INFLUENCE OF WIND LOADING ON STABILITY OF THE TRUSS

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1. Introduction

Steel trusses have a much greater strength and stiffness in their plane than out of their plane, and therefore should be braced against lateral deflection and twisting. The problem of bracing requirements necessary to provide lateral stability of compressed members is present in design code [1]. The calculation models for assessment of the lateral supporting of the bottom truss chords as the flexible restraint in the roof trapezoidal sheets were presented in [2]. Usually the lateral (translational) brace stiffness is considered. However, the rotational stiffness of braces caused by interaction between torsional stiffness of the truss top chord and bending stiffness of the roof elements (purlins, sandwich panels, trapezoidal sheet) should be taken into account.

The experimental and numerical analysis for out-of-plane buckling of trusses were presented in [3] and [4]. On the basis of analysis results the full bracing condition can be defined as the minimum bracing stiffness that causes the maximum buckling load of the truss.

The present paper is focused on the numerical investigation of stability and load bearing capacity of the truss stiffened by elastic braces situated only at the top chord. The present analysis is a continuation of previous research [5]. The antisymmetric truss loading due to [6] was considered (Fig. 1a). The linear buckling results were presented for the shell [7] (Fig.1b) and beam [8] (six degrees of freedom at node) model of the structure. The modified 1D model with reduced element stiffness was proposed. Initial geometric imperfection shape referred to the buckling mode were taken into account in the nonlinear static analysis (geometric and material nonlinearity).

The steel (f_y=235MPa) truss length was L = 24.0 m and the depth was h = 1.6 m in the middle of the span. The top chord consisted of 2 × L90×90×9 rolled profiles and the bottom chord of 2 × L80×80×8. The built-up cross-section of the top chord was battened every 0.4 m and the bottom chord every 0.8 m. Battens were made of C65 rolled profiles. The diagonals and verticals were made of C65 profiles besides two diagonals near the marginal supports. These members consisted of 2 × L65×65×7 (battened every 0.4 m). The truss was braced at the top chord by elastic supports of translational k [kN/m] and rotational k_{rot} [kNm/rad] stiffness. The distance between braces was equal to 2.4 m. The loading was applied in the form of concentrated forces at the braced joints.

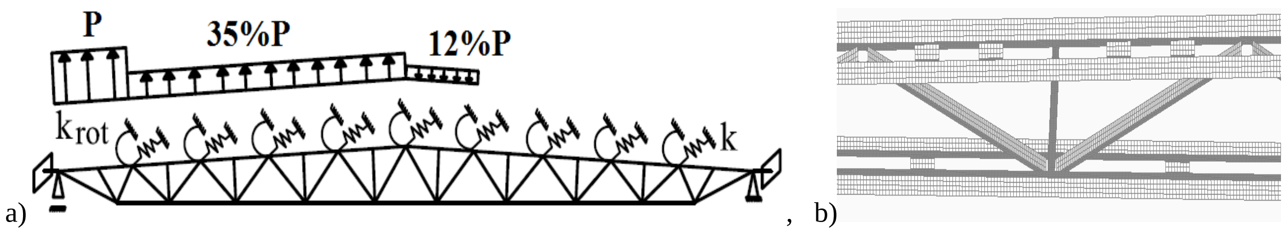


Figure 1. Model of the truss: a) static schema, b) shell model detail.

2. Numerical analysis results and conclusions

Linear buckling analysis (LBA) results are presented in Fig. 2a and Fig. 3. The full bracing condition for the shell model of the truss (with battens) can be defined by brace rotational stiffness equal to k_{rot}= 600 kNm/rad. In this case the buckling load was only 10% lower with comparison to the structure with rigid braces.

The calculation of the reduced bending and torsional stiffness of the top and bottom chord members (built-up cross section) implemented to the 1D model (1D modified) was obtained from the static analysis results performed for the shell model sections (method of unit kinematic enforcement).

The increase of rotational brace stiffness had a significant impact (up to 30%) on the magnitudes of limit load obtained from nonlinear analysis (GMNIA). In this case the shape of initial geometric imperfection was very important (*L*/500 – implemented maximum imperfection magnitude).

