Imperial College London

NUMERICAL STUDY OF COMPOSITE FLOOR SYSTEMS CONSISTING OF COLD-FORMED STEEL BEAMS AND WOOD-BASED FLOORBOARDS

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INTRODUCTION

Floor systems consisting of cold-formed steel beams and wood-based particle boards are widely used in industry as they save on cost and time. However, the benefit from their composite action is currently not taken into account during design. A finite element model has been developed and validated against a series of four-point bending experimental tests. Parametric studies were then carried to investigate the effects of varying screw spacing, thickness of the steel member, thickness of the floorboard and elastic modulus of the floorboard.

FINITE ELEMENT MODEL

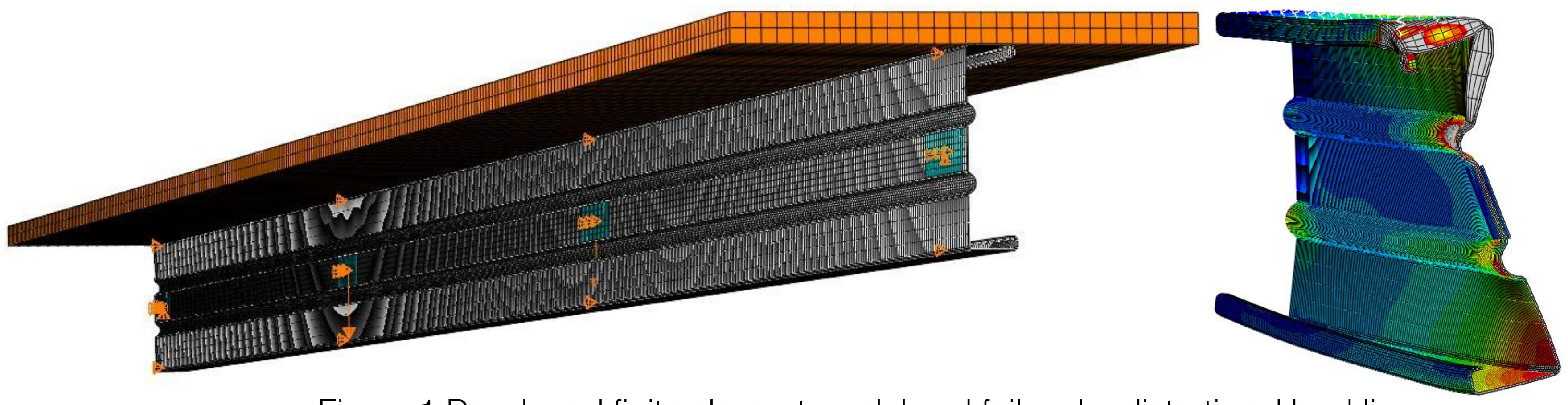

Figure 1 Developed finite element model and failure by distortional buckling

Five four-point bending tests were conducted on four composite sections with varying degrees of shear connection and a bare steel section to provide a point of reference.

1. Bare steel section
2. Screws at 600mm intervals
3. Screws at 150mm intervals
4. Screws at 150mm intervals with wood adhesive between floorboard joints
5. Screws at 100mm intervals with wood adhesive between floorboard joints and structural adhesive at the beam-board interface

The discontinuities in the floorboard have not been included in the developed finite element model. Hence, the same model is validated against the third and forth test specimen.

