TWP Timber and Wood Products Research Centre

REPORT ON MODEL PANEL RACKING TESTS

TO

AUSTRALIAN PARTICLEBOARD RESEARCH INSTITUTE

TWP REPORT NO. 105

C.G. McDOWALL, A.I.W.S
December, 1983

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SUMMARY

This report presents the results obtained from eleven racking tests performed on 600 x 600 mm model panels to evaluate the suitability or otherwise of various particleboards as a sheathing media in dwelling construction. The panel frames were constructed of F8 Radiata Pine members 70 x 45 mm sheathed with 4mm Fineline, 6 mm Texpan, 9 mm Texpan, 10 mm Pineboard, and 7 mm Radiata Pine plywood. A preliminary testing programme was implemented in which the sheathing was attached to the timber framing members using nails at 75 and 38 mm centres. A final testing programme followed in which nail centres were expanded to 150 mm except for one test using 6 mm Texpan for which connection was effected by gluing using Araldite.

Karri plywood sheathing was not available at the time of testing.

ACKNOWLEDGEMENTS

The author wishes to express his gratitude to Mr. W. Grigg, Head, Department of Civil Engineering for permission to use the Civil Engineering facilities to perform the tests.

Thanks are also offered to Messrs. V. McLellan and D. Limpus, Civil Engineering Technicians for providing a suitable loading frame for carrying out the tests and also for performing the tests. Appreciation is also acknowledged of discussions with Dr. M. Murray and Mr. R. Thomas during the testing programme.

Mrs. Pat Lieschke, Civil Engineering Departmental Secretary's efforts in the preparation of the report are also recognised.

SECTION 1

GENERAL TEST DETAILS

1.1 INTRODUCTION

The testing programme described herein was performed for the Australian Particleboard Research Institute (APRI) on particleboard sheathed, timber framed model wall panels.

The panels were constructed at CIAE from 70 x 45 mm F8 Radiata Pine framing material supplied by J.B. Hinz & Sons, Rockhampton. The sheathing material was either supplied through APRI or purchased locally and consisted of:

4 mm Fineline
6 mm Texpan - standard
9 mm Texpan
All of the above were supplied through APRI
10 mm Pineboard purchased locally
7 mm F11 Radiata Pine ply purchased locally
3 mm F22 Karri Plywood yet to be supplied through APRI

The nails used for all tests were 2.8 mm diameter x 40 mm galvanised clouts.

1.2 PURPOSE OF TESTING PROGRAMME

The purpose of the testing programme was to evaluate the above range of particleboards as potential sheathing materials to resist racking forces induced in timber framed dwellings due to lateral wind.

The following factors were considered to be of importance when performing the evaluation:

(i) the need to use plywood sheathing to provide a performance based standard as a means of direct comparison. Particleboard sheathing developing a model panel stiffness comparable to that of an equivalently thick plywood sheathed panel must at least be considered a candidate for full scale racking tests. This of course must ultimately depend upon whether or not initial stiffness is the only criteria to be considered in assessing racking resistance.

(ii) applying the Nail Force equation McKee[1] to determine a connector stiffness to enable the racking resistance of a full scale wall to be evaluated if necessary

(iii) to investigate the load transfer mechanism of thin sheathing compared to thick sheathing

1.3 LOADING RIG

1.3.1 General

All model panels were tested in the special loading frame located in the Heavy Structures Laboratory of the Civil Engineering Department, CIAE. Figure 1.1 shows a diagrammatic representation of the frame with a panel positioned ready for loading.

The loading in all tests was applied by means of a 50 kN capacity Enerpac hydraulic jack reacting against the loading frame. The load was applied by a hand operated pump and measured by a load cell connected to a 4½ digit Fluke multimeter. Accuracy of measurements of applied loads is estimated to be within $\pm$ 5%.

1.3.2 Model Racking Test Arrangement

The model panels were attached to the 75 x 38 mm channel and the reinforcing rod fitted prior to bolting the channel to the loading frame as shown in Figure 1.1.

Dial gauges 1 and 6 were positioned as shown in Figure 1.1 to measure the horizontal racking and loading frame deflections. Dial gauge 2 was attached to monitor panel rigid body movement. Hence the total panel deflection at the corner remote from the load is given by:

$$\Delta = (DG1 + DG6) - DG2$$

Even with the reinforcing rod positioned a small amount of panel rotation was observed. However, because it was small and occurred in all tests to about the same degree its effect on horizontal deflection Δ was neglected

1.4 MODEL PANEL CONSTRUCTION

Twelve frames of the type shown in Figure 1.2(a) were constructed from 70 x 45 mm seasoned F8 Radiata pine studding. The frames were purposely constructed such that without the sheathing attached they were mechanisms. Strain gauges were attached at the mid-lengths of members A, B, and C to determine the forces (axial and bending) in these members when the panel was subjected to racking. Panels sheathed with the following board materials were strain gauged:

- 4 mm thick Fineline
- 9 mm thick Texpan
- 6 mm thick Texpan
- 10 mm thick Pineboard

Figure 1.2(b) shows a typical panel complete with nailing schedule and strain and dial gauge locations. The purpose of the strain rosette was to monitor sheathing response and hence, in conjunction with the strain readings from the framing members, enable system response to be determined. The function of the dial gauges was to obtain a qualitative description of the buckling modes assumed by the sheathing under racking.

To eliminate the possibility of twisting of the model panels, all frames were sheathed both sides with the material to be evaluated.

Nails used to connect all sheathing to framing members were 2.8mm diameter x 40 mm long galvanised clouts. Using these nails ensured at least 10 x diameter penetration even for the 10 mm thick boards.

1.5 MODEL PANEL TESTING PROGRAMME

The panel testing programme divides itself naturally into the two following phases:

(i) preliminiary testing programme
(ii) final testing programme

1.5.1 Preliminary Testing Programme

Tests performed on the three strain gauged panels, 4 mm Fineline, 9 mm Texpan, and 6 mm Texpan provided the opportunity to evaluate the testing procedure.

These panels were constructed with nails at 75 mm centres. The panels were loaded to 1 kN or 2.5 kN depending upon considered response and all strain and dial gauge readings monitored. The load was then released and the panel nailing pattern was halved to 38 mm centres and the panels reloaded, once again monitoring all gauge readings. The load was again released, dial gauges 3, 4 and 5 removed and the panels loaded to failure.

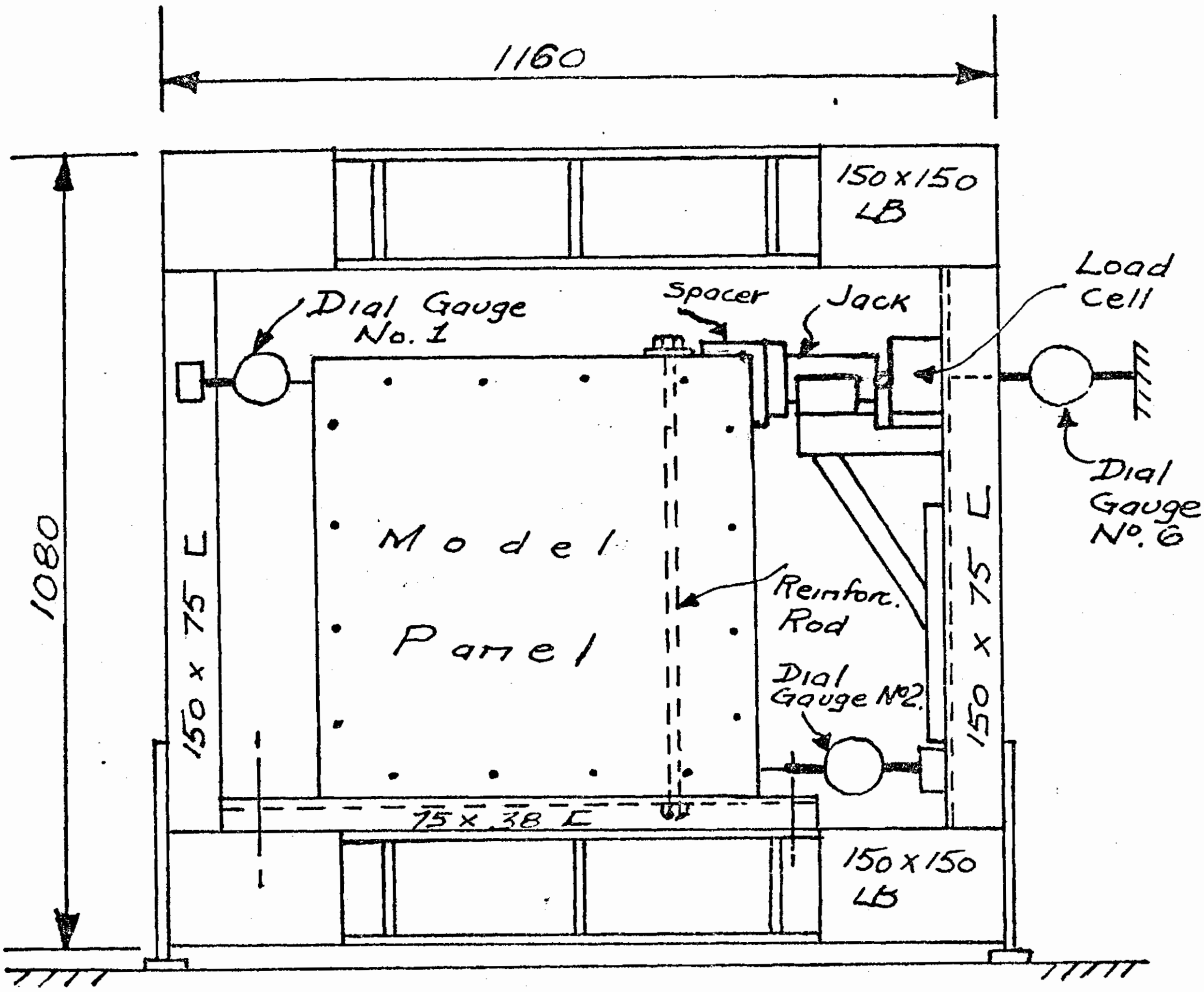
Information obtained from these tests is discussed in some detail in Section 2 of this report.

1.5.2 Final Testing Programme

Except for the 10 mm Pineboard panel which had nails at 75 mm centres all other nailed panels tested had nails located at 150 mm centres.

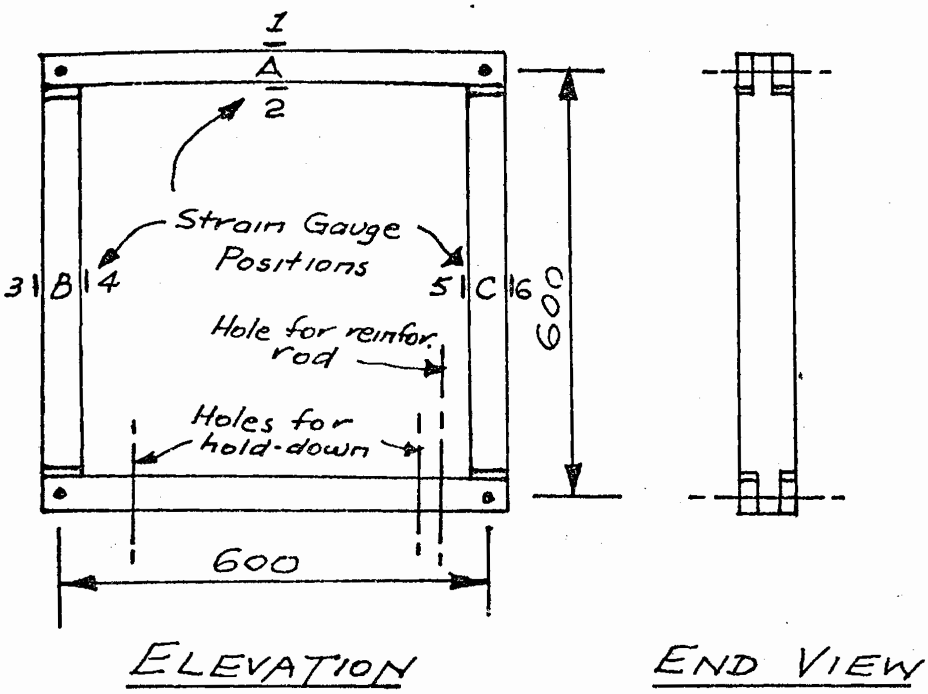
This modification was considered necessary after viewing the results obtained from the preliminary tests.

