Behaviour of Pultruded FRP Beam-to-Beam Sub-assemblies Connected by Bolted Web Cleats

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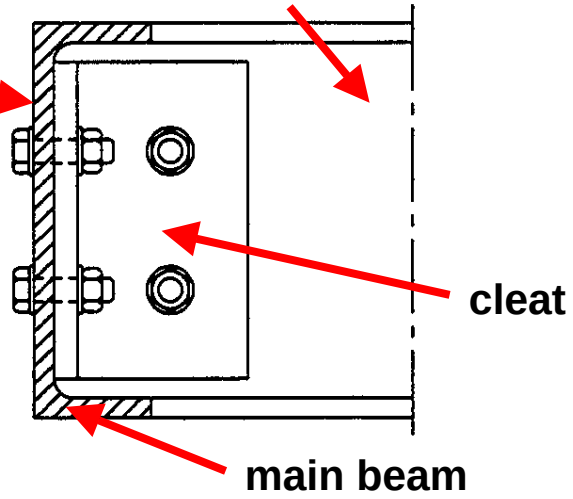
Innovative Materials and Technologies for Construction and Restoration (IMTCR04)

THE UNIVERSITY OF WARWICK

Motivation - PFRP Bolted Beam-to-Beam Connections

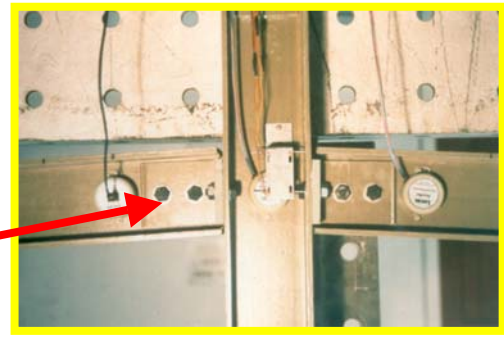
Fiberline Composites beam-to-beam web-cleated connection



Walkways, etc.

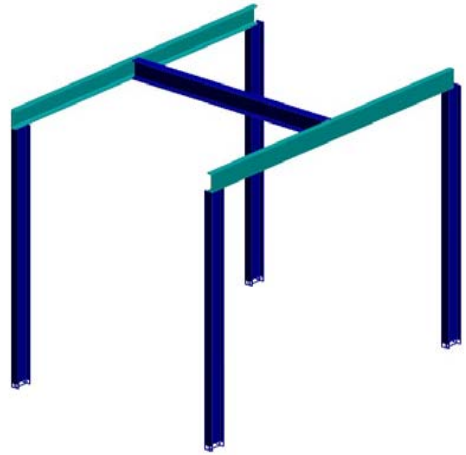
Motivation - PFRP Bolted Beam-to-Beam Connections

Many physical tests have been conducted to characterise beam-to-column connections. Web cleated connections are found to give joints which can be classified as SIMPLE.



Beam-to-beam connections have NOT been similarly characterised.

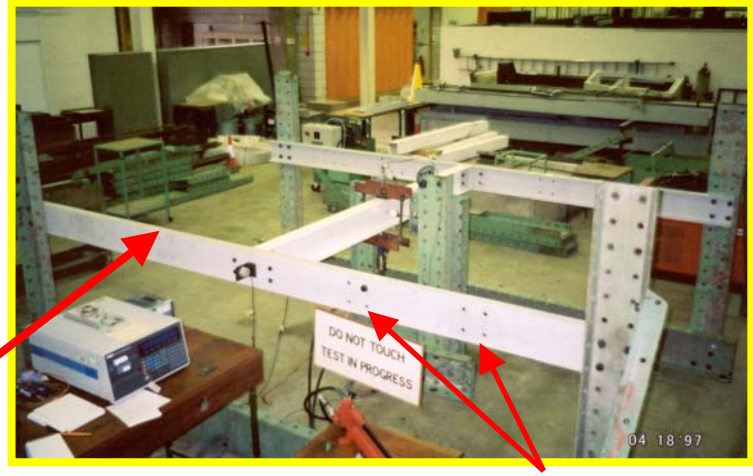
Repeating structural form for walkways



Beam-to-Beam Sub-assembly Tests

To determine the:

- **overall stiffness behaviour**
- **interaction of the main and transverse beams**
- **resistance.**