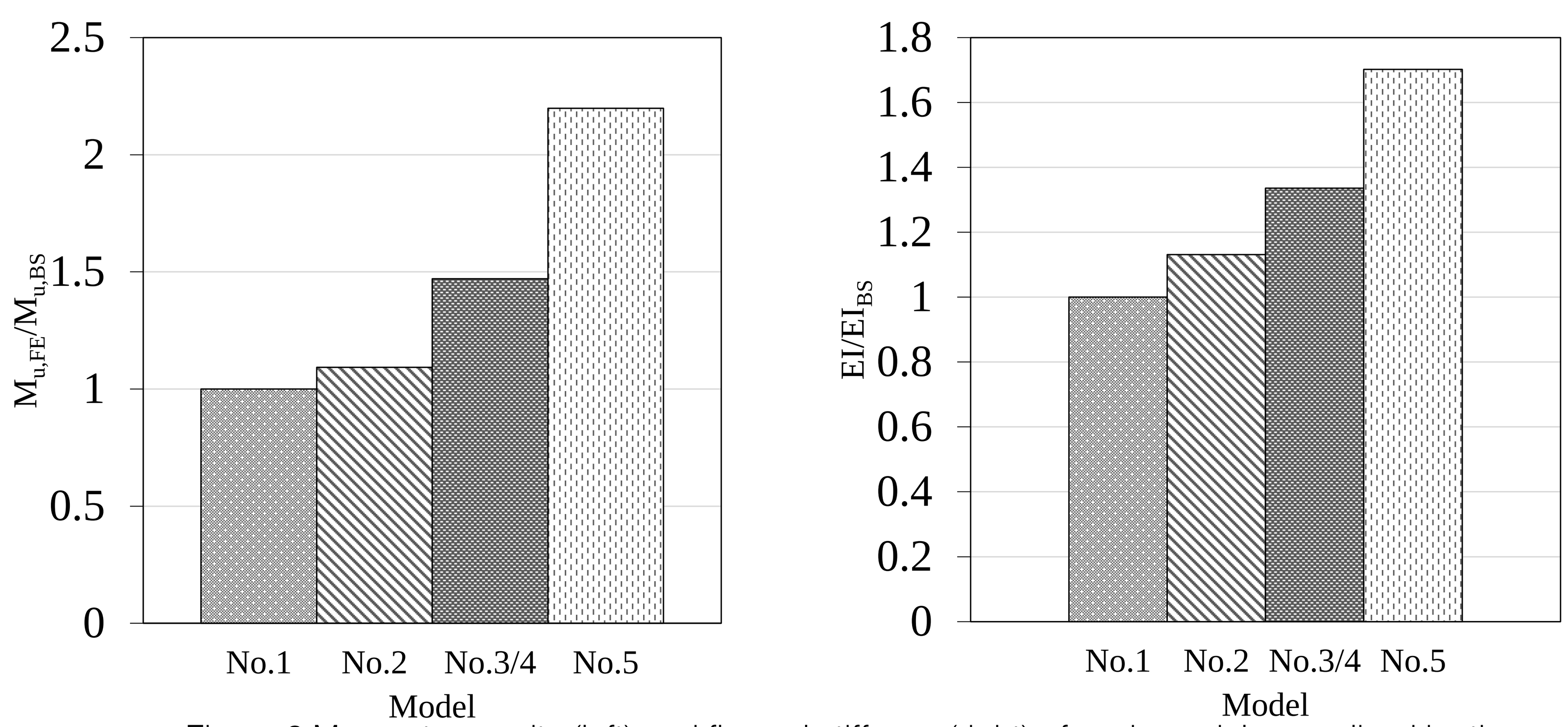

Figure 2 Moment capacity (left) and flexural stiffness (right) of each model normalized by the capacity and stiffness of the bare steel model

The developed finite element model was able to predict the response of the composite systems with good accuracy. The failure modes were predicted accurately and the maximum load the test specimens could carry only differed to that of the finite element model by 0.02 - 6%.

