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TENSILE BEHAVIOUR OF PRESTRESSED HIGH STRENGTH STEEL ELEMENTS

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1. INTRODUCTION

- High strength steel (HSS) can substantially reduce the weight and material cost of structures but its use in design has been limited by the uncertainties in its behaviour and poor ductility provided.
- In the current investigation, the tensile performance of high strength steel tubular elements containing internal prestressing cables, is examined. Controlled parametric tests on these specimens have been performed highlighting the increase in strength, stiffness and ductility, provided by the addition of prestressing and grout.

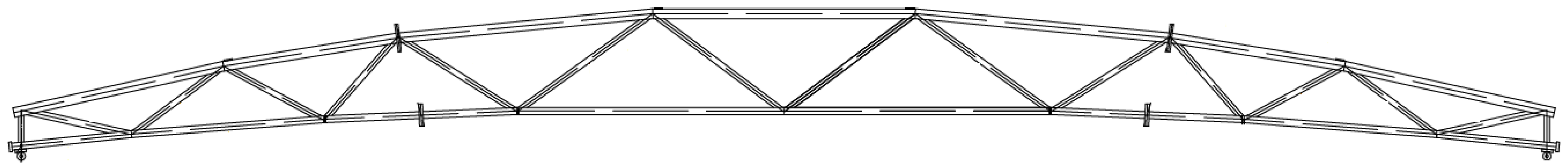

Figure 1: Drawing of HSS arch truss

- The (50 x 50 x 5) SHS members represent the bottom chords of the HSS arch truss shown in figure 1. The truss and single members have been fabricated as part of a wider research initiative assessing the uses of HSS for long span applications, known as the HILONG project.
- The behaviour observed from the single member tests will contribute toward the expected performance of the entire truss shown in figure 1.

2. EXPERIMENTAL SETUP

- Twelve HSS specimens, 6 of steel grade S460 and 6 being grade S690, were loaded in tension until failure. Tests were carefully organised, varying the prestress level and addition of grout to fully explore the benefits of both components.

Prestressing - A cable-in-tube system was utilised with an optimal prestress level such that the tube and cable yield simultaneously, maximising the elastic range of the system. Providing the required level of prestress was extremely difficult in practice due to the wedge slip loss as recorded in figure 3.

Figure 2: Stressing jack and cable

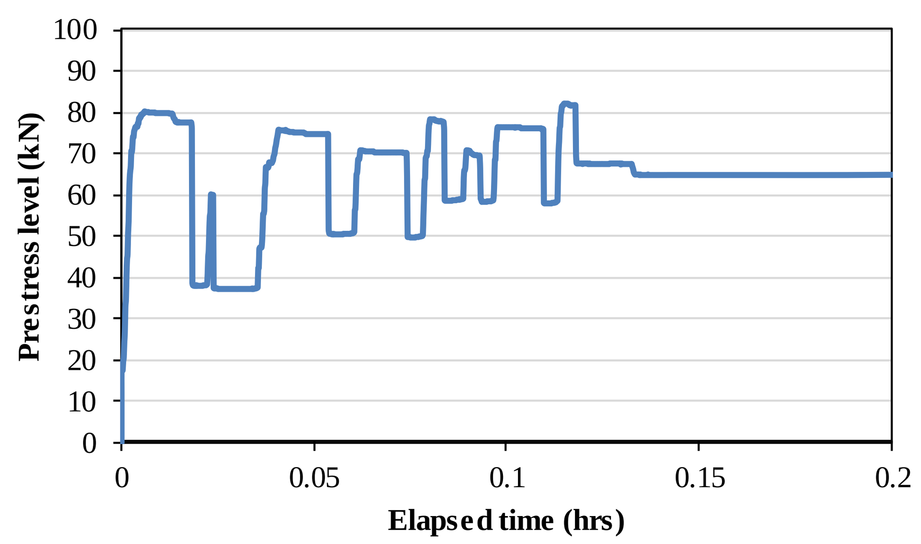

Figure 3: Prestress level against time during prestressing

Grouting - For the grouted specimens, a grouting collar was fashioned to provide a separate inlet for the grout mixture, ensuring that all air voids were released from within the tube. Grouted specimens were left for 10 days to cure whilst the cube strength of each pour was monitored.

