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FLANGE WIDTH CONTRIBUTION TO SHEAR STRENGTH IN ENGINEERED I-JOISTS

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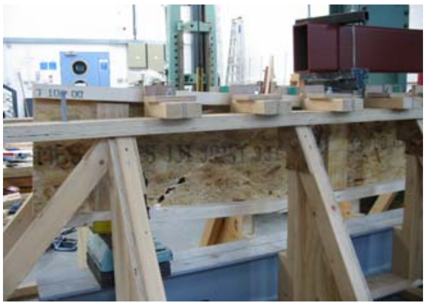

1. Introduction

Knowledge of shear performance of composite sections is of great interest to designers working with engineered timber I-joists. Unlike solid timber sections there are the additional complications of non-rectangular sections and the combined performance of two or more different materials. Whilst the shear capacity of a composite timber section can be calculated using a number of accepted methods [2]&[3] shear testing may be necessary to confirm the calculation results or as part of production quality control.

The conventional method of shear testing full size beams uses a short sample typically with a span to depth ratio of 3 to 8. This reduces the relative effect of bending increasing the likelihood of a shear failure. Several test configurations are possible, however, the results may not be consistent between methods. Analysis of daily quality assurance data from the JJ & S, Timber Systems Division plant indicated that the flanges were contributing more to the shear capacity of the joist than was theoretically predicted. A new trial was conducted testing 30 samples each with the Quality Assurance (QA) method and European Technical Approval Guidelines (ETAG) test method to assess the influence of test method on the results. This paper examines the difference in test results from the two test methods and how they compare with calculated results.

2. Testing

The shear test set-up used for QA testing (Fig. 1) was a symmetrical three-point loading over a span of 5 times the joist depth resulting in a length-in-shear of 2.5 times the depth either side of the centre line. Flat steel bearing plates (125mm long) provide the support and the vertical load is applied through a 150mm long steel plate.

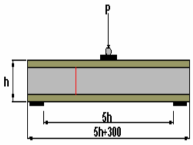

Fig.1 Schematic of three-point QA shear test set-up. The vertical line indicates the position of a web joint.

The ETAG method (Fig. 2) uses a symmetrical four-point loading over a span of 10 times the joist depth. The load is applied at two locations 6 times the joist depth apart. This results in a length-in-shear of twice the depth at each end of the sample loading and support was through 150mm steel bearing plates. For both test methods a ramped load was applied using a hydraulic ram at a displacement rate chosen to result in ultimate sample failure in approximately 300 seconds. Lateral restraint in the form of nylon faced guide plates, is provided at 600mm centres on the top flange to prevent lateral buckling of the compression member.

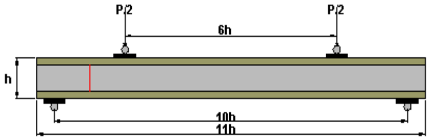

Fig.2 Schematic of four-point ETAG shear test set-up. The vertical line indicates the position of a web joint.

4. Summary

- The three-point QA shear test method results in a greater flange width effect than the four-point ETAG method.
- The ETAG method results are systematically higher than the QA method results probably due to the reduced length in shear.
- Care should be taken when choosing a shear test set-up and in applying the test results to further design work.
- Detailed FE Analysis is required to further investigate the discrepancies highlighted by the results

3. Results & Discussion

The QA samples were taken from the normal production run resulting in more test samples coming from the more popular joist specifications. To ensure a statistically meaningful (i.e. n ≥10) sample size across all four flange widths, test data for 195, 220, 245 & 300mm deep joists was used for this analysis. The flange sizes A to D were 45mm deep by 45, 60, 72 & 97mm wide respectively. The sample failure modes were predominantly web shear or web joint failure, there were, however, two other failure modes observed. These were bending failure of the bottom flange in tension, usually due to a knot or grain disturbance and perpendicular to grain compression of the top flange under the loading plate.

The results in this paper are presented as normalised figures. For example $V_{test/195}$ is the test result divided by the mean value for a 195mm deep joist and $V_{test/A}$ is the test result divided by the mean value for the A-Flange of the same depth.

