SHEAR PANEL COMPONENTS IN THE VICINITY OF BEAM-COLUMN CONNECTIONS IN FIRE

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As the final goal of performance-based structural fire engineering design is to develop the robustness of buildings to prevent any possibility of progressive collapse, columns and joints become the key elements of a building in fire scenarios. On the one hand, the investigation of “7 World Trade” in New York City indicated that the building was unaffected by the aeroplane impacts but collapsed totally due to the effect of fire. This was triggered by the failure of beam-to-column joints as a result of large thermal expansions of beams. Joint failure may initiate fire spread or may lead to progressive collapse of the whole building. On the other hand, once a column buckles the redistribution of column loading may overload the adjacent columns. This phenomenon may cause severe local collapse, or even progressive collapse of the whole building.

This project has so far mainly been concerned with developing component models for the shear panel zones close to the ends of beams. Several of the full-scale Cardington Fire Tests indicated that shear buckling at the ends of the steel sections of composite beams is very prevalent under fire conditions. Beams can hardly break in fire scenarios, but shear panel behaviour in the vicinity of the steel beam-column connections can have two significant effects on the adjacent joint. Firstly, shear buckling can cause redistribution of the forces in the column-face bolts. In the post-buckling stage, most of the vertical beam reaction is resisted by the tensile stress across the diagonal of the shear panel. Together with the effect of lower-flange buckling, which is essentially a rotational effect, the forces generated may differ from the traditional design forces for the connections. Secondly, transverse drift of the shear panel, and rotation of the lower-flange, can contribute to the deflection of the beam. This effect will help with catenary action under large beam deflections. Catenary action may in turn change the redistributed stresses in the shear panel zone.

In the first year of this study, three steps have been carried out:

1. A logical component-based mechanical theory has been proposed, based on tension field theory, particularly to predict the geometry and stress redistribution within the shear panel zone during the plastic buckling period. This theory is firstly applied at ambient temperature, and then extended to elevated temperatures.

2. A range of ABAQUS models have been created to investigate the behaviour in the vicinity of the connection and to validate the component model over a range of geometries. The model can be used to produce force-transverse deflection relationships which are necessary for a component-based beam-end finite element.

3. By validating the mechanical theory with ABAQUS models, reasonably consistent results have shown that the proposed method provides a good approximation to the more complicated numerical analysis.

The next objective, after sufficient validation has been carried out, is to implement the component-based shear panel element in the software *Vulcan*, which will then be tested against existing experimental data. The software will subsequently be used to conduct a series of parametric studies to investigate the effects of shear panels in beams and columns on performance of steel frames in fire.