The results of these tests is discussed in detail in Section 3 of this report.



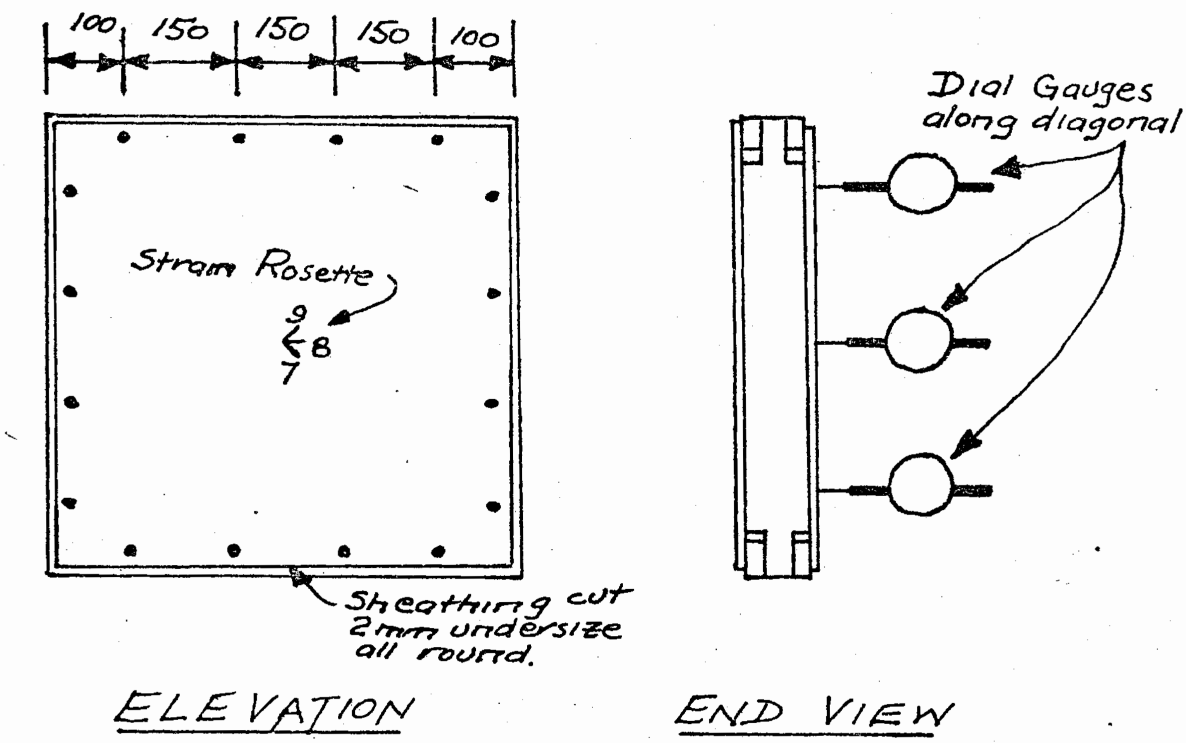
MODEL PANEL TEST RIG

FIGURE 1.1



TYPICAL FRAME

FIGURE 1.2(a)



TYPICAL PANEL.

FIGURE 1.2(b)

FIGURE 1.2

SECTION 2

PRELIMINARY TESTING PROGRAMME

2.1 INTRODUCTION

The test programme originally proposed to APRI was based on work done previously by McKee[1] at CIAE on model panels of hardwood framing sheathed with plywood. The test programme followed in this work applied the racking load below the horizontal member to ensure frame rotation was not inhibited, a procedure adopted for these preliminary tests, except for the final test of the series.

Nail spacings used in the original CIAE tests were 75 and 38 mm centres and this nail geometry was retained for the preliminary tests.

The main differences between the tests described herein and those performed originally were as follows:

- (i) pine studding was used, not hardwood
- (ii) frames used were 600 mm on nail centres, not 450 mm
- (iii) nails used were 2.8 mm diameter x 50 mm length galvanised clouts, not 2.03 mm diameters x 32 Bostitch power driven nails
- (iv) stud sizes used were 70 x 45 mm not, 75 x 38 mm

2.2 4mm FINELINE TEST RESULTS

Model panel No. 1 was positioned in the loading frame as described in Section 1.3. The 4 mm Fineline sheathing was attached to the timber framing members by nails at 75 mm centres. The racking load was applied below the horizontal member A thus inducing bending into this member. This point is further illustrated in Plate 2.1 which also shows the position of the six dial gauges.

Data sheet 1 (Test 1) shows the strain and dial gauge readings for 0.1 kN load increments up to 1.1 kN. The load was then released and residual values of strain and displacement taken. The racking loads R have to be modified initially by the factor 545/600 = 0.91 and then halved to obtain the racking load/side. Dial gauge 6 readings have not been included in these data.

Data Sheet 2 (Test 2) shows the racking load and corresponding horizontal deflection of the panel. During this loading strain readings were not taken and dial gauges 3, 4 and 5 were removed.

Following this loading, the model frame was checked for squareness and additional nails driven to reduce the nail spacings to 38mm centres.

Data Sheet 3 (Test 3) shows the strain and dial gauge readings for the loading increments tabulated. During this loading it was proposed to take the panel to failure. However, at 8.1 kN the hold-down bolt securing the bottom horizontal member to the 75 x 38 mm channel fractured the weld restraining it thus terminating the test.

This panel was later failed after further modifications had been made to the test procedure.

At this stage the loading frame was modified by replacing the damaged holding down bolt by one sufficiently large to withstand the applied forces.

2.2.1 Analysis of Results

Before attempting to analyse the results the following points concerning the strain readings should be noted:

- (i) if strain readings are equal but of opposite sign then pure bending exists
- (ii) if strain readings are equal but of the same sign then axial forces only exist
- (iii) if strain readings are unequal but of opposite sign then uniaxial stresses are less than bending stresses. Implies bending predominates.
- (iv) if strain readings are unequal but of the same sign then uniaxial stresses are greater than bending stresses. Implies axial force predominates.

The usual relationship between stress and strain for linear elastic members subjected to uniaxial force, gives, taking the average value of Modulus of Elasticity for Radiata pine as 11,800 MPa, the following force for 1 micro strain.

$$\sigma = \varepsilon E = (1 \times 10^{-6} \times 11{,}800) \text{ MPa}$$

$$P = \sigma A = (0.0118 \times 70 \times 45) \text{ N}$$

$$P = 37.2\text{N/1 micro strain}$$

Since the strain readings in members A and B are all negative then uniaxial compression exists in conjunction with some bending. The strain readings in member C are of opposite sign with significant differences indicating considerable bending to be present with uniaxial tension.

Strain rosette readings show the presence of a compression field running in the direction of gauge 9 and a tension field in the direction of gauge 7. This is of course as expected, however if the 7 and 9 directions coincided with those of the principal strain directions then it would be expected that the strain readings of gauge 8 would be small or zero. The strain readings of gauge 8 are large and negative and may well have been influenced by the out of plane bending due to buckling of the sheathing.

Readings from dial gauges 3, 4 and 5 show the buckled modes for the 75 mm and 38 mm nailing patterns to be as diagrammatically illustrated in Figure 2.1.

2.2.2 Failure Mode

Loading resulting in bending of member C produced no apparent distress of the nails nor of the sheathing apart from the buckled modes shown in Figure 2.1. During this loading failure of the timber frame, in the form of splitting through the bolt hole at the loaded end, did occur. Fracture of the weld restraining the hold down bolt at the loaded end also occurred at a load of approximately 8.1 kN.

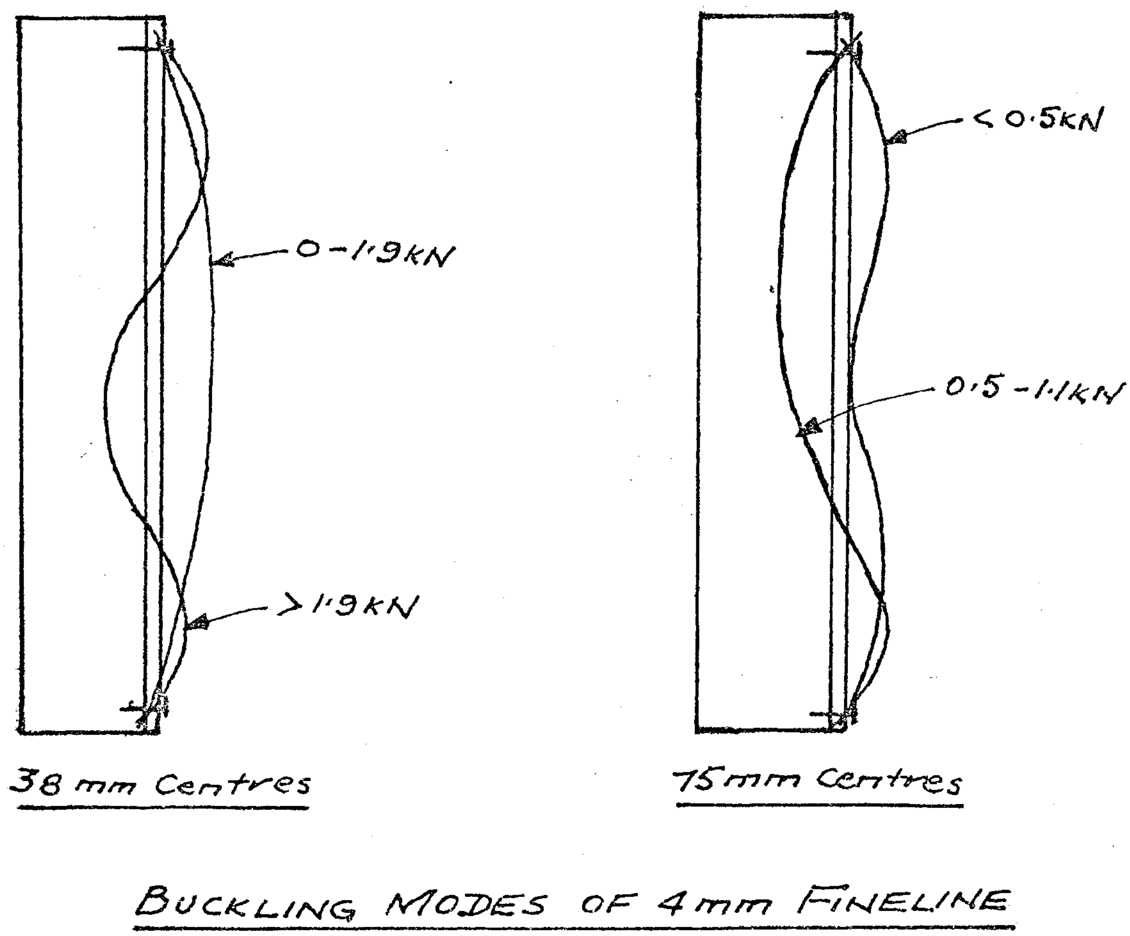


FIGURE 2.1

After increasing the dimensions of the hold down bolt and retesting failure of the sheathing followed in the form of nail pull through at the loaded end causing a bending failure of the particleboard as shown in Plate 2.2.

The actual buckled mode for the 38 mm nail spacing is shown in Plate 2.3. This photograph also shows that bending stresses due to buckling out of plane should no doubt significantly influence the strain rosette readings.

Graph 2.1 shows for the case when bending of the vertical member C occurs, nail spacing has no appreciable effect on model panel stiffness. This implies that once sufficient connection has been developed to enable the sheathing to assume the required buckling mode assocaited with a certain load level additional connection has no influence on load response. This does not imply however, that ultimate load carrying capacity remains unchanged with increased connectivity.

2.3 9mm TEXPAN TEST RESULTS

Model panel No. 2, after attaching of sheathing to the timber frame using nails at 75 mm centres, was positioned and loaded in the same manner as the 4 mm Fineline panel.

Data Sheet 1 (Test 4) shows the strain and dial gauge readings for 0.1 kN load increments to 1.1 kN and 0.5 kN load increments from 1.5 to 3.5 kN. The load was then released and residual values of strain and displacement recorded. Racking loads have been modified and halved to obtain the racking load/side. Dial gauge 6 readings have not been included in these data.

