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GBT LINEAR BUCKLING ANALYSIS OF CHANNEL COLUMNS WITH MULTIPLE PERFORATIONS

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The Generalised Beam Theory (GBT) is a very efficient method to carry out full buckling analysis of thin walled structures. This is due to its modal nature, and to the fact that it is implemented in beam type finite elements. However, as it is based on beam theory assumptions, it cannot deal with members with discrete variations, such as holes.

In the present investigation, it is attempted to adapt the GBT beam finite element procedure to the analysis of perforated members. The GBT beam element initially developed by N. Silvestre and D. Camotim in [1] is used. The presence of perforations is taken into account through the use of two beam elements with different properties, for the non-perforated and perforated parts of the member. Consequently, two different GBT cross-sectional analysis are carried out: in one case, the full cross-section is considered; while in the other case, the thickness of the perforated parts of the cross-section is set to zero (actually, it is set to $t/100$, where t is the original wall thickness). The non-perforated and perforated parts of the member are then meshed with their corresponding beam elements and, finally, they are linked. The procedure used to set this connection is similar to that applied when two members are joined in the standard GBT analysis of a frame (see [2,3]). It consists in using constraint equations that combine degrees of freedom of the non-perforated and perforated parts. These equations are implemented in the finite element analysis by means of the Lagrange multipliers method.

The proposed procedure was applied to carry out linear buckling analysis of channel cross-sections with multiple perforations uniformly distributed along the web (see one example in Figure 1). The perforation patterns are similar to those used in steel storage rack uprights. It should be noted that the investigation has only been focused on linear buckling analysis of compressed members, and that it has been limited to the calculation of the elastic global and distortional buckling loads. The procedure is validated by comparing the resulting buckling loads to values obtained from finite element analysis performed with shell finite elements. The actual holes were included in the 3D shell finite element models.

In Figure 2, the results of the buckling analysis carried out on the column shown in Figure 1 can be observed. The shape and size of this column is similar to those used in cold formed rack structures in the United States. Additional analyses have been performed on other rack columns applied in real rack structures.

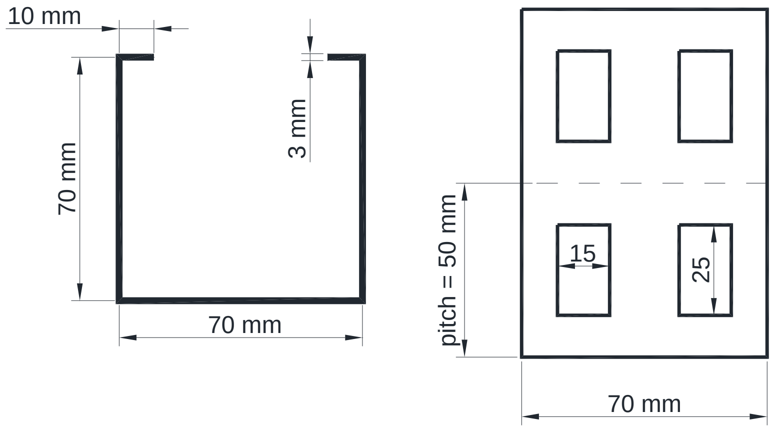

Figure 1. Column analysed.

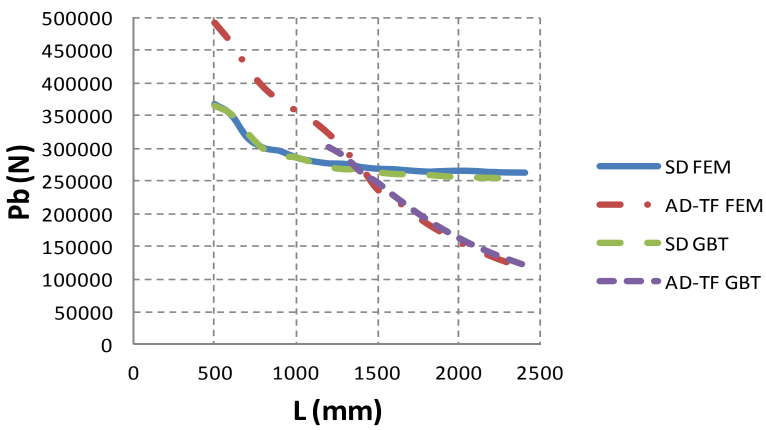

Figure 2. Result of a linear buckling analysis (SD: symmetric distortional buckling; AD-TF: anti-symmetric distortional buckling - torsional-flexural buckling; FEM: Finite Element Method; GBT: Generalised Beam Theory).

Generally speaking, the results of the presented method can be considered reasonably good, or slightly conservative, especially for “symmetric” modes: symmetric distortional buckling and flexural buckling. On the contrary, the resulting errors for the torsional-flexural buckling mode can be up to 10 %. These errors are produced by the torsional component of the buckling mode. The proposed procedure is not so accurate for “anti-symmetric” modes, such as torsional buckling and anti-symmetric distortional buckling. Further work will be carried out in the near future to attempt to solve these problems.

REFERENCES

[1] N. Silvestre, D. Camotim, GBT buckling analysis of pultruded FRP lipped channel members. *Computers and Structures*, 81, pp. 1889-1904, 2003.

[2] C. Basaglia, D. Camotim, N. Silvestre, Global buckling analysis of plane and space thin-walled frames in the context of GBT. *Thin-Walled Structures*, 46, pp. 79-101, 2008.

[3] C. Basaglia, D. Camotim, N. Silvestre, GBT-based local, distortional and global buckling of thin-walled steel frames. *Thin-Walled Structures*, 47, pp. 1246-1264, 2009.