Imperial College London

NUMERICAL ANALYSIS OF COLD-FORMED STEEL PURLINS

AMAR DUSHYANT PATEL SUPERVISOR: PROFESSOR LEROY GARDNER

Department of Civil and Environmental Engineering,

Imperial College London

INTRODUCTION

Background

- High strength-to-weight ratio
- Easy to prefabricate
- Rapid assembly on-site
- Widespread usage from the 1950s

Aims

- Investigation into the benefits gained by using cold-formed steel purlins of yield strength 450 N/mm^2 instead of 390 N/mm^2 which is used in current practice. The degree of moment redistribution at the support is also investigated and a design framework is proposed

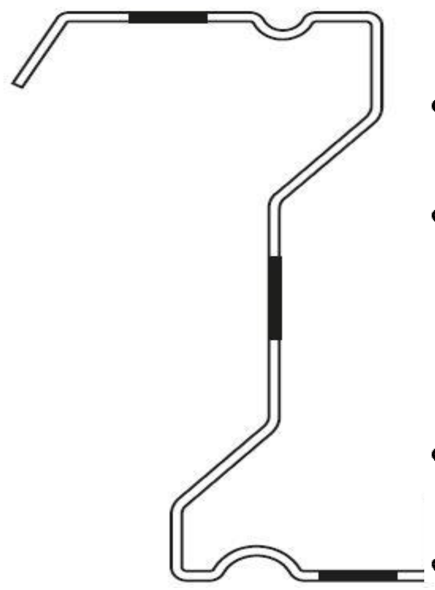

Figure 1: Zeta I purlin

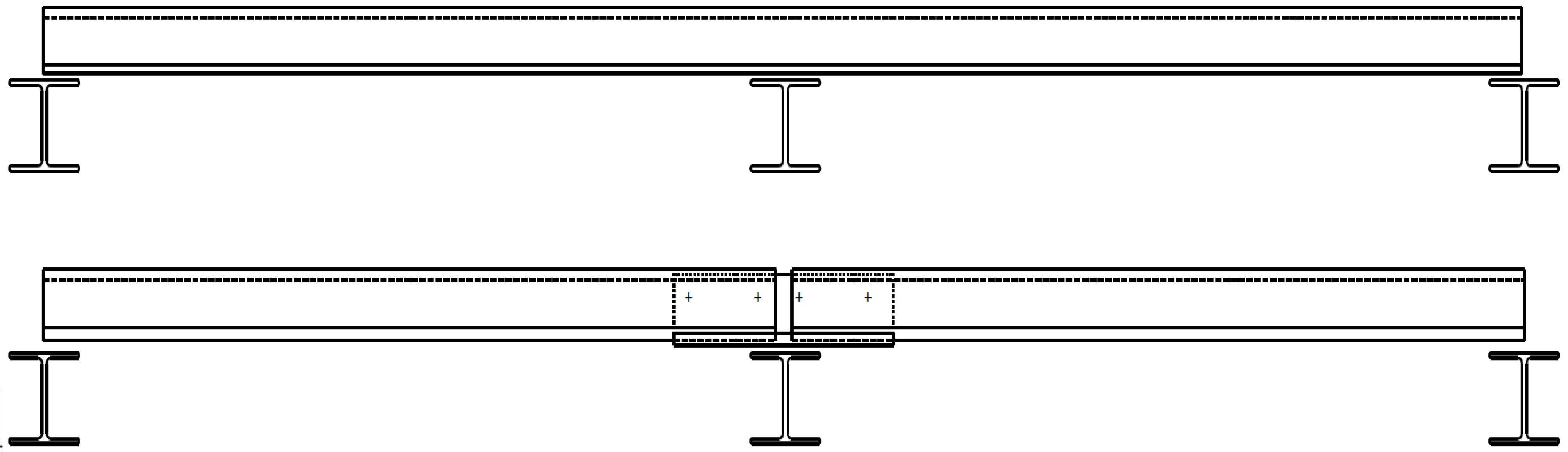

Figure 2: Bare and Sleeved 2-span system

NUMERICAL MODELLING

- Two-stage Ramberg-Osgood model (Gardner and Ashraf) used to model material behaviour of cold-formed steel
- Restraining effects of trapezoidal sheeting incorporated by using a 2-spring model
- Finite strip software CUFSM used to generate geometric imperfections to include in finite element models
- corner properties have been enhanced due to the cold-forming process
- Boundary conditions applied to rigid plates to closely replicate the support cleat
- Pressure load applied to bare system and whiffletree used to applied point loads on sleeved system
- Non-linear springs used to model bolts and SR4 shell elements for the purlins