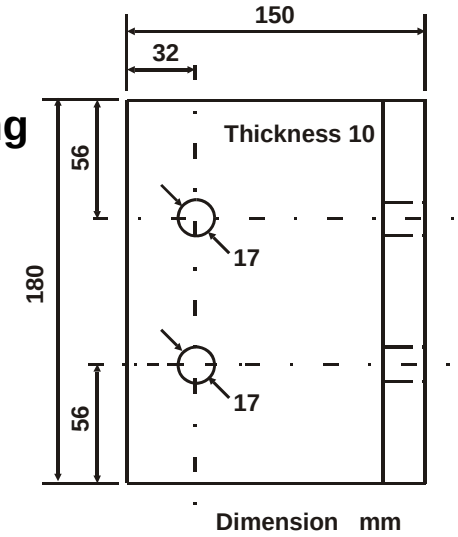
Bolt holes to change span

Main beams U 200×60×10 mm, spanning 3.64, 2.44 and 1.22 m. +

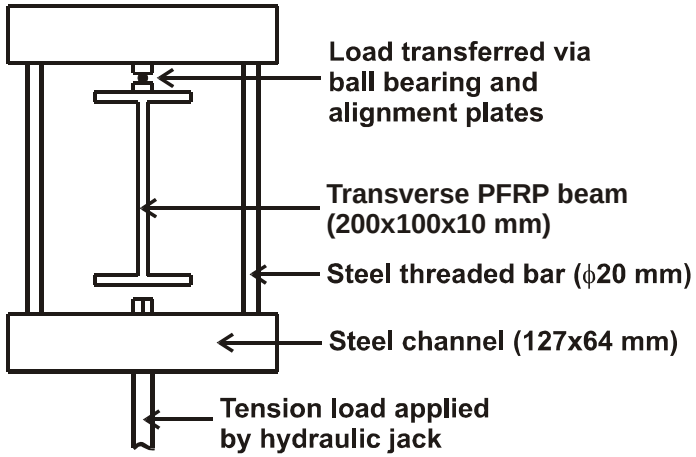
Transverse beam 200×100×10 mm, spanning 2.42 m.

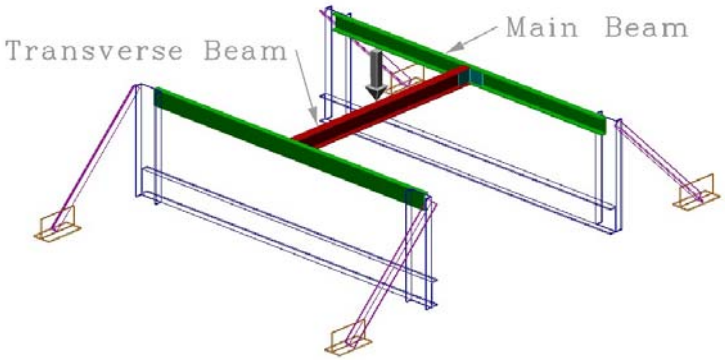
M16 stainless steel bolts and 1 mm clearance holes.

Bolts torqued to 100 Nm.

