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TEST REPORT

Ceram Reference:	121557 (QT21489/2/SL)/Ref: 1.0A
Project Title:	Tensile and Frictional Tests on the Fast Fit BeamClamp Systems
Client:	Kee Safety Limited
For The Attention of:	Mr Phil Higgs
Author(s):	Mr Peng He
Report Date:	03 May, 2012
Purchase Order No.:	std414037
Work Location:	Ceram UK

This report supersedes the report issued 20 April 2012.

Miss Lisa Cobden
Consultancy Team
Reviewer

Mr Peng He
Consultancy Team
Project Manager

CONTENTS

1 INTRODUCTION

Kee Safety Ltd provide an off the shelf Fast Fit BeamClamp system that requires no drilling or welding to connect two steel sections together. This system is designed to fit a wide range of steel section flange widths and thicknesses and at a variety of crossover angles.

Ceram proposes to carry out a programme of tests on the Fast Fit BeamClamp systems in order to assist Kee Safety Ltd to determine the static tensile capacity of the system and also the frictional capacity of the system and to better understand the performance of the system.

2 SAMPLE DESCRIPTION

The current design of the self Fast Fit BeamClamp system is available in one size which features four 15.88mm SAE Grade 5 bolts and four 15.88mm Type BM clamps. The system is made up of four plates each having four slots in them. The smaller slots are used for locating the plates together to speed up initial installation and reduce the risk of trapping hands or dropping the plate's onsite. The larger slots are designed to allow the 15.88mm bolt to pass through and secure a clamp at the top and bottom of the connection.

A general view of the slotted plate details and dimensions are illustrated in Figure 4

3 TEST PROGRAMME

3.1 Tensile Testing

Three tests were carried out for each configuration as follows:

- 90 degree configuration with 195mm wide beam sections
- 45 degree configuration with 100mm wide beam sections and furthest bolt positions

In order to determine the performance of the clamp system, the tensile load and the deflection between the two beams were measured and recorded at all times until no further load could be applied or the test was deemed to be unsafe. Deflection between the two sections of steel beam was monitored with the measurement being considered as the difference between the two recorded values. The minimum tensile load expected by Kee Safety Ltd was 150.30kN however in some instances this load was not achieved and the test was halted as it was not deemed safe to continue.

The test was considered to have failed if any of the following occurred:

- Cracking or visible defects of the clamps
- The bolts or nuts strip
- Bending of the plates is excessive and considered to be too high

3.2 Frictional Testing

Three shear tests were carried out to determine the initial frictional slip (1mm deflection after load is released) as well as the ultimate frictional load when no further load can be applied to the connection. Load should be applied until a deflection of 1mm was achieved after the load was released. The test was continued with load being applied until failure. The measurements of load and deflection were recorded throughout the test.

The test was considered to have failed if any of the following occurred:

- Any cracking or visible defects of the clamps
- The bolts or nuts strip
- The whole connection is seen to visually slip

4 TEST PREPARATION

4.1 Tensile Testing

Two 195mm wide beam sections were fastened together by the Fast Fit BeamClamp system in either 45 degree or 90 degree configuration. The upper beam was simply supported by rigid steel supports with a bearing length of 100mm at each end. A steel portal frame was bolted down to the structures lab strong floor and positioned centrally over the whole tested system with two hydraulic pull-through rams above the lower beam. The hydraulic rams were set at the same distance from the centre of the system and linked via a common manifold such that they would be able to apply tensile forces to the system equally on both sides. A general view of the test arrangement is shown in Plates 1 & 2 for both testing configurations.

Linear voltage displacement transducers (LVDT) were fixed in place so as to record deflection between the two beams at all times. The positions of the LVDTs are shown in Figure 1 & 2 for both testing configurations.

4.2 Frictional Testing

As stated in section 4.1, two 100mm wide beams were fixed together, which the bottom beam was welded down to the strong floor, by the clamp system in 90 degree configuration. A hydraulic ram was fixed to a steel column which was bolted down to the strong floor such that the ram with an incorporated load cell was positioned centrally at base intersection between web and flange of the top beam to enable application of a transverse load as shown in Plate 3.

LVDTs were fixed transversely to the top beam and the clamp system to measure the deflection between the two beams. The positions of the LVDTs are shown in Figure 3.

5 TEST METHOD

A tensile load or a frictional load as appropriate was applied to the Fast Fit BeamClamp system via the hydraulic rams at a constant loading rate until failure. The deflection was monitored by means of calibrated LVDTs and the load was measured by a calibrated load cell. Deflection and load values were recorded using a calibrated data logger.

6 RESULTS

6.1 Tensile Testing

The ultimate tensile loads and the deflections at failure are given in Tables 1 & 2 for the Fast Fit BeamClamp systems in the 90 degree and 45 degree configurations respectively. Typical failure modes of the clamp systems with the both configurations are illustrated in Plates 4 & 5.

Graphs of applied tensile load against deflection are given in Charts 1 & 2 for the 90 degree and 45 degree configurations respectively.

6.2 Frictional Testing

The maximum frictional load and the deflection at failure are given in Table 2 for each test sample.

Graphs of applied tensile load against deflection are given in Chart 3.

7 DISCUSSION

Prior to Ceram commencing tensile tests, Kee Safety Ltd stated that they considered the worst case loading scenario in tension would be achieved when the maximum sized beam was used in both directions at 90 degrees to each other i.e. the bolts were extended to their outermost position such that they could not slide further outwards in all four positions (See Figure 1). They believed that this was because the maximum bending moment of the plates would be achieved in this condition.

