Glued-in basalt FRP rods as moment connections in box section frames

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Glued-in Basalt FRP Rods as moment connections in box section frame corners

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ABSTRACT: This paper presents an experimental programme that investigates the application of glued-in rods as moment connections in a post and beam connection. Nine such frame corners were constructed of box sections using a combination of sawn timber sections with orientated strand board and sawn sections with birch plywood. 12mm diameter basalt fibre reinforced polymer rods were used with a constant embedded length of $23 \cdot d_r$ (280mm) and glueline thickness of $0.125 \cdot d_r$ (2mm). Specimens with 2 no. and 3 no. rods were tested. Testing is ongoing at the time of writing this abstract therefore final conclusions cannot be drawn. However, early results show that the connection method is providing full moment transfer between the beam and post. In the OSB box sections failure was governed by the strength of the OSB beams, with the glued-in rods remaining fully intact.

KEYWORDS: Application of Glued-in Rods, Basalt FRP, Box sections, Frame corners, Multiple Rods

1 INTRODUCTION

Glued-in rods have a wide range of uses in both new build and restoration projects where they offer a sustainable alternative to traditional connection and reinforcement methods. Successful renovation using glued-in rods has been carried out in roof and floor beams in buildings subject to decay [1, 2]. In new build, five areas were identified where GiR rods may be used for connections: frame corner, beam-post connection, beam-beam joint, supports and hinged joints [3]. It is the frame corner application that is examined in this study.

Previous new build that has used the glued-in rod connection method has used steel rods embedded in to large glulam elements. In this experimental programme, the timber box sections used are constructed primarily of indigenous solid timber flanges and orientated strand board (OSB) or plywood webs. The rods used are basalt fibre reinforced polymer (BFRP). Despite its significant cost effectiveness compared to Carbon FRP and its greater tensile strength compared to Glass FRP, BFRP has only been investigated in a very limited manner for use in glued-in technology [4]. BFRP has a modulus of elasticity closer to timber than the more commonly used steel and has a significantly better weight to strength ratio. These advantages make glued-in BFRP rods the ideal connection method where a lightweight, durable and sustainable building solution is required. In order to investigate the behaviour of such a connection, nine frame corners were built and tested to failure, as summarised below.

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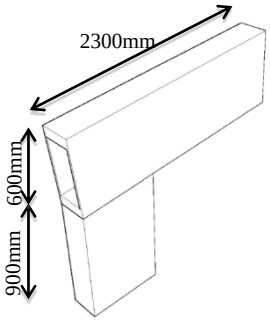
2 MATERIALS AND METHODS

2.1 SPECIMEN DETAILS AND FABRICATION

Frame corners with a 5° pitch were constructed with the dimensions shown in Figure 1 below:



Sawn timber flanges:
220mm x 70mm

OSB or Plywood Webs:
12mm x 600mm

Figure 1: *Frame corner dimensions*

Holes were drilled through the back end of the beam and in to the post and 12mm diameter Basalt fibre reinforced polymer rods embedded as per the specification detailed in Table 1. All specimens had a 2mm glueline thickness and an embedded length in the post of 280mm. A two-part thixotropic epoxy adhesive was used.

Table 1: *Specimen specification*

Series	Web Material	No. Rods	No. specimens
OFC_3	OSB	3	3
PFC_3	Birch Ply	3	3
PFC_2	Birch Ply	2	3

Rods were positioned as per the specification in Table 2 where a_1 = distance from edge of specimen and a_2 = distance from end of specimen. All dimensions are given in terms of rod diameter, d_r. Figure 2 shows a specimen in the OFC_3 series being prepared. As can be seen, an additional web stiffener was inserted at the end of the beam to locate and anchor the BFRP bars in position.

Table 2: *Drill hole positions*

Series	Rod 1		Rod 2		Rod 3	
	a_1	a_2	a_1	a_2	a_1	a_2
OFC_3	$3.5d_r$	$3d_r$	centred		$3.5d_r$	$3d_r$
PFC_3	$3.5d_r$	$3d_r$	centred		$3.5d_r$	$3d_r$
PFC_2	$3.5d_r$	$3d_r$	$3.5d_r$	$3d_r$	-	

Figure 2: *OFC_3 specimen being prepared*

2.2 TEST SETUP

Specimens were tested in a UKCAS calibrated hydraulic actuator. Figure 3 shows the test setup used.

Figure 3: *Test set-up*

Load was applied in 1.0kN steps until ultimate failure. Deflection was measured at the tip under the load point, along the top face at the back end of the specimen and near to the pivot point. Slip at each side of the post was also recorded as well as rotation about the top left-hand corner. Strain was measured using ERS gauges mounted on the timber surface at the back surface close to the beam-post interface.
Specimens were deemed to have failed when they could no longer carry any increase in applied load.

3 RESULTS

N.B. Testing of series PFC_2 and analysis of all results is currently ongoing therefore the results presented in this abstract are but a brief summary.

The most common failure mode observed in the OFC_3 series was failure of the box section itself, in all specimens in this series the glued-in rod remained completely intact. This series failed at an average applied load of 13.8kN. This was equivalent to a bending moment of 22.6kNm at the connection

Similar behaviour was observed in the PFC_3 series however it was evident that that glued-in bars were playing a more active role in these specimens with the build-up of stresses resulting in some cracking of timber at the back of the post.

It was expected that the PFC_3 series having stronger webs would fail at a higher load than the OFC_3 series and this was the case with an average failure load (applied) of 31.0kN or a bending moment of 50.9kNm at the connection

It is predicted that the PFC_2 series will fail at a similar applied load to the PFC_3 series however failure mode will move from the timber to the glued-in rod. This will allow comparison between specimens with different numbers of multiple rods as well as a comparison between the behaviour of the glued-in rod in the frame corner and that of a regular pull-out test.

4 CONCLUSIONS

Final conclusions cannot be made at the time of writing this abstract since testing is currently ongoing.
Preliminary results indicate that the connection method is providing full moment transfer between the beam and post. Where low strength timber was used, failure was governed by the strength of the OSB webs with the glued-in rods remaining fully intact.

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