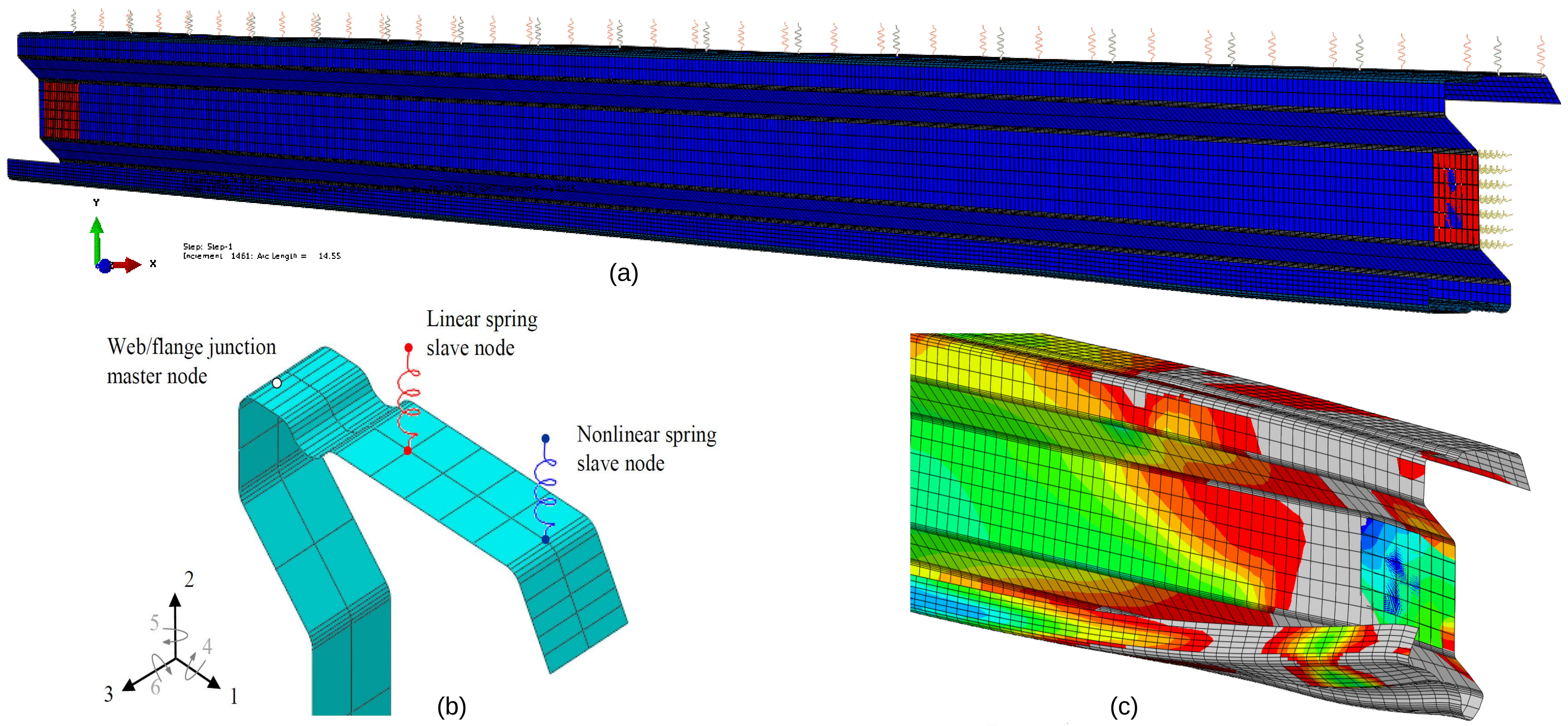

Figure 3: (a) Bare system, (b) 2-spring model and (c) distortional buckling at support