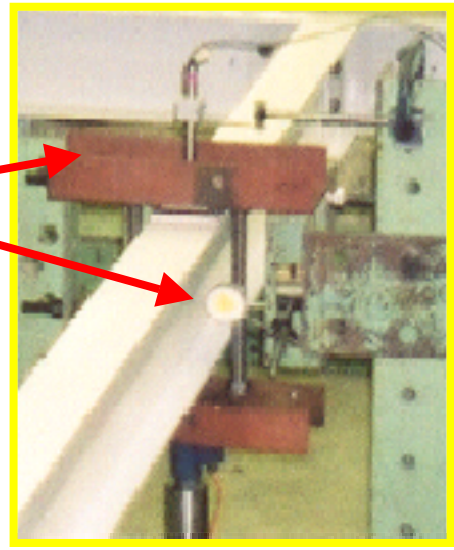


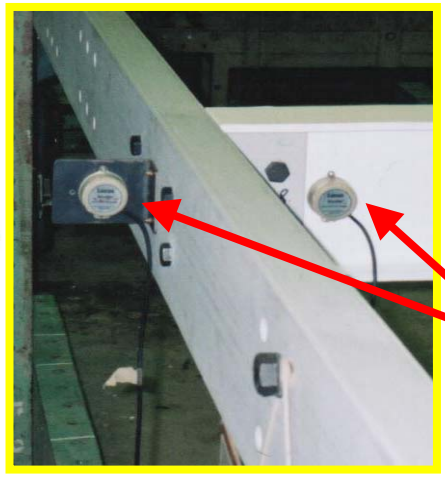
Load Fixture and Transducers





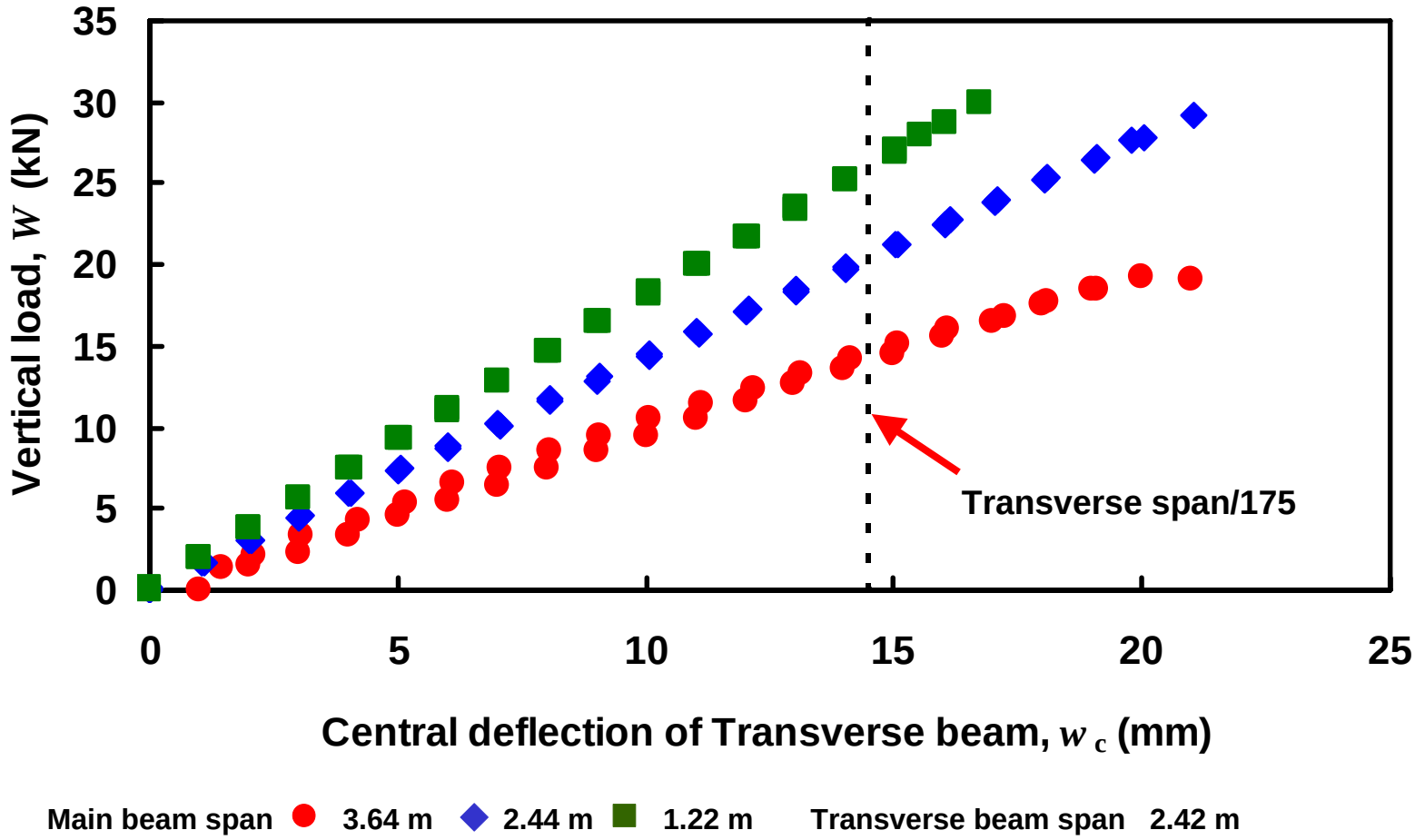
Load fixture and displacement transducers



