NUMERICAL STUDIES OF INTERACTIVE BUCKLING IN THIN-WALLED PLAIN CHANNEL SECTIONS

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INTRODUCTION

- Thin-walled channel sections are widely used in industry for their efficient use of material and relative ease of production;
- Thin-walled elements create additional buckling modes leading to possible nonlinear mode interaction, which may cause severely detrimental effects on the ultimate strength;
- Study examines the effect of two buckling mode interactions, prevalent in plain channel section columns: local—flexural and local—flexural-torsional interaction (Fig. 1).

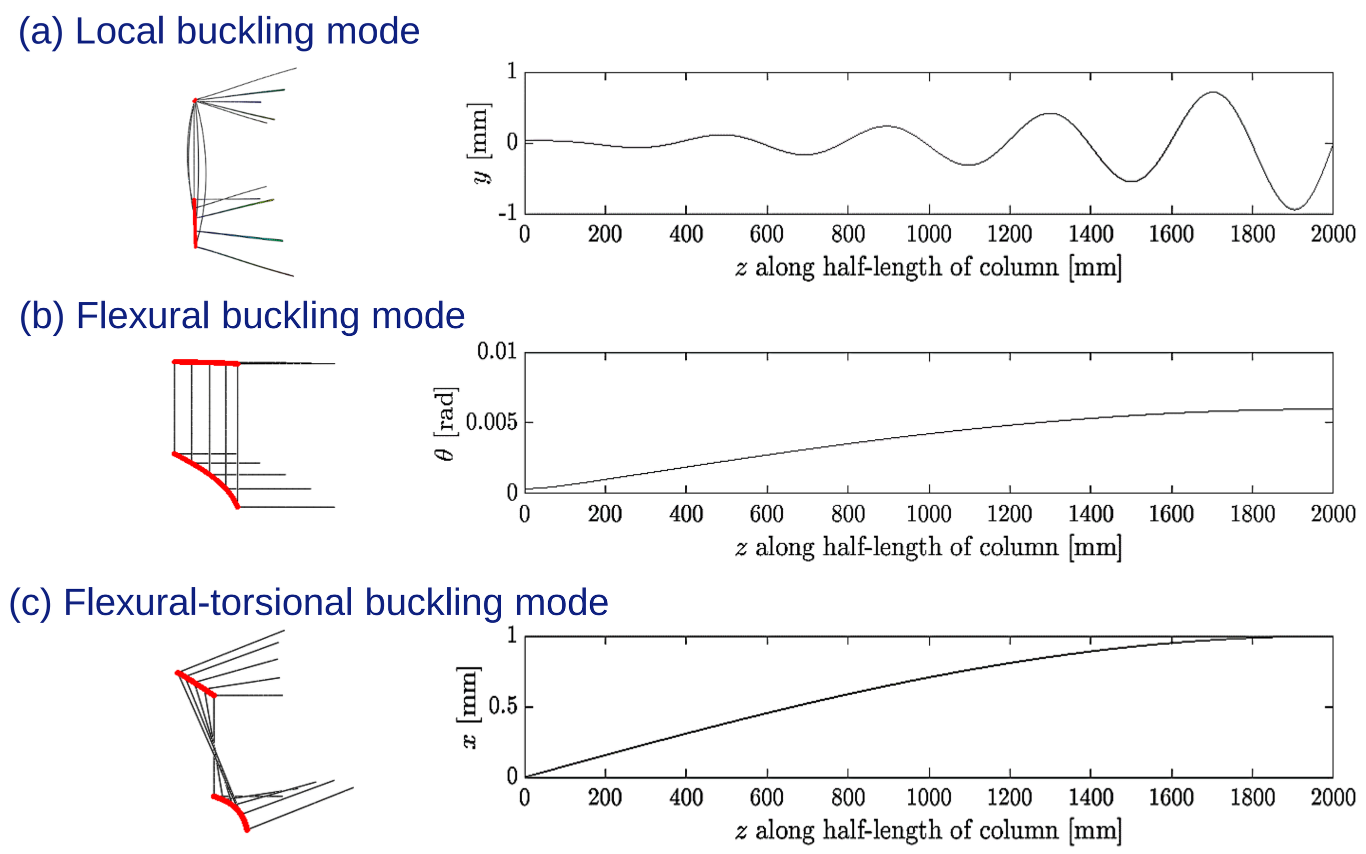

Fig 1: Mid-span cross-section views and mode shapes along half-length

FINITE ELEMENT MODELLING

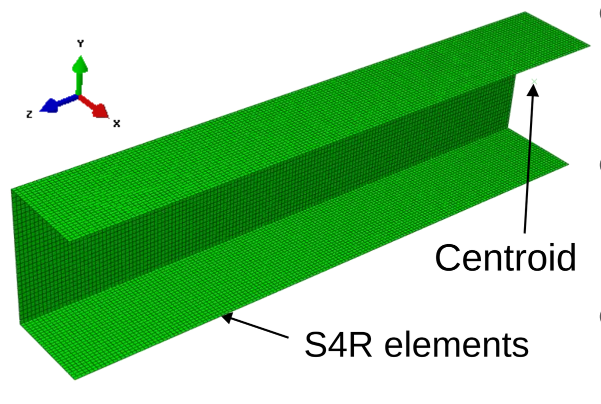

Fig 2: Mesh of half-length

- Study performed using the commercial finite element modelling software ABAQUS 6.14, modelled with a fine mesh of S4R elements (Fig. 2);
- Column is simply supported and axially loaded with a point load applied through the centroid;