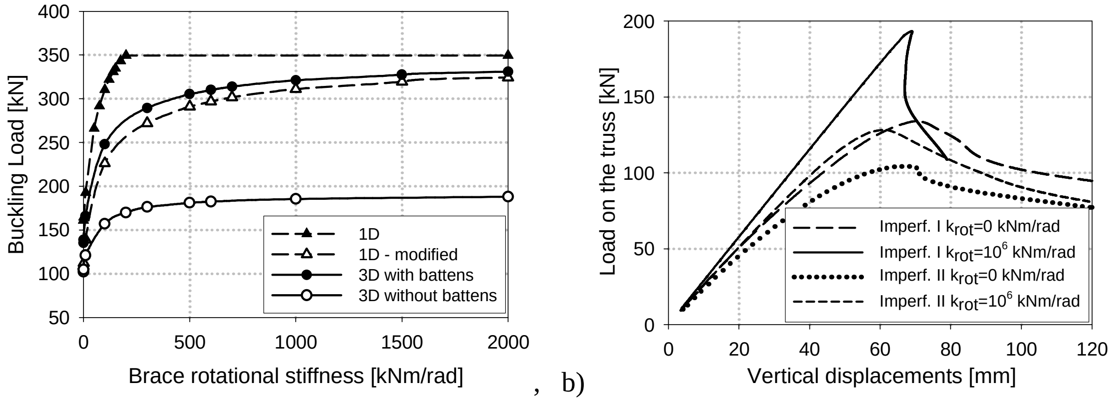
a) 

Figure 2. Numerical analysis results (for k=10^6 kN/m): a) linear buckling analysis (LBA) – truss buckling load vs. brace stiffness for 1D and 3D models, b) nonlinear static analysis (GMNIA) - truss loading vs. vertical displacements (in the middle of the truss bottom chord – 3D model).

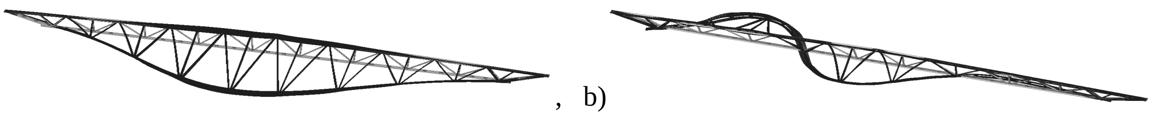
a) 

Figure 3. Buckling modes (initial geometric imperfections) for the truss with braces of stiffness: a) k=10^6 kN/m, k_{rot}= 0 kNm/rad – Imperf. I, b) k=10^6 kN/m, k_{rot}= 10^6 kNm/rad – Imperf. II.

6. References

[1] PN-EN 1993-1-3 Eurocode 3 (2006): *Design of steel structures.- Part 1-1: General rules an rules for buildings.*

[2] A. Biegus (2014). Trapezoidal sheet as a bracing preventing flat trusses from out-of-plane buckling, *Archives of Civil and Mechanical Engineering*, http://dx.doi.org/10.1016/j.acme.2014.08.007 .

[3] J. Jankowska-Sandberg and J. Kołodziej (2013). Experimental study of steel truss lateral-torsional buckling, *Engineering Structures 46*, 165-172.

[4] M. Krajewski and P. Iwicki (2014). Stability and load bearing capacity of a truss with elastic braces, *Recent Advances in Computational Mechanics*, CRC Press Balkema, Taylor & Francis, London, 17-22.

[5] M. Krajewski and P. Iwicki (2015). Sensitivity analysis of critical load and load bearing capacity of a truss with elastic braces, XI Conference New Developments on Mechanics, Sarbinowo Morskie, electronic version, 1-10.

[6] PN-EN 1991-1-4 Eurocode 1 (2008): Actions on structures, *Design of steel structures.- Part 1-4: General actions – Wind actions*.

[7] Femap with Nastran N.X., Finite element modeling and post-processing Version 10.1.1., Siemens Product Lifecyde Management Software Inc., (2009).

[8] Autodesk Robot Structural Analysis Professional, Autodesk Inc., (2010).