After initial testing of the samples in tension with the beams orientated at both 90 and 45 degrees it became apparent that the ultimate tensile capacity of the system in the 45 degree configuration was significantly lower than that when orientated in 90 degree configuration. The system in the 90 degree configuration was loaded in tension to failure such that a flexural failure was fully developed along the span of the slotted plate (See Plate 4). Vice-versa, the sample in 45 degree configuration was tested to failure which in turn was a shear failure within the slotted plate around the end of the beam flange (See Plate 5).

There are a number of effects which may have lead to this result, however, from a structural engineering point of view, it is clear that the clamps and the holding points were located close to the centre of the slotted plate on the clamp system when in the 45 degree configuration, so there would not be enough lever arm space for the flexural capacity of the plate to be fully developed. Also, shear forces normally act in combination with flexural and axial load and perhaps torsion. It is therefore quite difficult to isolate the effect of shear forces acting alone. Shear transfer in steel members relies on the yield strength of the steel as well as dimensional properties of the cross-section. The presence of a transverse tensile stress affects the strain-capacity of the steel which reduces as the tensile stress increases. As a result, when a shear force develops within the compression zone, the strain capacity of the steel in this region reduces and, hence, sections in the shear-span are more likely to fail before those subjected to pure flexure. Consequently, where the main beams crossed at 45 degrees, shear failure developed despite the span between the fixings being reduced from that when at 90 degrees. In most of the cases, failure in shear is relatively brittle compared with the more ductile failure in pure bending.

Table 1 - Results of Tensile Tests on the Fast Fit BeamClamp Systems with the 90 Degree Configuration

Test	Ultimate Tensile Load (kN)	Deflection at Ultimate Loading Condition (mm)	Failure Mode
1	133.96	13.90	Flexural failure within the slotted plate
2	122.39	11.80	
3	135.39	13.92	
Mean	**130.58**	**13.20**	**-**

Table 2 - Results of Tensile Tests on the Fast Fit BeamClamp Systems with the 45 Degree Configuration

Test	Ultimate Tensile Load (kN)	Deflection at Ultimate Loading Condition (mm)	Failure Mode
1	102.44	13.80	Shear failure within the slotted plate
2	96.84	9.47	
3	118.54	13.80	
Mean	**105.94**	**12.35**	**-**

Table 3 - Results of Frictional Tests on the Fast Fit BeamClamp Systems

Test	Initial Frictional Load at 1mm Deflection (kN)	Ultimate Frictional Load (kN)	Deflection at Ultimate Loading Condition (mm)
1	-	24.32	0.49
2	-	24.00	0.81
3	26.5	27.87	1.09
Mean	**-**	**25.40**	**0.80**

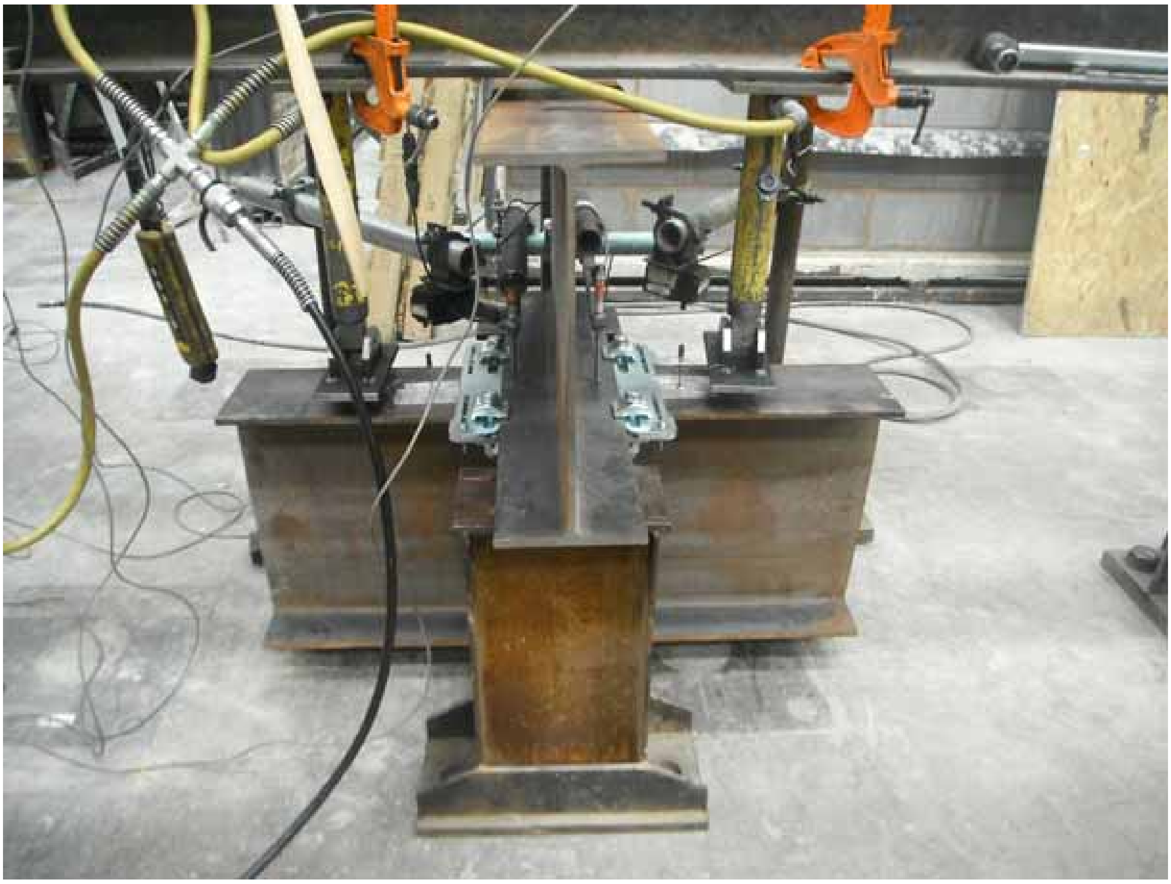


Plate 1 - General View of Tensile Test Arrangement for the Fast Fit BeamClamp System with a 90 Degree Configuration