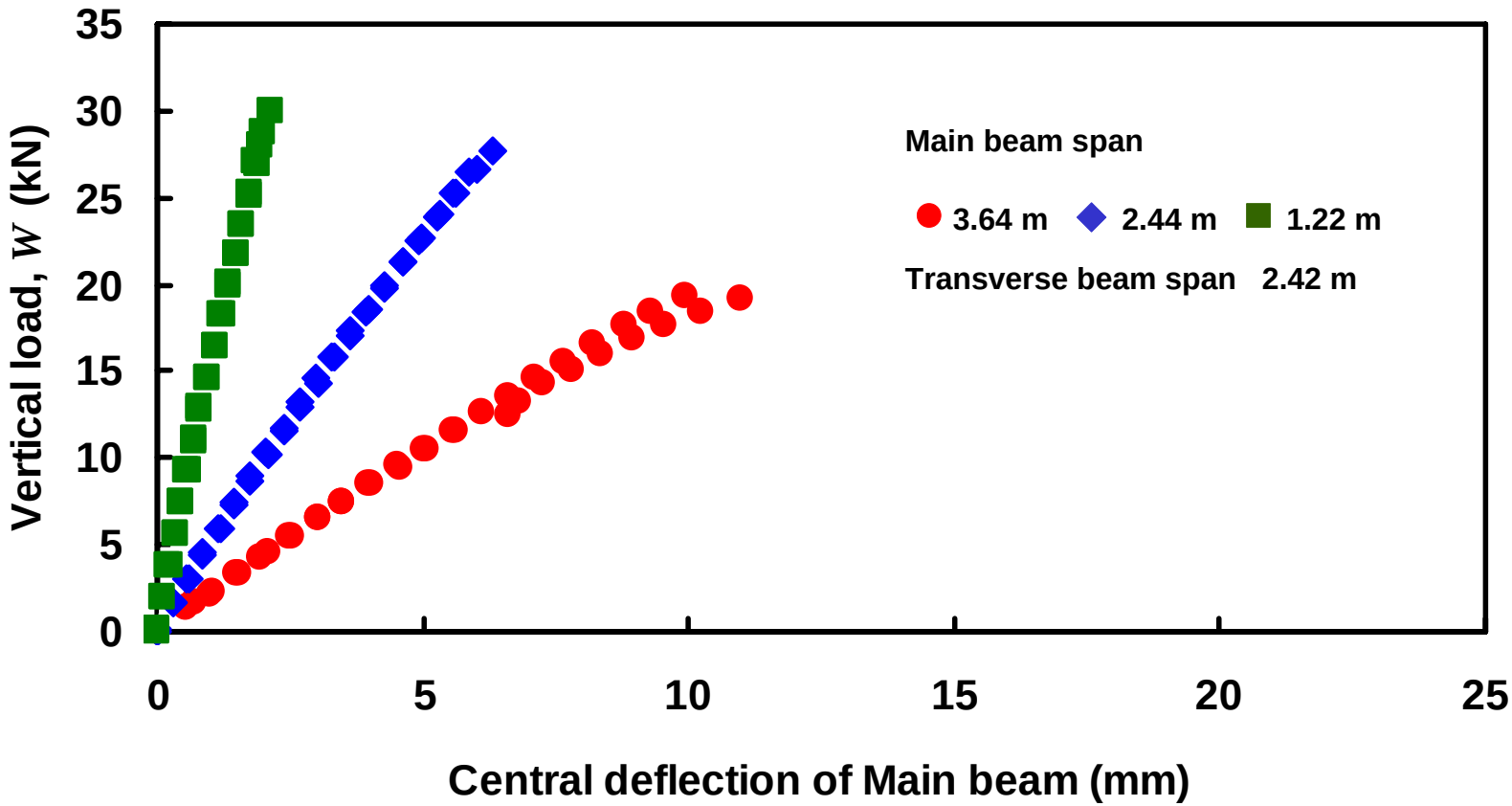


Rotation transducers on beams

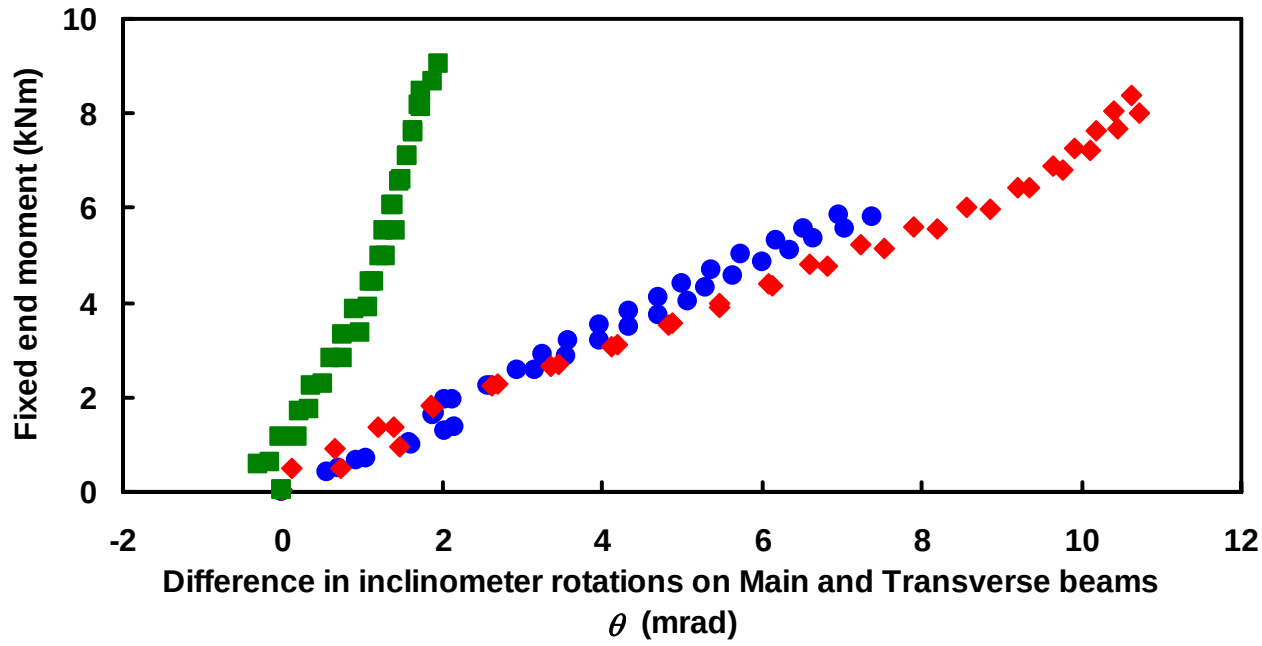
Central Deflection of Transverse Beam



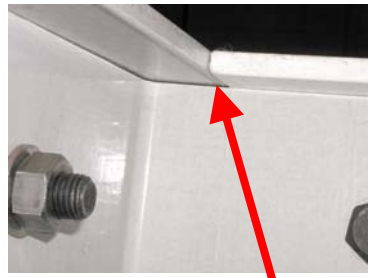
Central Deflection of Main Beam



Web Cleat Connection Rotation!

