Proceedings of the 5TH INTERNATIONAL CONFERENCE ADVANCED CONSTRUCTION
6 – 7 October, 2016, Kaunas, Lithuania
Kaunas University of Technology, Faculty of Civil Engineering and Architecture

Non-linear buckling analysis of steel frames with local and global imperfections

Jānis Šliseris[1*], Līga Gaile[1], Leonīds Pakrastiņš[1]

[1] Riga Technical University, Kaļķu street 1, LV-1002, Riga, Latvia.

*Corresponding author: janis.sliseris@gmail.com

EXTENDED ABSTRACT

The problem related to nonlinear analysis of steel frames is analyzed by taking into account local and global imperfections. A new method for estimation of optimal (in the worst case scenario causes smallest buckling load) pattern for geometrical and material imperfections is developed. The method is based on the optimization of structural topology.

Steel structural members are not geometrically perfectly shaped due to manufacturing and building tolerances. Three types of initial imperfections should be taken into account in advanced (second-order inelastic) analysis: (i) the member out-of-straightness (bow imperfection), (ii) the frame out-of-plumb (sway imperfection) and (iii) local material imperfections (Shayan et. al. 2014, Papp 2016) such as deviation in Young's modulus or residual stress. The pattern of initial imperfections is often chosen to be the worst case scenario to maximize their destabilizing effects and compliance under the applied loads in a global frame analysis.

The topology is optimized in a way where maximal compliance (minimal stiffness) and strain energy is reached (Tsavdaridis et.al. 2015, Sliseris and Rocens 2013).

In this paper is presented a method for accounting global geometrical imperfections is based on the work Shayan et.al. (2014). This method is extended in a more mathematical way. First of all, the linear static analysis is performed to calculate the axial forces in each member. In the next step, the linear-buckling eigenvalue problem is solved.

According to the gradient of compliance function the pattern of geometrical and material imperfections is iteratively obtained. Global geometrical imperfections are applied by using buckling modes (Eigenmodes) with a pre calculated weight coefficient according to the compliance function for each buckling mode. The proposed methods showed to be robust and practically applicable for designing complex steel structures.

KEYWORDS: Steel frames, buckling, imperfection's pattern, structural optimization.

ACKNOWLEDGMENT

The research leading to these results has received funding from the Latvia state research programme under grant agreement "INNOVATIVE MATERIALS AND SMART TECHNOLOGIES FOR ENVIRONMENTAL SAFETY, IMATEH". The research leading to these results has received the funding from Riga Technical University, Faculty of Building and Civil Engineering Grant "DOK.BIF".

References

Papp F. Buckling assessment of steel members through overall imperfection method. Engineering Structures, 2016, 106: 124–136.

Shayan S., Rasmussen K., Zhang H. On the modelling of initial geometric imperfections of steel frames in advanced analysis. Journal of Constructional Steel Research, 2014, 98: 167–177.

Sliseris J., Rocens K. Optimal design of composite plates with discrete variable stiffness. Composite Structures, 2013, 98: 15-23.

Tsavdaridis K.D., Kingman J.J., Toropov V.V. Application of structural topology optimisation to perforated steel beams. Computers and Structures, 2015, 158: 108–123.