i - S_j \qquad (2)$$

The change of output load-carrying capacity Y is characterised by variance V(Y). The sensitivity indices Si were evaluated utilizing the Monte Carlo. The conditional random arithmetical mean $E\left(Y \middle| X_\mathrm{i}\right)$ and the variance $V\left(E\left(Y \middle| X_\mathrm{i}\right)\right)$ were evaluated for N=50000 simulation runs.

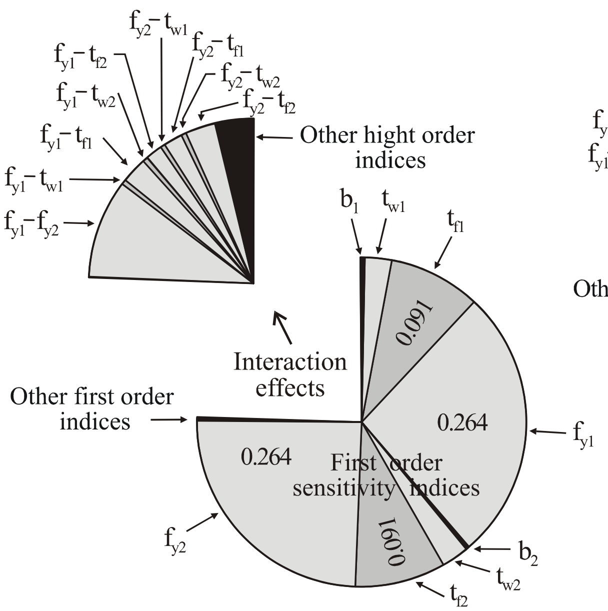

Fig. 4: Sensitivity indices of Variant 1

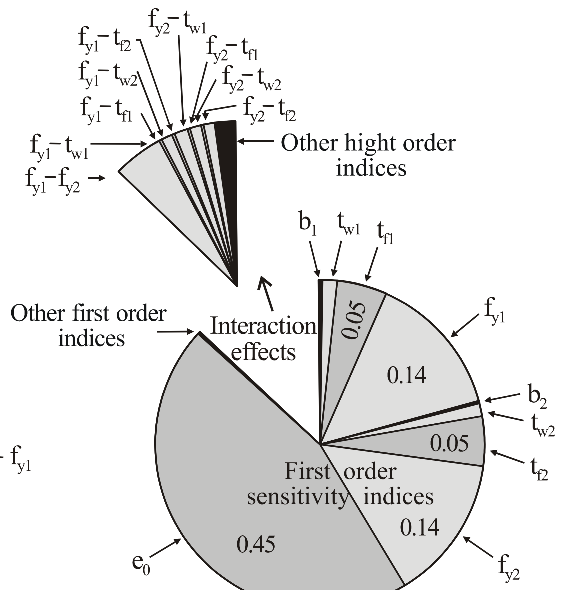

Fig. 5: Sensitivity indices of Variant 2

The first order (1) and second order (2) sensitivity indices of initial imperfection are presented in Fig. 4 and Fig. 5. The yield strength values $f_{\mathrm{y}1}$ and $f_{\mathrm{y}2}$ are dominant for the Variant 1. The sensitivity analyses results depicted in Fig. 5 clearly illustrate that the dominant variable for the monitored output is the system imperfection e_0.

The article was elaborated within the framework of projects GAČR 103/07/1067, KJB201720602 AVČR and GAČR 103/08/0275.

REFERENCES

[1] SALTELLI, A., RATTO, M., ANDRESS, T., et al, *Global Sensitivity Analysis Guiding the Worth of Scientific Models*, New York: John Wiley and Sons, 2007.

[2] SOBOL', I., "Sensitivity Estimates for Nonlinear Mathematical Models", *Matematicheskoe Modelirovanie 2*, pp.112–118, 1990. (in Russian)

[3] KALA, Z. "Sensitivity Analysis of the Stability Problems of Thin–walled Structures", *Journal of Constructional Steel Research 61* (2005), pp.415–422.

[4] 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 60* (2004), pp.795–808.