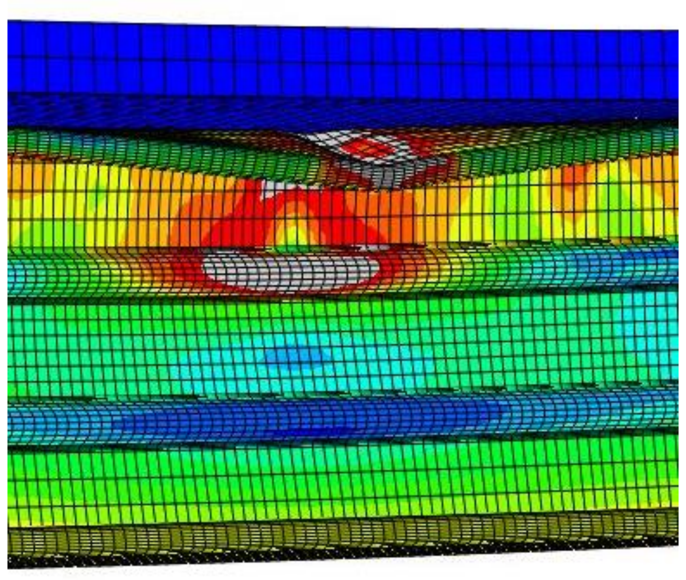

Figure 3 Distortional buckling of the top flange for the 600mm screw spacing model