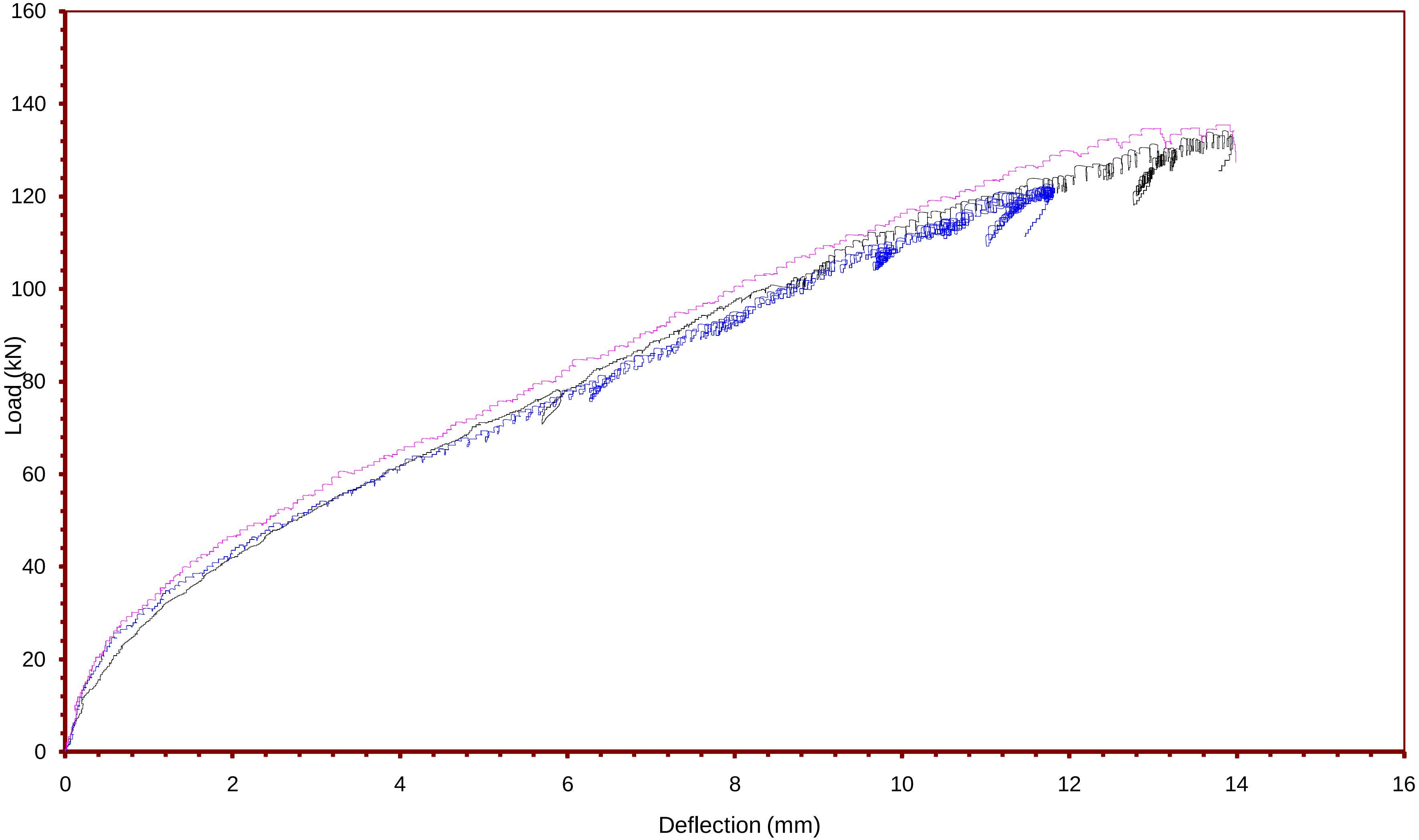
Plate 2 - General View of Tensile Test Arrangement for the Fast Fit BeamClamp System with a 45 Degree Configuration

Plate 3 - General View of Frictional Test Arrangement for the Fast Fit BeamClamp System

Plate 4 - Typical Failure of the Fast Fit BeamClamp System with a 90 Degree Configuration

Plate 5 - Typical Failure of the Fast Fit BeamClamp System with a 45 Degree Configuration

Chart 1
Load v Deflection for tensile tests
on the Fast Fit BeamClamp systems with the 90 degree configuration



Key	90 Degree Tensile Test 1	90 Degree Tensile Test 2	90 Degree Tensile Test 3	Kee Safety	Your partner in materials and technology	Queens Road, Penkhull, Stoke-on-Trent, Staffs. ST4 7LQ Tel. (01782) 746476 Fax. (01782) 764458

