COMPONENT-BASED ELEMENT FOR ENDPLATE CONNECTIONS IN FIRE

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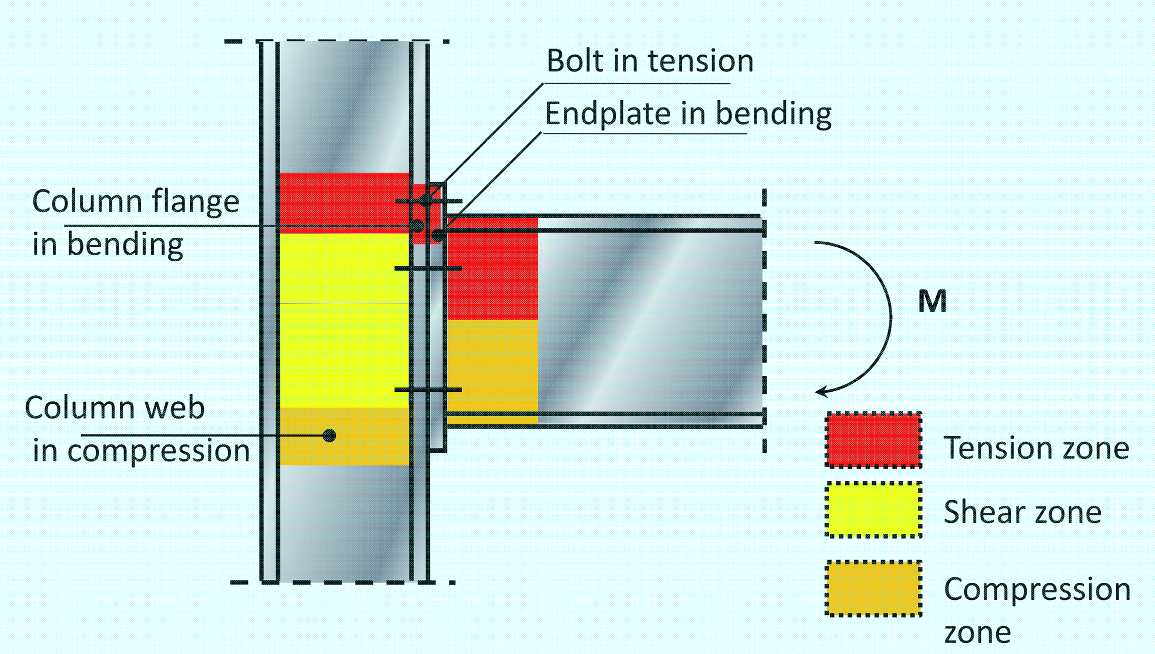
Introduction

This component-based finite element is intended to model endplate joints between beams and columns in steel structures under different fire conditions. The element is compatible with the EC3 Part 1-8 design method[1]. A joint is divided into a collection of key components, whose behaviour is characterised as that of nonlinear springs. Its essential properties, including temperature variation, physical connection details and unloading characteristics, are taken into account in assigning properties to its components. Rigid links are used to connect the components in order to represent the whole joint, which enables the element to tackle the interaction of internal forces, due to the thermal and mechanical effects on the global structure, both during and after a fire. This connection element has now been built into the nonlinear global structural analysis program *Vulcan*[2]. It contributes to accurate prediction of the behaviour of buildings in fire, including the ductility and failure of connections, allowing progressive collapse sequences to be traced, and facilitating global performance-based design against fire.