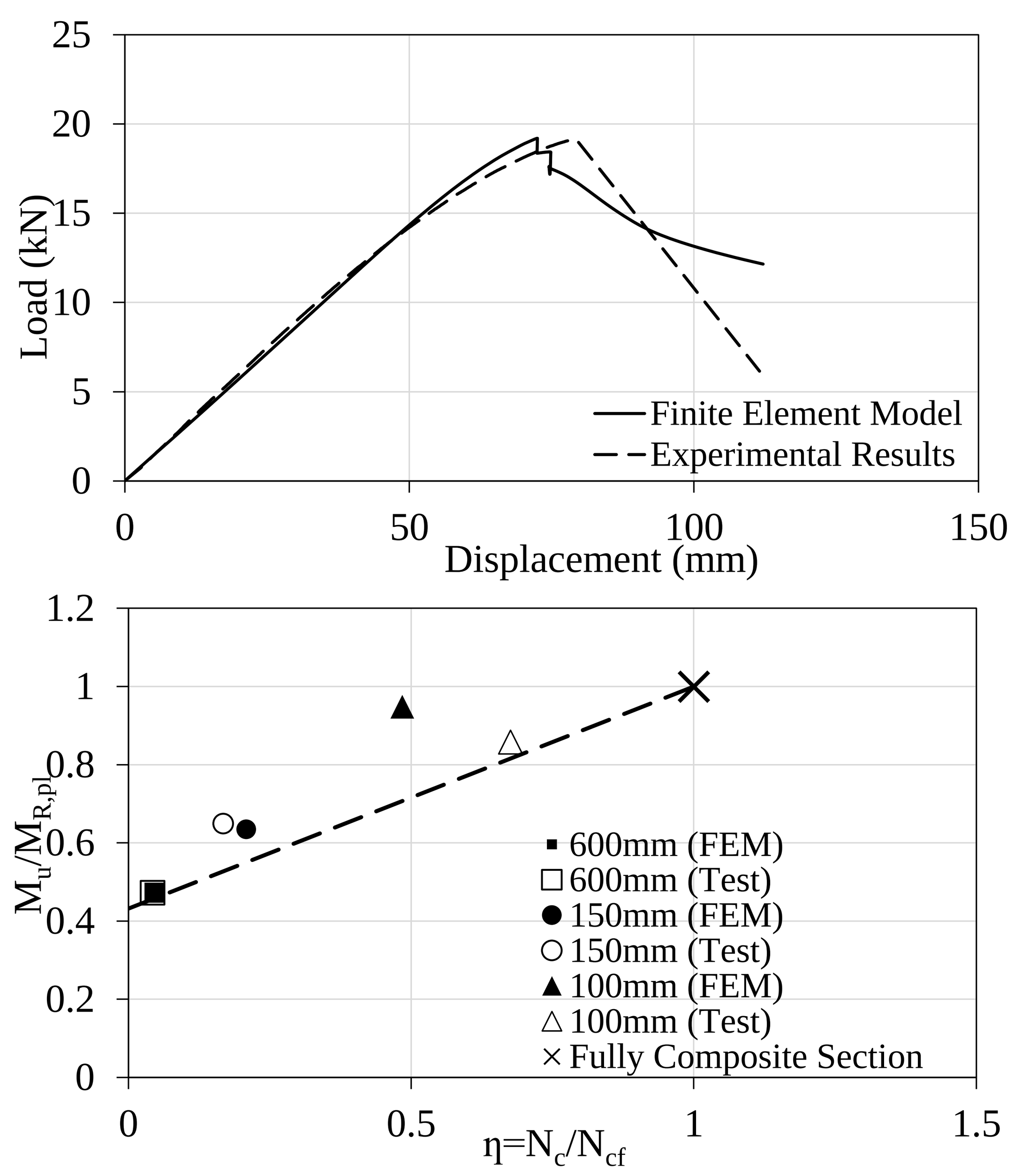

Figure 4 Load-displacement graph for the bare steel section (top) and degree of shear connection attained for the finite element model and experimental tests (bottom)

ACKNOWLEDGEMENTS

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PARAMETRIC STUDIES

Varying four parameters (screw spacing, steel section thickness, floorboard thickness and floorboard elastic modulus), results were analysed based on percentage increase in moment capacity and flexural stiffness when compared to the bare steel section and the achieved degree of shear connection.

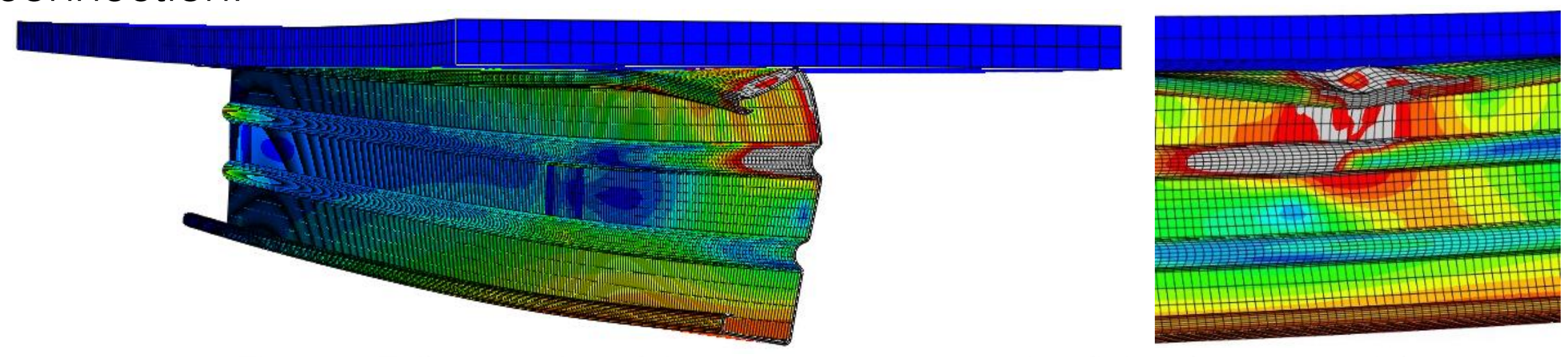

Figure 5 Failure modes of the 300mm screw spacing finite element model

It was found that:

- Decreasing screw spacing increased moment capacity, flexural stiffness and the degree of shear connection.
- Increasing steel thickness decreased the percentage increase in moment capacity and flexural stiffness and had little impact on the degree of shear connection.
- Increasing the floorboard thickness increased moment capacity, flexural stiffness and the degree of shear connection.
- Increasing the elastic modulus of the floorboard increased moment capacity, flexural stiffness and the degree of shear connection.