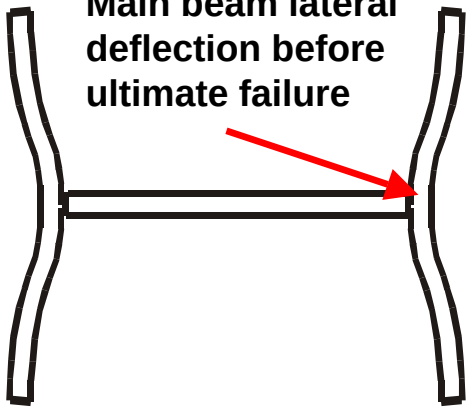


Top

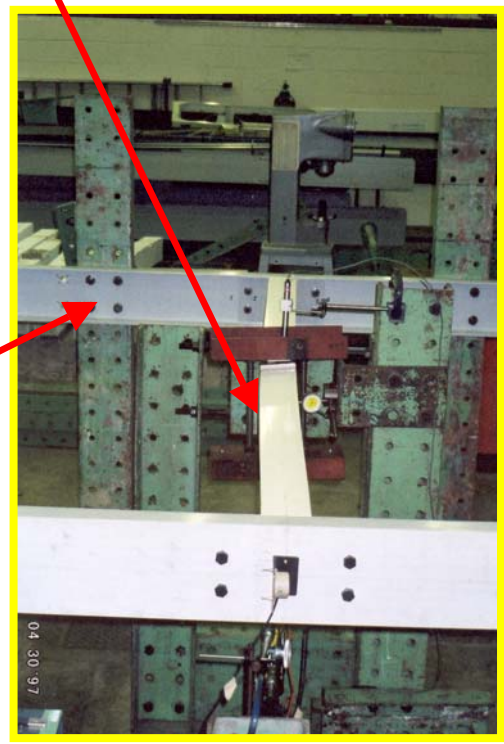


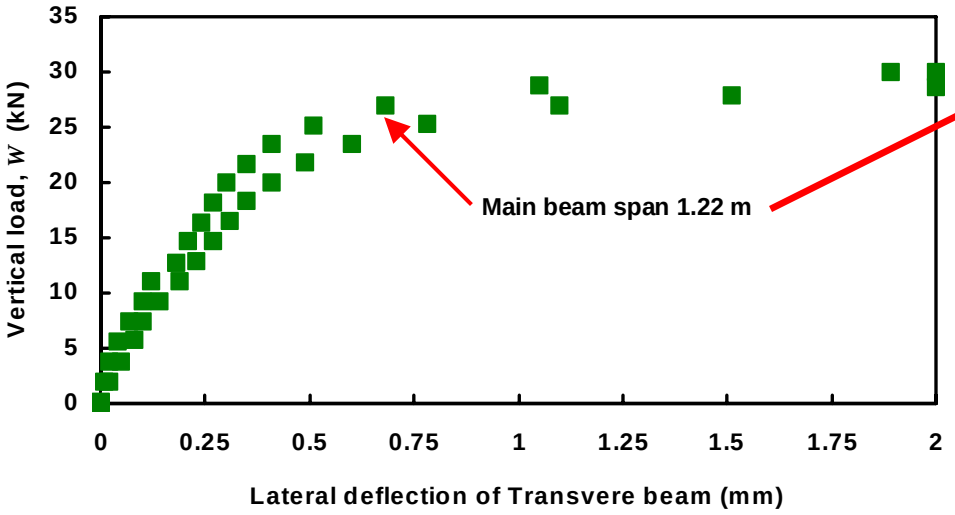
Bottom

Sub-Assembly Deformation and Failure



Lateral-torsional buckling in transverse beam





Lateral-torsional Buckling Loads (W_{cr}) using ANNEX J of EUROCODE 3

Major-axis flexure is	Minor-axis flexure is (k)	C_1	C_2	W_{cr} (kN) k_w = 1 (ss)	W_{cr} (kN) k_w = 0.5 (cl)
Simply supported (ss)	1.0 (ss)	1.07	0.432	9.4	18.5
Simply supported (ss)	0.5 (cl)	1.365	0.553	14.3	33.2
Clamped (cl)	1.0 (ss)	0.938	0.715	13.0	27.8
Clamped (cl)	0.5 (cl)	1.565	1.267	16.3	43.1

Elastic constants E = 23 GPa G = 3 GPa

Max. Test Load (W_{max}) and Sub-assembly Linear Stiffness using Simple Structural Analysis

Test	Span (m)	Test stiffness (kN/mm)	Predicted sub-frame stiffness (kN/mm)		Max. test load W_{max} (kN)
			ss web-cleats	cl web-cleats	
1●	3.64	0.96	0.94	1.03	N/A
2●	3.64	1.01	0.94	1.03	23.0
1◆	2.44	1.38	1.25	1.42	29.2
2◆	2.44	1.39	1.25	1.42	27.2
1■	1.22	1.78	1.46	1.69	30.0
2■	1.22	1.79	1.46	1.69	28.5

