UniS

University of Surrey
School of Engineering
Civil Engineering

Report on Racking Tests on 15 mm Bitroc and Bitvent Bitumen Impregnated Insulation Boards

For

Hunton Fiber UK Ltd

By

Dr D R Griffiths
Dipl.-Ing. J Bregulla

April 2002

Report No CV/ST/0402/1

Racking Tests on 15 mm Bitroc and Bitvent Bitumen Impregnated Insulation Boards

by

Dr D R Griffiths
Dipl.-Ing. J L Bregulla
University of Surrey

Contents | Page No.

Prepared for

Hunton Fiber UK Ltd

and

British Board of Agrément

1. Introduction and Objectives

The Heavy Structures Laboratory of the Civil Engineering Department of the University of Surrey was commissioned by **Hunton Fiber UK** Ltd to carry out standard racking tests on wall panels sheathed with two of their bitumen impregnated insulation board (BIIB) sheathings, **Bitroc** and **Bitvent**. Both had a nominal thickness of 15 mm. All panels were fixed using 3.35 mm nails using the standard nailing pattern for BIIB sheathings. The panels were tested in accordance with BS EN 594: 1996 (Ref. 1) and the results were reduced using BS 5268 Section 6.1: 1996 (Ref. 2). Each board material was tested under zero and 5 kN/ stud load and the weaker of the two boards was then subjected to a further test at each vertical load, meeting the minimum requirements for testing stated in BS 5268 Section 6.1.

A total number of six panels were tested, three at zero and three panels at 5 kN/stud vertical load. This enabled the principal objective of the work, which was to derive a value for Basic Racking Resistance (BRR) which would be safe for both 15mm Bitvent and Bitroc. The work allowed direct comparison with previous racking tests on Hunton boards but in the current tests extra calibration procedures were included to allow British Board of Agrément certification of the results.

2. Panel Details

The 2.4 m x 2.4 m standard test panels, detailed in Figure 1, were framed with 90 mm x 40 mm C16 grade European Redwood/ Whitewood timber. Test experience shows that frames alone have negligible racking resistance and that the effect of timber grade does not significantly affect the test performance. This factor has greater relevance as the strength and density of the sheathing material decreases. The studs were spaced at 580 mm centres for the end studs and at 600 mm centres internally. Top and bottom rails were fixed to the studs using two 100 mm long by 4.3 mm diameter hot dipped galvanised wire nails.

The Hunton boards were fixed to the frame by 50 mm long 3.35 mm diameter electro galvanised wire nails at 75 mm centres along the board perimeters and at 150 mm centres on internal studs. A Spotnail pneumatic tool was used to drive the nails and was set so that the nail heads just penetrated the sheathing. The nail length was slightly less than that recommended by BS 5268 Part 2 (Ref. 3) but is appropriate for use with BIIB since nail pullout is highly unlikely. Its use can only be conservative but in reality will not have affected performance. The sheathing was fixed with the long edge vertical, which is typical for timber frame panels as it avoids the need for noggins at mid height. The two sheets were joined on the centre stud with no gap between the boards. On the centre stud the edge nailing distance was approximately 9 mm, however along the more vulnerable bottom edge of the board, where it was fixed to the bottom rail, an edge distance of 18 mm was achieved.

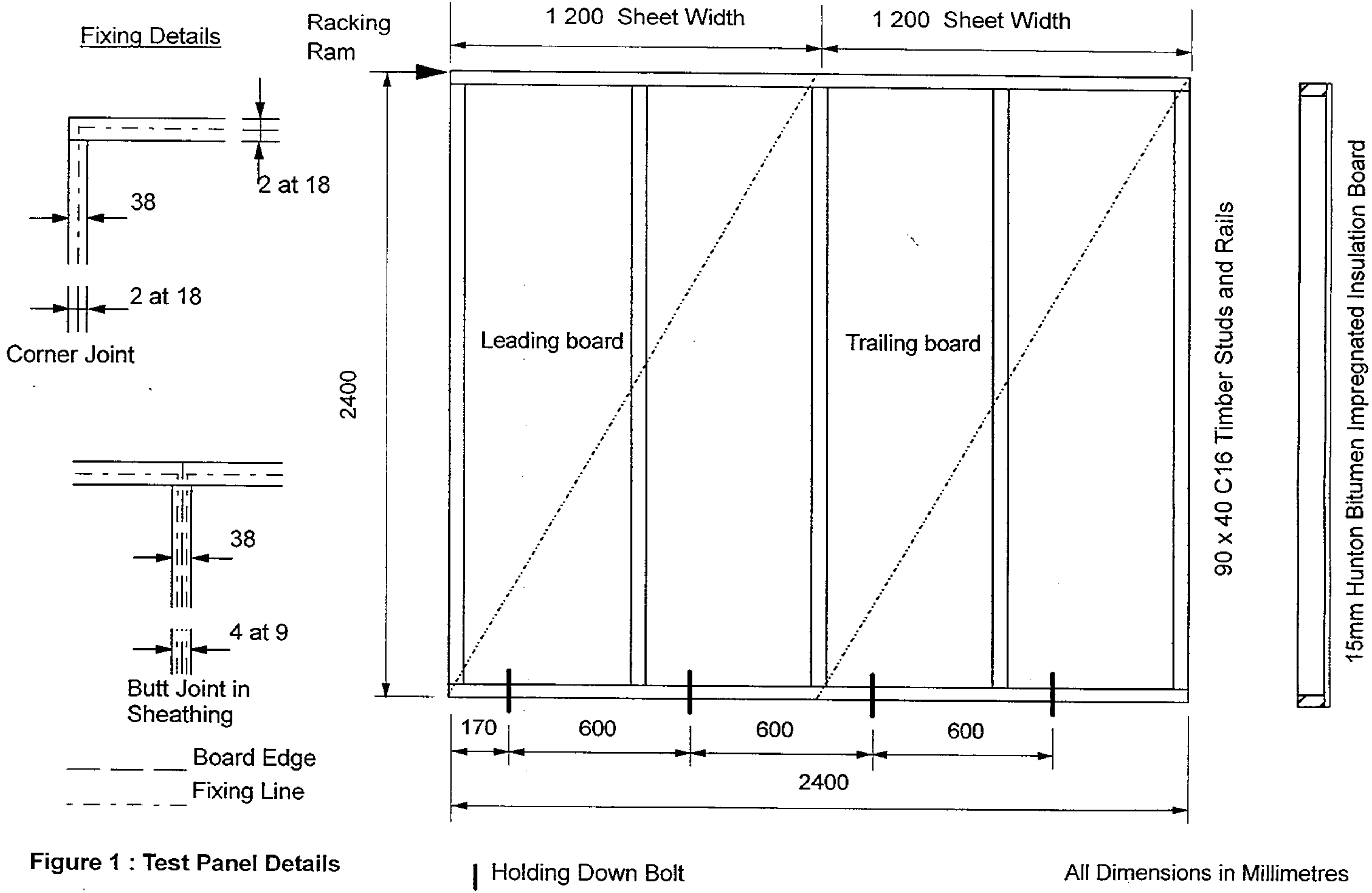


Figure 1 : Test Panel Details

3. The Test Rig

The panels were tested in purpose made rig that had previously been used for more than 350 racking tests. The rig enabled the panels to be loaded vertically and horizontally within their planes whilst allowing horizontal racking and upward movement. Restraint was provided against lateral deflection. Applied loads were measured by pressure gauges for the vertical loads, but supported by one load cell under the leading jack, and by a load cell for the horizontal racking load. Deflection measurements were taken using linear variable displacement transducers (LVDTs) at the top front and top rear of the panel for horizontal movement, at the bottom rear for sliding and the bottom front for uplift. Electronic data from the load cells and transducers was recorded and processed by an ORION data logger and PC computer system. The test rig fully complied with the Code requirements. Figure 2 shows the loading points and measurement locations for the deflection readings for each panel. Calibration certificates for the load cells and LVDTs are shown in Appendix A.