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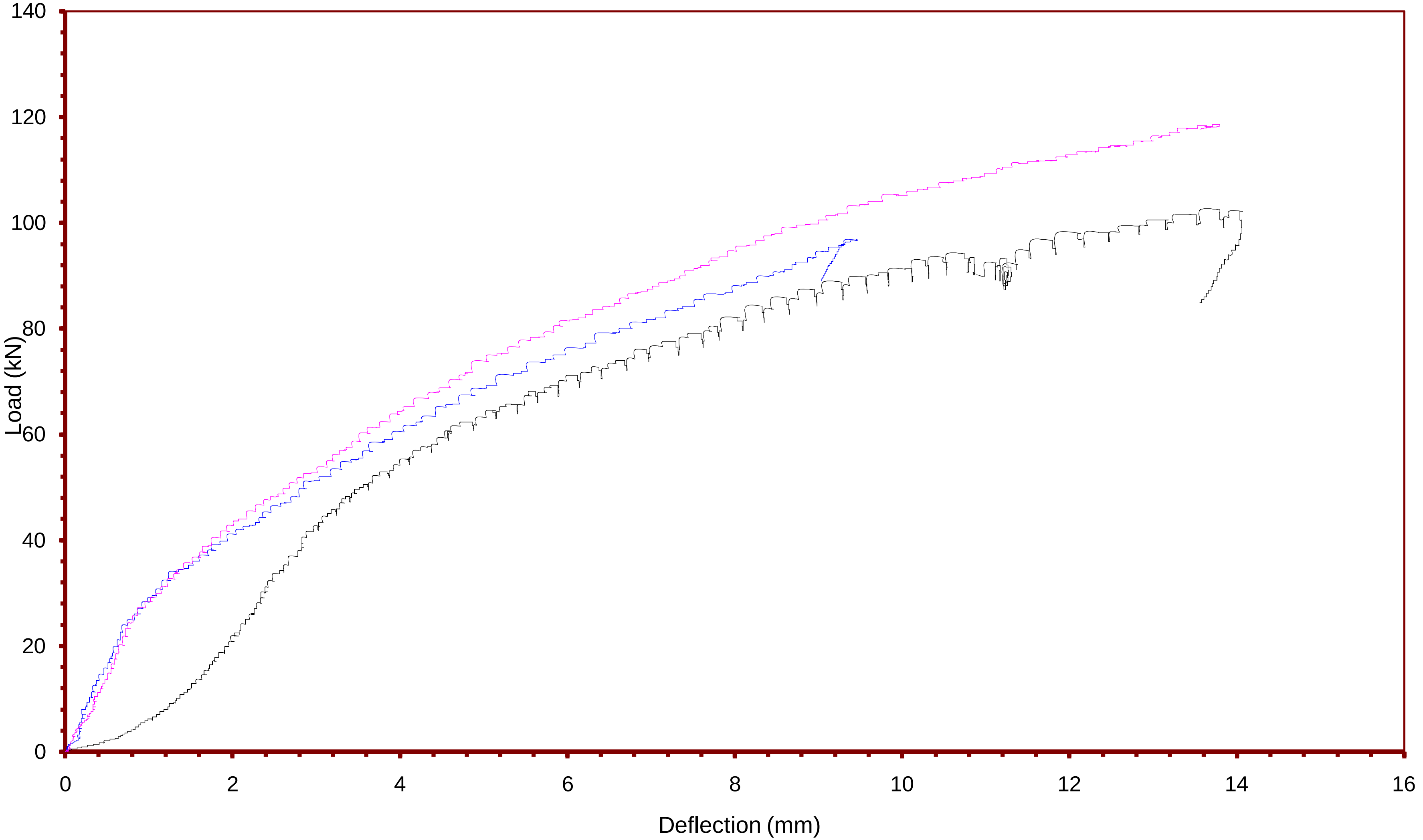
Chart 2

Load v Deflection for tensile tests

on the Fast Fit BeamClamp systems with the 45 degree configuration



Key	45 Degree Tensile Test 1 — 45 Degree Tensile Test 2 — 45 Degree Tensile Test 3	Kee Safety	Your partner in materials and technology	Queens Road, Penkhull, Stoke-on-Trent, Staffs. ST4 7LQ Tel. (01782) 746476 Fax. (01782) 764458