Conclusions

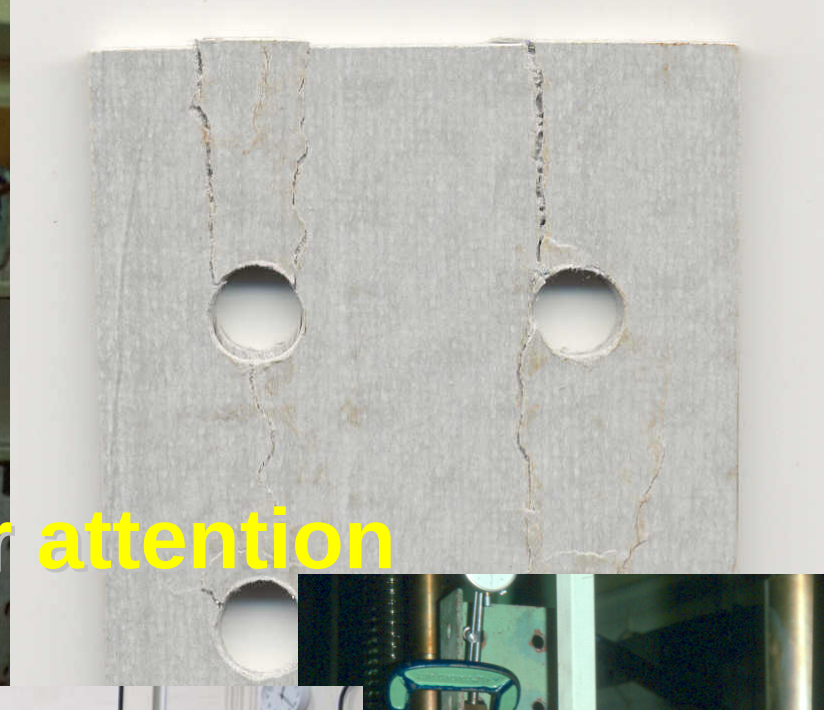
1. For the first time the structural behaviour of PFRP beam- to-beam sub-assemblies has been presented.
2. As the span of the two main beams is reduced, the increase in sub-frame stiffness is predicted reasonably by simple structural analysis.
3. Knowing the individual deflection contributions from the main and transverse beams to the sub-frame's deflection has the potential to improve guidance for the design at the Serviceability Limit State.
4. The mode of failure was lateral-torsional buckling in the transverse beam. The increase in the maximum load with a reduction in the main beam span is an important observation. (contd.)

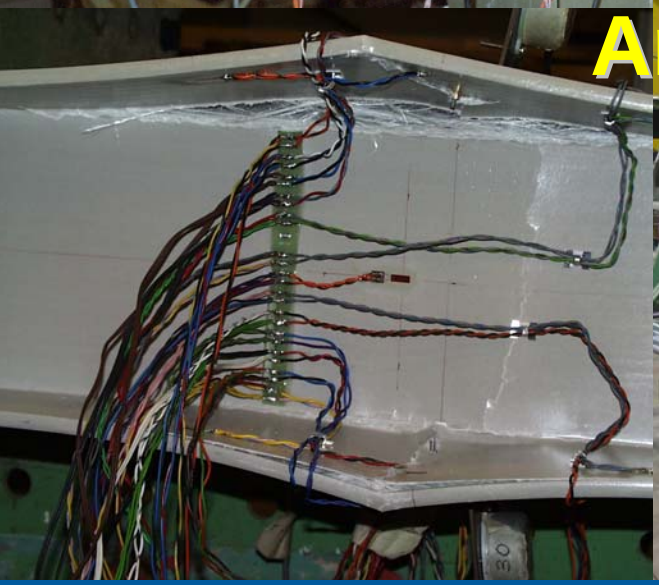
Conclusions

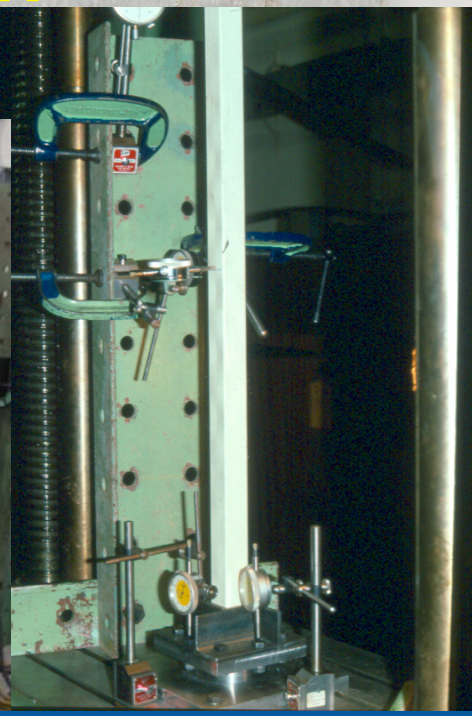
4. It emphasises the complex structural interaction between the members and the web-cleated joints. It is shown that a general expression taken from Annex F in Eurocode 3 can be used in design to predict a safe critical buckling load.

5. The classification of the Fiberline Composite A/S bolted web-cleated connections as semi-rigid or rigid is an important result.

6. Further work is necessary to confirm many of the preliminary observations, and to refine the simple structural analysis for general use in practice.







Thank you for your attention

Any questions?

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