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EFFECTS OF PRESTRESSING AND GROUTING ON HIGH STRENGTH STEEL TRUSSES

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INTRODUCTION

The use of high strength steel (HSS) is increasing across the globe in long span structures such as aircraft hangers. The increase in strength allows HSS to be more economical and sustainable however design is often governed by serviceability and instability. Overcoming these limitations would lead to a host of economic, environmental and design benefits.

This project forms a subset of the high strength steel long span structure (HILONG) research project; the objective of the research project is to determine ways in which the benefits of HSS in long span structures can be maximised.

TEST PROGRAM

10 HSS members, representing the bottom chord of a truss under uplift loading, were tested under axial compression; 5 members were of 460MPa steel and 5 were of 690MPa steel. Each specimen was a cable-in-tube system of varying levels of prestress, grout was introduced for 6 specimens. Three levels of prestress in the cables were targeted: P_{nom}, $1/2P_{opt}$ and P_{opt}. P_{nom} is a nominal prestress level to ensure that the cables were not slack during grouting and testing, Popt is the level of prestress required for the cable and tube to yield at the same load.

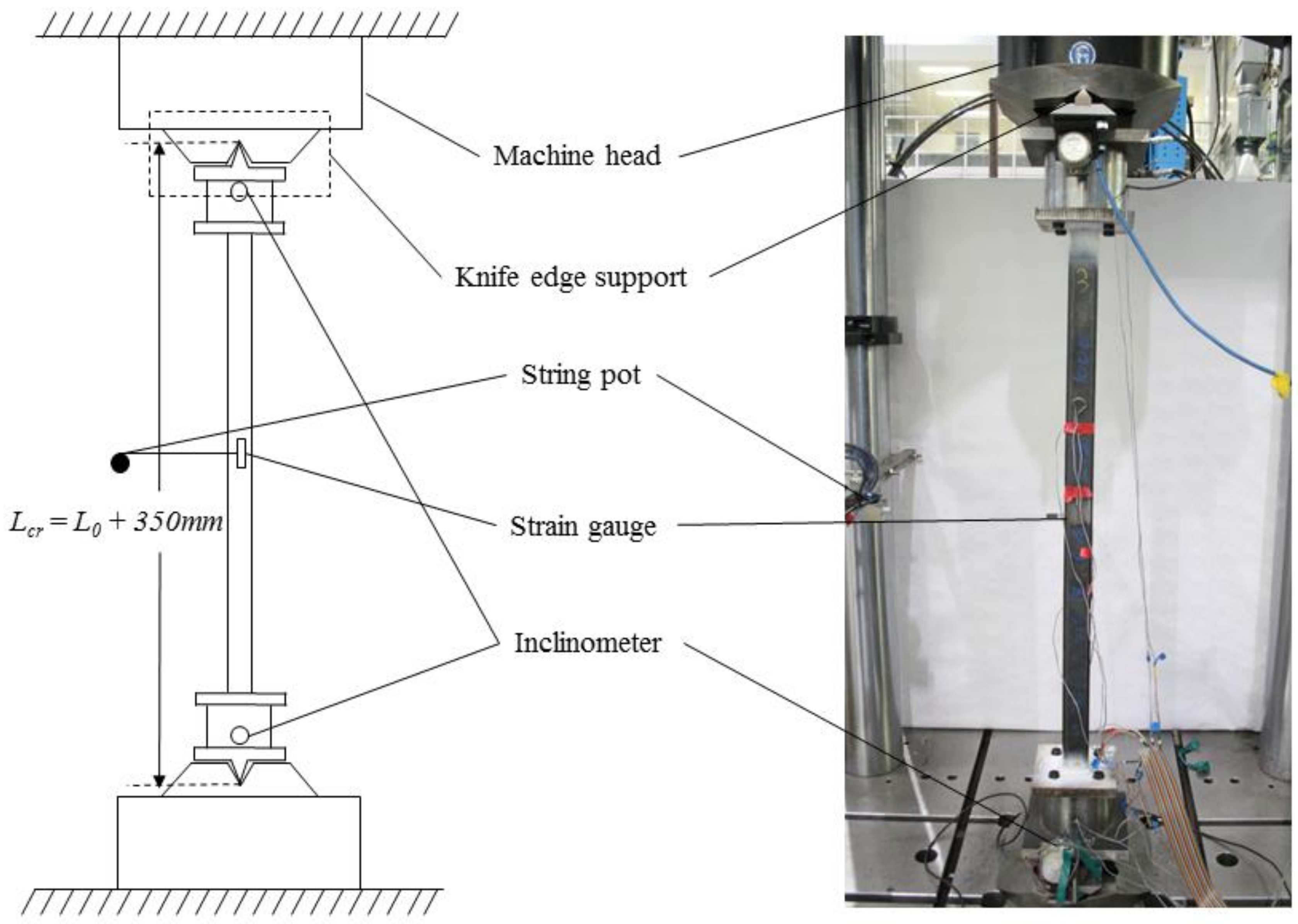

Fig 1: Specimen test setup and instrumentation arrangement

TEST RESULTS

All the specimens failed by global buckling; it was found that:

