COLD-FORMED STEEL PORTAL FRAME STRUCTURES IN FIRE
Preliminary full scale testing and numerical modelling

Ross Johnston

Queen's University Belfast, School of Planning, Architecture and Civil Engineering, Belfast, United Kingdom

Project goal and Objectives
The primary aim of this project is to provide design recommendations for the design of cold-formed steel portal frame structures at elevated temperatures. This is to ensure acceptable failure modes of such structures within fire boundary conditions (prevent outwards sway failure). Specific objectives of the research are as follows:

- To conduct a full scale fire test of typical portal frame arrangement.
- Test joint components at ambient and elevated temperature.
- Validate non-linear FEA shell models which incorporate semi-rigid joints.
- Investigate the effect of joint stiffness, initial imperfections and stressed skin action.

Background
Research on the behaviour of cold-formed steel portal frames [1] at elevated temperatures is limited [2] and has yet to include the effect of joint flexibility (Fig. 1) and imperfections. These are vital to the overall behaviour as cold-formed steel members are susceptible to complex coupled instability modes (Fig. 2). This susceptibility is heightened at elevated temperatures due to the thin-walled nature and high conductivity of the section (Fig. 3).

The current SCI design guide [3] outlines the fire boundary condition for hot-rolled steel portal frames only. There is no definitive guidance available for cold-formed steel portal frames. For this reason, a comprehensive experimental and numerical research programme is being carried out.

Method and Results
Experimental testing

A full scale fire test is planned and will comprise a full burn out test (Fig. 4) with appropriate instrumentation to measure temperature and displacement. Most vital is to determine the overall collapse mechanism. Laboratory testing on joint components is also being carried out. Experimental testing will provide input data and validation for numerical simulations.

FE Models

The commercial package ABAQUS is being used to develop non-linear FE models for the following at ambient and elevated temperatures.

- Individual joint components (Solid and Shell models of lap joints and B2B beam tests)
- Single bay portal spans (Shell model incorporating semi-rigidity of joints)
- Multi bay portal frame arrangements (As above including purlins/side-rails/cladding).
- Study into effect of initial imperfections and residual stresses.
- Parametric study investigating effect of fire location, knee braces, span, pitch, un-symmetric frame arrangements and diaphragm action.

Potential for application of results
The results of the research will lead to improved understanding of the behaviour of cold-formed steel portal frame at ambient and elevated temperatures. It will provide guidance for design engineers and act as a base for further research into the behaviour of such structures at elevated temperatures.

Images

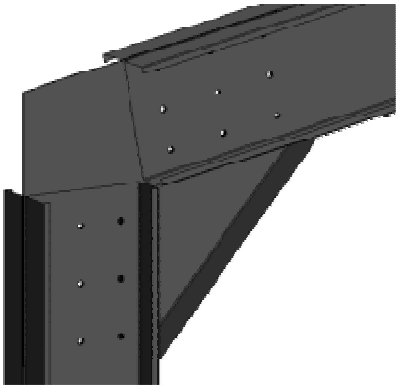

Fig. 1 - Eaves connection detail

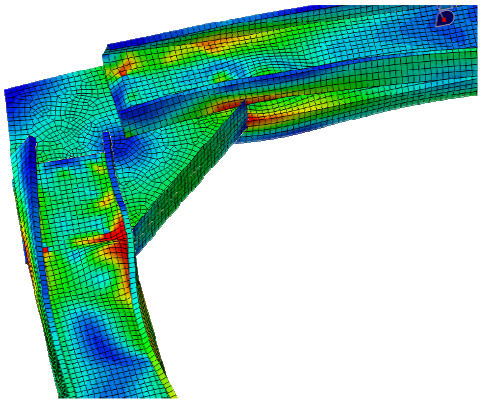

Fig. 2 - FEM of eaves connection

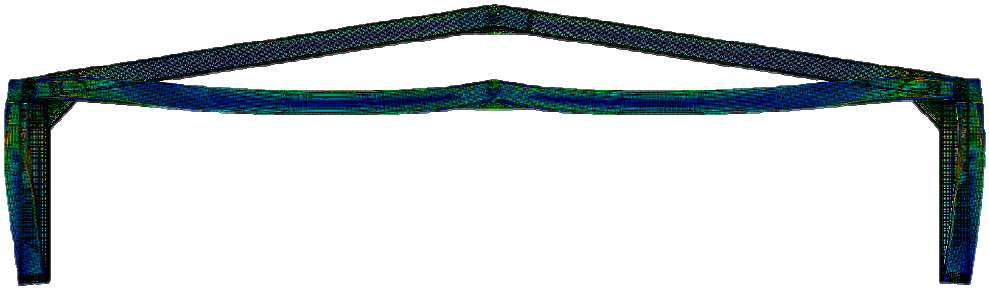

Fig. 3 - FEM of single portal at elevated temperature

Fig. 4 - Full scale site fire test frame

References

[1] Lim, J. B. P., Nethercot, D. A., "Finite element idealization of a cold-formed steel portal frame", Journal of Structural Engineering - ASCE, Vol.130, 2004, pp. 78-94.

[2] Pyl, L., Schueremans, L., Dierckx, W., Georgieva, I., "Fire safety analysis of a 3-D frame structure consisting of cold-formed sections; numerical modelling versus experimental behaviour based on a full-scale fire test", Journal of Thin-Walled Structures, Vol. 61, 2012, pp. 204-212.

[3] Simms, W. and Newman, G., "Single-story steel framed buildings in fire boundary conditions", The Steel Construction Institute, SCI Publication P313, Berkshire, 2002, 78 p

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Further Information

Ross Johnston (rjohnston29@qub.ac.uk); Dr. M Sonebi (m.sonebi@qub.ac.uk); Dr. J Lim (j.lim@qub.ac.uk); Prof. CG Armstrong (c.armstrong@qub.ac.uk).