COMPUTATIONAL MECHANICS 2018
34th conference with international participation
Srní
October 31 - November 2, 2018

Fast calculation of collapse load of shell structures

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Numerical calculation of collapse load (limit load) of a structure, made of elastic-plastic material, is often of practical interest. Standard approach is based on repetitive use of nonlinear finite element calculation, where the collapse load is determined iteratively. However, more efficient approach called *finite element limit analysis* (FELA) is possible. In this approach the collapse load is searched as a minimum of a certain optimization problem.

Practical interest of the FELA was raised, when it was combined with the so-called second order cone programming (SOCP). This combination firstly appeared in literature in first decade of 21st century [1, 3], which made the FELA numerically very atractive. The FELA approach has also some drawbacks, mainly the assumption of ideal plasticity and geometrical linearity.

Let us demonstrate efficiency of the FELA approach on a symmetrical steel frame structure proposed in [2], see Figs. 1 – 3. The table in Fig. 1 compares calculation times of both approaches, which shows factor 34 in favour of the FELA approach. However, calculation efficiency is not the only benefit of the FELA approach – another one is high robustness of the calculation contrary to typical slow convergence of the nonlinear plastic calculations, when run near collapse load and when no hardening can be used.

Method	Calculation time
FELA ([4])	139 s
standard nonlinear FEM ([4])	4692 s

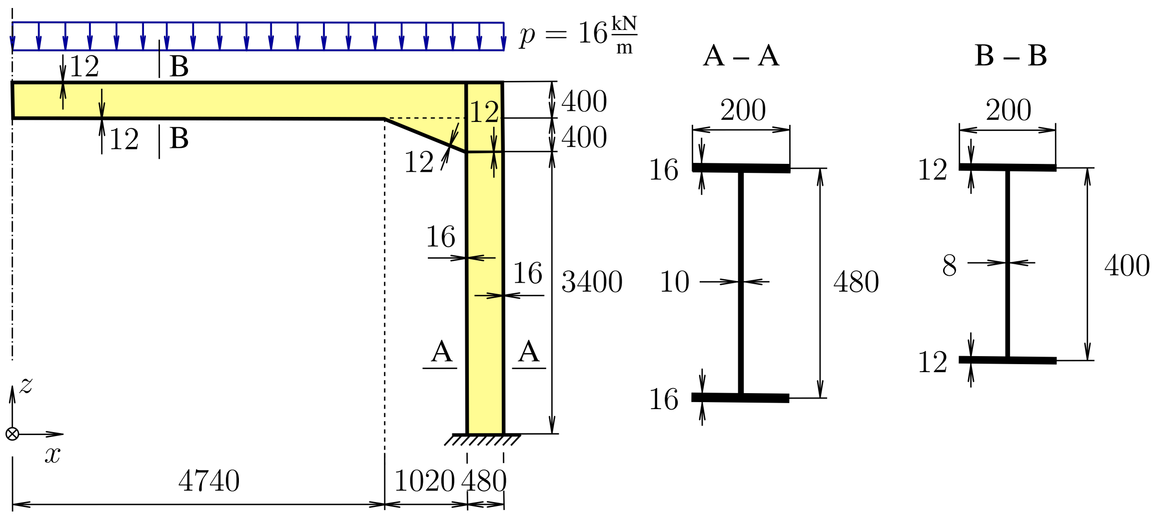

Fig. 1. Steel frame structure – problem sketch. Half of the structure is modeled due to symmetry

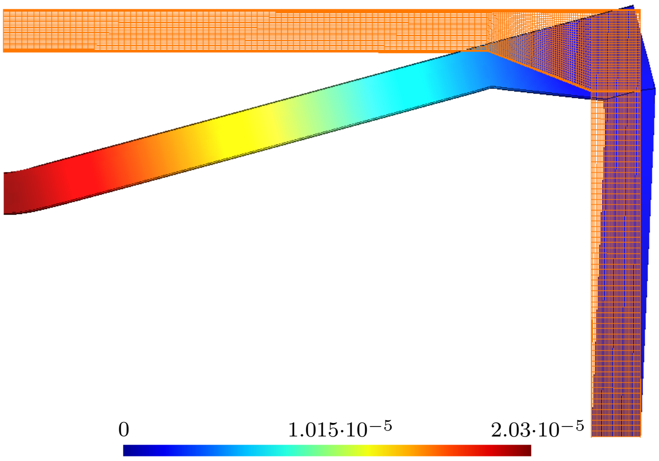

Fig. 2. Steel frame structure – undeformed mesh and absolute value of velocity of the plastic flow u is shown in colour. Structural deformation shows tendency of collapse

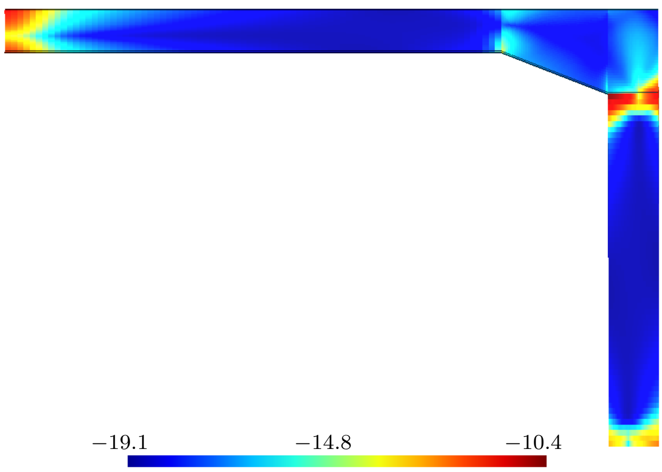

Fig. 3. Steel frame structure – logarithm of the dissipation energy $\log(e_{\mathrm{dis}})$ is shown in colour. Note the plastic hinge created under the right upper corner

References

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