Data Sheet 2 (Test 5) shows the racking load and corresponding horizontal deflection of the panel. During this loading strain readings were not taken and dial gauges 3, 4 and 5 were removed.

Following this loading the model frame was checked for squareness and additional nails driven to reduce the nail spacings to 38 mm centres.

Data Sheet 3 (Test 6) shows the strain and dial gauge readings for the loading increments tabulated. The load was then released and residuals noted prior to loading the panel to failure.

Data Sheet 4 (Test 7) shows the load/deflection data recorded during loading to failure. The load at which failure occurred was observed to be approximately 11.6 kN.

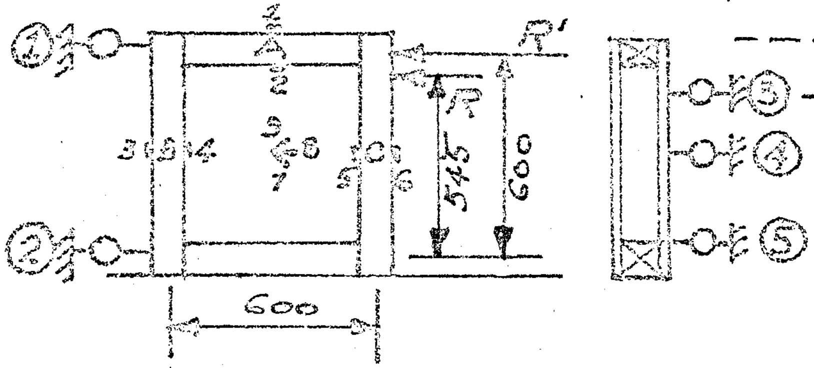
Racking Model Panel Test Results

Test Performed For: APRI — Date of Test: [illegible]-11-83

Panel Ident. No: 1 (FL 4)

Framing Members: Size 70 x 45
Species Radiata
Stress Grade F8
m.c. ___%

Sheathing Mat'l: Ident: Fineline
Thick. 4 mm
m.c. ___% Den. ___ kg/
Nail Spacing 75 mm



Test Data (Test 1)

R (kN)	R' (kN) = Rx0.9	R'' = R'/2 (kN)	Horiz. Defl. Δ (mm)	Strain Readings x10^-6: Member A: 1	2	Member B: 3	4	Member C: 5	6	Panel Rosette (45°): 7	8	9	Dial Gauge Readings (mm): 1	2	3	4	5
0.1	0.09	0.045	0.130	-10	-2	-2	-2	-4	+5	+12	-40	-16	0.13	0.0	0.03	0.0	0.0
0.2	0.18	0.090	0.248	-8	-4	-2	-3	-10	+14	+19	-76	-35	0.258	0.01	0.05	0.0	0.02
0.3	0.27	0.135	0.342	-12	-4	-2	-3	-12	+18	+39	-88	-30	0.352	0.01	0.05	0.0	0.02
0.4	0.36	0.180	0.478	-8	-4	-2	-4	-14	+25	+50	-118	-42	0.488	0.01	0.04	0.0	0.04
0.5	0.46	0.230	0.532	-12	-4	-2	-5	-20	+34	+74	-135	-44	0.542	0.01	-0.02	-0.01	0.04
0.6	0.55	0.275	0.654	-10	-4	-6	-4	-24	+38	+80	-168	-60	0.664	0.01	-0.02	-0.01	0.05
0.7	0.64	0.320	0.786	-26	-5	-10	-5	-30	+43	+96	-204	-77	0.736	0.02	-0.02	-0.01	0.06
0.8	0.73	0.365	0.911	-23	-5	-10	-6	-32	+50	+106	-238	-95	0.906	-0.025	-0.03	-0.0	0.07
0.9	0.82	0.410	1.111	-26	-8	-10	-8	-36	+56	+130	-260	-96	1.106	-0.025	-0.03	-0.0	0.08
1.0	0.91	0.455	1.266	-22	-5	-8	-8	-40	+62	+136	-298	-124	1.266	-0.030	-0.12	-0.01	0.09
1.1	1.00	0.500	1.406	-30	-5	-12	-7	-45	+66	+150	-310	-125	1.406	-0.035	-0.21	-0.00	0.08
0.0				-14	+8	-4	+6	-8	+8	-66	-114	-90	0.27 (2 min later) 0.03 (Next day)				

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: A — DATE OF TEST: 8-11-83

PANEL IDENT. N°: 1 (FL4)

FRAMING MEMBERS: Size 70 x 45

Species Radiata

Stress Grade F 8

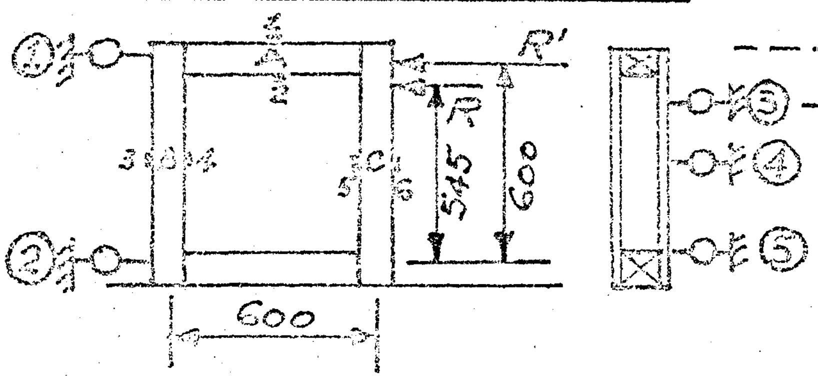
m.c. __ %

SHEATHING MAT^L^: Ident. Fineline

Thick. 4 mm

m.c. __ % Den. __

Nail Spacing 75mm

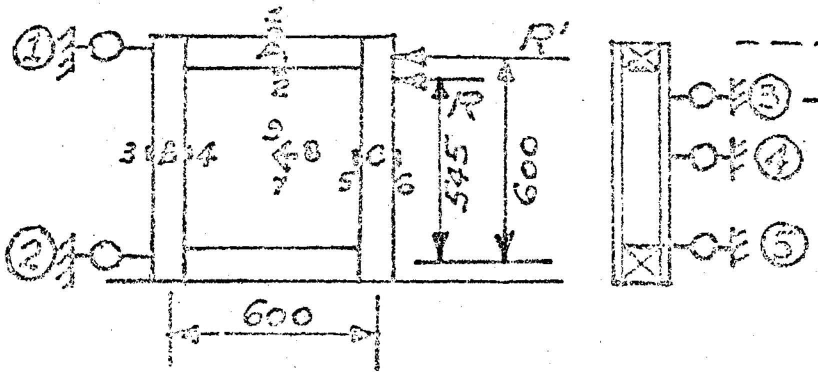


TEST DATA (TEST 2)

R (kN)	R' (kN) =Rx0.91	R'' = R'/2 (kN)	Horiz. Defln. Δ (mm)	Strain Readings x10⁻⁶ Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette (45°) 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.1	0.09	0.045	0.26										-0.25	0.0			
0.2	0.18	0.090	0.43										-0.41	-0.005			
0.3	0.27	0.135	0.58										-0.56	-0.01	D	I A	L
0.4	0.36	0.180	0.70	S	T	R	A	I	N	STRAIN			-0.68	-0.01			
0.5	0.46	0.230	0.83										-0.80	-0.01			
0.6	0.55	0.275	0.97										-0.94	-0.01	G	AU	GE
0.7	0.64	0.320	1.20		R	E A	D	I NG	S	READINGS			-1.05	-0.01			
0.8	0.73	0.365	1.23										-1.18	-0.015			
0.9	0.82	0.410	1.35			NOT		TAKEN		NOT TAKEN			-1.29	-0.015		NOT	
1.0	0.91	0.455	1.47										-1.40	-0.015			
1.1	1.00	0.500	1.61										-1.54	-0.02		RE	AD
1.2			1.74										-1.66	-0.02			

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI



DATE OF TEST: 8-11-83

PANEL IDENT. N°: 1 (FL4)

FRAMING MEMBERS: Size 70 X 45

Species Radiata

Stress Grade F 8

m.c. __ %

SHEATHING MAT'L: Ident: Fineline

Thick. 4 mm

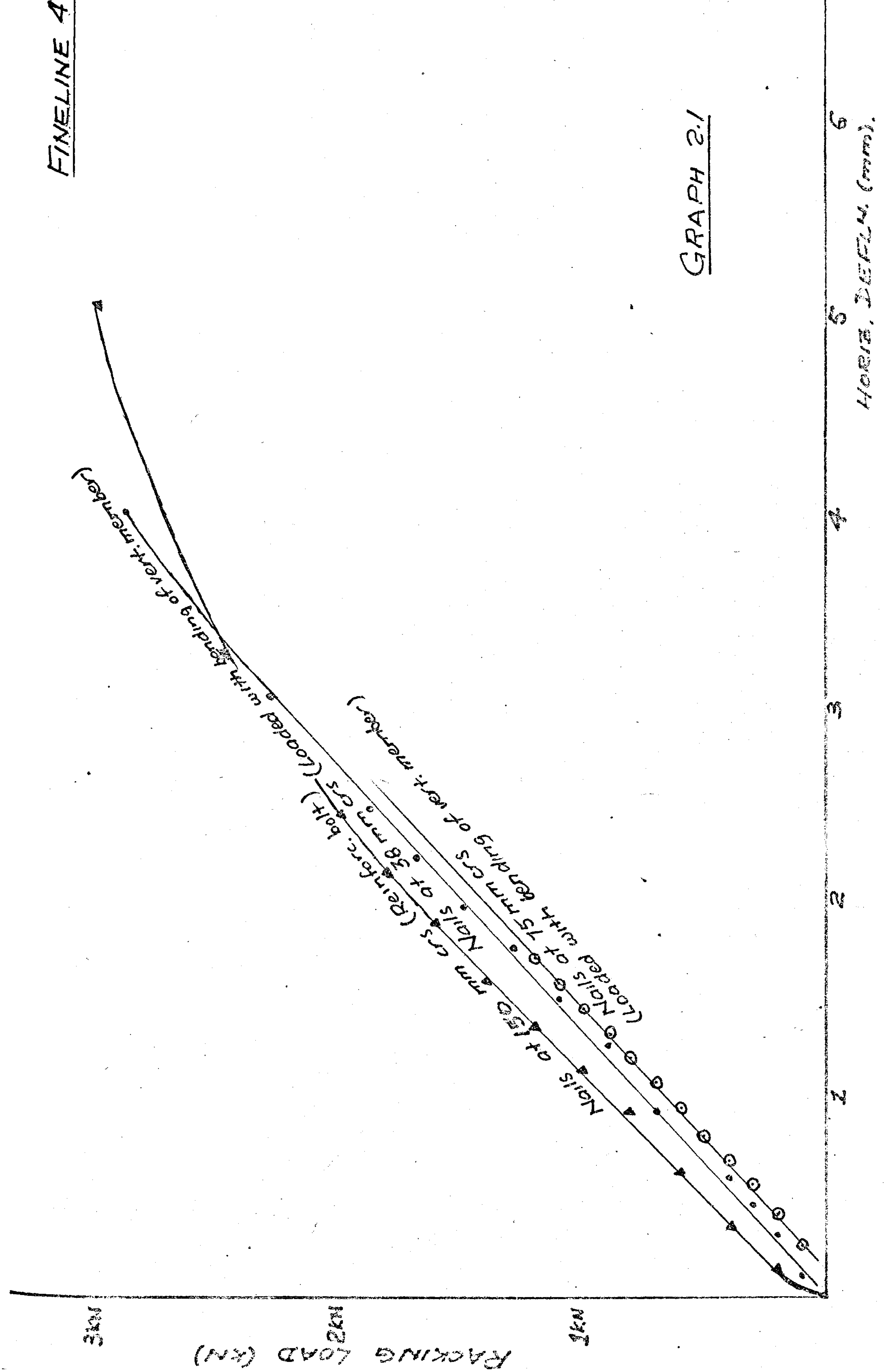
m.c. __ % Den. ____ kg/

Nail Spacing 38 mm

TEST DATA (TEST 3)

