Behaviour of a cold-formed steel portal frame in fire: Preliminary full scale testing and finite element analysis

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Determine the collapse behaviour of cold-formed steel portal frame structures at elevated temperatures (fire).

Provide guidance to prevent undesirable outwards collapse mechanism.
START: Simple Problem

FINISH: Simple Solution
What is a cold-formed steel portal frame?

Viable alternative Sustainable
Joints possess reduced capacity
Popular in Australia/NZ
Limited research + guidance
Current Practice

Only available for hot rolled steel portal frames. Based on SCI P313 Guidance Document. No such guidance for cold-formed steel portal frames.

A.1 Derivation of overturning moment

The model assumes a worst-case scenario in which the rafter is inverted and acts like a catenary. However, a small allowance is made for the residual bending resistance of the rafter.

The geometry and the forces acting on the collapsing rafter are shown in Figure A.1.
Where to Start?

Lab testing

Literature Review

Prescriptive versus Performance Based

Ambient validation prior to fire

Finite Element Analysis

What does industry need?

DEVELOP RESEARCH AT AMBIENT TEMPERATURE FIRST
OUTPUT:- BOLT STIFFNESS
OUTPUT:- JOINT RIGIDITY + AMBIENT VALIDATION
Elevated Temperature Study

CARRY OUT FULL SCALE SITE TEST AND VALIDATE NUMERICAL MODELS
Site Test Results - temperature
Site Test Results - temperature
Site Test Results – lateral eaves displacement

- EXP Column H
- EXP Column B
STRESS STRAIN CURVES

YOUNG’S MODULUS

CONNECTION STIFFNESS

EXPANSION

CONDUCTIVITY

SPECIFIC HEAT

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Stiffness (kN/mm)

0 200 400 600 800

Temperature

Connection Stiffness

Linear expansion

\[ \frac{\Delta L}{L_0} = \alpha \Delta T \]
Site Test Results – finite element
Variance in FE and EXP due to beneficial effect of purlins, side-rails and cladding?
Single portal frame model not able to accurately model this, need a multi-bay portal frame arrangement.
Effect of in-plane restraint and connection stiffness
Potential for Application of Results

- Practical design guidance for engineers
- Base for further research into the behaviour of such structures at elevated temperatures.

- Design Procedure
- Critical Temperature
- Influence of purlins/side rails
- Effect of fire scenario
- Base fixity and Overturning moment
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Thank you for your attention