Fig. 3 shows the ranked relative shear failure loads for the 195, 220, 245 & 300 A-Flange samples. The failure loads are represented as a ratio of the sample failure load to the mean failure load of the 195 A samples. It can be clearly seen that for the lower strength samples (including the 5th %ile) there is a marked difference between the shear strength of the different joist depths. This difference is less pronounced at the mean values with the spread reducing further for the higher strength samples.

The increase in strength resulting from increased flange width for all depths tested can be seen in Figures 4 to 6. These Figures suggest that flange width makes a significant contribution (up to 28% increase between and A & D flange) to the overall shear performance of the joists. In all cases this beneficial effect reduces at the low end of the strength spectrum, but is very clear at the mean values indicating its potential use in the design of load sharing systems.

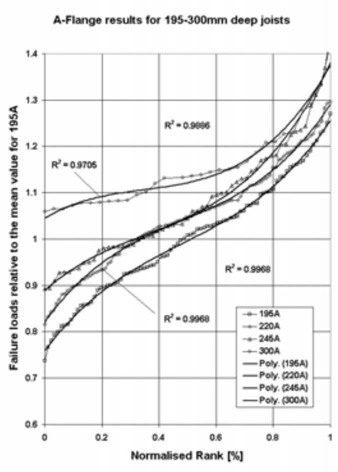

Fig. 3 A- Flange results for all depths

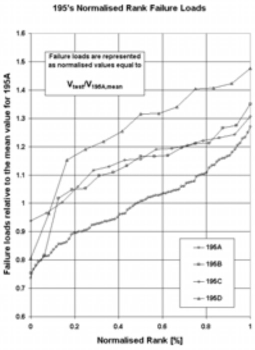

Fig. 4 All flanges at 195mm

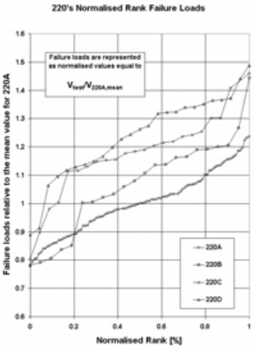

Fig. 5 All flanges at 220mm

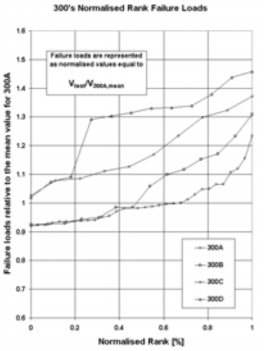

Fig. 6 All flanges at 300mm

Table 1 summarises the mean values of the QA test data showing that for the 300mm deep joists this test method indicates an increase in shear strength of 28% from A-Flange to a D-Flange.

Table 1 Summary of mean QA test results

Joist Depth	Flange Width	Sample Size	$V_{test/195}$	$V_{test/A}$	CoV (%)	SE (%)
195	45	87	1.000	1.000	12.6	1.4
	60	17	-	1.120	13.7	3.3
	72	15	-	1.141	9.4	2.4
	97	13	-	1.252	15.3	4.2
220	45	100	1.049	1.000	11.0	1.1
	60	22	-	1.067	16.1	3.4
	72	24	-	1.180	12.9	2.6
	97	25	-	1.236	12.1	2.4
245	45	59	1.077	1.000	11.8	1.5
	60	23	-	1.099	11.7	2.4
	72	10	-	1.214	14.0	4.4
	97	21	-	1.254	12.9	2.8
300	45	32	1.153	1.000	7.5	1.3
	60	14	-	1.056	12.0	3.2
	72	10	-	1.183	9.9	3.1
	97	12	-	1.281	11.1	3.2

Table 2 summarises the results of the comparative trial between the QA and ETAG test methods.

Table 2 QA/ETAG comparison

Test Method	Joist Depth	Flange Width	V_{QA-A}	$V_{ETAG/QA}$	$V_{A-Flange}$	CoV (%)	SE (%)
QA	245	45	1.00	1.00	1.00	13.6	3.5
	245	97	1.27	1.00	1.27	10.6	2.8
ETAG	245	45	1.36	1.36	1.00	14.4	3.8
	245	97	1.48	1.16	1.09	11.1	2.9