IMPERIAL

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Experimental investigation of lightweight cold-formed steel (CFS) frames with semi-rigid connections

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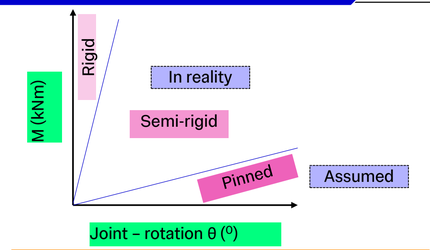
Year 3
PhD : Cold-formed steel structures

BACKGROUND & MOTIVATION

- Experimental evidence indicates semi-rigid rotational stiffness present in floor-to-wall joints of cold-formed light weight steel frames
- Neglecting this behaviour affects force distribution and global response



Stiffness classifications based on Eurocode 3

OBJECTIVES

- Investigate **moment–rotation** behaviour
- Demonstrate the **semi-rigid** behaviour of the joints
- Quantify **joist–stud joint stiffness** for different fastener configurations
- Develop a validated methodology for **joint characterisation**

CONCLUSIONS & IMPACT

- Up to **78% increase** in **rotational stiffness** were achieved
- **Fastener** configuration is influential
- Predominant Failure : **Distortional Buckling**
- Underscore the potential for more realistic analytical modelling and **more efficient** structural design strategies for **lightweight steel framing**.

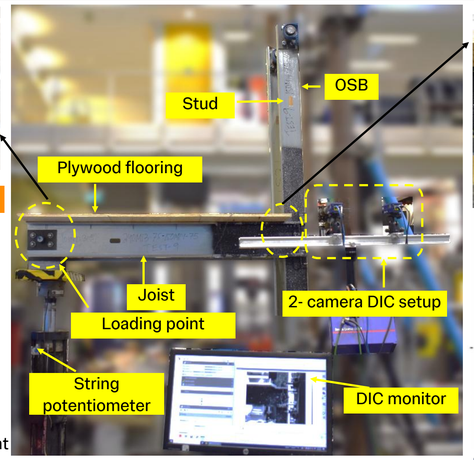
RESEARCH APPROACH – PROOF OF CONCEPT

PHYSICAL TESTS

10 T-frame specimens of varying joint-stiffness
+
8 tests : Plywood flooring
2 tests : No plywood flooring
+
Employed Instrumentation

- 8 LVDTs
- 4 Inclinometers
- 2 DIC-camera setup

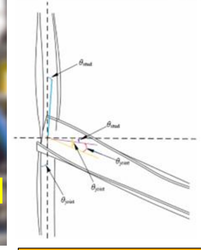
Loading point



Experimental T-frame test setup

- Quasi-static loading
- Half-cyclic tests (FEMA-461)
- Loaded till any failure appeared on the member
- String-potentiometers were used to calculate the displacements at the loading point.
- 5.5 mm self-drilling screws

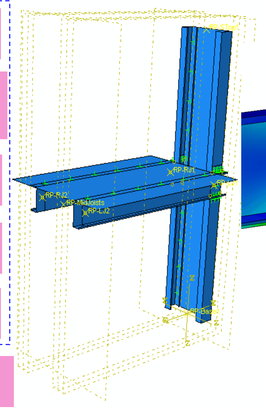
JOINT-ROTATION DEFINITIONS



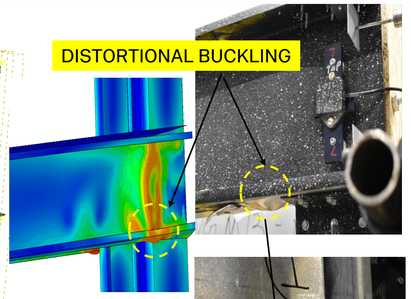
$$\theta_{joint} = \theta_{joist} - \theta_{stud}$$

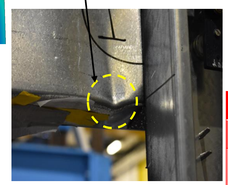
NUMERICAL VALIDATION

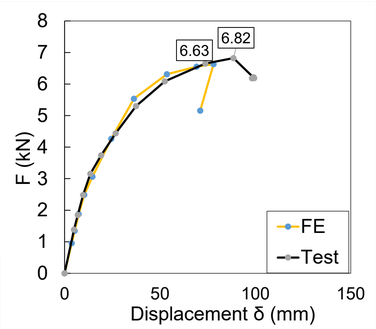
Shell elements
Coupon and lap-shear tests → Material properties
Connector types
Boundary conditions
Reference points
L-δ | M-θ
Distortional buckling