R (kN)	R' (kN) =R x 0.91	R'' = R'/2 (kN)	Horiz. Defl'n. Δ (mm)	Strain Readings x10^-6 Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette (45°) 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
[illegible]	0.09	0.045	0.140	+3	-4	+2	-2	-5	+14	+20	-45	-18	-0.14	-0.005	+0.14	+0.01	+0.02
[illegible]	0.18	0.090	0.330	-4	-4	+2	0	-12	+25	+48	-66	-18	-0.34	-0.010	+0.22	+0.04	+0.04
[illegible]	0.27	0.135	0.475	-2	-6	+2	-4	-18	+35	+56	-96	-34	-0.46	-0.010	+0.23	+0.06	+0.04
0.4	0.36	0.180	0.620	-4	-6	+2	-5	-22	+34	+82	-110	-32	-0.60	-0.015	+0.25	+0.10	+0.05
0.5	0.46	0.230	0.730	+3	-5	+3	-5	-24	+50	+96	-134	-40	-0.77	-0.015	+0.27	+0.11	+0.06
0.7	0.55	0.275	0.960	-4	-8	+2	-7	-32	+54	+132	-168	-47	-1.02	-0.02	+0.29	+0.11	+0.08
0.9	0.82	0.410	1.290	-2	-8	+2	-8	-36	+62	+155	-220	-69	-1.25	-0.025	+0.29	+0.11	+0.10
1.1	1.00	0.500	1.540	-6	-10	-4	-12	-44	+69	+188	-260	-85	-1.50	-0.030	+0.30	+0.11	+0.11
1.3	1.18	0.590	1.810	-3	-11	-2	-12	-50	+78	+212	-300	-100	-1.75	-0.035	+0.31	+0.13	+0.13
1.5	1.36	0.680	2.010	-7	-14	-3	-15	-54	+86	+248	-340	-112	-1.95	-0.040	+0.31	+0.13	+0.14
1.7	1.54	0.770	2.250	-5	-16	-4	-16	-62	+92	+270	-384	-130	-2.17	-0.045	+0.31	+0.13	+0.15
1.9	1.73	0.865	2.500	-8	-16	-4	-18	-66	+97	+306	-428	-146	-2.41	-0.050	0.32	+0.12	+0.17
2.3	2.01	1.005	3.080	-11	-22	-4	-24	-80	+114	+366	-550	-200	-2.98	-0.070	0.34	-0.03	0.21
2.9	2.63	1.315	3.790	-10	-25	-8	-28	-95	+130	+446	-780	-340	-3.68	-0.10	0.43	-0.52	0.27
3.6	3.27	1.135	4.510	-20	-34	-18	-36	-122	+150	+560	-1202	-596	-4.39	-0.15	0.36	-1.60	0.35
4.	3.72	1.360	5.360	-20	-40	-26	-42	-147	+172	+680	-1614	-806	-5.25	-0.24	0.54	-1.70	0.35
4.6	4.18	2.090	6.330	-32	-46	-26	-54	-166	+190	+858	-2036	-1046	-6.36	-0.40	0.82	-2.53	0.44
8.1	7.35	3.675		Panel		Hold-down bolt				fractured			Dial	Gauges Removed at 4.6			

Sheet 3 of 3


FINELINE 4m
GRAPH 2.1
HORIZ. DEFLN. (mm)
1
2
3
4
5
6
RACKING LOAD (kN)
1kN
2kN
3kN
Nails at 150 mm c/s (Reinforc. bolt)
Nails at 38 mm c/s (Loaded with bending of vert. member)
Nailed at 75 mm c/s (Loaded with bending of vert. member)

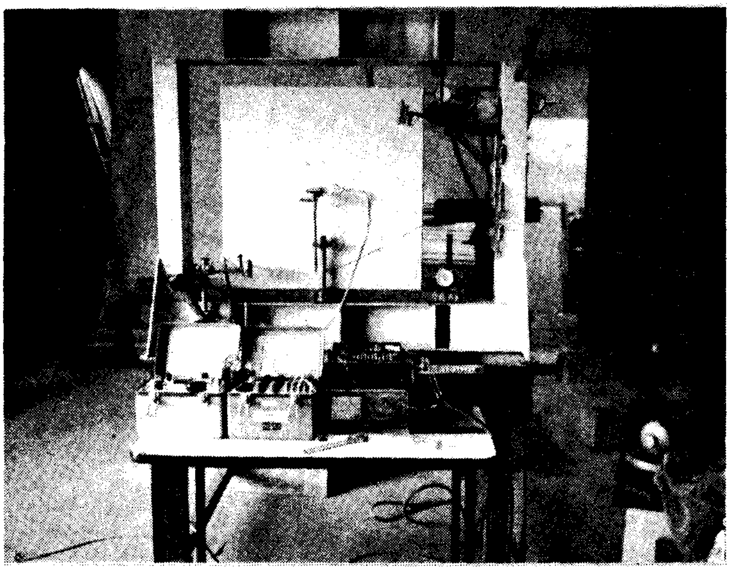


PLATE 2.1

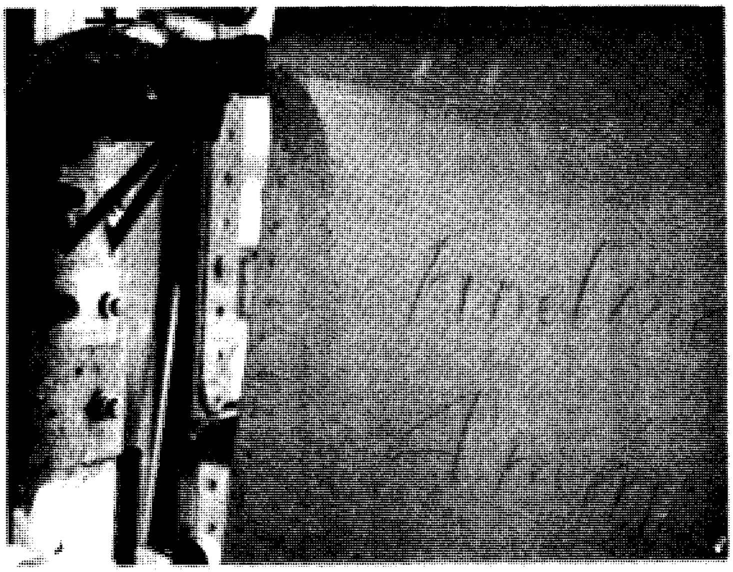


PLATE 2.2

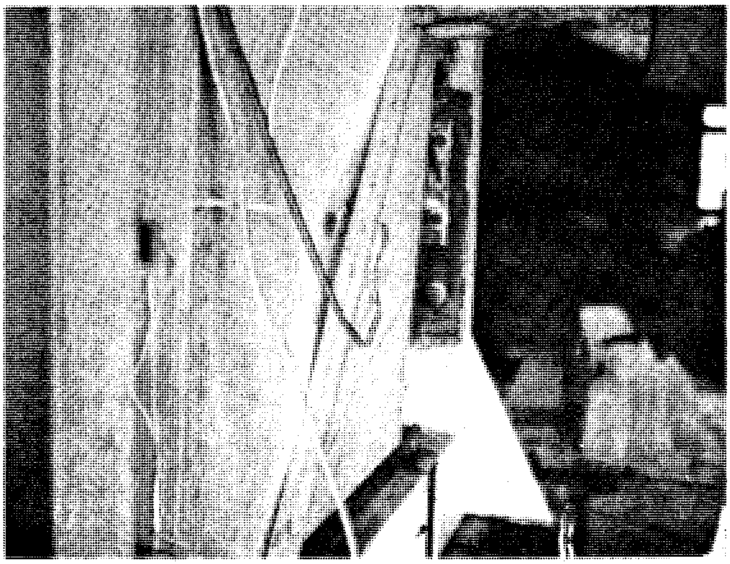


PLATE 2.3

2.3.1 Analysis of Results

For the 75 mm nail centres the strain readings in members A and B are basically negative indicating uniaxial compression exists with some bending. The strain readings of member C are of opposite sign and approximately the same magnitude indicating the existence of pure bending. This response is different from that of the 4 mm Fineline panel.

Strain rosette readings are similar in form to those observed in the Fineline panel.

For the 38 mm nail spacings the strain readings in members A and B are of opposite sign showing bending to be present generally with uniaxial compression.

Strain rosette readings show the same trend as previously.

Dial gauges 3, 4 and 5 show positive readings for both nailing patterns indicating a tendency for the sheathingto buckle convex out from the framing members in a half sine wave.

2.3.2 Failure Mode

Loading resulting in bending of member C caused a first failure to occur in the timber frame, again in the form of splitting through the bolt hole at the loaded end. The second failure to occur was a splitting through the bolt hole vertically below the loaded corner.

Plate 2.4 shows the general direction of the nail deformations. The direction of the force in the sheathing is of course opposite to the nail forces. This would mean the force across the diagonal from botton left corner to top right corner is compression and along the opposite diagonal a tension. This is as predicted by the strain rosette. This type of action implies that the section to the left of the diagonal running from the bottom left top right corner is contributing very little to structural action. The system is therefore working as a braced frame as shown in Figure 2.2.

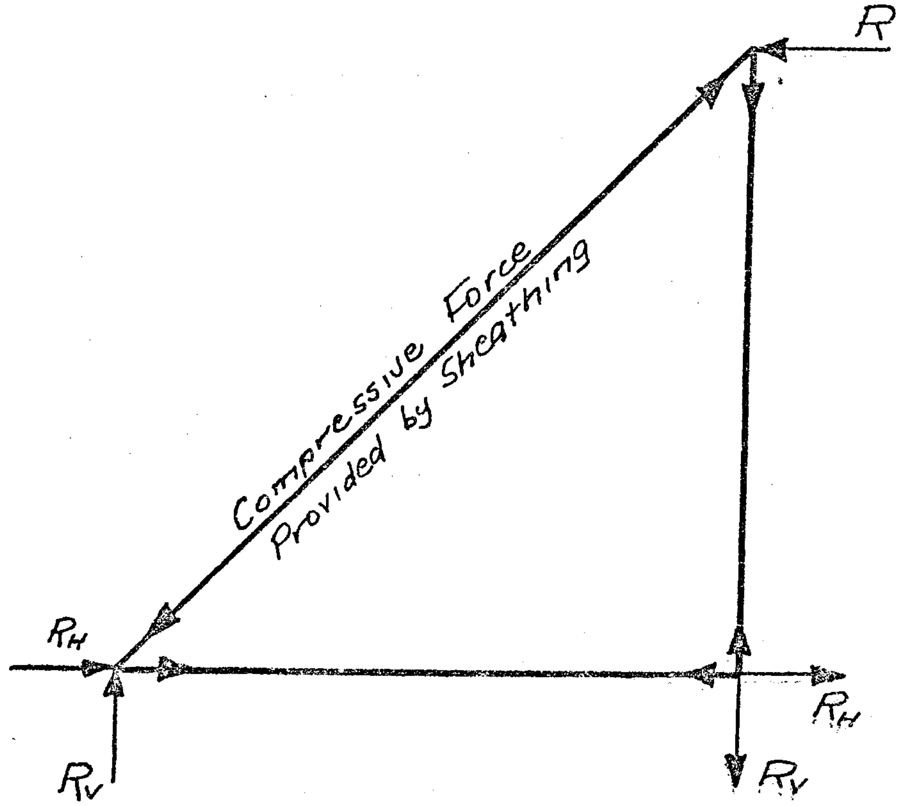


FIGURE 2.2

A consequence of the failure at bolt hole in the bottom right corner of the frame was to cause premature tearing away of the sheathing from the nails in this area. This mode of failure prevented the sheathing from developing full strength. From this test it can be concluded that in order to develop full sheathing strength early failure of the timber framing members must be prevented.

This point will be discussed more fully in Section 3.

Graph 2.2 shows for the case of bending of the vertical member C, nail spacing does increase panel strength, but not to any great extent.