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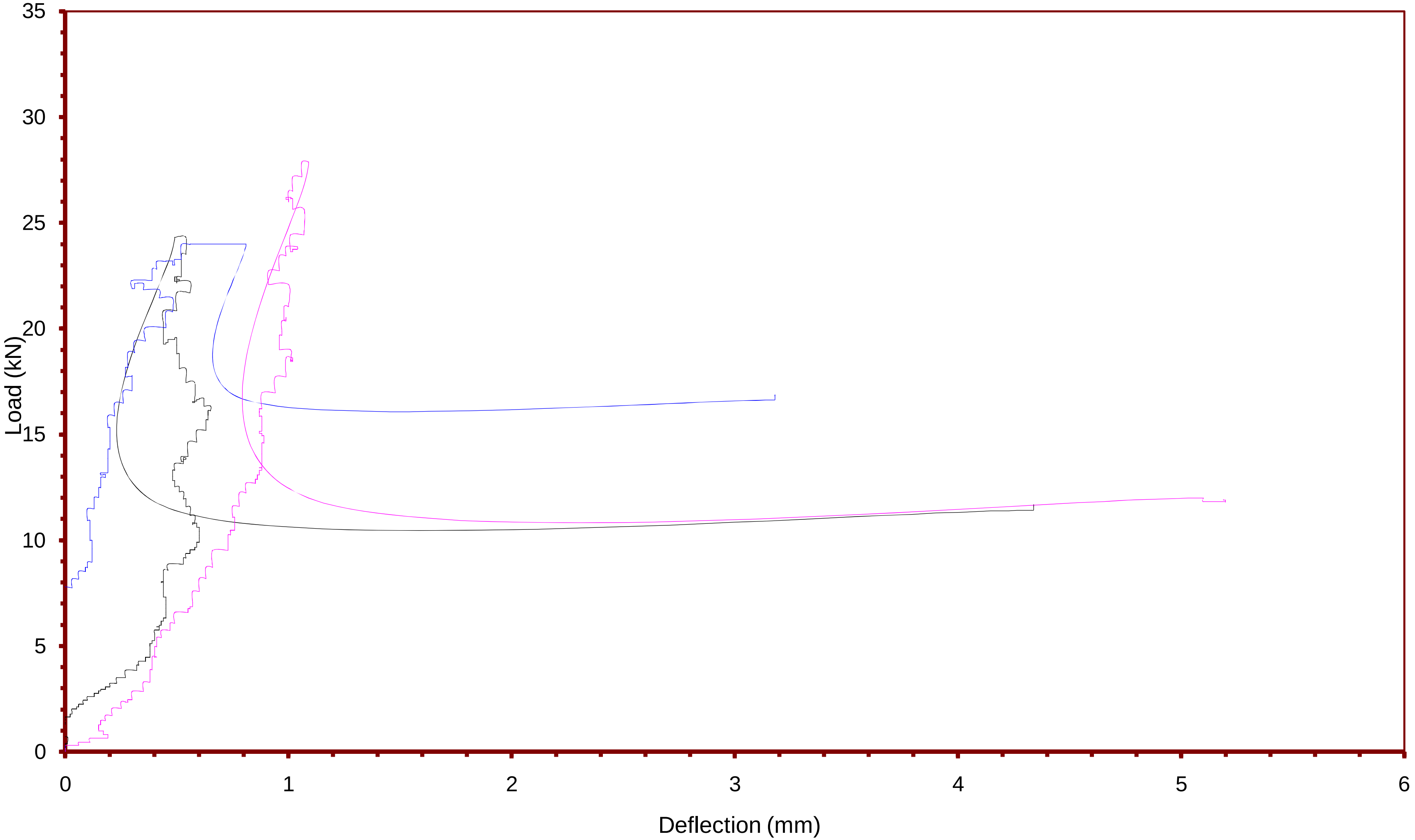
Chart 3
Load v Deflection for frictional tests
on the Fast Fit BeamClamp systems



Key	Frictional Test 1	Frictional Test 2	Frictional Test 3	Kee Safety	Your partner in materials and technology	Queens Road, Penkhull, Stoke-on-Trent, Staffs. ST4 7LQ Tel. (01782) 746476 Fax. (01782) 764458

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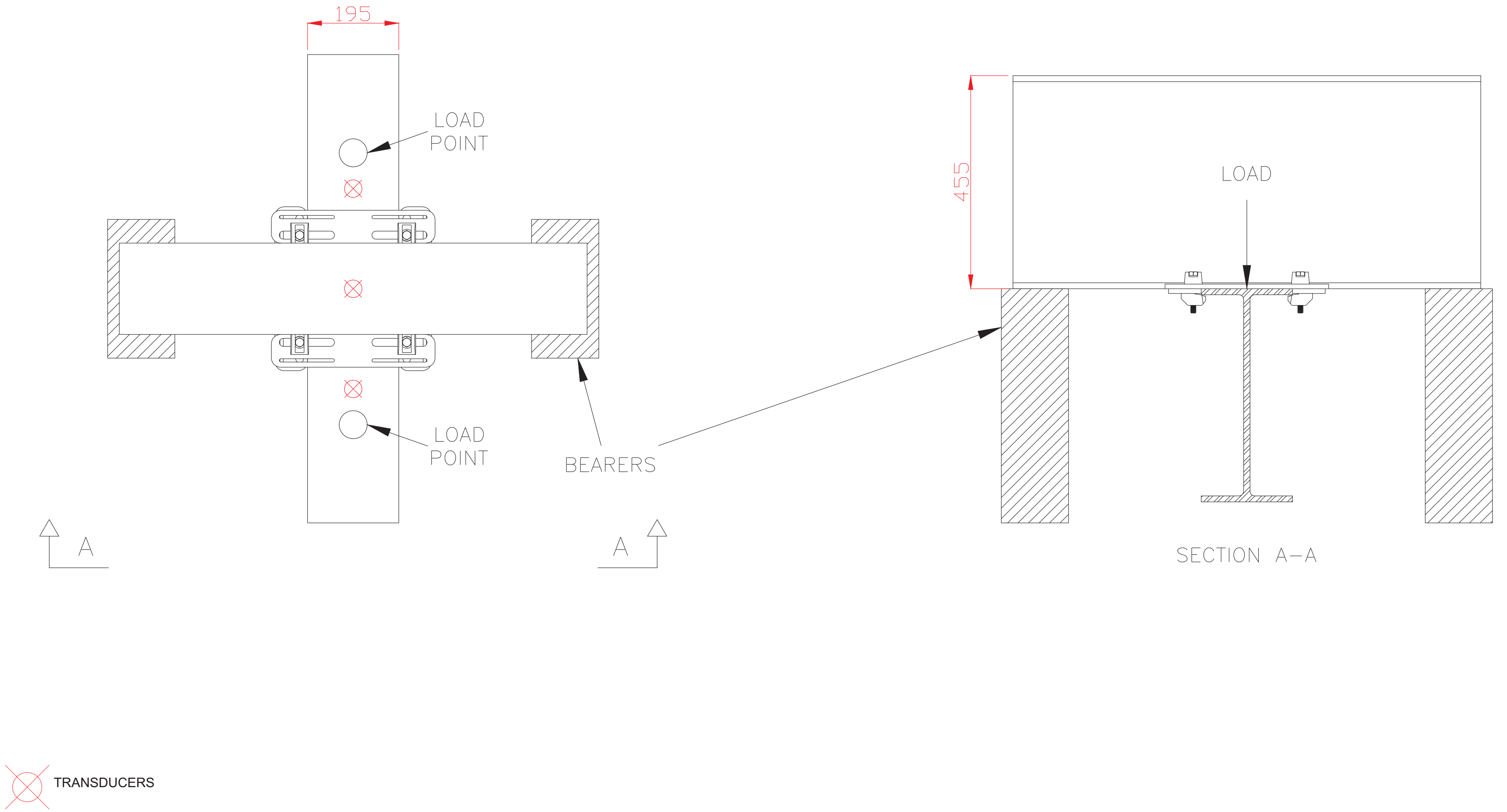