Figure 4: Pouring grout into specimen

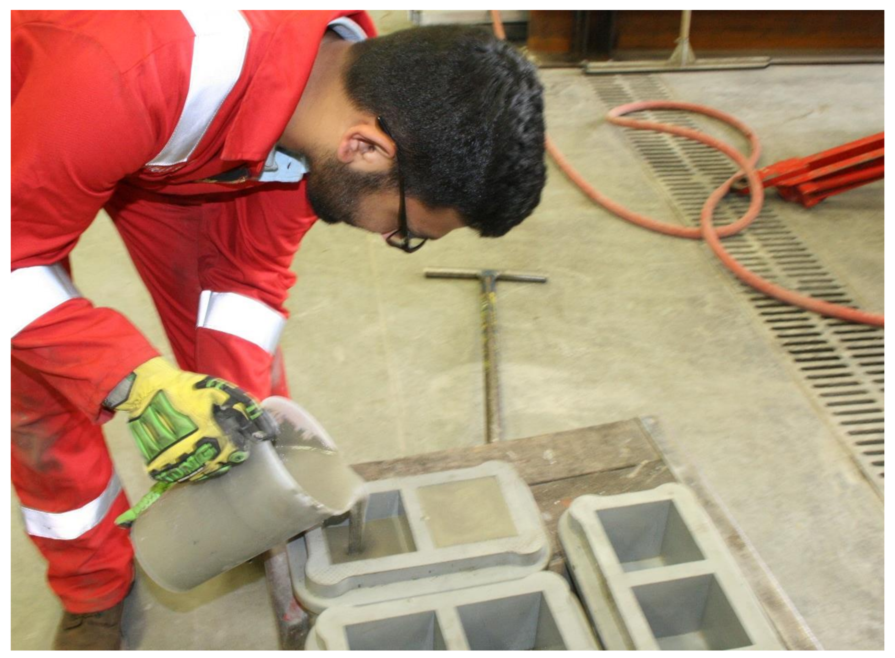

Figure 5: Filling moulds for cube strength testing

3. EXPERIMENTS

Loading - The tensile loading was performed using displacement control at a rate of 2mm/min which was later increased once yielding had occurred. Displacement control, as opposed to load controlled testing, was valued as the safer option with the advantage of ensuring that gradual yielding and failure of the system was observed.