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 8-11-83

PANEL IDENT. No: 2 (TP9)

FRAMING MEMBERS: Size 70 x 45

Species Radiata

Stress Grade F8

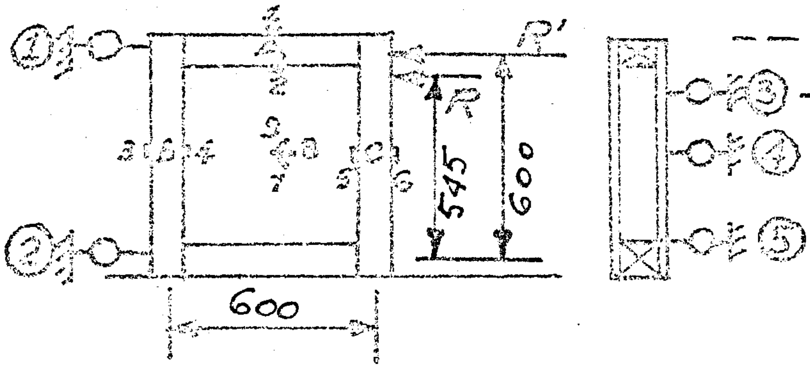
m.c. __ %

SHEATHING MAT'L: Ident. TEXPAN

Thick. 9 mm

m.c. __ % Den. 550 (Nom) kg/

Nail Spacing 75 mm



TEST DATA (TEST 4)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Deflec. Δ (mm)	Strain Readings x10^-6 Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette (45°) 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0	0.09	0.045	0.10	+4	+2	+2	+2	-6	+2	-2	-16	-24	-0.10	0.0	+0.21	+0.08	+0.01
0.2	0.18	0.090	0.16	-4	0	+2	+2	-6	+6	+10	-14	-25	-0.16	0.0	+0.31	+0.12	+0.03
0.3	0.27	0.135	0.26	+2	0	0	+2	-7	+13	+14	-18	-42	-0.25	0.0	+0.41	+0.17	+0.04
0.4	0.36	0.180	0.33	-5	-2	-2	0	-12	+12	+22	-20	-50	-0.31	0.0	+0.52	+0.22	+0.05
0.5	0.46	0.230	0.48	-3	-3	-3	-4	-18	+18	+26	-30	-68	-0.45	0.0	+0.62	+0.28	+0.07
0.6	0.55	0.275	0.59	-5	-4	-2	-2	-23	+24	+34	-28	-74	-0.57	0.01	+0.70	+0.30	+0.08
0.7	0.64	0.320	0.72	-4	-6	-3	-6	-30	+30	+37	-34	-86	-0.69	0.01	+0.79	+0.34	+0.09
0.8	0.73	0.365	0.82	-7	-7	-4	-8	-37	+36	+44	-37	-97	-0.80	0.015	+0.90	+0.42	+0.10
0.9	0.82	0.410	0.97	-5	-8	-2	-8	-44	+46	+46	-42	-110	-0.95	0.02	+1.02	+0.49	+0.12
1.0	0.91	0.455	1.10	-7	-9	-3	-8	-52	+52	+56	-45	-126	-1.07	0.02	+1.15	+0.57	+0.13
1.1	1.00	0.500	1.28	-6	-10	-4	-10	-56	+57	+58	-50	-134	-1.25	0.02	+1.33	+0.62	+0.15
1.3	1.18	0.590	1.49	-6	-12	-2	-10	-71	+68	+80	-46	-120	-1.46	0.03	1.03	+0.56	+0.11
1.5	1.36	0.680	1.74	-5	-14	-3	-15	-84	+82	+90	-56	-164	-1.70	0.03	1.03	+0.55	+0.11
2.0	1.82	0.910	2.40	-10	-19	-2	-21	-120	+116	+120	-66	-200	-2.34	0.04	1.05	+0.52	+0.11
2.5	2.28	1.138	3.12	-8	-26	-2	-29	-154	+152	+144	-86	-264	-3.04	0.05	1.13	+0.50	+0.11
3.0	2.73	1.365	3.95	-14	-30	0	-40	-194	+186	+174	-100	-257	[illegible]	0.07	1.13	+0.50	+0.13
3.5	3.19	1.593	4.86	-10	-36	+4	-48	-226	+222	+195	-120	-325	[illegible]	0.09	1.21	+0.50	+0.14
0.0			0.17	-10	0	+6	-6	-49	+66	-24	-52	-26	-0.19	-0.045	0.04	+0.05	-0.04

Load stopped

RACKING MODEL PANEL TEST RESULTS

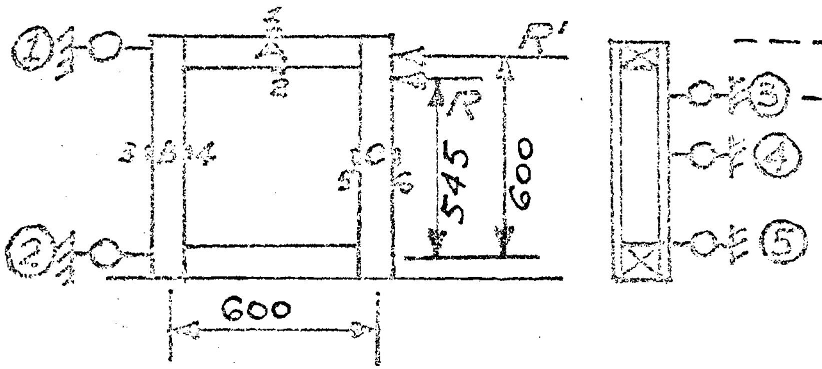
TEST PERFORMED FOR: APRI

DATE OF TEST: 2-11-83

PANEL IDENT. No: 2 (TP9)

FRAMING MEMBERS: Size 70 x 45
Species Radiata
Stress Grade F8
m.c. ___ %

SHEATHING MAT'L: Ident. TEXPAN
Thick. 9 mm
m.c. ___ % Den. 550 Nom kg
Nail Spacing 75 mm



TEST DATA (TEST 5)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defl. Δ (mm)	Strain Readings x10⁻⁶ Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette (45°) 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.1	0.09	0.045	0.05										-0.05	0.0			
0.2	0.18	0.090	0.19										-0.19	0.0			
0.3	0.27	0.135	0.25										-0.25	0.005			
0.4	0.36	0.180	0.37										-0.38	0.01			
0.5	0.46	0.230	0.46	S	T	R	A	I N		ST	RAI	N	-0.45	0.01			
0.6	0.55	0.275	0.55										-0.57	0.01	DI	AL	
0.7	0.64	0.320	0.66										-0.65	0.015			
0.8	0.73	0.365	0.74	R	E	A D	I N	G S		RE	A DI	NGS	-0.75	0.015	GA	UG	ES
0.9	0.82	0.410	0.86										-0.85	0.02	RE	MOV	ED
1.0	0.91	0.455	0.96										-0.96	0.02			
1.1	1.00	0.500	1.07		NOT		TAK	EN		NOT	TA	KEN	-1.05	0.02			
1.3	1.18	0.590	1.35										-1.31	0.02			
1.5	1.36	0.680	1.6										-1.55	0.025			
2.0	1.82	0.910	2.24										-2.15	0.03			
2.5	2.28	1.140	2.84										-2.70	0.04			
3.0	2.73	1.365	3.34										-3.20	0.06			
3.5	3.19	1.595	3.90										-3.73	0.08			

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 9-11-83

PANEL IDENT. No: 2 (TP9)

FRAMING MEMBERS: Size 70 x 45

Species Radiata

Stress Grade F 8

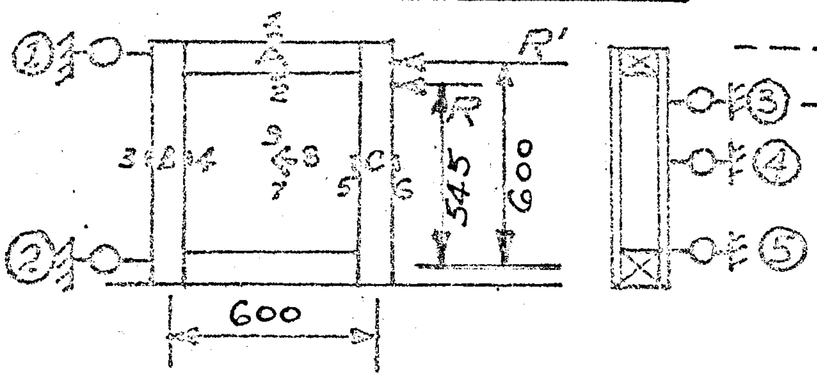
m.c. __ %

SHEATHING MATL.: Ident. TEXPAN

Thick. 9 mm

m.c. __ % Den. 550 kg/m³

Nail Spacing 38 mm



TEST DATA (TEST 6)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defln. Δ (mm)	Strain Readings ×10⁻⁶: Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette (45°) 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.1	0.09	0.045	0.12	+12	+4	+10	0.0	-28	+45	+9	-10	-24	-0.12	0.0	0.39	0.16	0.03
0.2	0.18	0.090	0.21	+17	+2	+10	-4	-30	+52	+10	-14	-38	-0.20	0.0	0.68	0.32	0.05
0.3	0.27	0.135	0.30	+13	+2	+10	-6	-34	+54	+20	-18	-52	-0.3[illegible]	-0.01	0.90	0.45	0.07
0.4	0.36	0.180	0.39	+16	0.0	+8	-5	-37	+60	+25	-20	-62	-0.38	-0.01	0.96	0.47	0.05
0.5	0.46	0.230	0.50	+14	-4	+9	-9	-41	+62	+36	-22	-70	-0.4[illegible]	-0.02	1.04	0.52	0.05
0.6	0.55	0.275	0.59	+16	-4	+6	-8	-44	+68	+40	-26	-78	-0.5[illegible]	-0.02	1.11	0.55	0.05
0.7	0.64	0.320	0.66	+15	-6	+10	-9	-48	+76	+46	-27	-93	-0.6[illegible]	-0.02	1.15	0.57	0.10
0.8	0.73	0.365	0.79	+16	-7	+8	-10	-52	+76	+54	-30	-102	-0.76	-0.02	1.19	0.58	0.10
0.9	0.82	0.410	0.88	+14	-9	+8	-10	-56	+82	+58	-35	-113	-0.85	-0.02	1.21	0.59	0.10
1.0	0.91	0.455	1.00	+18	-9	+8	-12	-60	+88	+64	-37	-122	-0.9[illegible]	-0.025	1.24	0.60	0.10
1.2	1.09	0.546	1.17	+18	-10	+10	-12	-66	+98	+80	-38	-128	-1.12	-0.025	1.26	0.61	0.12
1.5	1.37	0.683	1.45	+18	-13	+8	-17	-82	+112	+97	-44	-162	-1.40	-0.03	1.29	0.61	0.11
2.0	1.82	0.910	1.94	+18	-16	+10	-21	-102	+136	+132	-55	-206	-1.85	-0.04	1.34	0.63	0.12
2.3	2.09	1.045	2.28	+20	-20	+8	-23	-115	+152	+150	-60	-225	[illegible]	-0.04	1.36	0.63	0.125
2.6	2.37	1.183	2.57	+16	-24	+10	-30	-130	+164	+166	-67	-255	[illegible]	-0.04	1.37	0.63	[illegible]
3.0	2.73	1.365	3.00	+18	-28	+10	-34	-148	+184	+190	-76	-280	[illegible]	-0.0	1.40	0.63	[illegible]
3.5	3.19	1.593	3.53	+18	-35	+8	-40	-166	+206	+220	-88	-324	[illegible]	-0.0	[illegible]	0.63	[illegible]
4.0	3.64	1.820	4.06	+16	-40	+8	-40	-182	+226	+265	-100	-372	[illegible]	-0.03	[illegible]	0.63	[illegible]
0.0				+25	+2	+18	0.0	-35	+56	-14	-14	-6	-0.22	-0.01	0.03	0.01	0.00

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 9-11-83

PANEL IDENT. Nº: 2 (TP9)