- Mode interactions are modelled using a combination of linear modes, introduced as initial geometric imperfections;
- Models are subsequently solved using the Riks arc length method (Riks, 1979).

POST-BUCKLING BEHAVIOUR

- $L > L_0$: global buckling is critical and mode interaction does not influence buckling load P_u. Characterised by a "neutral" equilibrium, where P_u tends to global buckling load P_G^C;
- $L_1 < L < L_0$: mode interaction induces severe instability due to loss of flexural and torsional rigidity caused by local buckling. Maximum interaction at $L = L_C$, illustrated by explosive "snap-back" in equilibrium path;
- $L < L_1$: local-buckling is critical and mode interaction is no longer dominant. Stable equilibrium, with $P_u > P_L^C$ such that $P_u = \eta P_G^C$, where η is a reduction factor due to effects of local buckling (van der Neut, 1969).

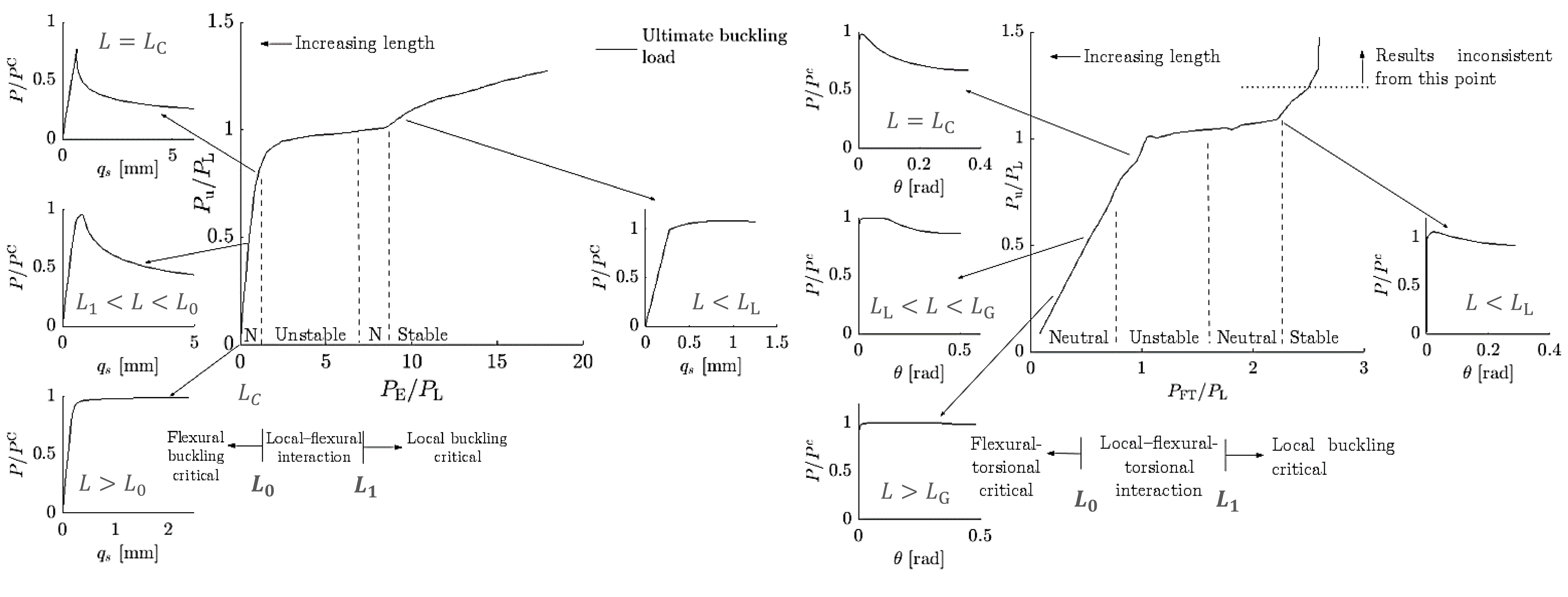

Fig 3: Columns under local—flexural (left) and local—flexural-torsional (right) mode interaction, and equilibrium paths of critical lengths.