4. Test Procedure

The standard test procedure outlined in BS EN 594: 1996 (Ref. 1) has been used throughout the tests together with the method of reduction to determine design values given in BS 5268 Section 6.1: 1996 (Ref. 2). Each panel was tested under one vertical load only. A vertical pre-load cycle was performed on each panel to seat it in the test rig. The racking test procedure consisted of the stabilising cycle, the stiffness cycle and a strength test. Details of each cycle are described in the Code. Before a full test can be performed an estimation of the panel's maximum racking load is required in order to determine the stabilising load (0.1 $F_{max\ est}$) and the stiffness cycle test load (0.4 $F_{max\ est}$). The code allows an estimated maximum load to be within 20% of the test maximum before results must be checked. The estimated maximum load is allowed to be adjusted as further tests proceed to attain a value close to the test failure load and thereby achieve a more accurate stiffness result for the panel. During the tests the panels were carefully monitored for damage. Racking was continued after failure as indicated by maximum load to check for recovery of the panel. Damage at this stage is secondary but is used to indicate the weaker areas within the overall construction

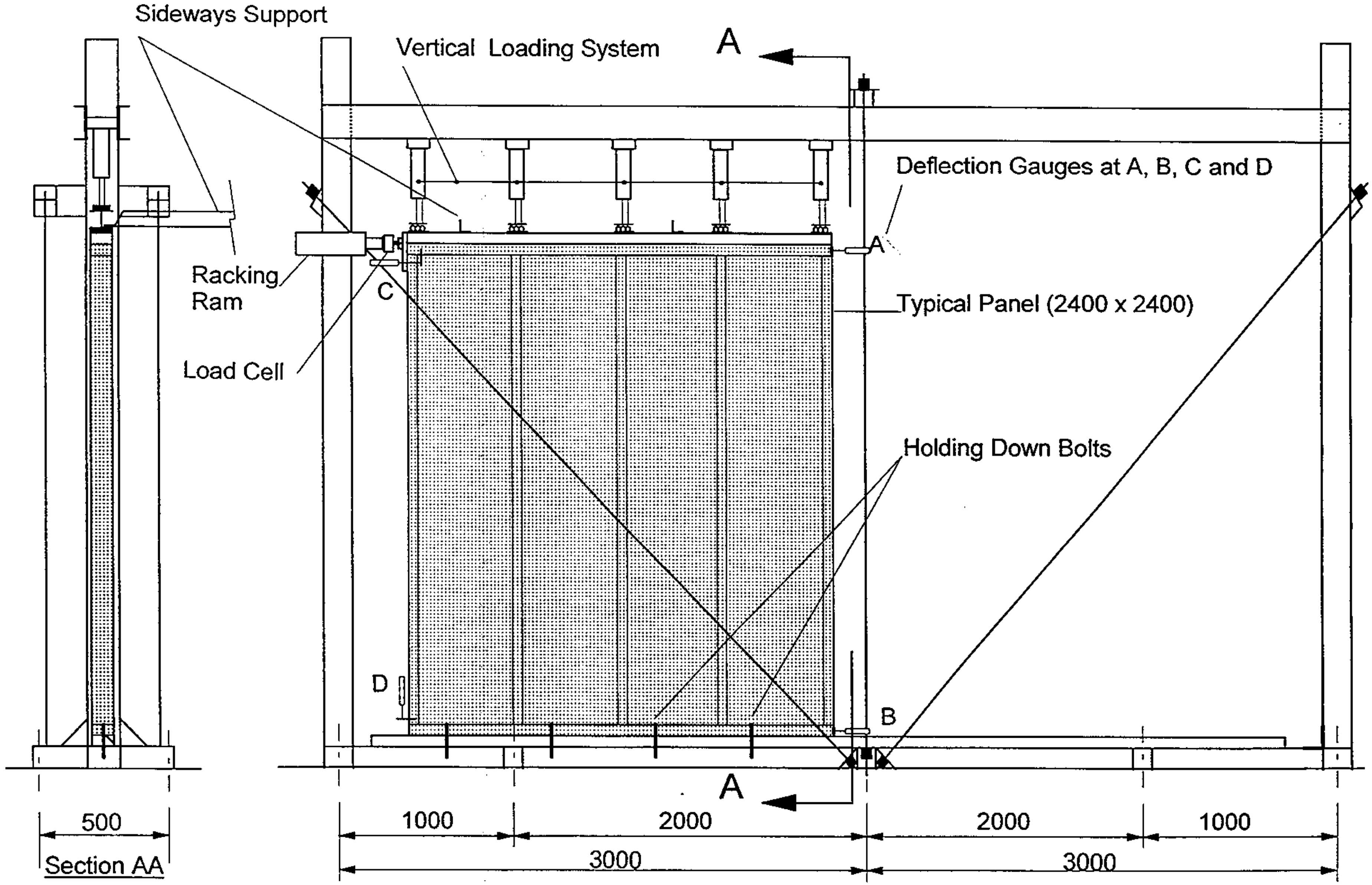


Figure 2 Racking test rig

5. Results

The data recorded for the six test panels is shown in Table 1 and the racking load versus racking deflection plots for each panel are shown in Figures 3 to 8. Sample board densities are recorded in Table 2 along with the load per unit face area of the panel and the thickness of the panel. A discussion of this table and the appropriate readings is given in Appendix B.

The results show the Bitroc board to perform better than the Bitvent but this is very much in proportion with the board densities.

As would be expected the strength performance of the boards is markedly higher under the 5 kN per stud vertical load but unusually the stiffness of the panels is little affected by vertical load. Inspection of the results does not reveal any abnormalities in performance and previous work on BIIBs using EN 594 confirms this trend (Ref. 4).

In one case, Panel 1, the estimation of the failure load was outside the limits prescribed by the Code and has resulted in the stiffness of the panel, being measured over a lower proportion of the true panel strength. This means the stiffness will have been over-estimated. Fortunately the stiffness behaviour is fairly linear in this area so the effect is small and the reduction of the results has shown that stiffness does not influence overall panel performance.

At failure the panel performance was reasonably ductile at both zero and 5 kN/stud vertical loads. Typically, maximum load was reached at around a deflection of 20 mm under zero vertical load and 50 mm under 5 kN/ stud vertical load. 90% of failure load was sustained over a deflection of 10 mm and 20 mm respectively for the two vertical load conditions. The ductility is a consequence of the mode of failure, which was similar for both boards and reasonably similar for the two vertical load conditions. All failures are a result of bearing in the plane of the board causing elongation of the nail holes as the board moves relative the frame under racking forces.

The critical zone is where the sheathing is attached to the leading end of the bottom rail. Here the differential movement of the board relative to the restrained bottom rail is very high. At the maximum load the vertical movement of the leading stud is approximately 10 mm and 12-15 mm for the two load cases and this deformation would be similar to the maximum displacement of a nail in the bottom edge of the board. At this displacement, due to the edge distance of the nails, the board will have torn around the nail removing its contribution to panel resistance and leading to overall failure. The effect of vertical load is to reduce the significance of the failure of the leading nails in the bottom rail, allowing greater uplifts before maximum load is reached.

The second area of weakness in all panel tests is the vertical joint of the two boards on the centre stud where, due to the racking load, the leading board is moving down relative to the stud and the trailing board is moving up. In both vertical load cases relative movement is detected at failure. Typically the movement is greater at failure under 5 kN/stud load due to the greater racking deflections and the more independent rotations of the two boards