- The analytical results were in good agreement with test results (Fig 2) including a modified Perry-Robertson approach (Gosaye et al. 2015).
- Prestress reduced the ultimate buckling capacity of the specimens, however the reduction in capacity was restricted as prestress increased.
- Grout improved the compressive behaviour of the members, increased the stiffness of members and increased the slenderness of the members.
- It was shown that the presence of grout helped to limit the reduction in the tensile stress in the cable during compressive loading.

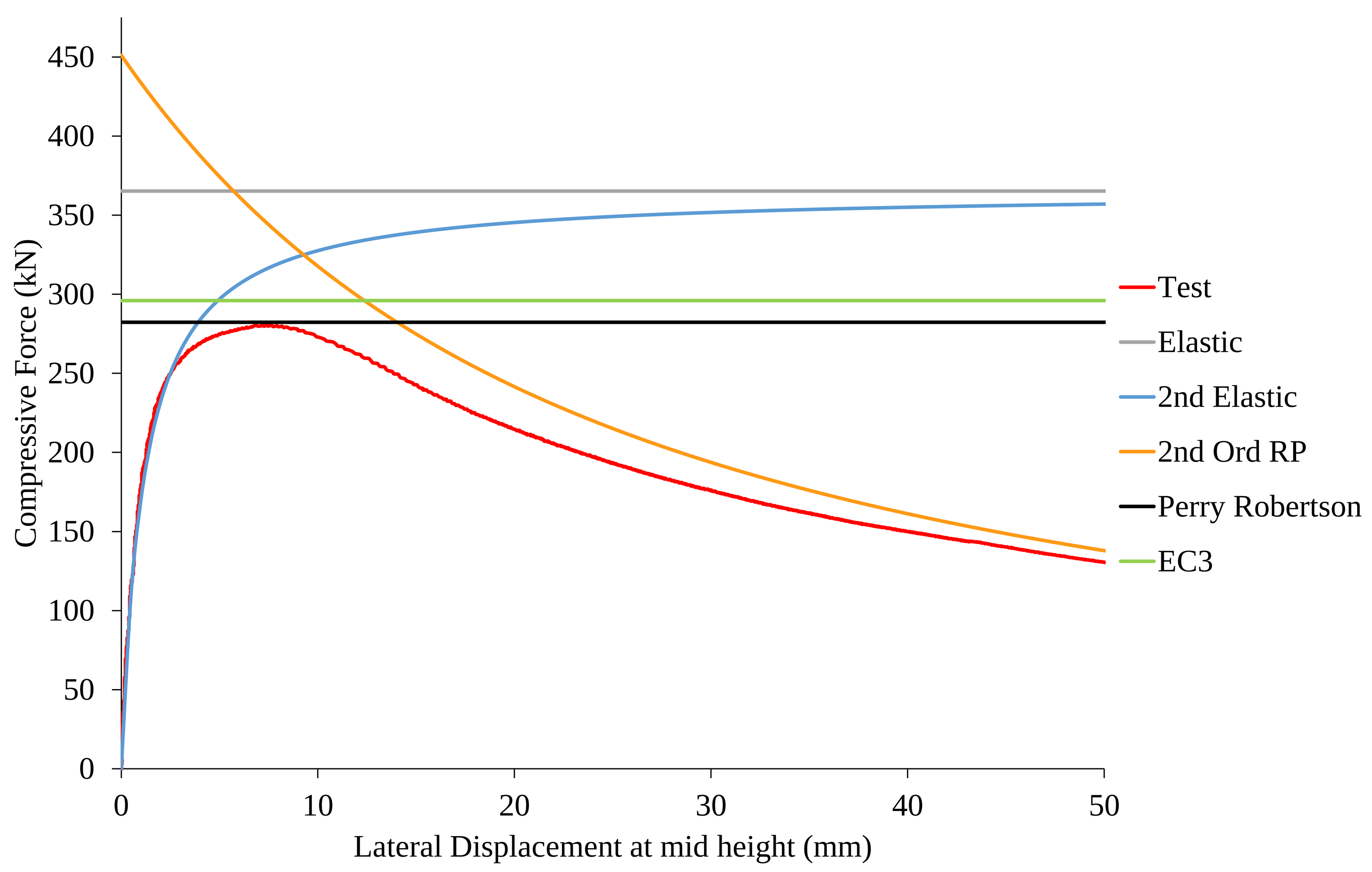

Fig 2: Load vs lateral deflection at mid height for C460NG0

DESIGN RECOMMENDATIONS

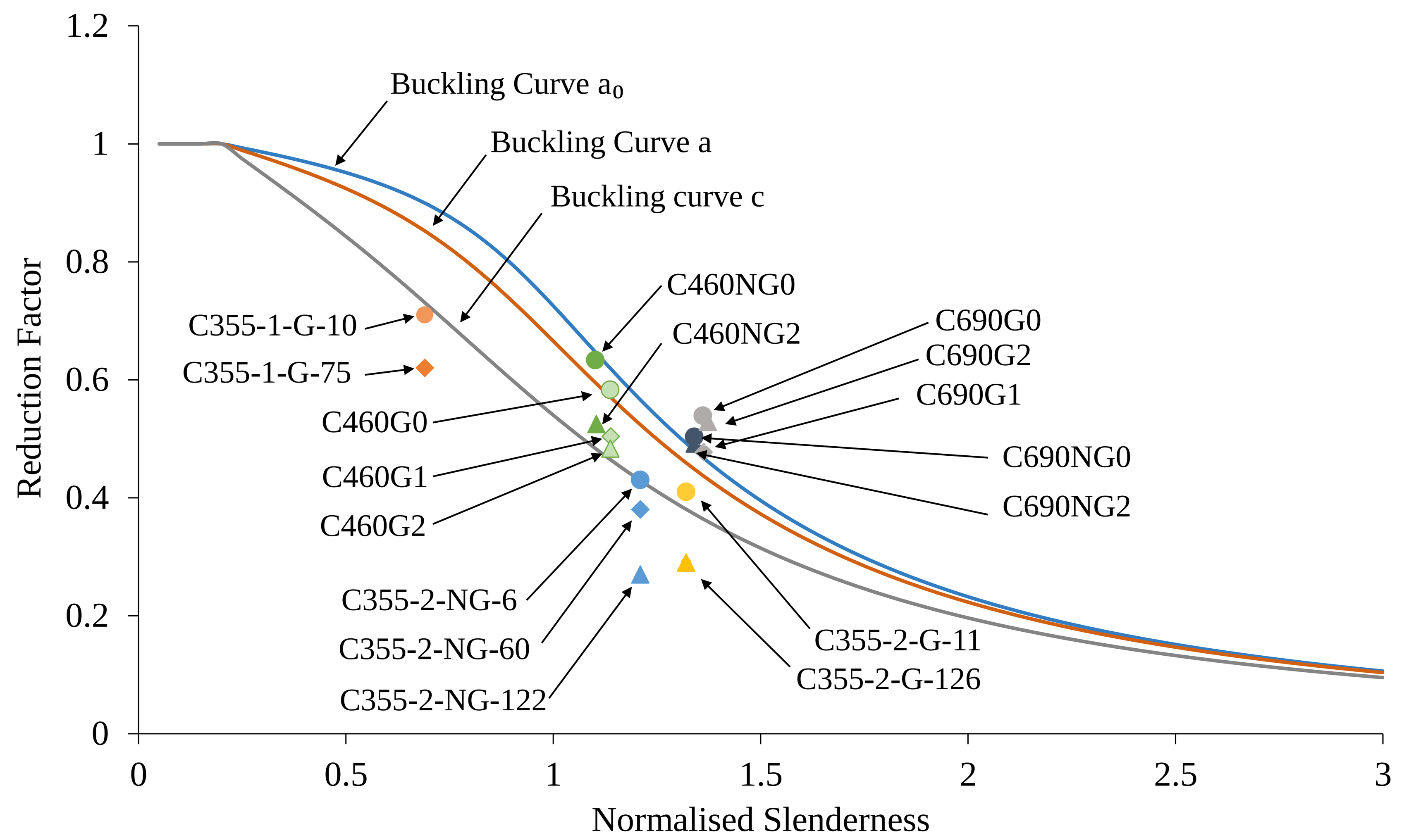

Fig 3: Comparison between all cable-in-tube HSS specimens and EC3 buckling curves (Gosaye et al., 2015)

The test results were compared to Eurocode 3 and 4 design curves based on buckling curve a_0 (Fig 3). It was found that:

- For S690 members buckling curve a_0 proved to be adequate and provided a sufficiently conservative reduction factor.
- For non-grouted S460 members buckling curves *a* or a_0 could be used.
- For grouted S460 members the buckling curve *a* should be used.
- Eurocode predicts the spread of reduction factors across different levels of prestress reduces as steel grade increases. This was verified when comparing the data from this test program to that in Gosaye et al. (2015)

DYNAMIC TESTING

HSS tends to be used in long span projects such as bridges and thus the dynamic properties are important to avoid resonant frequencies being activated. The natural frequencies of the truss with each level of prestress were determined and compared. A methodology to find the mode of the truss was developed based on a roving accelerometer.