FRAMING MEMBERS: Size 70 X 45

Species Radiata

Stress Grade F 8

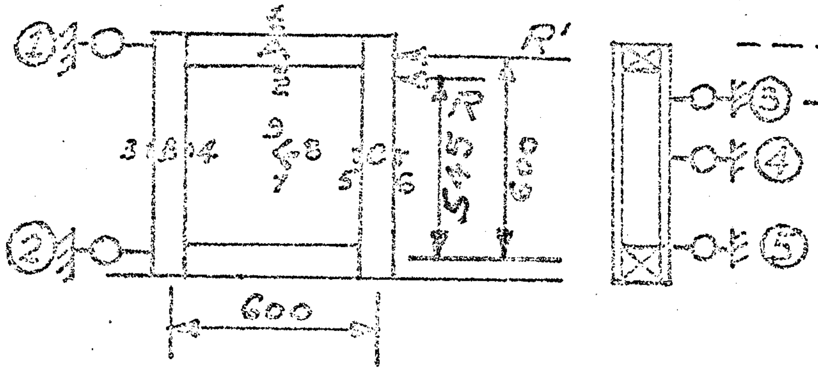
m.c. ___%

SHEATHING MAT'L: Ident. TEXPAN

Thick. 9 mm

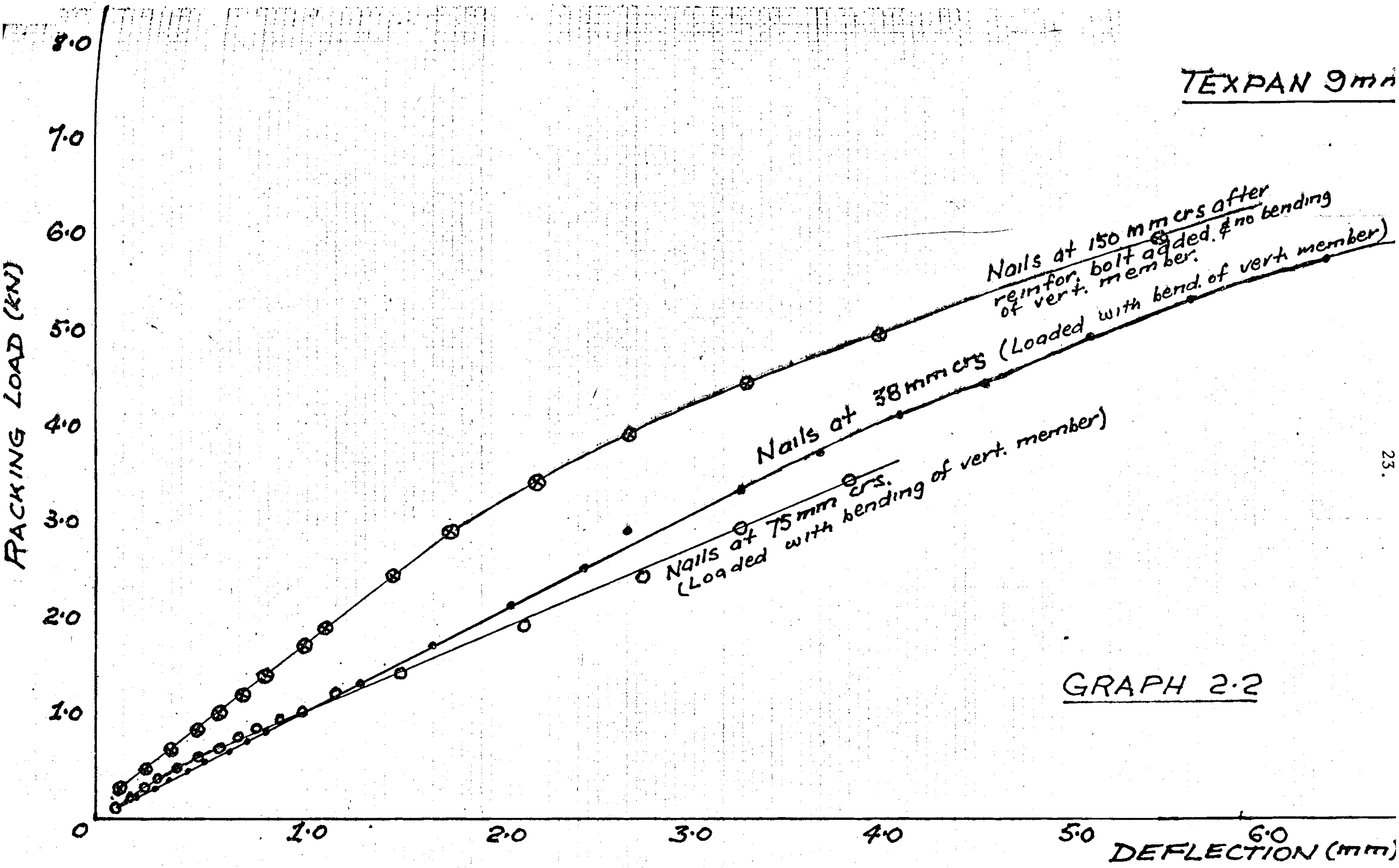
m.c. ___% Dens. ___ 550 Nom.

Nail spacing 38



TEST DATA (TEST 7)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defl'n. Δ (mm)	Strain Readings ×10⁻⁶ Member A 1	2	B 3	4	C 5	6	Panel Rosette (45°) 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.1	0.09	0.045	0.12										0.12	0.0			
0.2	0.18	0.090	0.21										0.21	0.005			
0.3	0.27	0.135	0.31										0.31	0.005			
0.4	0.36	0.180	0.38										0.38	0.01			
0.5	0.46	0.230	0.48	S	T	R	A I	N					0.48	0.01			
0.6	0.55	0.275	0.57							S T	R A	I N	0.56	0.01	D	I A	L
0.7	0.64	0.320	0.70										0.66	0.015			
0.8	0.73	0.365	0.80	R	E A	D	I N	G	S				0.77	[illegible]			
0.9	0.82	0.410	0.87							R E	A D I	N G S	0.84	0.02	G	A U	GES
1.0	0.91	0.455	0.99										[illegible]	0.02			
1.4	1.27	0.635	1.37	N O	T	T	A	K E	N	NOT	TA	KEN	1.32	0.03	R E	M O	VE
1.8	1.64	0.820	1.75										1.67	0.035			
2.2	2.00	1.000	2.16										2.06	0.04			
2.6	2.37	1.185	2.54										2.42	0.05			
3.0	2.73	1.365	2.75										2.79	0.055			
3.4	3.09	1.545	3.34										3.16	0.07			
3.8	3.46	1.730	3.75										3.55	0.08			
4.2	3.82	1.910	4.1[illegible]										3.9[illegible]	0.09			


TEXPAN 9mm
GRAPH 2·2
RACKING LOAD (KN)
DEFLECTION (mm)
0
1·0
2·0
3·0
4·0
5·0
6·0
7·0
8·0
Nails at 150 mm crs after reinfor. bolt added. & no bending of vert. member.
Nails at 38 mm crs (Loaded with bend. of vert member)
Nails at 75 mm crs. (Loaded with bending of vert. member)

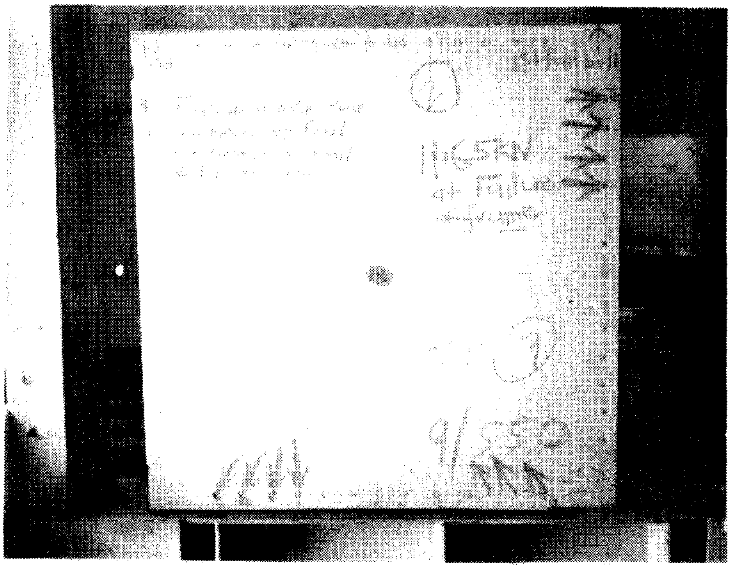


PLATE 2.4

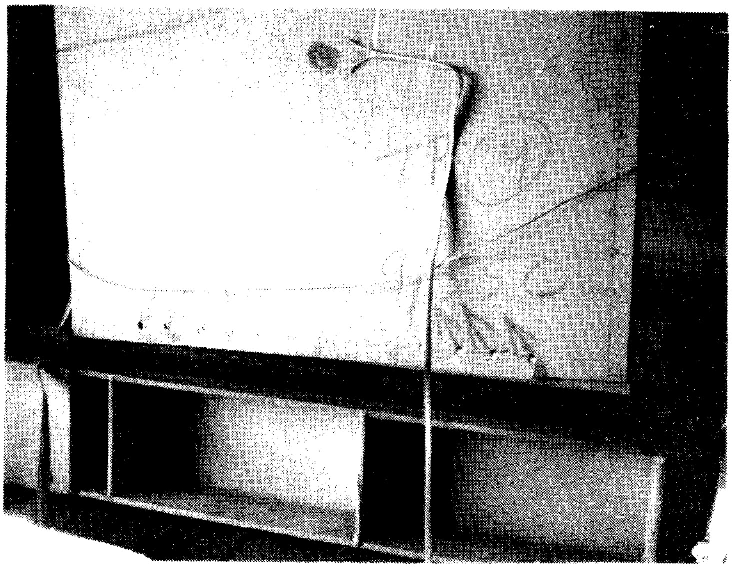


PLATE 2.5

2.4 6mm TEXPAN TEST RESULTS

Model panel No. 3, after attaching the sheating to the timber frame by nails at 75 mm centres, was positioned and loaded in the same manner as two previous model panels.

Data Sheet 1 (Test 8) shows the strain and dial gauge readings for 0.1 kN load increments to 1.0 kN and 0.2 kN load increments from 1.0 kN to 2 kN. At 2.5 kN the load was released and residual strains and displacements recorded. Racking loads have been modified and halved to obtain the racking load/side. Dial gauge 6 readings have not been included.

Data Sheet 2 (Test 9) shows the strain and dial gauge readings for identical load increments as for Test 8. However, in this case the load was applied directly to member A in an effort to eliminate some of the bending from member C.

Data Sheet 3 (Test 10) shows the racking load versus deflection results for a penl with nails at 150 mm centres. The loading for this case was again applied directly through member A.

2.4.1 Analysis of Results

For the 75 mm nail centres the strain readings in members A and B are all negative indicating uniaxial compression exists with some bending. Strain readings in member C are of opposite sign with the positive readings predominating indicating the presence of bending with axial tension. Strain rosette readings are similar in form to those previously recorded.

For the 38 mm nail centres strains in members A and B follow the same general pattern as for the 75 mm centres case. However, there is an obvious increase in the nagnitude of the axial compressive forces.

Strain readings of member C indicate an appreciable reduction in bending as would be expected due to loading along the axis of member A.

Strain rosette readins are again similar to previous cases.

2.4.2 Failure Mode

Loading the panel with nails at 38 mm centres to failure, with the load applied along the longitudinal axis of member A, resulted in first failure occurring at the bottom left corner of the panel due to the nails bending and the heads pulling through the sheathing. Nail head rotation was also observed at the bottom right corner where the bottom member had split through the hole. Some sheathing distress was evident around these nails but premature failure of the bottom framing member is considered to have caused this. The failure load for the frame was estimated at approximately 13.6 kN.

Figure 2.3 shows the direction of nail movement after failure.

Loading of the panel with nails at 150 mm centres resulted in first failure occurring at the hole in the vertical member C resulting in pull-out of a plug of timber due to bearing of the bolt. The load at which this occurred was approximately 7 kN.

Connector failure resulted in the nails deforming in the pattern shown in Figure 2.4.

Graph 2.3 shows thatincreasing the number of nails attaching sheathing to timber frame marginally increases panel stiffness.

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: __________

DATE OF TEST: 10-11-83

PANEL IDENT. N°: 3 (TP6)

FRAMING MEMBERS: SIZE 70 X 45

Species Radiota

Stress Grade F 8

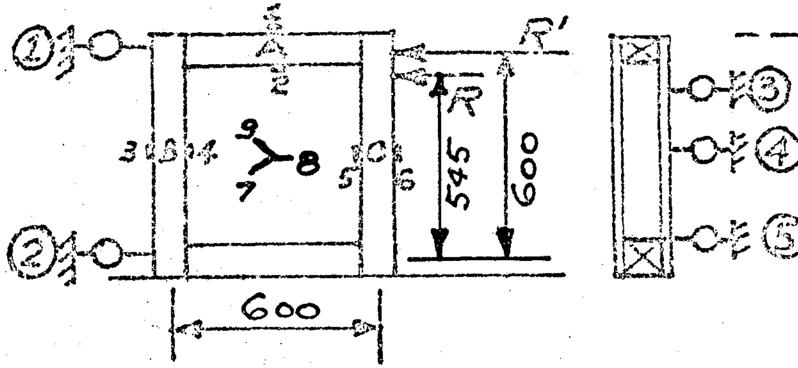
m.c. __ %

SHEATHING MAT'L: Ident. TEXPAN

Thick. 6 mm std.

m.c. __ % Den. ___ kg/

Nail Spacing 75 mm.