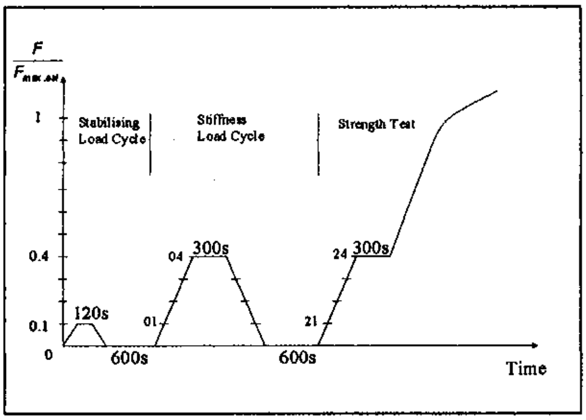
Table 1: Test Data

Panel ID	3 (HNBr15-E)	4 (HNBv15-F)	5 (HNBv15-G)	1 (HNBr15-C)	2 (HNBv15-D)	6 (HNBv15-H)
Board type	Bitroc	Bitvent	Bitvent	Bitroc	Bitvent	Bitvent
Vertical load	0			5		
F01 (kN)	0.81	0.8	0.82	1.04	1.04	1.15
w01(mm)	0.5	0.45	0.53	0.31	0.4	0.38
F04	3.22	3.2	3.2	4.42	4.39	4.42
w04	2.97	2.73	3.4	2.73	4.04	3.64
F21	0.87	0.83	0.87	1.16	1.11	1.15
w21	1.51	1.08	1.44	0.98	1.94	1.79
F24	3.22	3.21	3.21	4.42	4.43	4.43
w24	3.23	3.03	3.62	3.11	4.88	4.32
R (N/mm) [1)]	**1170.99**	**1136.57**	**951.33**	**1463.61**	**1024.79**	**1149.76**
$F_{max\ est}$ [kN]	8	8	8	11	11	11
F_{max} (kN)	**8.17**	**7.82**	**6.99**	**13.7**	**11.55**	**11.77**
Deflection at F_{max} (mm)	**23.89**	**22.07**	**18.66**	**49.72**	**52.13**	**52.77**
Error in $F_{max\ est}$ (%) [2)]	**2.13**	**2.25**	**-12.63**	**24.54** [3)]	**5.00**	**7.00**

NOTES

1) Racking stiffness

$R = 0.5x[(F04 - F01)/(w04 - w01) + (F24 - F21)/(w24 - w21)]$



Extract from BS 594: 1996: Loading History Diagram

2) $$\left(\frac{F_{max} - F_{max\ est}}{F_{max}}\right) \times 100\%$$

3) Underestimation of F_{max} will give increased stiffness for panel.
However, stiffness is not critical to design. Also behaviour is fairly linear in this area.

Table 2: Board Density Information for Bitroc and Bitvent

SPECIMEN	Width- 1 (mm)	Width- 2 (mm)	Length- 3 (mm)	Length- 4 (mm)	Thick- 1 (mm)	Thick- 2 (mm)	Thick- 3 (mm)	Thick- 4 (mm)	AverageThickness (mm)	Weight (g)	Density (Av. Thickn.) (kg/m³)	Nominal Thickness (mm)	Density (Nom. Thickn.)	Design Thickness (mm)	Density (Design Thickn.)	Area Weight[4] (kg/m²)
Board 1																
BR-A(end)	*199.79*	*199.82*	*199.87*	*199.98*	*15.39*	*15.8*	*15.61*	*15.47*	15.57	*192.06*	309		321		300	4.81
BR-B(end)	*200.01*	*200.11*	*199.8*	*199.78*	*15.86*	*15.14*	*15.00*	*15.73*	15.43	*187.90*	305		313		294	4.70
BR-C(mid)	*199.56*	*199.98*	*199.4*	*199.56*	*15.71*	*15.74*	*15.65*	*15.76*	15.72	*191.12*	305		320		300	4.80
BR-D(mid)	*199.95*	*199.68*	*199.59*	*199.40*	*15.43*	*15.41*	*15.86*	*15.60*	15.58	*193.01*	311		323		303	4.84
Average	199.83	199.90	199.67	199.68	15.60	15.52	15.53	15.64	15.57[1]	191.02	307.38	15	319.12[2]	16	299.17[3]	4.79
Board 2																
BR-E(mid)	*199.62*	*199.54*	*199.61*	*199.52*	*15.59*	*15.49*	*15.91*	*15.83*	15.71	*185.19*	296		310		291	4.65
BR-F(mid)	*199.68*	*199.70*	*199.32*	*199.30*	*15.60*	*15.48*	*15.83*	*15.61*	15.63	*181.95*	292		305		286	4.57
BR-G(end)	*199.27*	*199.27*	*199.94*	*199.52*	*15.40*	*15.80*	*15.92*	*15.60*	15.68	*185.02*	296		310		291	4.65
BR-H(end)	*199.64*	*199.66*	*199.70*	*199.16*	*15.65*	*15.76*	*15.68*	*15.68*	15.69	*184.00*	294		308		289	4.62
Average	199.55	199.54	199.64	199.38	15.56	15.63	15.84	15.68	15.68[1]	184.04	294.88	15	308.19[2]	16	288.92[3]	4.62

SPECIMEN	Width- 1 (mm)	Width- 2 (mm)	Length- 3 (mm)	Length- 4 (mm)	Thick- 1 (mm)	Thick- 2 (mm)	Thick- 3 (mm)	Thick- 4 (mm)	AverageThickness (mm)	Weight (g)	Density (Av. Thickn.) (kg/m³)	Nominal Thickness (mm)	Density (Nom. Thickn.)	Design Thickness (mm)	Density (Design Thickn.)	Area Weight[4] (kg/m²)
Board 1																
BV-A(end)	*199.20*	*199.25*	*199.82*	*199.34*	*16.43*	*16.62*	*17.05*	*16.68*	16.70	*174.90*	263		293		275	4.40
BV-B(end)	*200.19*	*199.58*	*199.62*	*199.58*	*16.65*	*16.51*	*16.35*	*16.16*	16.42	*171.96*	263		287		269	4.31
BV-C(mid)	*199.70*	*199.40*	*199.60*	*199.61*	*16.35*	*16.40*	*16.21*	*16.43*	16.35	*172.43*	265		289		271	4.33
BV-D(mid)	*199.45*	*199.42*	*199.72*	*199.71*	*16.17*	*16.12*	*16.08*	*16.15*	16.13	*171.08*	266		286		268	4.30
Average	199.635	199.4125	199.69	199.56	16.4	16.4125	16.4225	16.355	16.39[1]	172.59	264.28	15	288.88[2]	16	270.83[3]	4.33
Board 2																
BV-E(end)	*199.36*	*199.59*	*199.43*	*199.58*	*16.37*	*16.63*	*16.66*	*16.8*	16.62	*176.86*	267		296		278	4.44
BV-F(end)	*199.28*	*199*	*199.27*	*199.44*	*16.69*	*16.22*	*16.64*	*16.74*	16.57	*177.71*	270		298		280	4.48
BV-G(mid)	*199.37*	*199.51*	*199.1*	*199.01*	*16.67*	*16.54*	*16.52*	*16.53*	16.57	*178.78*	272		300		281	4.50
BV-H(mid)	*199.49*	*199.42*	*199.44*	*199.03*	*16.54*	*16.55*	*16.35*	*16.39*	16.46	*175.35*	268		294		276	4.41
Average	199.375	199.38	199.31	199.265	16.5675	16.485	16.5425	16.615	16.55[1]	177.18	269.39	15	297.27[2]	16	278.69[3]	4.46

Untested Bitvent

SPECIMEN	Width- 1 (mm)	Width- 2 (mm)	Length- 3 (mm)	Length- 4 (mm)	Thick- 1 (mm)	Thick- 2 (mm)	Thick- 3 (mm)	Thick- 4 (mm)	AverageThickness (mm)	Weight (g)	Density (Av. Thickn.) (kg/m³)	Nominal Thickness (mm)	Density (Nom. Thickn.)	Design Thickness (mm)	Density (Design Thickn.)	Area Weight[4] (kg/m²)
Board 1																
BV-1	*199.85*	*199.93*	*199.73*	*199.88*	*15.01*	*15.29*	*15.13*	*15.23*	15.17[1]	*143.36*	236.69	15.00	239.30[2]	16	224.34[3]	3.59

Notes

1) The average density of the boards as measured
2) The average density of the board using the nominal thickness instead of the measured thicknesses
3) The design thickness of the board to achieve target density 280, +20, -10 kg/m³ i.e. Range 300 kg/m³ down to 270 kg/m³
4) Area weight is independent of thickness and is a more uniform assessment as board thickness is prone to variation related to compression in storage. Area weight best describes the mass of the material bearing on a nail and will therefore be more indicative of panel performance. Area weight is the multiple of density and thickness but is calculated as Weight/(Length x Width)

when a vertical load is present on the centre stud. However, a greater movement is noted at zero vertical load than would be expected in stronger and more brittle board materials. This observation is closely linked to the similarities in stiffness of the panels at the two vertical loads.

In some cases it is notable that where relative nail movements are greater there is a tendency for the board to pull away from the frame such that the nail head penetrates into the board. This may have greater significance with the Bitroc where the benefit of the denser surface layer would be lost.