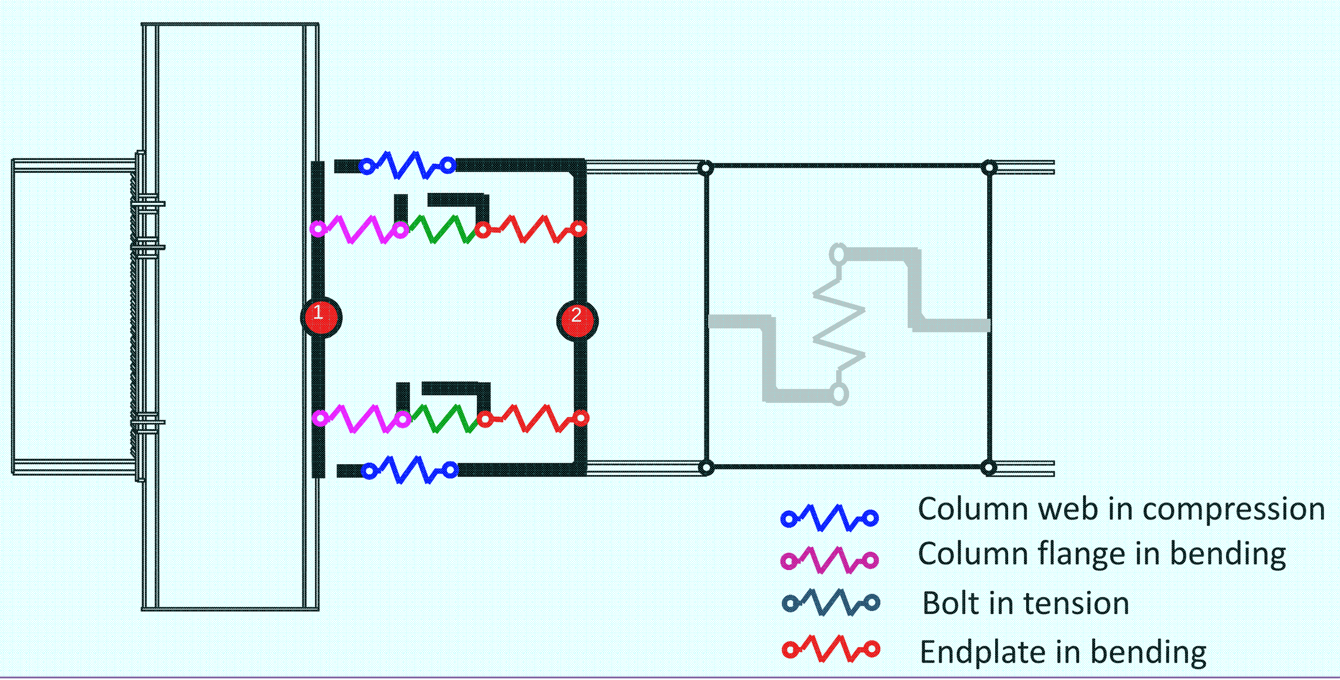
Development of the component-based element

Step1: identification of the active components.
Step2: specification of the component characteristics.
Step3: assembly of the active joint components.

Identification of active components[2]