The effect of applying a structural adhesive at the beam board interface was also compared and indicated a significant increase in moment capacity, flexural stiffness and the degree of shear connection when the adhesive was applied at the beam-board interface.

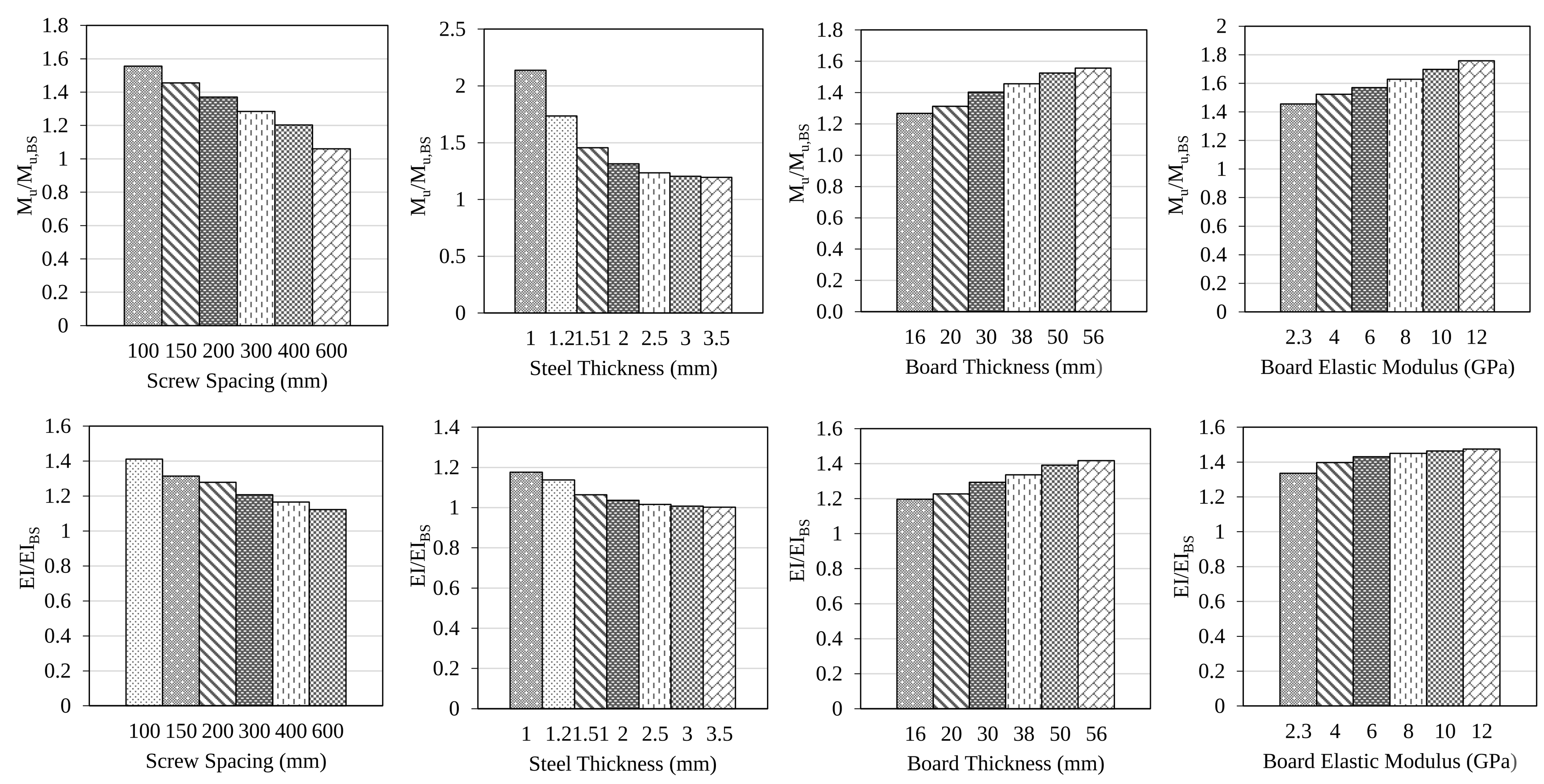

Figure 6 Moment capacity (top) and flexural stiffness (bottom) of each model normalized by the capacity and stiffness of the equivalent bare steel model

Steel thickness was found to have the greatest impact on the moment capacity, but with a reduction in composite benefit while elastic modulus of the board had the greatest impact on the flexural stiffness of the examined systems. Screw spacing also had a significant impact on both moment capacity and flexural stiffness of the section.