6. Reduction of results

The result of the six racking tests are combined in Table 3 and are reduced as required by the Code to give a Basic Racking Resistance (BRR) for the board material. This is a single performance figure, which will work conservatively with Code modifications factors to provide design values for wall units. The value for the BRR covers both vertical load and stiffness/ strength behaviour and is reduced from the critical test condition. In the reductions it is important to note that stiffness is based on average test performance and strength on lowest test performance. A modification factor is then included to take account of the reliability of the results based on the number of similar tests.

In the Hunton tests the results for the two boards have been combined due to similarities in behaviour recorded during these and previous tests (Ref. 4).

The BRR value calculated for the Hunton boards is 1.58 kN/m and this can be seen to be critical to the strength performance at 5 kN/stud vertical load. This form of result is typical for BIIBs but the value of 1.58 kN/m is relatively high as a result of the thickness of the board, its density and its bitumen content.

The relative performance for strength and stiffness at zero vertical load is more typical of racking tests. At 5 kN/stud the very small improvement in stiffness, noted to be more characteristic of BIIBs, has resulted in a much smaller differential. The improvement of the strength result with vertical load is lower than that expected of denser sheathing boards such as plywood and oriented strand board and on which the Code values for K_{111} and K_{107} have been based. However, the difference is less than expected of the BIIBs tested in the 1970's, which were typically less dense, and only 12 mm thick. As a consequence the use of the BRR result shows only 7% loss in efficiency at zero vertical load.

7. Comparisons with Code values for BRR

The value of 1.58 kN/m determined for the 15 mm Hunton BIIBs relates to the use of 3.35 mm diameter nails in the standard fixing pattern for BIIB of 75 mm centres on board perimeters and 150 mm centres on internal studs to the board. The Code value for BIIB of 0.9 kN/m is a lower bound value for such boards and relates to a 12 mm thickness and the use of 3.0 mm diameter nails. Table 4 compares the values for the appropriate range of

Table 3: Reduction of Results

	Abbr.	Panel Number					
		3	4	5	1	2	6
		(HNBr15-E)	(HNBv15-F)	(HNBv15-G)	(HNBr15-C)	(HNBv15-D)	(HNBv15-H)
Vertical load (kN)	F_v	0			5		
Racking stiffness (N/mm)	R	1171	1137	951	1464	1025	1150
Maximum load (kN)	F	8.17	7.82	6.99	13.7	11.55	11.77
DESIGN STIFFNESS							
Average stiffness (N/mm)	R_{mean}	1086			1213		
No. of tests		3			3		
Modification factor	K_{109}	0.93			0.93		
Design stiffness load (kN)[1)]	R_1	**6.06**			**6.77**		
DESIGN STRENGTH							
Lowest failure	F_{min}	6.99			11.55		
No. of tests		3			3		
Modification factor	K_{109}	0.93			0.93		
Factor of Safety	FofS	1.6			1.6		
Design strength[2)]	R_2	**4.06**			**6.71**		
BASIC RACKING RESISTANCE							
Design load (kN)[3)]	R_3	4.06			6.71		
Design resistance (kN/m)[4)]	DRR	1.69			2.80		
Vertical load modification factor	K_{111}	1			1.77		
Basic racking resistance (kN/m)[5)]	BRR	**1.69**			**1.58**		

1) $R_1 = R_{mean} \times 0.002 \times H_{WP} \times 1.25 \times K_{109}$

2) $R_2 = F_{min} \times K_{109} / FofS$

3) *Lower of* R_1 *and* R_2

4) R_3 */ Length of partition*

5) $BRR = DRR / K_{111}$

nails and enhances the Code value to cover a 15 mm board. It can then be shown that in direct comparison the test performance for the Hunton boards is 39 % higher than the Code value.

The test value may be substituted for the Code value of BRR and used safely with all wall modification factors, i.e. those for length, openings, vertical load and height. Additionally it is recommended that

(i) the test value can be used with the K_{101} nail diameter factor to predict performance for nails reducing in diameter to 2.8 mm

(ii) the test value should not be used with the material modification factors for thickness (K_{103}), nail spacing (K_{102}) and nail size (K_{101}) in general due to the limited amount of test data and the degree of improvement over the Code value.

Table 4 also shows the performance of Category 1 sheathings for the range of nail diameters.

Table 4: Test Racking Resistance Values (kN/m) for Hunton Boards compared with Code Values (kN/m)

Nail diameter (mm)	*Category II boards*		*Hunton Bitroc and Bitvent*	*Category I boards*
	12 mm BIIB	*15 mm BIIB*	*15 mm*	
2.87	0.86	0.98	1.35	1.61
3.00 (Code norm)	0.9	1.02	1.41	1.68
3.35 (tested)	1.01	1.14	1.58	1.88

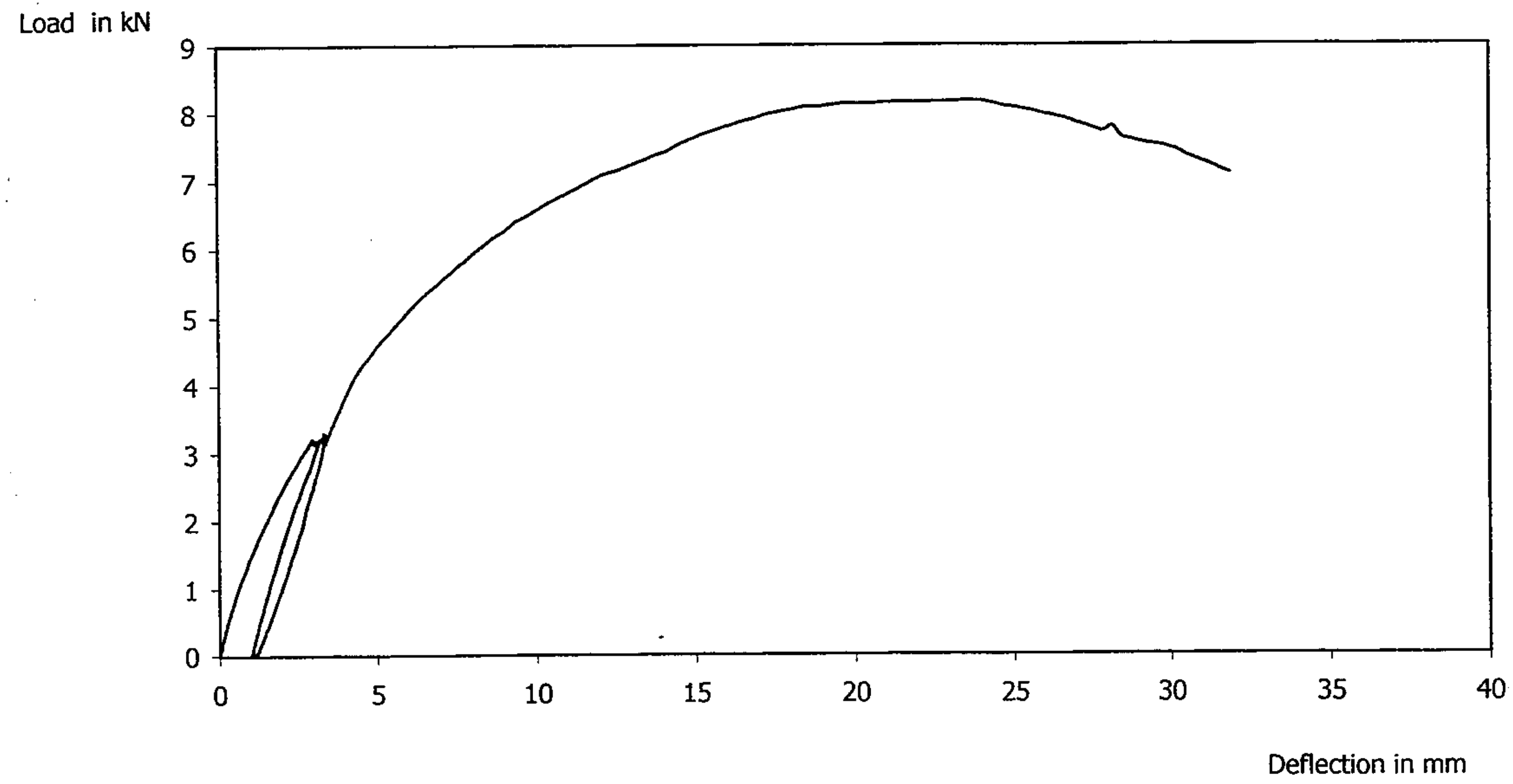
8. Conclusions

Both Hunton Bitroc and Bitvent boards performed well in the racking tests. The design value for BRR of 1.58 kN/m has been derived for safe use with these boards and shows a substantial increase on the Code value for a lower bound BIIB material.

