

THE DUCTILITY DEMAND OF STEEL-FRAMED STRUCTURES IN FIRE

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Abstract

During a fire in a steel framed building, its floor beams experience both thermal expansion and progressive material weakening as their temperatures rise. At temperatures below about 600°C the dominant effect is thermal expansion, which can impose large compressive forces on the surrounding structure if restrained, causing thermal buckling of beams, cracking of concrete slabs and occasionally the fracture of connections. At high temperature, the bending resistance of beams largely vanishes, and they eventually hang in tension between their supporting connections. At this stage, given the low residual strength of the connection components, their fracture can only be avoided if the axial tension forces in beams are kept very low and the connection components are not over-stressed. A typical floor beam can therefore be considered as having a “ductility demand”, comprising a safe range of end movement and rotation at high temperatures within which the beam force does not become unacceptably high and the connection does not fracture. This ductility demand can be reduced, either by using a high level of fire protection on the beam, or by specifying connections, which provide the required ductility in fire conditions.

Previous research at Sheffield has characterized conventional beam-to-column connections in terms of their strength, rotation capacity and range of movement at high temperatures. This has been done experimentally and numerically, and the work has led to the development of component-based models of these connection types that can be incorporated in numerical analysis of structural subframes for performance-based fire engineering design.

However, it is apparent that the whole range of standard connections has too little inherent ductility to cope with the demands of long-span beams without very high levels of fire protection. As an alternative, this presentation shows the early results of research aimed at developing connections whose properties can be designed to match the ductility demand imposed by the supported beams in fire conditions, while performing satisfactorily as simple connections under the normal limit states at ambient temperature.