IMPERFECTION SENSITIVITY

- Effect of the local—global mode interaction increases with the size of the initial global imperfection;
- The load carrying capacity reduces significantly, down to ~50% of the critical buckling load P^C;
- Columns under both mode interactions exhibit a different dependency on direction of global imperfection.

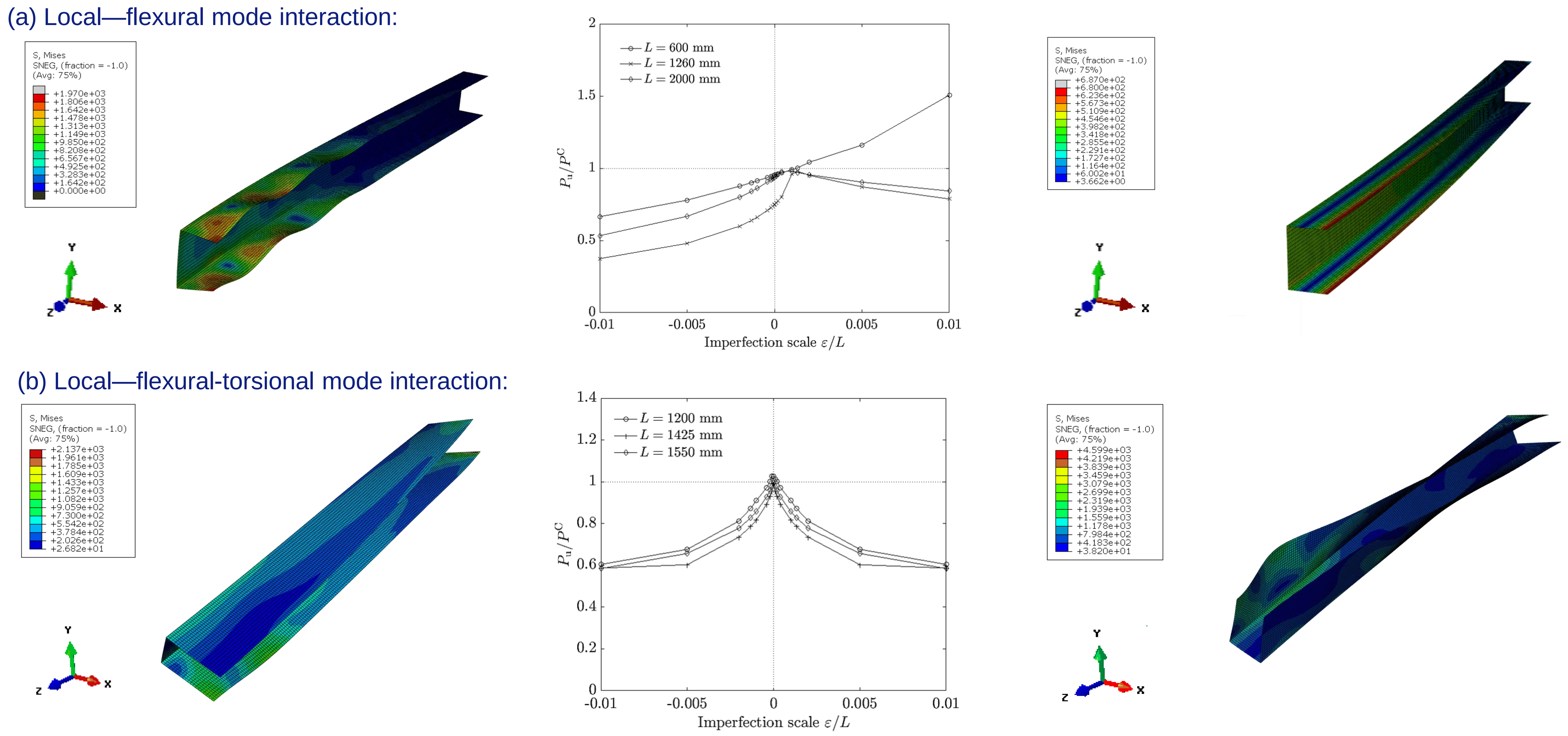

Fig. 4: Imperfection sensitivity (centre) with half-length under negative (left) and positive (right) global imperfection.

- Under local—flexural interaction, mono-symmetry of channel sections is a significant factor. Direction of imperfection puts flanges predominantly into either compression or tension, respectively encouraging or impeding local buckling (Fig. 4a);
- Under local—flexural-torsional interaction, combined bending and warping stresses induce predominant local buckling in top or bottom flange. Effect of interaction is independent of imperfection direction (Fig. 4b).

CONCLUSIONS

- The columns exhibit similar post-buckling behaviour under both types of local—global mode interaction;
- The interaction is prevalent in columns of intermediate lengths: local buckling reduces the stiffness, causing highly unstable equilibrium;
- The severity of both mode interactions increases with the size of initial global imperfections;
- Effect of local—flexural interaction is highly dependent on the direction of the initial imperfection. Effect of local—flexural-torsional interaction shows no such dependency.

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