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MULTI-SCALE OVERLAPPING DOMAIN DECOMPOSITION METHOD TO CONSIDER LOCAL EFFECTS IN THE ANALYSIS OF THIN-WALLED MEMBERS SUBJECTED TO NON-UNIFORM BENDING MOMENT

Ashkan Afnani[1]* and R. Emre Erkmen[2]

[1] Centre for Built Infrastructure Research, Faculty of Engineering and IT, University of Technology, Sydney, P.O. Box 123 Broadway, NSW, Australia ashkan.afnaniEsfandabadi@student.uts.edu.au
[2] Centre for Built Infrastructure Research, Faculty of Engineering and IT, University of Technology, Sydney, P.O. Box 123 Broadway, NSW, Australia Emre.Erkmen@uts.edu.au

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Thin-walled members are vastly used in civil-structures and are conventionally modeled by one dimensional beam-type finite elements. Due to the rigid cross section assumption in the formulation of beam-type elements, they can only be used to consider axis-related-deformations including flexural, torsional and lateral buckling. Consequently, deformations corresponding to cross-sectional distortion such as local buckling of web and flanges cannot be captured by these types of elements. However, local deformations might have significant effects on the global response of the member and shall not be ignored. In order to model these types of deformations, shell-type elements are used throughout the domain of the member. While the former (i.e. the beam-type element) lacks accuracy in some cases, the latter (i.e. full-shell-type-model) creates oversized models that are computationally uneconomical.

The multi-scale method allows overcoming the limitations of both of the aforementioned method by using the overlapping domain decomposition technique. The roots of this method come from the bridging multi-scale technique developed by Liu et al. [1]. The multi-scale method provides a basis to couple problems based on two different physical assumptions, which allows the separation of the analysis domain according to two different levels of structural idealization. In other words, it can be used to separate the local analysis – for which relatively more sophisticated modelling assumptions are required – from the global analysis, in which rather simplistic structural assumptions are satisfactorily implemented. Consequently, the implementation of accurate numerical models only at the regions of interest becomes achievable without necessitating the imposition of the same model for the whole structural domain. As a result, a less detailed model for the rest of the structure can be used, leading to a computationally efficient model. Based on the aforementioned method, Erkmen [2] developed a numerical technique to consider the effect of the local deformations on the global behaviour of the thin-walled structures. This method allows the use of different kinematic assumptions in the local and global model. Therefore, simple nonlinear beam-type elements were used to evaluate the global behaviour, and more detailed shell-type elements were used in the place of localized behaviour.

However, the use of the method developed by Erkmen [2] was limited to cases with uniform internal bending moment due to the specific decomposition operator used. In the current study, the method is generalized to become applicable to beams subjected to loading cases resulting in a non-uniform bending moment profile, which is mostly the case in practice. To this end, kinematic assumptions adopted for the beam element are modified to include second order displacement terms. Application of these new assumptions modifies the decomposition operator into a nonlinear matrix (i.e. displacement terms appear in that). Therefore, it needs to be updated at every iteration.

Numerical examples are conducted to specify the efficiency and accuracy of the method, one of which is presented in this abstract. As show in Fig. 1, a two-span continuous steel I beam is subjected to point loads at the middle of each span to study its buckling behaviour. Local deformations are then introduced by a co-linear load couple applied at the tip of the flanges at the middle of one of the spans (i.e. P_s in the Figure).

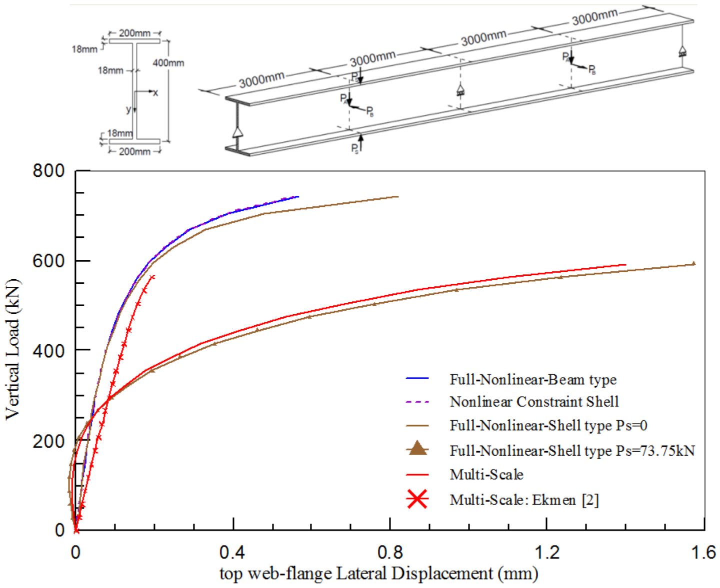

Figure 1: Geometry, boundary conditions and load-deformation curve for two-span beam

The results are presented in terms of the applied load versus the lateral displacement of the top web-flange intersection in the middle of the span. It can be observed that the effect of the local deformations on the buckling behaviour has been captured accurately by the proposed multi-scale method by using approximately ¼ of shell elements used in the full-shell model.

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