Problems of Code Design Concepts Ensuring the Reliability and Efficiency of Structures

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Summary

The topic of this paper is an analysis of the reliability misalignment of a steel structure designed according to the EUROCODE 3. For the elaboration of the parametric study, a simplified problem of a compressed member loaded by permanent load action combined with a single variable load action is considered. Majority of input material and geometrical characteristics are independent random variables. The probabilistic reliability assessment is calculated by the Monte Carlo method.

Keywords: Design, reliability, probability, steel, imperfections, stability.

1. Introduction

When designing a steel structure in the EU, a designer proceeds in compliance with the topical standards, the EUROCODES. The design reliability of a steel structure is ensured, to a basic extent, by partial safety factors of the standards, and by the manufacturing quality in individual EU countries. Reliability analysis of steel structures is aimed at safety and serviceability assessment in the limit state methods.

The paper is aimed at the reliability analysis of the ultimate limit state of a steel strut. The Monte Carlo method was employed for the calculation of failure probability. Majority of the input imperfections were measured and their random realizations computed using their histograms whilst employing the Monte Carlo method. The reliability study of a design of a bilaterally hinged steel strut loaded by permanent and long–time single variation action is the topic of the paper. In the probabilistic calculation, the loading effect is to be considered as random one; however, it causes the uncertainty because the histogram of real loading effects cannot be known at the design stage.

2. Parametric Study of Failure Probability

For the elaboration of a parametric study, a simplified problem of a compressed member loaded by permanent G action combined with a long-time leading single variable Q action is considered. The corresponding design criterion can be expressed as:

$$S_d = \gamma_G \cdot G_C + \gamma_Q \cdot Q_C \le \frac{R_{A\chi} \cdot f_{y,C}}{\gamma_M} \tag{1}$$

with buckling parameter $R_{A\chi} = \chi A$.

The aim of this paper is the analysis of the influence of partial safety factors of standard EC 3 and EN 1990 on the reliability of design. The material partial safety factors were chosen as γ_M =1.0, γ_G=1.35 and γ_Q=1.5, See EC 3 and EN 1990. The reliability analysis was performed according to the methodology described in [1, 3, 4].

https://doi.org/10.2749/222137809796089007

3. Conclusion Remarks

From probabilistic solution, a considerable misalignment of the failure probability due to the ratio δ of the permanent and long-time leading variable load has been observed in Fig. 1. Partial safety factors are basic indicators, which determine structural dimensions in relation to loading. The partial safety factors should be calibrated and verified through probability calculation. The maximum failure probability was observed for δ=1.0; the minimum failure probability was observed for δ=0.36.

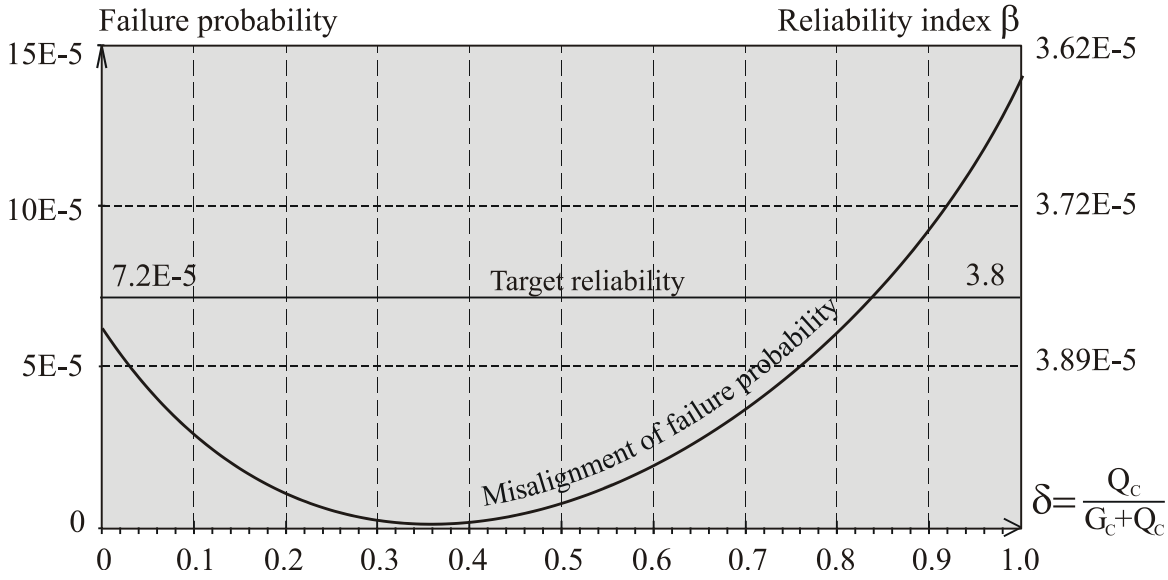

Fig. 1: Misalignment of Failure Probability

The probabilistic analysis of the failure probability is very valuable from the technology point of view because it is one of effective methods quantifying the uncertainty in design of steel structures. The presented study pertaining to the simplest case of compression loading can be applied to more complex loading cases. The suitability of probabilistic methods for the reliability analysis of steel structures with regard to the availability of objective data from experiments could be also discussed. Limitation to purely probabilistic methods is misleading. Very effective implementation of all available methods of the general uncertainty theory is feasible in reliability analysis [2].

Acknowledgement

The authors gratefully acknowledge the partial support provided by (i) the Czech Science Foundation within the projects of GACR No.103/07/1067 and No. 103/08/0275 and (ii) the Czech Ministry of Education, Youth and Sports within the Research Project MSM0021630519.

References

[1] HOLICKY, M. and MARKOVA, J., Calibration of Reliability Elements for a Column, In *Proc. of the JCSS Workshop on Reliability Based Code Calibration*, Zürich: Swiss Federal Inst. of Technology, 2002, pp. 1 - 13.

[2] KALA, Z. OMISHORE, A., Fuzzy and Stochastic Theories and Their Applications in Structural Engineering, In *CD Proc. of 3rd ASRANet Int. Colloquium*, Glasgow UK, 2006, ISBN 0–9553550–0–1.

[3] VROUWENVELDER, T. and FABER, M. (Editors), *Probabilistic model code*, Part 1 - Part 3, Zurich: JCSS, 12th draft, 2001, (http://www.jcss.ethz.ch/).

[4] JCSS Probabilistic Model Code, Part 3, Resistance Models. (http://www.jcss.ethz.ch/)