RESULTS

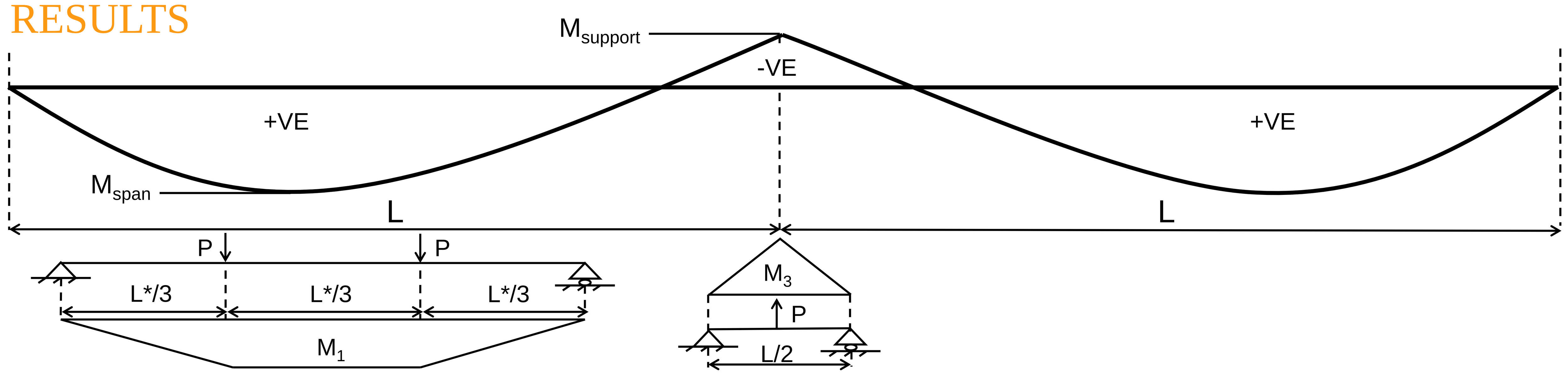

Figure 4: Elastic bending moment diagram

- A drop in moment capacity at the support is observed at the failure load for slender sections. Stocky sections are able to achieve full moment redistribution, without a drop in capacity
- The load carrying capacity of a 2-span system can be predicted by:

$$M_{span} = \frac{(qL^2 - 2M_{support})^2}{8qL^2}$$

where M_{span} is equal to M_1 and $M_{support}$ is equal to αM_3

- α is the ratio of reduction in moment capacity at the support section and can be calculated from the formula:

$$\alpha_{design,g} = \left[0.7 - 0.0045\left(\frac{L}{d}\right)\right] \bar{\lambda}_{cs,-ve}^{\left[-0.003\left(\frac{L}{d}\right) - 1.4\right]}$$

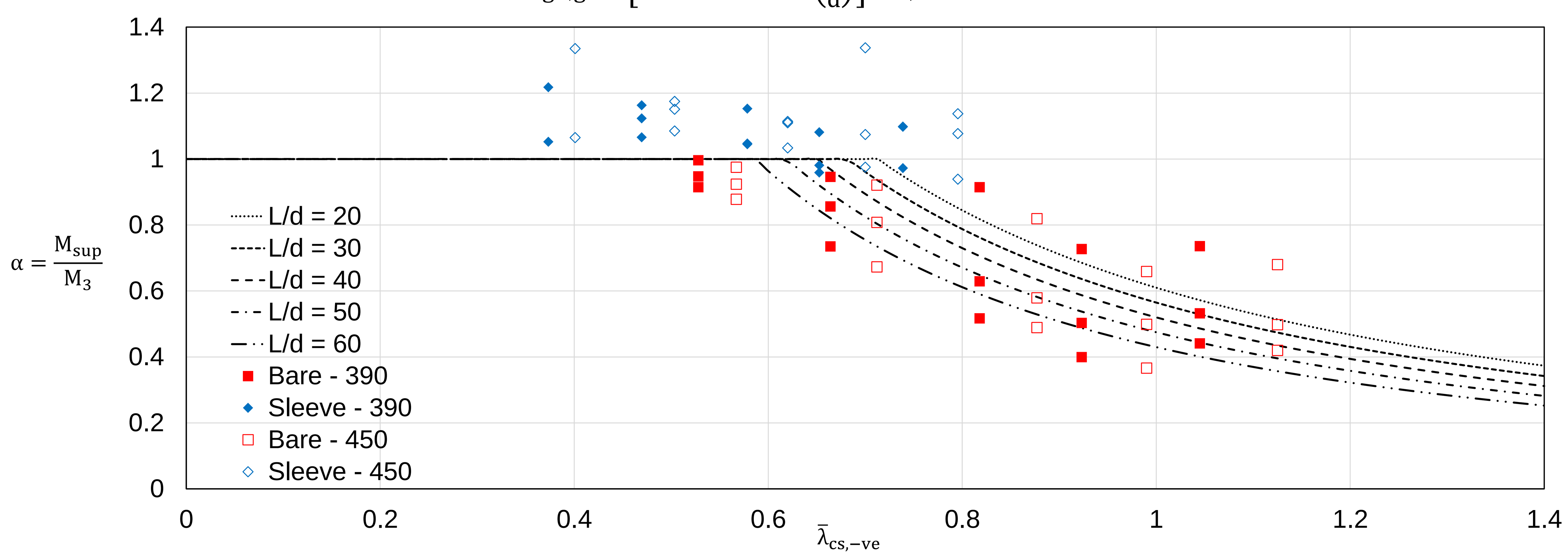

Figure 5: Alpha framework plot for both yield strengths 390 N/mm^2 and 450 N/mm^2

CONCLUSION

- A good fit was obtained for the design framework, with no significant scatter, therefore the proposed model can be used for both yield strength
- The load carrying capacity of the sleeved system exhibited a 14% increase when compared to its equivalent bare system. This increase corresponded to an increase of 6.22% in material required for the sleeve
- Increase of 11.4% in the ultimate load was attained when yield strength increased from 390 N/mm^2 to 450 N/mm^2

ACKNOLEDGEMENTS

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REFERENCES

Nethercot, D.A., Kyvelou, P., Hui, C. & Gardner, L., 2015. The changing basis for the design of cold-formed purlin systems. *8th International Conference on Advances in Steel Structures*.

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