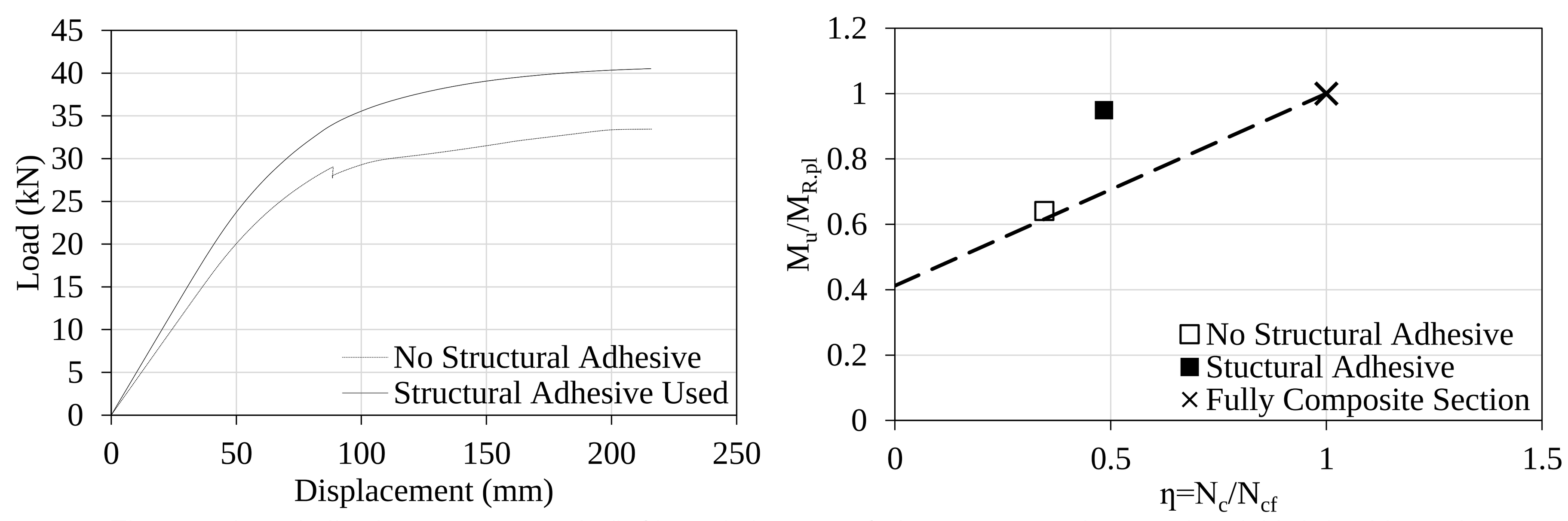

Figure 7 Load-displacement graph (left) and degree of shear connection attained (right) with and without structural adhesive applied at the beam-board interface

CONCLUSION

The developed finite element model was able to predict the response of the composite systems with good accuracy. Parametric studies indicated that the composite section can be further improved by varying certain parameters based on the requirements for the section. Evidently, there is a lot of benefit in considering the beam and board as a composite section.

REFERENCES

Kyvelou, P., Gardner, L. & Nethercot, D. A. (2015) Composite Action Between Cold-Formed Steel Beams and Wood-Based Floorboards. *International Journal of Structural Stability and Dynamics*. 15(8), 1540029.