D R Griffiths

D R Griffiths
University of Surrey
April 2002

<u>Figure 3:</u> Test 3 Bitroc (HNBr15-E)
15 mm board, 3.35 mm nails
Vertical Load: 0 kN/Stud



<u>Figure 4:</u> Test 4 Bitvent (HNBv15-F)
15 mm board, 3.35 mm nails
Vertical load: 0kN/Stud

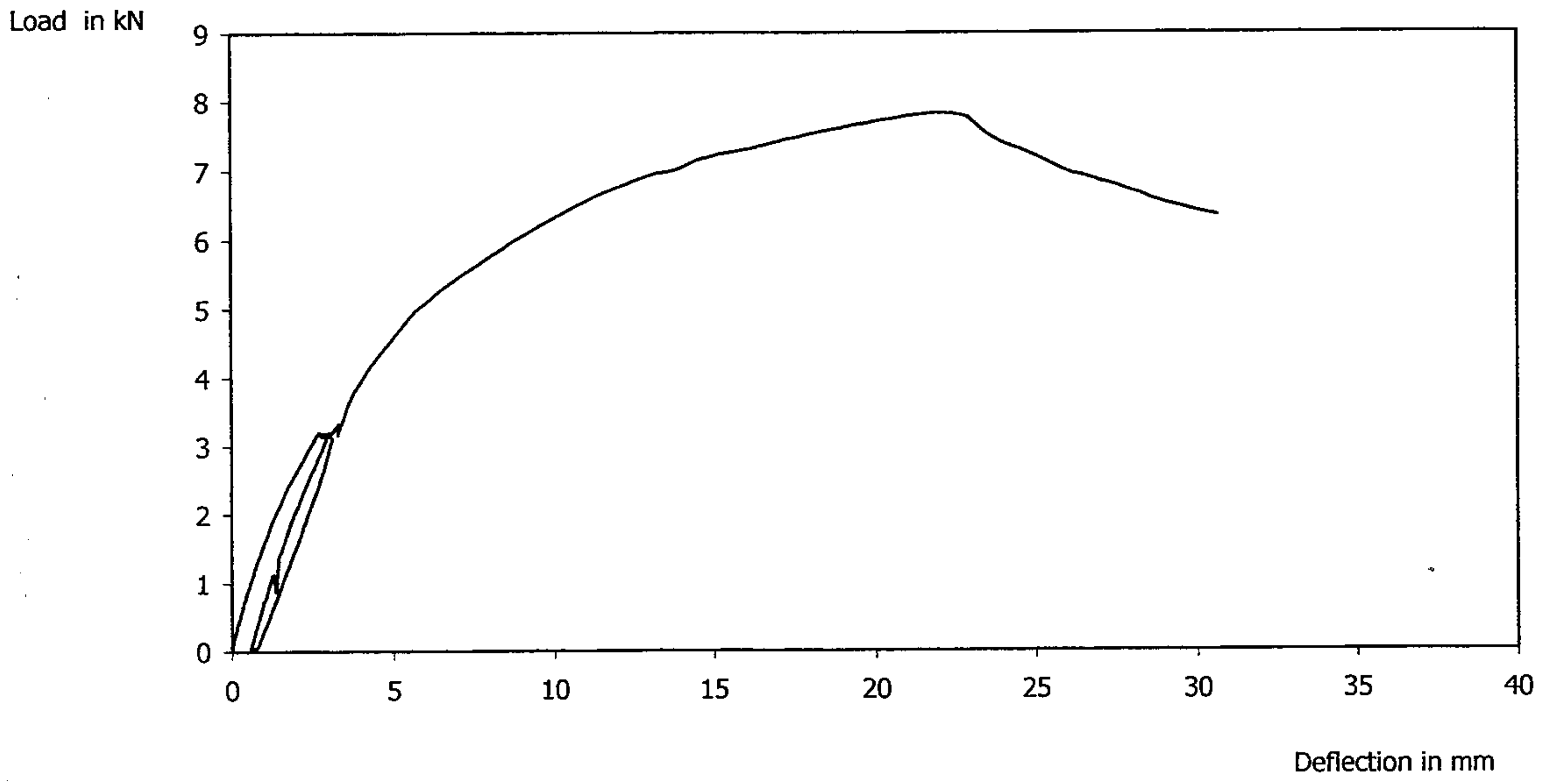
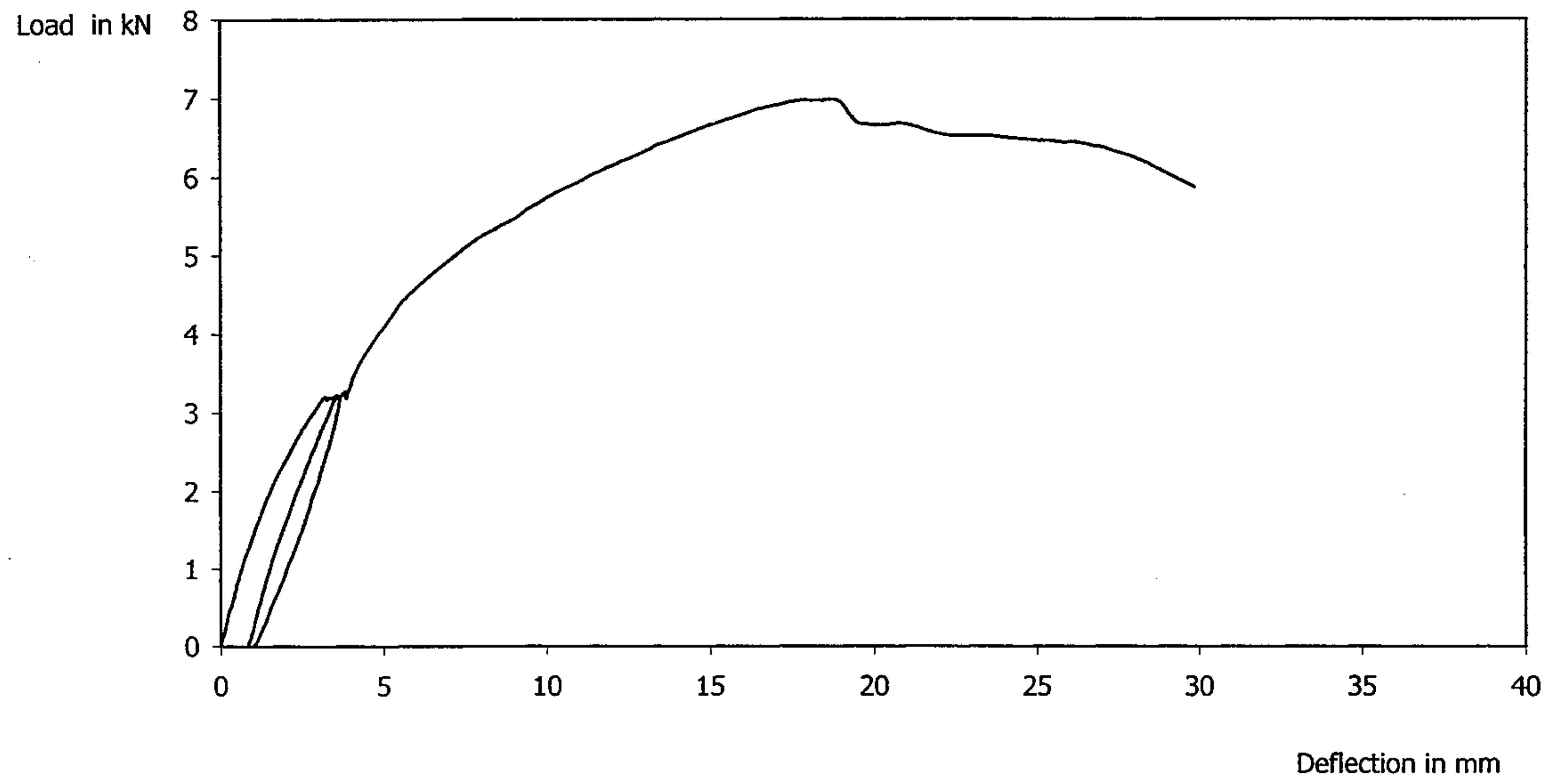


