STABILITY OF INNIVATIVE COLD-FORMED GEB SECTION

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1. Introduction

Cold-formed steel sections are generally used as secondary elements like purlins or sheeting. An innovative GEB cross-section was developed and it may serve as primary load-bearing member in fabricated steel panels and trusses. The stability of typical cold-formed open steel sections (e.g. bended C- and Z-sections) have been studied in recent years [1], however according to the European Standards requirements [2, 3] every new section shape should be tasted. The application of the GEB member in the metal building structures depends on configuration of the optimal dimensional parameters [4]. These parameters are in this case associated with cross section production possibilities.

The paper is devoted to the numerical and experimental investigation of stability of steel GEB section (Fig.1a). The present analysis is a continuation of previous research [5],[6]. For the axially compressed GEB member the linear buckling analysis and nonlinear static analysis (geometric and material nonlinearity) were conducted. Two types of initial geometric imperfection were implemented to the shell model (Fig.1b) [7] of the structure. The experimental set-up was prepared (Fig.1c) to verify the numerical analysis results. The tests were conducted by Zwick-Roell Z400 strength-testing machine.

The length of tested GEB member was equal to L=1.0 m. Four element samples were used to conduct the experimental research. Each one was made of DC04 grade steel. The material characteristics were determined using separate testing (E = 178 GPa, f_y = 206 MPa). Due to the complicated cross-section shape the member have been manufactured with two steel sheets assembled together by longitudinal butt weld.

In the numerical analysis FEM was used to solve the problem. About 29.000, four node shell elements *QUAD4* [7] were used. The minimum element size was 5.0 × 5.0 mm^2. The arc-length method was used to apply loading. It was assumed that the structure was pinned at marginal supports.

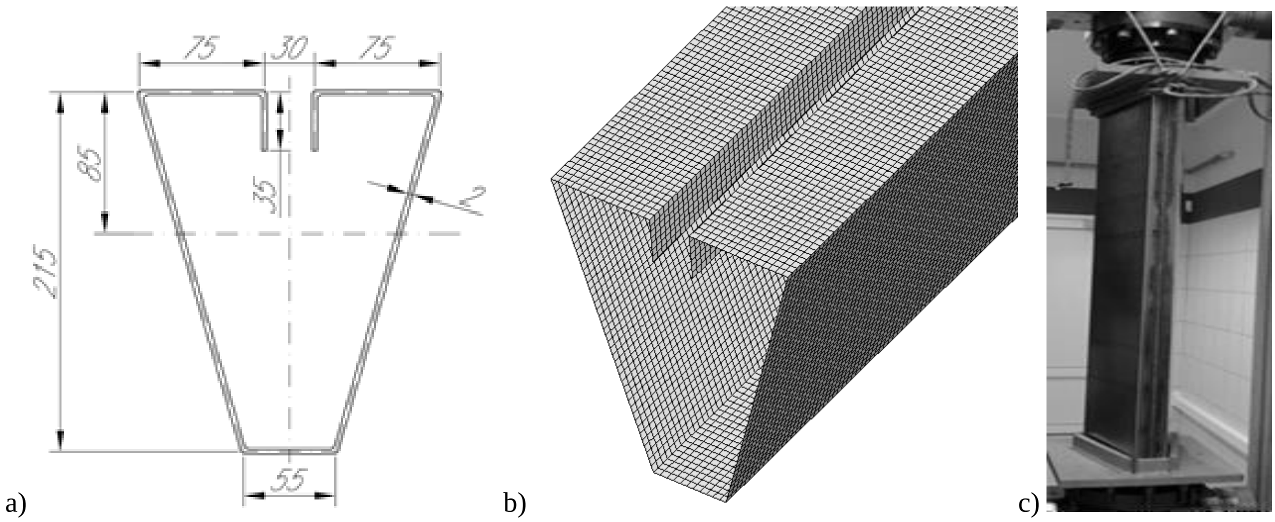
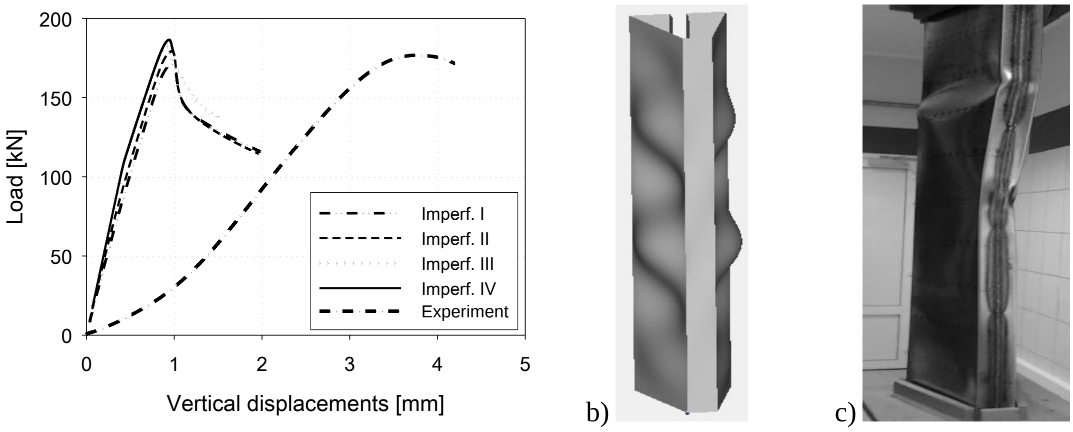