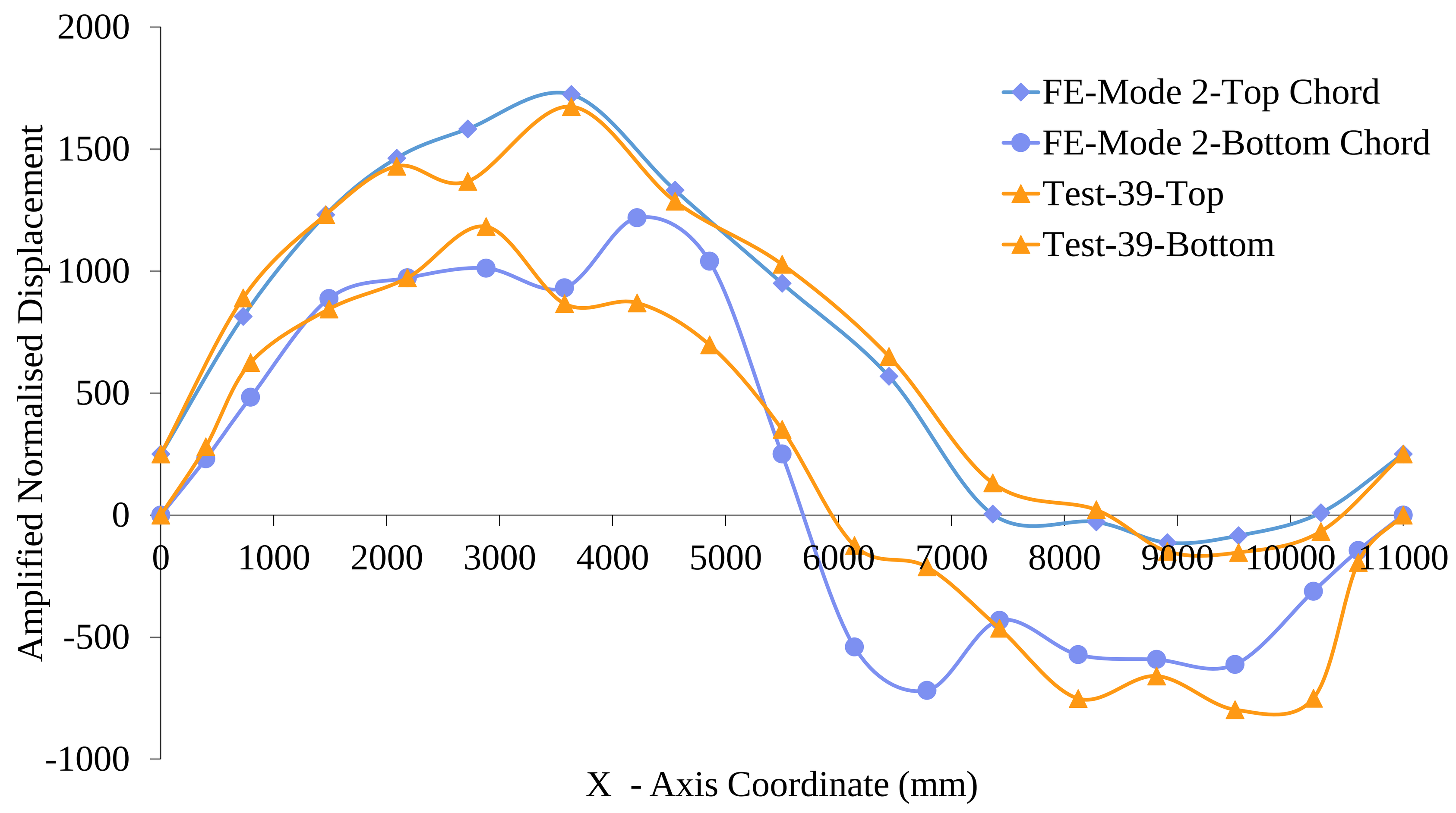

Fig 4: Comparison of ABAQUS and test data for the second mode shape for a truss with no cable

The presence of prestress had marginal impacts on the fundamental frequencies of the trusses as the level of prestress increased. The method to find the mode shapes was developed to utilise existing techniques with reduced instrumentation. Results found that it provided a highly accurate representation of the mode shapes when compared to *ABAQUS* (Fig 4). It was found that there was no difference in mode shapes when the level of prestress increased.

ACKNOWLEDGEMENTS

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REFERENCES

Gosaye, J., Gardner, L., Wadee, A. M. & Ellen, M. E. (2015) *Compressive behaviour and design of prestressed steel elements.* Journal of Constructional Steel Research. Journal Article edition.