TEST DATA (TEST 8)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defln. Δ (mm)	Strain Readings ×10⁻⁶ — Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette (128) 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.1	0.09	0.045	0.11	0	0	0	0	-4	+9	-10	+6	-18	-0.11	0.0	+0.33	0.14	+0.04
0.2	0.18	0.090	0.21	0	0	0	0	-8	+14	-14	+4	+8	-0.21	0.005	+0.33	0.14	+0.04
0.3	0.27	0.135	0.28	-2	-3	0	-4	-10	+14	-19	0	-14	-0.28	0.01	+0.28	0.14	+0.04
0.4	0.36	0.180	0.36	-6	-3	-2	-4	-13	+20	-21	-3	+8	-0.36	0.01	+0.22	0.13	+0.04
0.5	0.46	0.230	0.44	-2	-4	0	-4	-16	+24	-24	-4	-9	-0.43	0.01	+0.140	0.10	+0.04
0.6	0.55	0.270	0.53	-9	-5	-2	-4	-19	+27	-30	-3	+18	-0.51	0.015	+0.11	0.08	+0.04
0.7	0.64	0.320	0.63	-4	-6	0	-5	-20	+30	-34	-6	0	-0.59	0.015	+0.06	0.05	+0.035
0.8	0.73	0.365	0.72	-8	-7	-2	-5	-26	+36	-36	-7	+24	-0.69	0.02	+0.01	0.02	+0.03
0.9	0.82	0.410	0.81	-7	-9	-2	-6	-30	+42	-42	-8	+10	-0.77	0.02	-0.03	0.02	+0.03
1.0	0.91	0.455	0.90	-11	-9	-4	-8	-34	+44	-46	-12	+26	-0.86	0.025	-0.06	0.02	+0.03
1.2	1.09	0.545	1.11	-6	-11	-2	-10	-45	+54	-56	-14	+7	-1.07	0.030	-0.13	-0.01	+0.025
1.4	1.27	0.635	1.18	-10	-10	-3	-10	-50	+60	-64	-21	+25	-1.13	0.035	-0.17	-0.05	+0.025
1.6	1.46	0.730	1.47	-11	-11	-4	-10	-56	+66	-74	-24	+34	-1.41	0.040	-0.20	-0.08	+0.025
1.8	1.64	0.820	1.68	-11	-14	-5	-12	-60	+74	-84	-30	+42	-1.61	0.050	-0.23	-0.10	+0.020
2.0	1.82	0.910	1.94	-10	-16	-4	-13	-64	+80	-90	-32	+50	-1.85	0.050	-0.26	-0.13	+0.020
2.3	2.09	1.045	2.23	-11	-17	-4	-14	-70	+90	-104	-37	+58	-2.14	0.060	-0.30	-0.17	+0.010
2.5	2.28	1.140	2.46	-11	-18	-6	-14	-77	+96	-112	-40	+62	-2.36	0.070	-0.32	-0.20	+0.005
0.0				+6	-5	+10	-4	-16	+27	-14	0	-14	-0.3	0.01	+0.02	+0.03	-0.035

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: ----------

DATE OF TEST: 10-11-83

PANEL IDENT. N°: 3 (TP6)

FRAMING MEMBERS: SIZE 70 X 45

Species Radiata

Stress Grade F 8

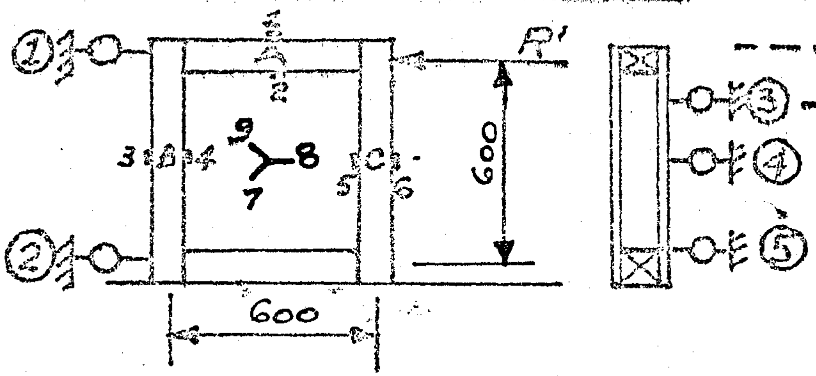
m.c. ___ %

SHEATHING MAT'L.: Ident. TEXPAN

Thick. 6 mm

m.c. ___ % Den. std. kg

Nail spacing 38



TEST DATA (TEST 9)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defln. Δ (mm)	Strain Readings ×10⁻⁶ Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette (120°) 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.1			0.02	-2	0	-3	0	+3	+3	-14	-4	+10	0.02	0.0	+0.75	+0.37	0.06
0.2			0.046	-5	-4	-6	-2	+4	+4	-20	-6	+8	0.045	0.005	+0.84	0.40	0.06
0.3			0.09	-7	-4	-8	-2	+4	+4	-28	-6	+12	0.09	0.010	0.90	0.42	0.0
0.4			0.14	-5	-2	-6	+4	+6	+4	-32	-6	+12	0.14	0.015	0.95	0.45	0.0
0.5			0.20	-8	-4	-10	0	+6	+3	-38	-6	+22	0.20	0.015	1.02	0.46	0.0
0.6			0.29	-8	-4	-8	0	+8	+6	-42	-6	+22	0.29	0.020	1.05	0.47	0.08
0.7			0.36	-10	-6	-10	-3	+8	+2	-48	-6	+22	0.36	0.020	1.08	0.47	0.0
0.8			0.43	-13	-8	-12	-4	+8	+4	-60	-12	+20	0.42	0.025	1.11	0.49	0.0
0.9			0.53	-14	-8	-13	-3	+10	+5	-62	-12	+22	0.51	0.030	1.13	0.50	0.0
1.0			0.62	-15	-12	-14	-4	+8	+6	-70	-12	+22	0.60	0.030	1.14	0.50	0.0
1.2			0.76	-17	-14	-14	-4	+10	+4	-80	-17	+23	0.73	0.035	1.17	0.50	0.0
1.4			0.91	-20	-17	-17	-6	+9	+6	-92	-18	+29	0.88	0.040	1.18	0.51	0.0
1.6			1.09	-23	-20	-17	-7	+10	+6	-105	-21	+31	1.06	0.050	1.21	0.52	0.0
1.8			1.26	-22	-22	-20	-7	+12	+12	-114	-20	+35	1.21	0.055	1.22	0.52	0.0
2.0			1.41	-24	-24	-20	-7	+15	+11	-126	-20	+39	1.37	0.065	1.22	0.53	0.0
2.3			1.70	-26	-30	-21	-6	+16	+14	-126	-23	+45	1.65	0.08	1.22	0.53	0.0
2.5			1.89	-26	-32	-24	-17	+20	+18	-134	-22	+54	1.83	0.09	1.24	0.53	0.0
0.0				-8	0	-12	+11	+10	-7	+14	-12	-37	0.16	0.01	0.33	0.14	-0.0

... PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 10-11-83

PANEL IDENT. Nº: 4 (TP6)