Figure 1. GEB section: a) geometric details, b) shell model detail, c) experimental set-up

2. Analysis results

The numerical analysis and experimental test results are presented in Fig.2. The first buckling load for the GEB member obtained from linear buckling analysis was equal to 107 kN. The local buckling mode presented in Fig. 2b (coupled to buckling load) was implemented as initial geometric imperfection in the nonlinear static analysis. The magnitude of imperfection was equal to *L*/500 (Imperf. I) or *L*/1000 (Imperf. II). Also the geometric imperfections in the form of global arch curvature were considered (Imperf. III – magnitude *L*/500, Imperf. IV – magnitude *L*/1000). The differences between limit loads obtained from GMNIA were up to 9%. The differences between loading magnitudes obtained from numerical results and experimental tests were up to 5%, depending on the shape and magnitude of imperfection. The stiffness of the supporting elements located at the experimental set-up (boundary conditions) was not taken into account in the nonlinear analysis. It may be the reason for large discrepancies between displacement magnitudes obtained from the numerical and experimental test results.



a) b) c)

Figure 2. Numerical and experimental analysis results : a) static nonlinear analysis (GMNIA) – loading vs. vertical displacement (at the top of the GEB section) for the imperfect shell model, b) first buckling mode (linear buckling analysis – LBA) – shape of initial geometric imperfection I and II, c) GEB deformation at the limit state

3. References

[1] Schafer B. W., 2002. *Local, Distortional, and Euler Buckling of Thin-Walled Columns*. Journal of structural engineering.

[2] EN 1993-1-3 Eurocode 3 (2006): *Design of steel structures. Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting..*

[3] EN 1993-1-5 Eurocod 3 (2006): *Design of steel structures. Part 1-5: General rules - Plated structural elements.*

[4] Łukowicz A., Urbańska-Galewska E., Deniziak P., Gordziej-Zagórowska M. 2015. *Classification of restraints in the optimization problem of a cold-formed profile*, Advances in Science and Technology, vol. 9, iss.28, p.61-67.

[5] Łukowicz A., Urbańska-Galewska E., Gordziej-Zagórowska M. 2015. *Experimental testing of innovative cold-formed GEB section*. Civil and Environmental Engineering Reports, vol 16, iss.1, p.129-140.

[6] Łukowicz A., Urbańska-Galewska E. 2014. *Deformations of innovative cold-formed GEB sections*, 7th European Conference on Steel Composite Structures: Eurosteel 2014, Naples.

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