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Moment–rotation–temperature curves for semi-rigid joints

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Abstract

Although connections are known to have a very significant effect on the behaviour of steel and composite framed buildings in the event of fire, the cost of high temperature tests on the broad range of connections used in practice means that their influence is not well detailed in current design codes. The paucity of data also limits the effective use of numerical models developed to simulate the behaviour of complete structures at elevated temperature. This research describes a series of elevated temperature tests conducted on beam-to-column connections. This paper presents moment–rotation–temperature curves for a variety of connections.

Keywords: Bare-steel; Composite; Connections; Joints; Elevated-temperature; Moment–rotation curves; Fire

1. Introduction

Traditionally the design of steel framed structures assumes that the actual behaviour between the beam and the column is either rigid (implying complete rotational continuity)

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Nomenclature

L	distance from the connection centreline to the point where deflection is determined.
u	deflection of the point along the beam
M	level of moment
A	temperature dependent parameter representing connection's stiffness
B	temperature dependent parameter representing connection's strength
n	temperature dependent parameter defining curve sharpness
M_1	moment corresponding with ϕ_1
A_1	temperature dependent constants for stage two of response representing connection's stiffness
B_1	temperature dependent constants for stage two of response representing connection's strength
n_1	temperature dependent constants for stage two of response defining curve sharpness
ϕ	connection's rotation
ϕ_1	rotation at which the beam flange comes into with the column

or pinned [1]. However actual connection behaviour exhibits characteristics over a wide spectrum between these two limits; connections regarded as pinned generally possess some rotational stiffness whilst rigid connections display some flexibility. Design procedures for 'semi-rigid' frames have been developed but to simplify both design and construction, steel beams in multi-storey buildings are normally considered as simply supported with no transfer of moment to the columns. However, observations from fire damaged structures [2] and the fire tests on the Cardington full-scale frame [3] have demonstrated that even simple connections can resist significant moments, albeit at large deformations. This improves the survival time of the structure.

The traditional method for fire protecting structural steelwork is to use a suitable applied protection material. However this can increase the overall cost of the structure by up to 30% [4], and extend the time for construction, offsetting some of the advantages associated with steel-framed construction. In order to minimise reliance on protection materials there has been increased interest in developing a fundamental understanding of structural behaviour under fire conditions, considering members either in isolation or as a part of a more complete structure. Some research has focused on studying the influence of temperature on the connection response. Most recent work has shown the importance of modelling appropriate structural assemblies – beams, columns and slabs – rather than just isolated members. If this is done properly the characteristics of the connections need also to be included, but this has been hampered by a lack of experimental data on the behaviour of steel and composite connections in fire.