DWG. N°.	SCALE:	DATE:	DRAWN BY:
Figure 1	NOT TO SCALE	16/04/2012	A. BELLAMY

TITLE:
Detail and dimensions for 90° tension test

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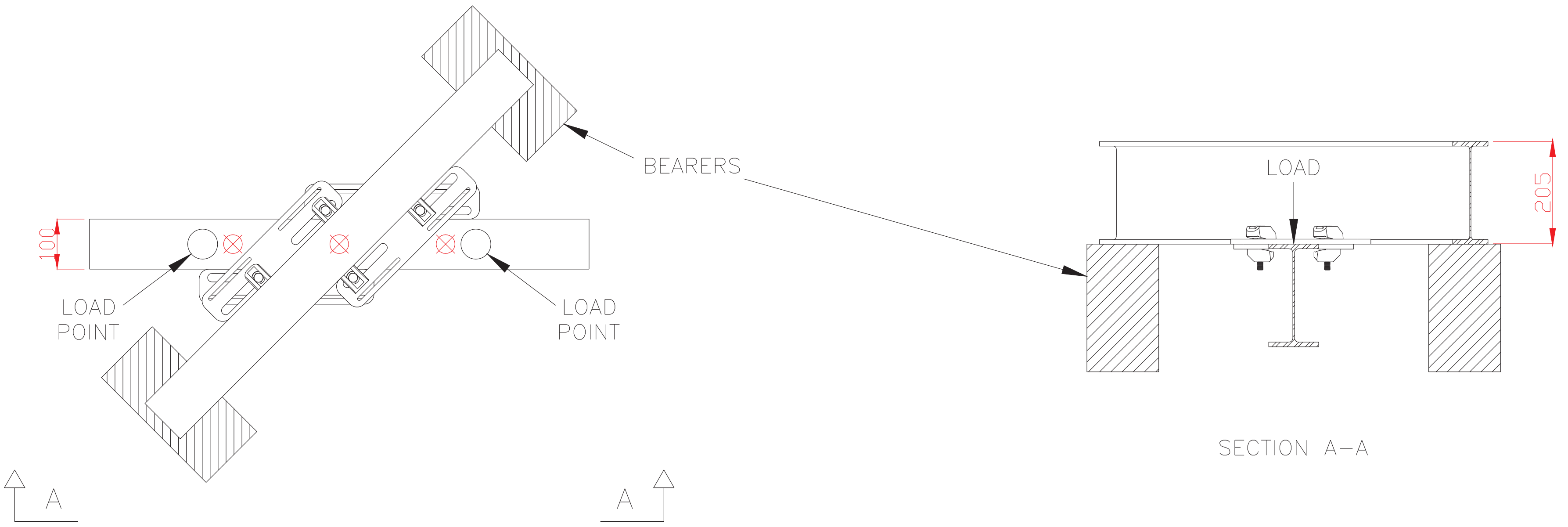