Figure 5: Test 5 Bitvent (HNBv15-G)
15 mm board, 3.35 mm nails
Vertical Load: 0kN/Stud



<u>Figure 6 :</u> Test 1 Bitroc (HNBr15-C)
15 mm board, 3.35 mm nails
Vertical Load: 5 kN/Stud

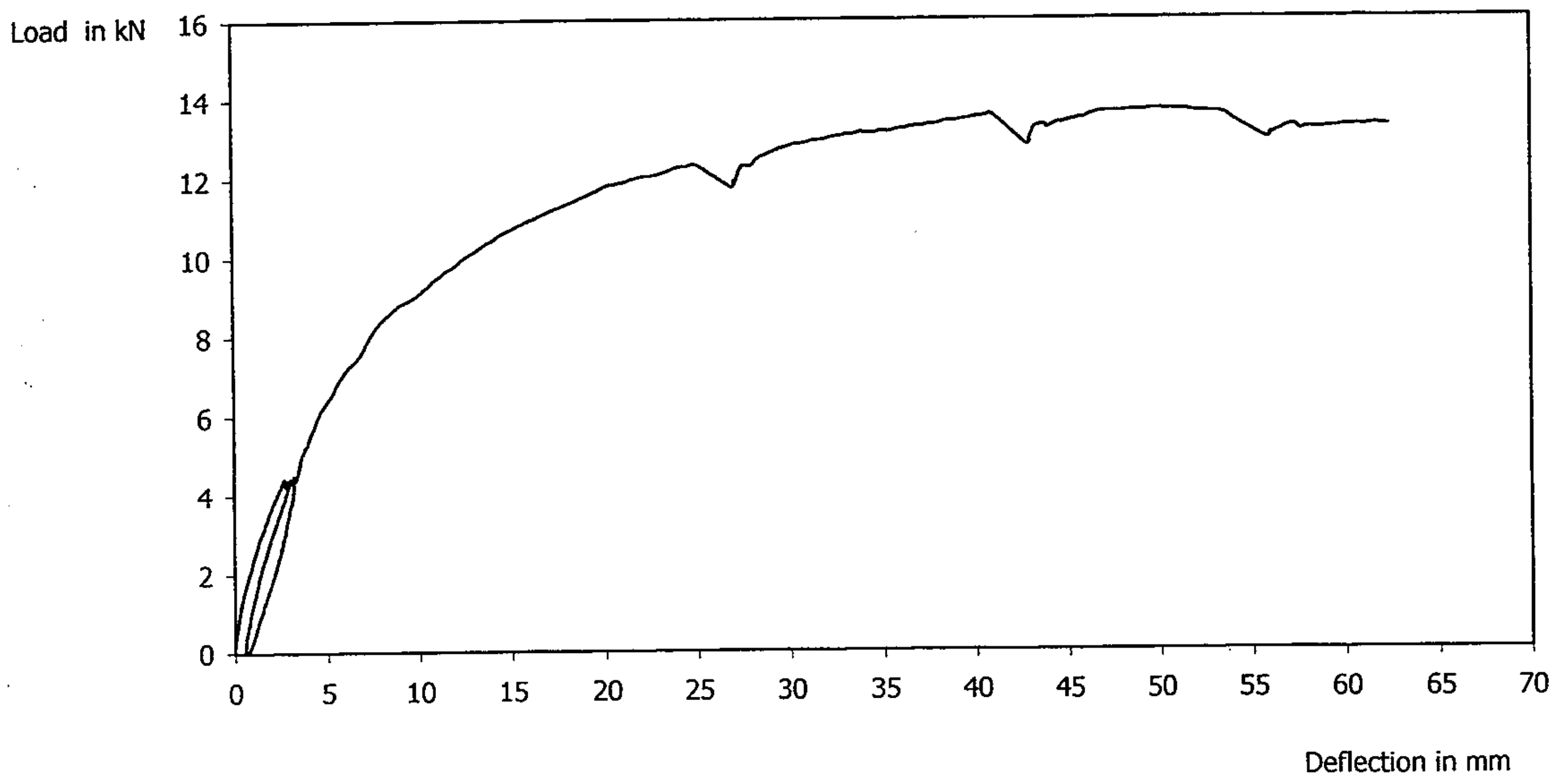


Figure 7: Test 2 Bitvent (HNBv15-D)
15 mm board, 3.35 mm nails
Vertical Load: 5 kN/Stud