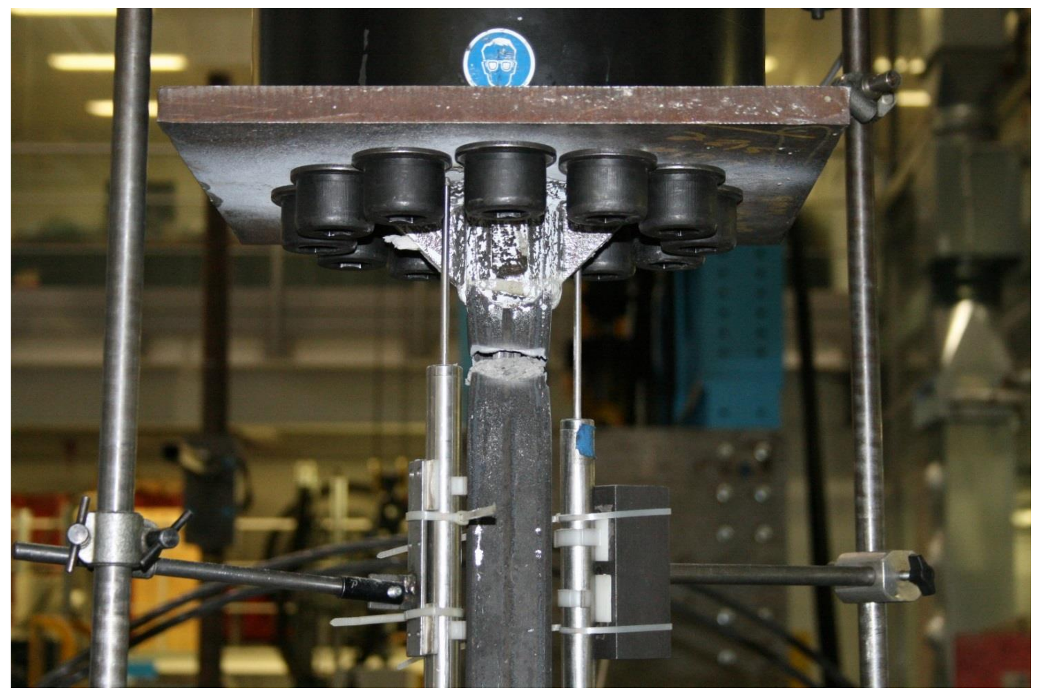

Figure 6: Specimen in loading rig with LVDT's attached

Figure 7: Failure of an S690 grouted specimen

4. RESULTS

Capacity Analysis

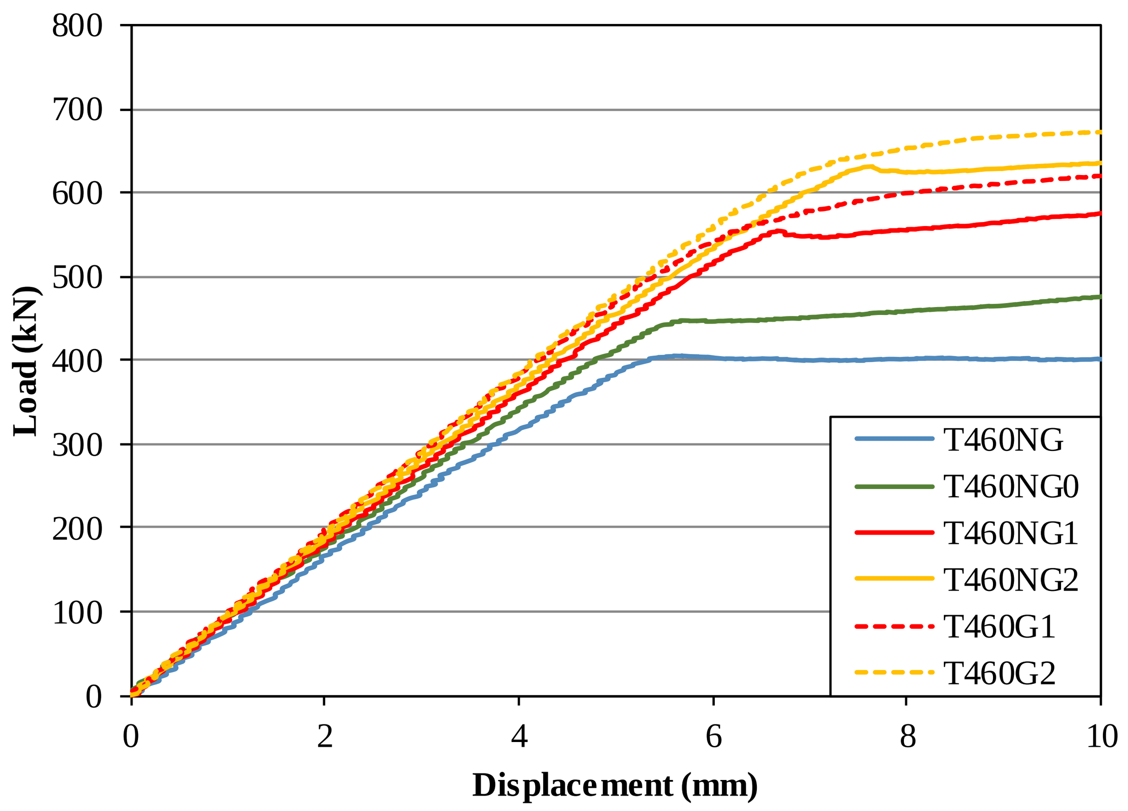

Figure 8: Load against displacement until yield for S460 members

Ductility Analysis

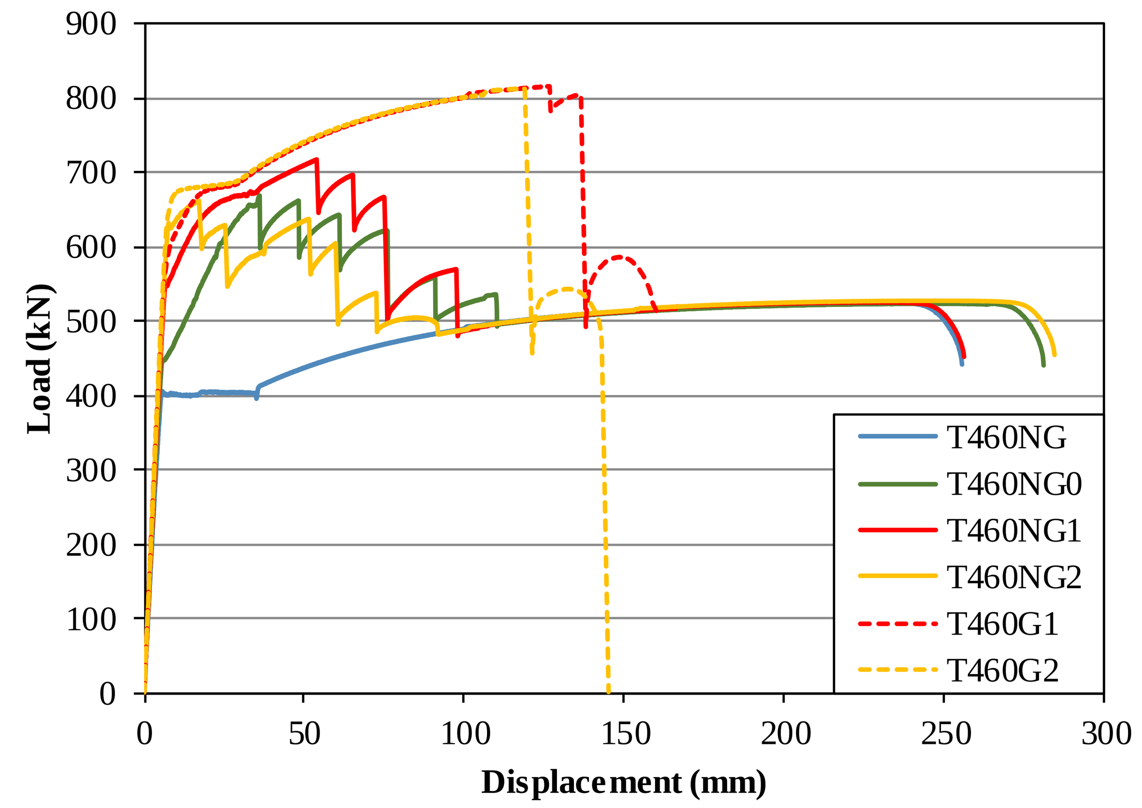

Figure 9: Load against displacement until failure for S460 members

The sharp drops in the load correspond to the breaking of individual cable strands.

5. CONCLUSION

- Both the addition of a prestressed cable and grouting of the section produced measurable benefits to the structural system.
- Similarly to Gosaye (2014), the addition of the cable consistently increased the yield load and the displacement at which it occurred.
- The grout effectively distributed the load between the cable strands, evidenced by simultaneous cable strand breakage and twice the extension of the cable in service.
- The benefits of the grout, coupled with the strain hardening of the tube, significantly increased the ultimate load of the system as shown. This effect was less pronounced in the grade S690 members which exhibit a limited amount of strain hardening compared to the S460 members.

ACKNOWLEDGEMENTS

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REFERENCES

Gosaye, J., Gardner, L., Ahmer Wadee, M. & Ellen, M. E. (2014) Tensile performance of prestressed steel elements. Engineering Structures. 79, 234-243.