TRANSDUCERS

DWG. N°.	SCALE:	DATE:	DRAWN BY:
Figure 2	NOT TO SCALE	16/04/2012	A. BELLAMY

TITLE:
Detail and dimensions for 45° tension test

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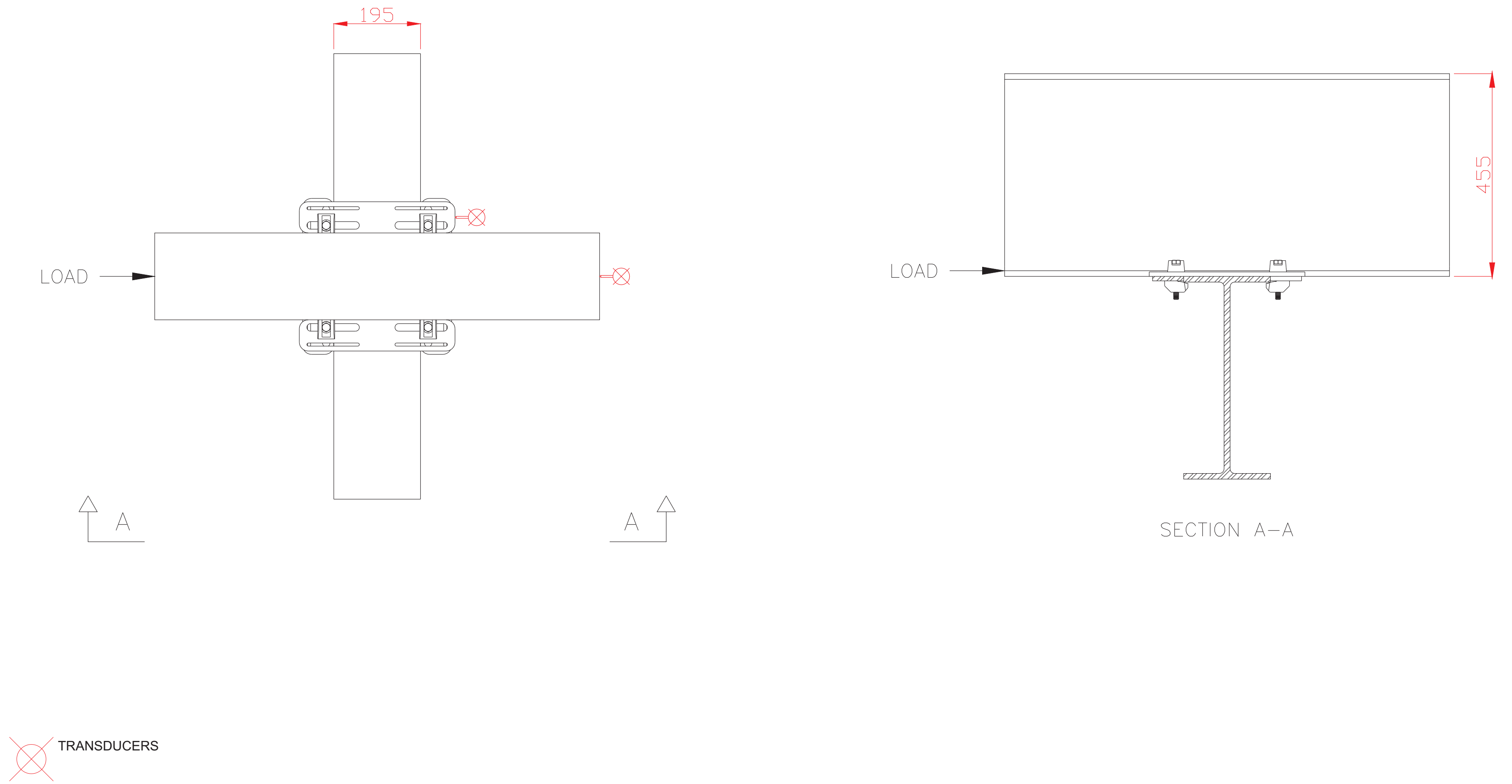

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Figure 3	NOT TO SCALE	16/04/2012	A. BELLAMY

TITLE:
Detail and dimensions for shear test

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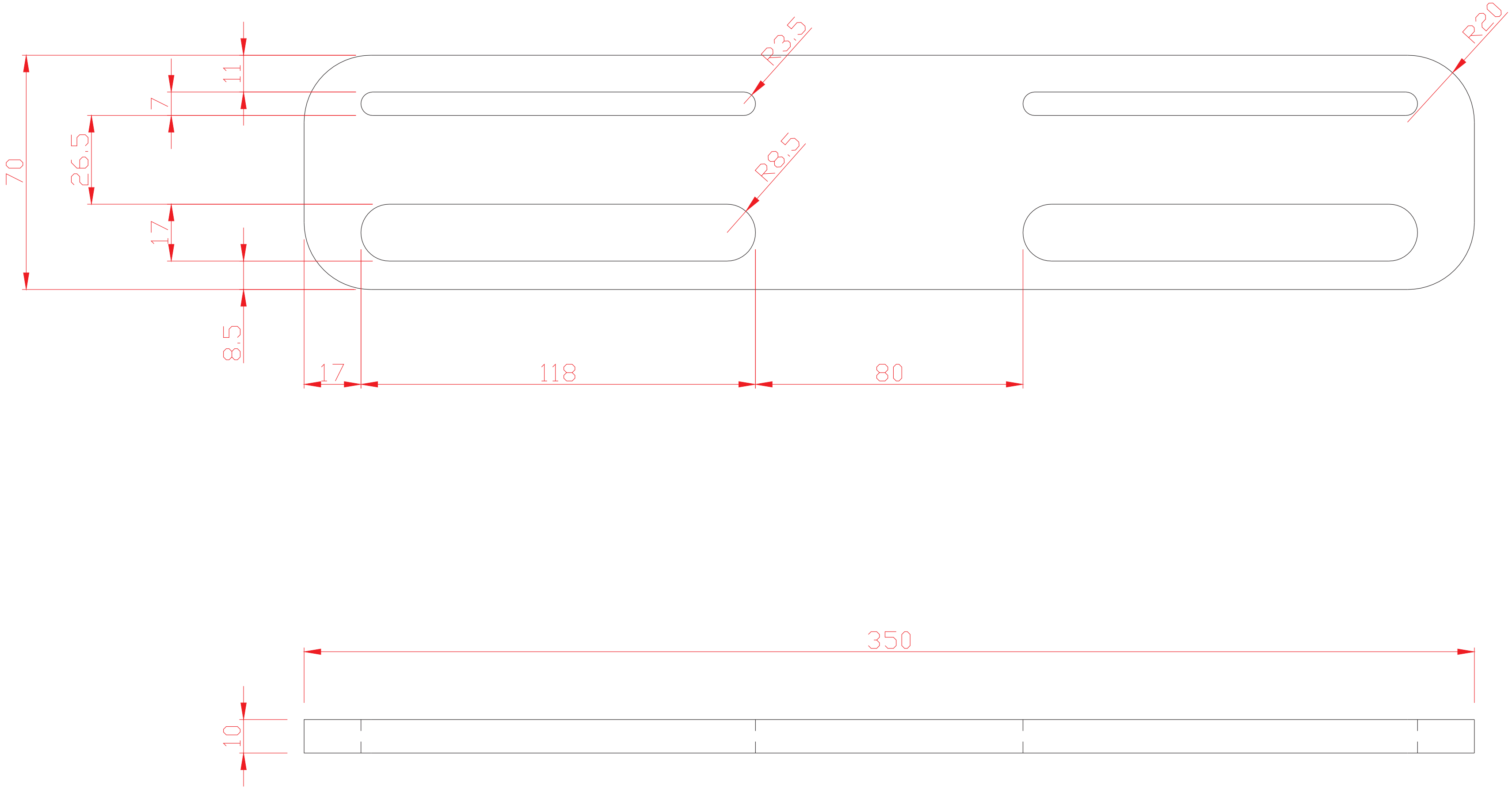