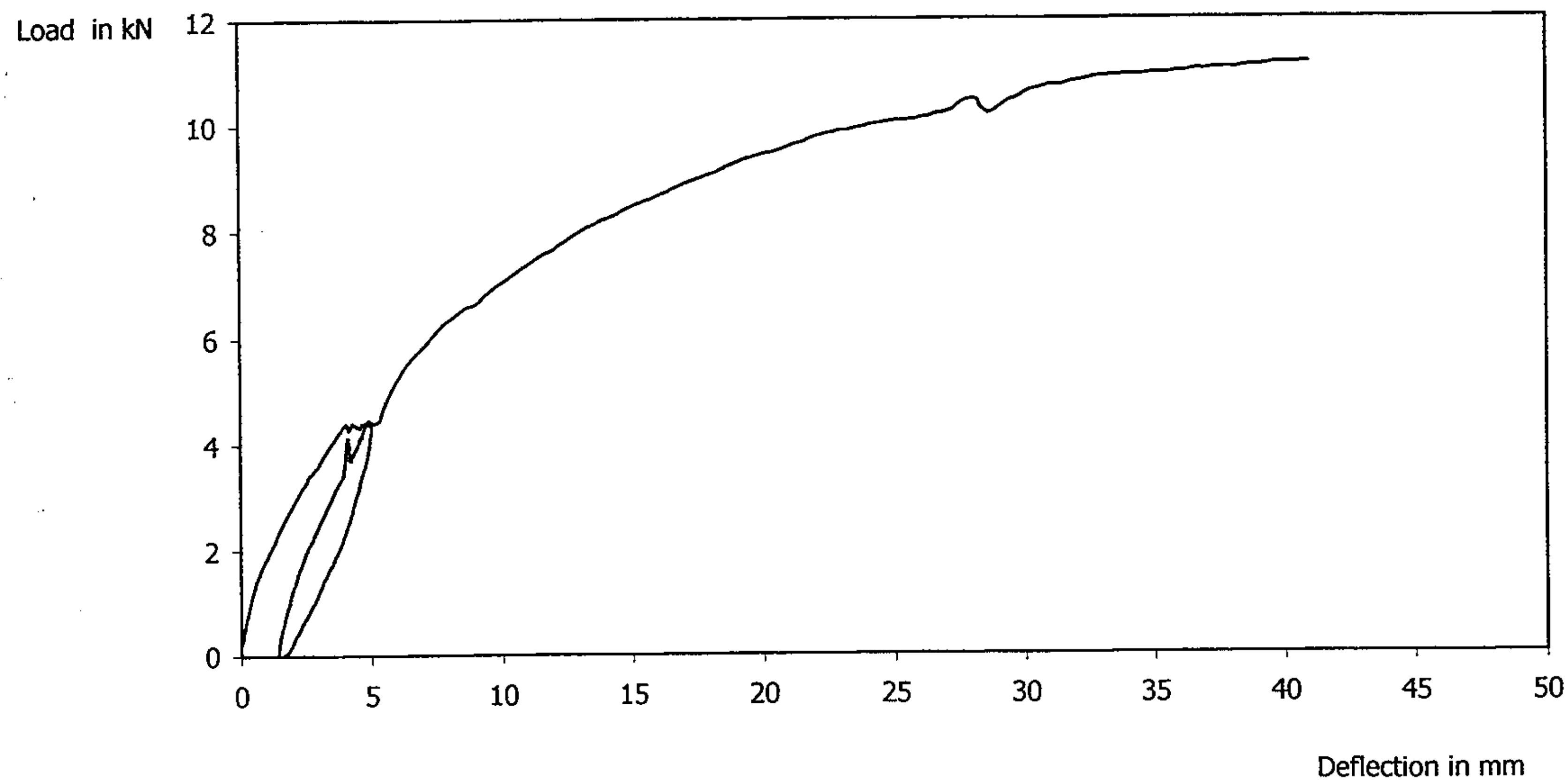
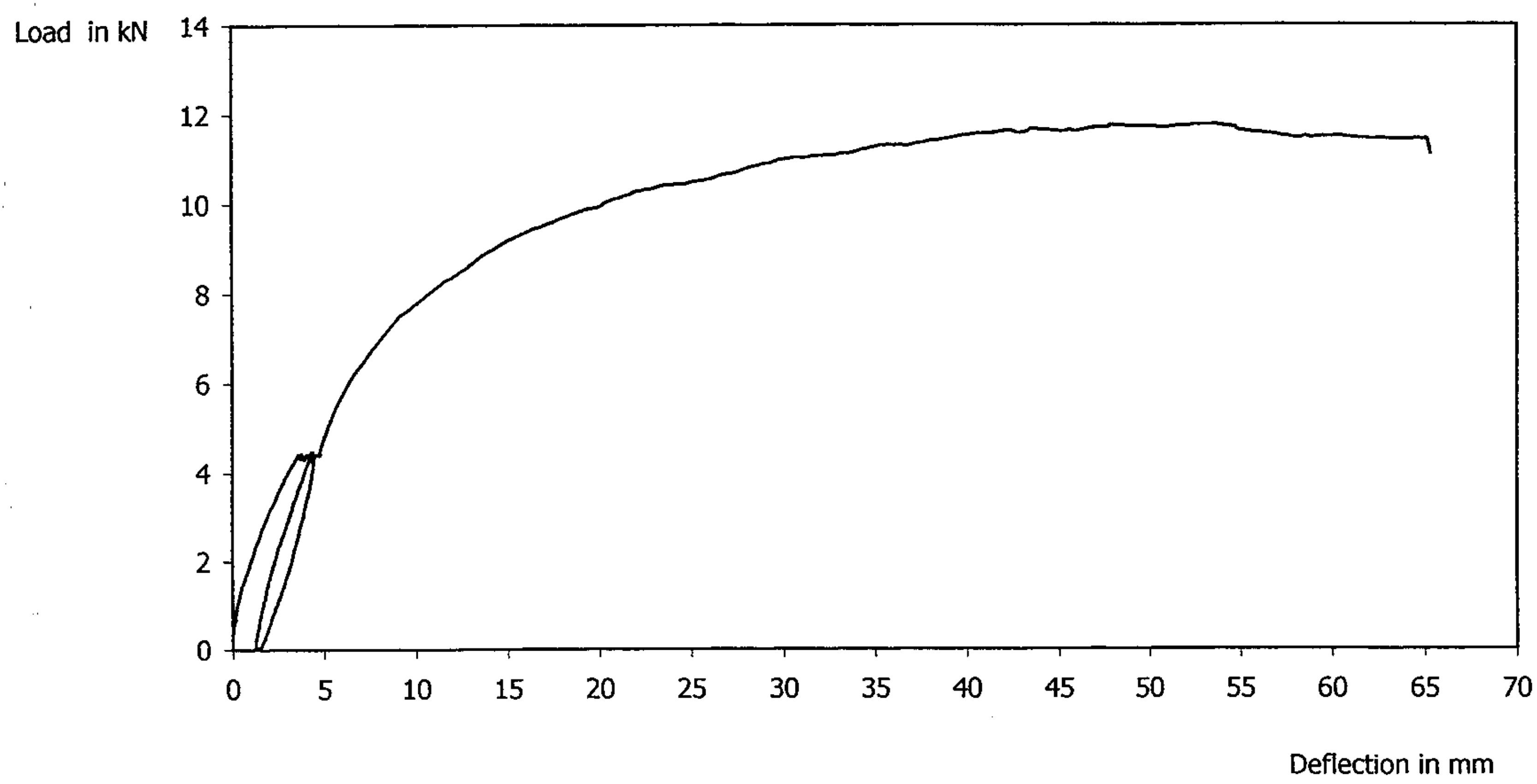


Figure 8: Test 6 Bitvent (HNBv15-H)
15 mm board, 3.35 mm nails
Vertical Load: 5kN/Stud



References

1. British Standards Institution (BSI), 1996
EN 594: Timber Structures and Test Methods- Racking strength and stiffness of timer frame wall panels. London: BSI

2. British Standards Institution (BSI), 1996
BS 5268: Structural Use of Timber, Part 6: Code of Practice for timber frame walls. Section 6.1: Dwellings not exceeding four storeys. London: BSI

3. British Standards Institution (BSI), 1996
BS 5268: Structural Use of Timber, Part 2: Code of Practice for permissible stress design, materials and workmanship. London: BSI

4. Report on Racking Tests on 12 mm TF board, 15 mm Bitvent and 15 mm Bitroc Bitumen Impregnated Insulation Boards for Hunton Fiber UK Ltd, University of Surrey: Dr D R Griffiths, Mr H G Wickens, March 1999
Report No.: CV/ST/0399/3

Appendix A

1. Personnel undertaking the tests

Dr D R Griffiths	Management of test programme
Mr P Haynes	Technician responsible for testing
Dipl.-Ing. J Bregulla	Research Officer responsible for data interpretation and report presentation

2. Equipment to be used

1- Specialist racking rig: used for more than 300 racking tests including work for BBA
2- Data Logger: Schlumberger Technologies SI 3535D (Scorpio)
Serial No.: IF 00029433
3- Load cells W.H. Mayes & Son (Windsor) Ltd. Type 403

Load cell	Channel	Serial No.	Load
Racking load	1	3216N	20 kN
Vertical load	3	3218N	20 kN

4- LVDTs

Channel	Model	Serial No.
25	D5/2000A	271
26	D5/1000A	353
30	D5/3000A	912
31	D5/3000A	916

LVDT Conditioning equipment: R.D.P. Electronics Ltd.

3. Documentation of maintenance of calibration

Calibration Equipment:
1- Testing machine for load cell calibration: SATEC Systems (Serial No. 120CG-1007)
2- Slip Gauges for LVDT calibration: T1 Coventry Gauge Ltd. Grade 1, Serial No. 05418 M33/2 BS4311

4. Traceability (are calibrators UKAS approved)

SATEC UKAS calibrated by R&H Testing Services Ltd.

5. Implementation for checking procedures between external calibration

1- The data logger is calibrated internally before each test programme, to give load cell and LVDT readings in appropriate units.
2- Load cells are calibrated on the SATEC. They are scaled over the anticipated load range to read to the nearest 0.01 kN.
3- LVDTs are calibrated on a purpose built rig with slip gauges. They are scaled over the anticipated deflection range to read to the nearest 0.01 mm.
4- Pressure gauges for vertical loading are calibrated to indicate 5 kN/ load point with 20 kN load cell.

6. Documentation of test method and procedures

Racking tests were carried out to BS EN 594. Note that the test method was drafted by Dr Griffiths and much of the data used to establish the test and design method in this code was gained using the Surrey test rig.

7. Calibration certificates

Calibration certificates are included for the SATEC universal testing machine.