FE model



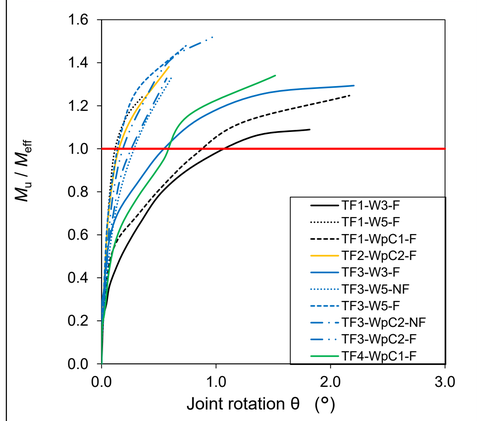




	TEST	FE	% Error
LOAD (kN)	6.82	6.63	2.8
DISPLACEMENT (mm)	88.5	78.1	13.3
STIFFNESS (kN/mm)	0.23	0.21	9.5

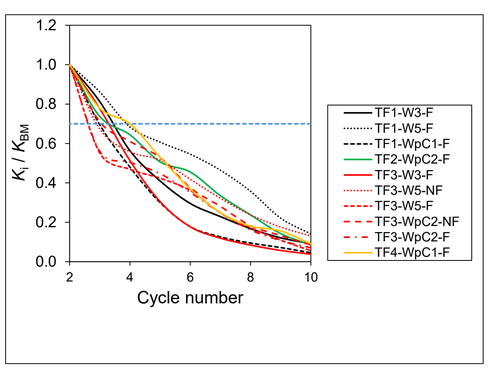
KEY - RESULTS

Normalised cyclic moment-rotation



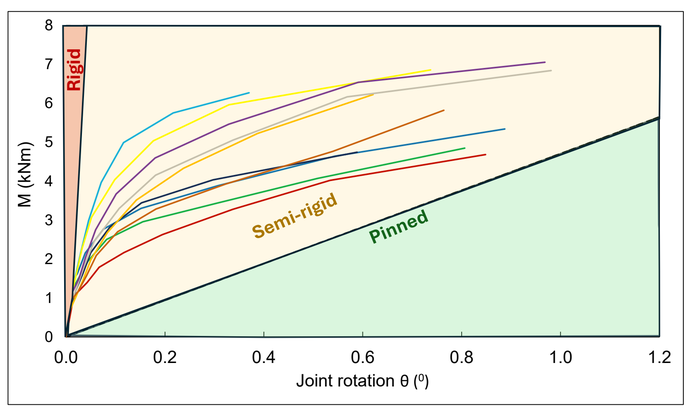
All test series exceeded M_{eff} → Onset of failure was triggered by local instabilities

Stiffness degradation



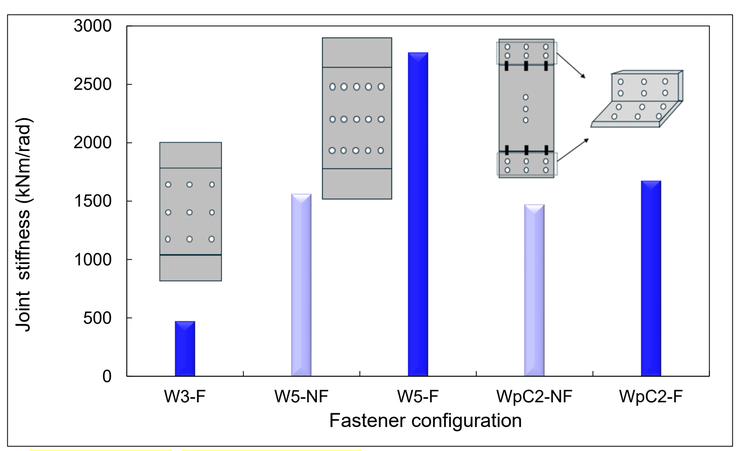
Stiffness degrade with progress of cycles → Rigidity

Stiffness regions based on Eurocode 3



- All test series exhibited **semi-rigid** behaviour based on **Eurocode 3**
- Increased rotational restraint : Enhancing joint detailing

Joint-stiffness vs fastener configuration



NF : No Flooring F : Plywood Flooring

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- **Metsec** for supplying the test specimens
- Les Clark, Bob Hewitt, Paul Crudge ,Freddy Olivo

REFRENCES
1. Eurocode 3: Design of Steel Structures – Part 1-8: Design of Joints. prEN 1993-1-8 527 (2021). Brussels: European Committee for Standardisation

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