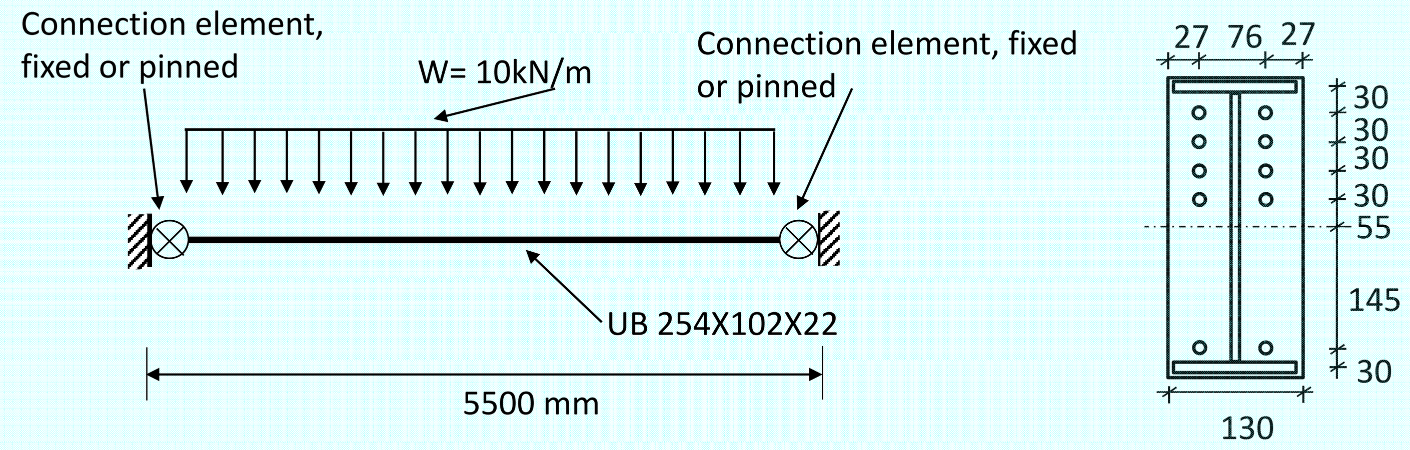


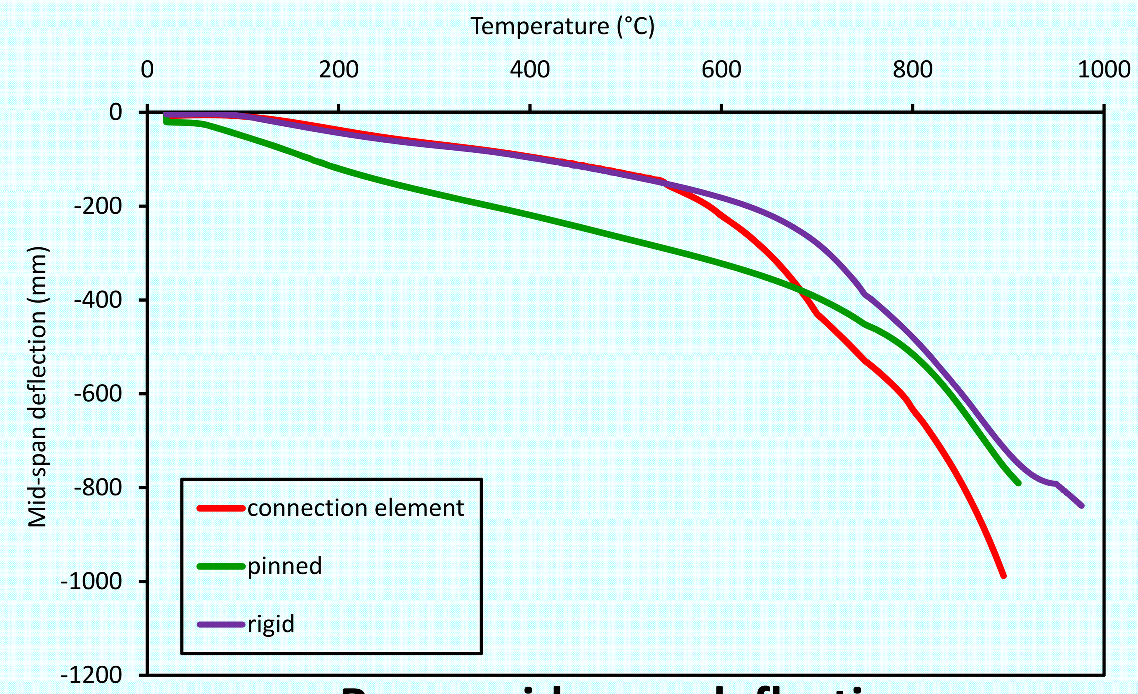
Component assembly



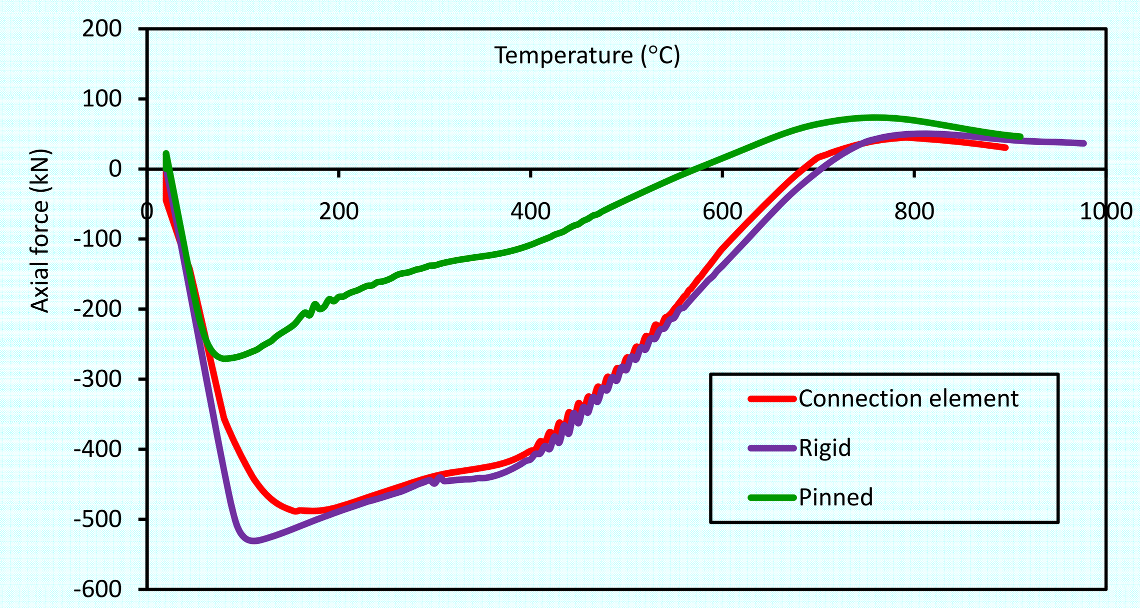
Validation

In order to test the element, an isolated beam, with connection elements at its ends, and with complete axial restraint beyond these, was designed. The beam section is 254x102UKB22. Endplate thickness is 12mm and the steel grade is S275. No out-of-plane deflection is allowed. The joint is designed to test the connection element's full capacity for 5 tension bolt rows. The joint data are hard-coded in the current version of the connection element.

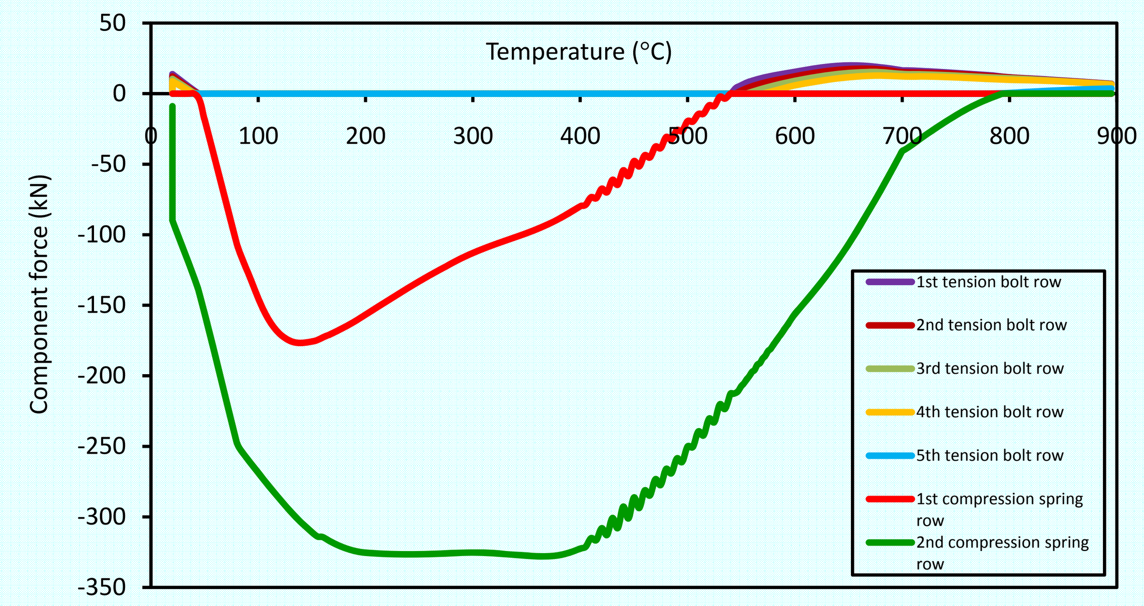




Beam mid-span deflections



Axial force in connection



Component forces

The calculation has stopped due to fracture of the bolt in the upper tension bolt row. It is noticeable that the deflection of the beam with the connection elements (logically) lies between those of the beams with rigid and pinned connections. These figures also show that the connection element is capable of modelling the behaviour of connections in fire and tackling the combination of internal forces.

Conclusion

This connection element can be integrated into global modelling of the behaviour of steel structures in fire, and has now been very largely validated. Further component development and parametric studies are currently under way. The development of the component-based connection element will enable structural modelling to be used in performance-based structural fire engineering design to specify connections with the appropriate combination of strength and ductility to avoid disproportionate collapse scenarios in fire..

References

1. CEN (2005), *"EC3: Design of steel structures, Part 1.8: Design of Joints"*, European Committee for Standardization, Document BS EN1993-1-8:2005.
2. Huang, Z., Burgess, I.W. and Plank, R.J., *'3D Modelling of Beam-Columns with General Cross-Sections in Fire'*, Paper S6-5, Third International Workshop on Structures in Fire, Ottawa, Canada, (May 2004) pp 323-334.
3. Spyrou S. *"Development of a component-based model of steel beam-to-column joints at elevated temperatures"*, PhD Thesis, University of Sheffield, 2006.

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