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Figure 4	NOT TO SCALE	16/04/2012	A. BELLAMY

TITLE:
Detail and dimensions for slotted plate

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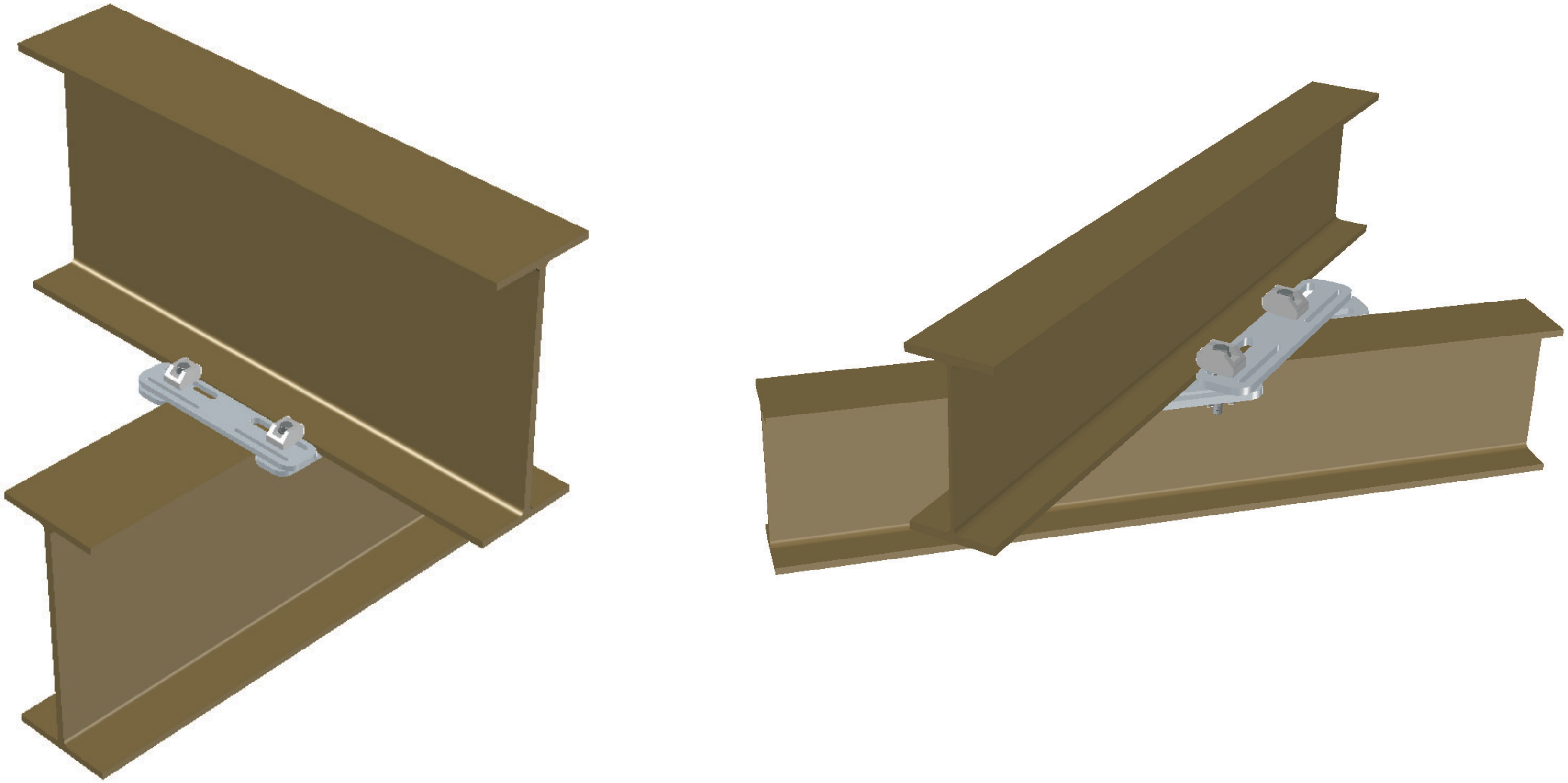

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Figure 5	NOT TO SCALE	16/04/2012	A. BELLAMY

TITLE:
General view of test arrangements

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