HUNTON RACKING TESTS (BBA)

LOAD CELL CALIBRATION

SATEC TESTING MACHING

9th JAN'02

RACKING LOAD
20 kN CELL
CHAN 1
SERIAL No. 3216N
CALIB.FACTOR

SATEC RANGE 20 kN

SATEC (kN)	LOAD CELL (kN)
0.00	0.00
0.50	0.49
1.00	0.98
2.50	2.46
5.00	4.97
7.50	7.49
10.00	10.00
12.54	12.54
15.00	15.00
17.59	17.59
20.00	20.00
17.54	17.54
15.04	15.05
12.51	12.51
10.01	10.00
7.50	7.47
5.00	4.97
2.46	2.44
0.97	0.97
0.50	0.48
0.00	-0.01

RACKING LOAD
20 kN CELL
CHAN 1
SERIAL No. 3216N
CALIB.FACTOR

SATEC RANGE 20 kN

TIME SECONDS	SATEC (kN)	LOAD CELL (kN)
0	10.00	9.99
5	10.00	9.99
10	10.00	9.99
15	10.00	9.99
20	10.00	9.99
25	10.00	9.99
30	10.00	9.99
35	10.00	9.99
40	10.00	9.99
45	10.00	9.99
50	10.00	9.99
55	10.00	9.99
60	10.00	9.99
65	10.00	9.99
70	10.00	9.99
75	10.00	9.99
80	10.00	9.99
85	10.00	9.99
90	10.00	9.99
95	10.00	9.99
100	10.00	9.99
105	10.00	9.99
110	10.00	9.99
115	10.00	9.99
120	10.00	9.99

VERTICAL LOAD
20 kN CELL
CHAN 3
SERIAL No. 3218N
CALIB.FACTOR 474.293

SATEC RANGE 20 kN

SATEC (kN)	LOAD CELL (kN)
0.00	0.00
0.50	0.49
1.02	1.00
2.50	2.49
5.00	5.00
7.50	7.50
10.00	10.01
12.54	12.54
15.00	15.00
17.58	17.55
20.00	19.97
17.53	17.52
15.04	15.04
12.51	12.51
10.01	10.01
7.50	7.48
5.00	4.99
2.46	2.46
0.97	0.97
0.50	0.48
0.00	0.00

VERTICAL LOAD
20 kN CELL
CHAN 3
SERIAL No. 3218N
CALIB.FACTOR 474.293

SATEC RANGE 20 kN

TIME SECONDS	SATEC (kN)	LOAD CELL (kN)
0	5.00	4.98
5	5.00	4.98
10	5.00	4.97
15	5.00	4.97
20	5.00	4.98
25	5.00	4.97
30	5.00	4.97
35	5.00	4.97
40	5.00	4.97
45	5.00	4.97
50	5.00	4.97
55	5.00	4.97
60	5.00	4.97
65	5.00	4.97
70	5.00	4.97
75	5.00	4.97
80	5.00	4.97
85	5.00	4.97
90	5.00	4.97
95	5.00	4.97
100	5.00	4.97
105	5.00	4.97
110	5.00	4.97
115	5.00	4.97
120	5.00	4.97

HUNTON RACKING TESTS (BBA)
LOAD CELL CALIBRATION

AMSLER TESTING MACHING

9th JAN'02

RACKING LOAD
20 kN CELL
CHAN 1
SERIAL No. 3216N
CALIB.FACTOR 179.34

AMSLER RANGE 30 kN

AMSLER (kN)	LOAD CELL (kN)
0.00	0.00
0.50	0.49
1.00	0.97
2.50	2.48
5.00	5.00
7.50	7.51
10.00	10.02
12.50	12.52
15.00	15.02
17.50	17.52
20.00	20.03
17.50	17.52
15.00	15.03
12.50	12.53
10.00	10.02
7.50	7.51
5.00	5.01
2.50	2.49
1.00	0.98
0.50	0.48
0.00	0.00

RACKING LOAD
20 kN CELL
CHAN 1
SERIAL No. 3216N
CALIB.FACTOR 179.34

AMSLER RANGE 30 kN

TIME SECONDS	AMSLER (kN)	LOAD CELL (kN)
0	10.00	10.04
5	10.00	10.04
10	10.00	10.04
15	10.00	10.04
20	10.00	10.04
25	10.00	10.04
30	10.00	10.04
35	10.00	10.04
40	10.00	10.04
45	10.00	10.04
50	10.00	10.04
55	10.00	10.05
60	10.00	10.05
65	10.00	10.04
70	10.00	10.05
75	10.00	10.04
80	10.00	10.04
85	10.00	10.04
90	10.00	10.05
95	10.00	10.05
100	10.00	10.04
105	10.00	10.05
110	10.00	10.05
115	10.00	10.05
120	10.00	10.04

VERTICAL LOAD
20 kN CELL
CHAN 3
SERIAL No. 3218N
CALIB.FACTOR 179.28

AMSLER RANGE 30 kN

AMSLER (kN)	LOAD CELL (kN)
0.00	0.00
0.50	0.47
1.00	0.97
2.50	2.49
5.00	4.99
7.50	7.49
10.00	9.98
12.50	12.47
15.00	14.97
17.50	17.45
20.00	19.94
17.50	17.46
15.00	14.98
12.50	12.48
10.00	9.99
7.50	7.50
5.00	5.01
2.50	2.50
1.00	0.99
0.50	0.48
0.00	0.00

VERTICAL LOAD
20 kN CELL
CHAN 3
SERIAL No. 3218N
CALIB.FACTOR 179.28

AMSLER RANGE 30 kN

TIME SECONDS	AMSLER (kN)	LOAD CELL (kN)
0	5.00	4.99
5	5.00	4.99
10	5.00	4.98
15	5.00	4.99
20	5.00	4.99
25	5.00	4.99
30	5.00	4.99
35	5.00	4.98
40	5.00	4.99
45	5.00	4.99
50	5.00	4.99
55	5.00	4.99
60	5.00	4.99
65	5.00	4.98
70	5.00	4.99
75	5.00	4.98
80	5.00	4.99
85	5.00	4.99
90	5.00	4.99
95	5.00	4.99
100	5.00	4.98
105	5.00	4.99
110	5.00	4.99
115	5.00	4.99
120	5.00	4.99

HUNTON RACKING TESTS (BBA)
LVDT CALIBRATION **9th JAN'02**

UPLIFT
CHAN 25
SERIAL No. 271
CALIB.FACTOR 59.328
RANGE 100mm
EST.RANGE 40mm

SLIP GAUGE (mm)	LVDT (mm)
0.00	-20.00
0.20	-19.79
0.40	-19.58
0.60	-19.38
0.80	-19.18
1.00	-18.98
1.20	-18.77
1.40	-18.57
1.60	-18.37
1.80	-18.17
2.00	-17.97
4.00	-15.96
6.00	-13.96
8.00	-11.97
10.00	-9.98
15.00	-4.97
20.00	0.00
25.00	5.00
30.00	10.00
35.00	14.96
40.00	19.96
45.00	25.01
50.00	30.04

SLIDING
CHAN 26
SERIAL No. 353
CALIB.FACTOR -50.127
RANGE 75mm
EST.RANGE

SLIP GAUGE (mm)	LVDT (mm)
0.00	0.00
0.10	0.10
0.20	0.20
0.30	0.30
0.40	0.40
0.50	0.50
0.75	0.75
1.00	1.00
1.25	1.25
1.50	1.50
1.75	1.76
2.00	2.01
2.25	2.26
2.50	2.51
2.75	2.76
3.00	3.02

BACK DEFLN
CHAN 31
SERIAL No. 916
CALIB.FACTOR 91.9
RANGE 150mm
EST.RANGE 100mm

SLIP GAUGE (mm)	LVDT (mm)
0.00	-30.00
0.50	-29.50
1.00	-28.99
1.50	-28.48
2.00	-27.98
2.50	-27.47
3.00	-26.96
3.50	-26.46
4.00	-25.95
4.50	-25.45
5.00	-24.94
10.00	-19.95
20.00	-9.98
30.00	0.00
40.00	9.93
50.00	19.87
60.00	29.89
70.00	40.02
80.00	50.18
90.00	60.23
100.00	70.57

FRONT DEFLN
CHAN 30
SERIAL No. 912
CALIB.FACTOR 91.00
RANGE 150mm
EST.RANGE 100mm

SLIP GAUGE (mm)	LVDT (mm)
0.00	30.00
0.50	29.49
1.00	28.97
1.50	28.45
2.00	27.94
2.50	27.44
3.00	26.93
3.50	26.42
4.00	25.91
4.50	25.40
5.00	24.93
10.00	19.95
20.00	9.99
30.00	0.01
40.00	-10.00
50.00	-20.04
60.00	-30.13
70.00	-40.14
80.00	-50.34
90.00	-60.42
100.00	-70.31