FRAMING MEMBERS: Size 70 X 45

Species Radiata

Stress Grade F 8

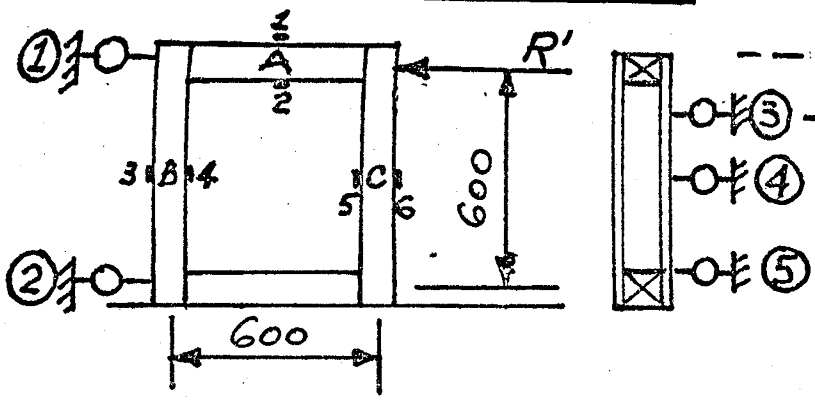
m.c. ___ %

SHEATHING MATL.: Ident. TEXPAN

Thick. 6 mm

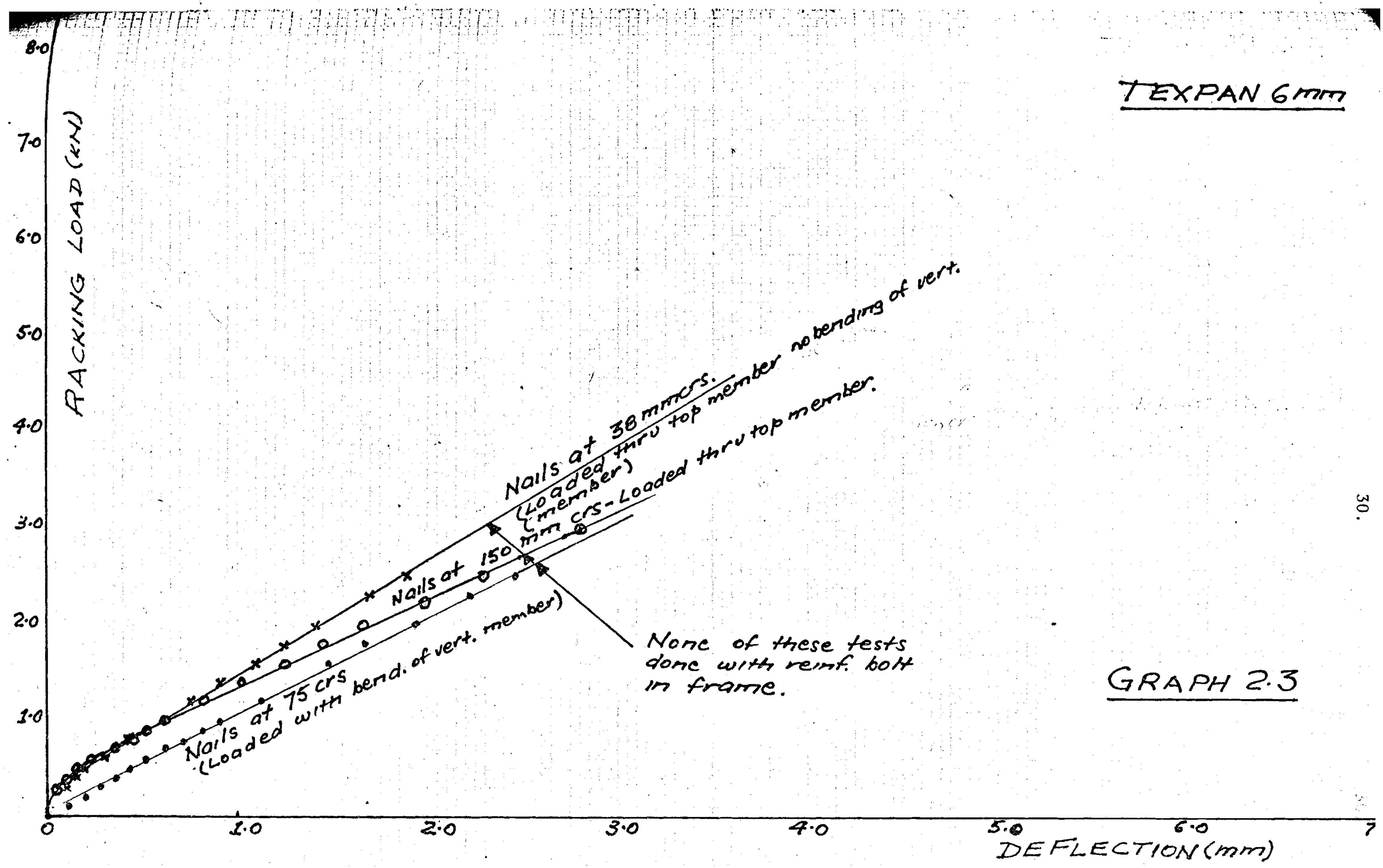
m.c. ___ % Den. ___ kg/m

Nail Spacing 150 mm

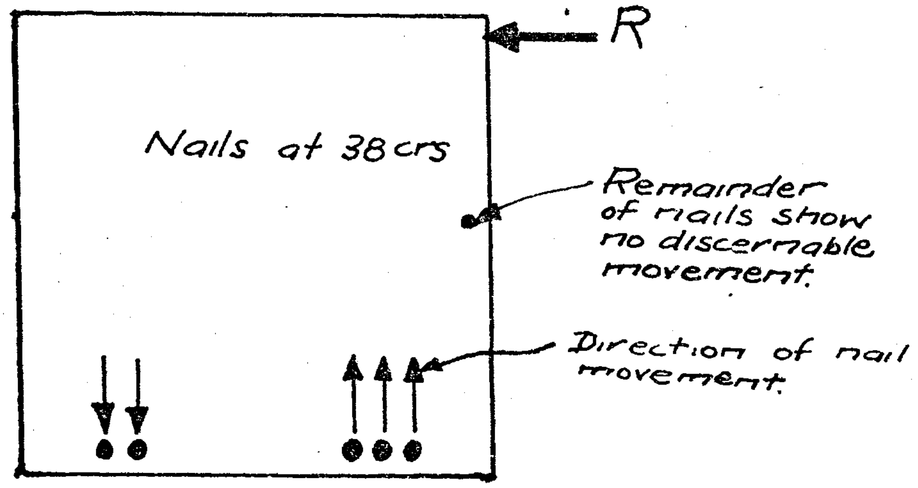


TEST DATA (TEST 10)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defln. Δ (mm)	Strain Readings ×10⁻⁶ Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.2			0.0										0.0	0.0			
0.3			0.05										0.05	0.0			
0.4			0.10										0.10	0.0			
0.5			0.20										0.20	0.0			
0.6			0.27	S	T	R	A I	N		ST	RA	IN	0.26	0.0	DI	A	L
0.7			0.36										0.35	0.0			
0.8			0.46										0.44	0.0			
0.9			0.52	R	EA	D	IN	GS		RE	ADI	NGS	0.50	0.0	GA	UG	ES
1.0			0.61										0.58	0.0			
1.2			0.83										0.77	0.0			
1.4			1.03	N	OT		TA	K	EN	NO	T TA	KEN	0.97	0.0	NO	T R	EAD
1.6			1.26										1.16	0.005			
1.8			1.45										1.35	0.010			
2.0			1.66										1.55	0.015			
2.3			1.97										1.84	0.015			
2.5			2.20										2.04	0.015			
3.0			2.60										2.60	0.01			
3.5													3.60	0.04			

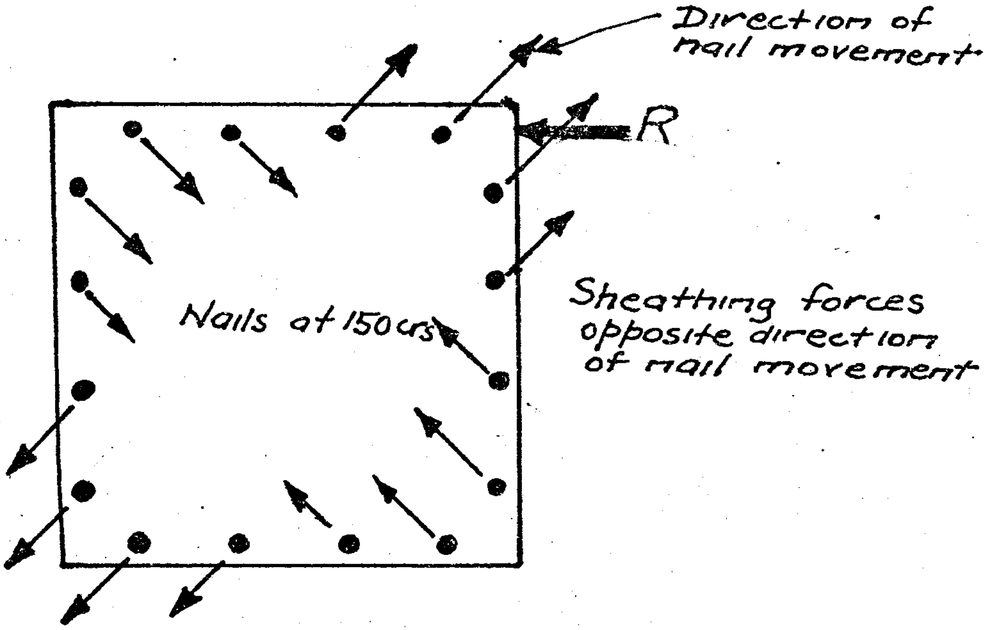

TEXPAN 6mm
RACKING LOAD (kN)
DEFLECTION (mm)
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
0
1·0
2·0
3·0
4·0
5·0
6·0
7
Nails at 38 mm crs. (Loaded thru top member) no bending of vert.
Nails at 150 mm crs - Loaded thru top member.
Nails at 75 crs (Loaded with bend. of vert. member)
None of these tests done with reinf. bolt in frame.

GRAPH 2·3



TEST PANEL No3

FIGURE 2.3



TEST PANEL No4

FIGURE 2.4

SECTION 3

FINAL TESTING PROGRAMME

3.1 INTRODUCTION

During the preliminary testing programme discussed in Section 2 of this report several factors influencing test results became evident. The most important of these observed factors are summarized as follows:

(i) loading such as to cause bending of the vertical member C resulted in frame action of the type illustrated in Figure 2.2

(ii) premature failure of the timber frame caused sheathing failures rather than connection failures in the thicker particleboards

(iii) having a nailing pattern using 38 mm and even 75 mm centres did not provide clearly defined information concerning connection failure

To minimize bending of the vertical member C during loading a steel packing piece was devised which allowed the load to be applied along the axis of member C but did not inhibit rotation of the frame.

Elimination of premature frame failure was facilitated by introducing the reinforcing rod shown in Figure 1.1. The function of the rod was to prevent frame failure at the bolt holes at the top and bottom corners of the loaded end.

Except for model panel No. 8, in which nail spacings were 75 mm on centres, all panels tested in this part of the programme either had nails at 150 mm centres or were glued, as was the case for test panel No. 10.

3.2 9mm TEXPAN TEST RESULTS

Model panel No. 5, after attaching of sheathing to the timber frame by nails at 150 mm centres, was positioned in the loading frame with the reinforcing rod located as shown in Figure 1.1.

Data Sheet 1 (Test 11) shows the racking load versus deflection results. Strain and dial gauge readings were not taken during loading.

Data Sheet 2 (Test 12) gives the racking load/deflection results for the same panel after having been squared up and renailed at 38 mm centres. Again strain and dial gauge readings were not taken.

3.2.1 Analysis of Results

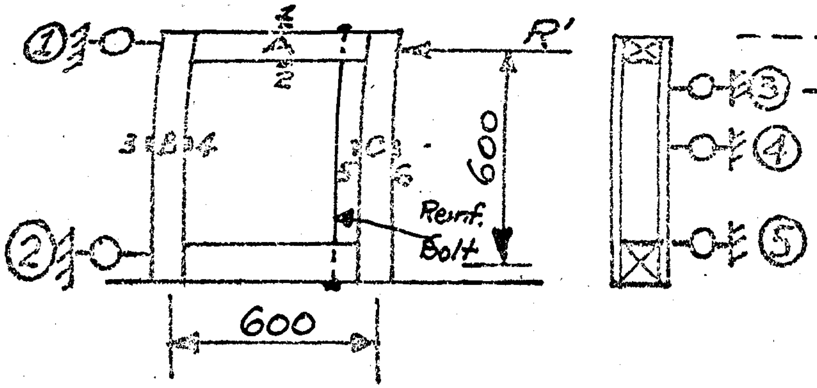
In the second loading case the load suddenly released itself for some reason. This same phenomena occurred in a later test but was attributed to the hydraulics of the loading equipment rather than anything untoward associated with the model panel tests.

3.2.2 Failure Mode

For the 150 mm nail centres case the panel was loaded until connection failure was observed at 12.5 kN. The failure mode of the nails was the same as that shown in Figure 2.4.

After squaring the frame and renailing at 38 mm centres it was felt that the nails at 150 mm centres would offer little or nothing to initial panel stiffness. In loading the panel to failure, a load of 18.6 kN was attained at which load the 75 x 38 mm support channel to which the panel was bolted bent at the reinforcing bolt. The test was terminated at this stage and the channel straightened and stiffened. The panel was not tested further.

Graph 3.1 shows the 150 mm nailing pattern to provide a decided bilinear type of response. It may be that in the initial stage of loading the nails respond in a certain stiffer mode, e.g. double curvature, and then with increased loading revert to a cantilever type response. For the 38 mm nailing pattern the initial high stiffness would seem to be more likely due to friction rather than the nails responding in some stiffer mode.



PANEL IDENT. No: 5 (TP9)

FRAMING MEMBERS: Size 70 x 45
Species Radiata
Stress Grade F 8
m.c. ___ %

SHEATHING MATL.: Ident. TEXPAN
Thick. 9 mm
m.c. ___ % Den. ____ kg/
Nail Spacing 150 mm

TEST DATA (TEST II)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defl. Δ (mm)	Strain Readings x 10⁻⁶									Dial Gauge Readings (mm)				
				Member						Panel							
				A		B		C		Rosette							
				1	2	3	4	5	6	7	8	9	1	2	3	4	5
0.1			0.11										0.10	0.0			
0.3			0.13										0.22	0.0			
0.5			0.27										0.24	0.0			
0.7			0.40										0.36	0.02			
0.9			0.54										0.49	0.02			
1.1			0.65										0.58	0.02	D I	AL	
1.3			0.77										0.70	0.02			
1.5			0.88	S	T	R	A	I	N	S T	R A I	N	0.79	0.02	G A	U G	ES
1.8			1.09										0.96	0.035			
2.0			1.20	R E	A	D	I NG	S		RE	ADI	NGS	1.08	0.04	NOT	RE	AD
2.5			1.54										1.39	0.075			
3.0			1.83		NOT	T	AK	EN		NOT	TA	KEN	1.71	0.09			
3.5			2.28										2.10	0.11			
4.0			2.77										2.56	0.13			
4.5			3.36										3.14	0.17			
5.0			4.04										3.87	0.23			
6.0			5.50										5.65	0.62			
7.0			8.12										8.12	0.96			

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 11-11-83

PANEL IDENT. N°: 5 (TP9)

FRAMING MEMBERS: Size 70 x 45

Species Radiata

Stress Grade F8

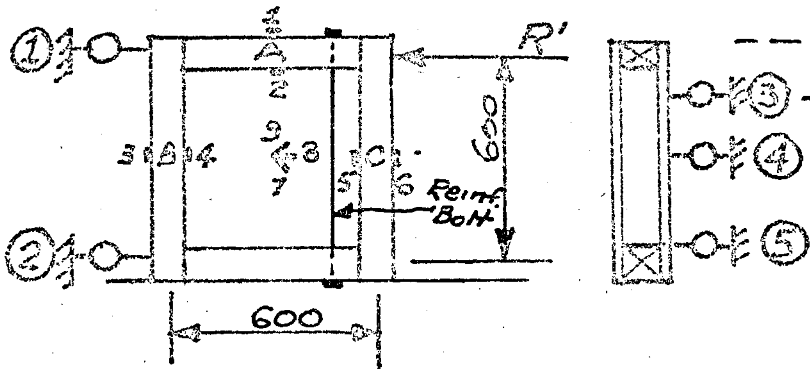
m.c. ___ %

SHEATHING MAT'L: Ident: TEXPAN

Thick. 9 mm

m.c. ___ % Den. ___ kg/

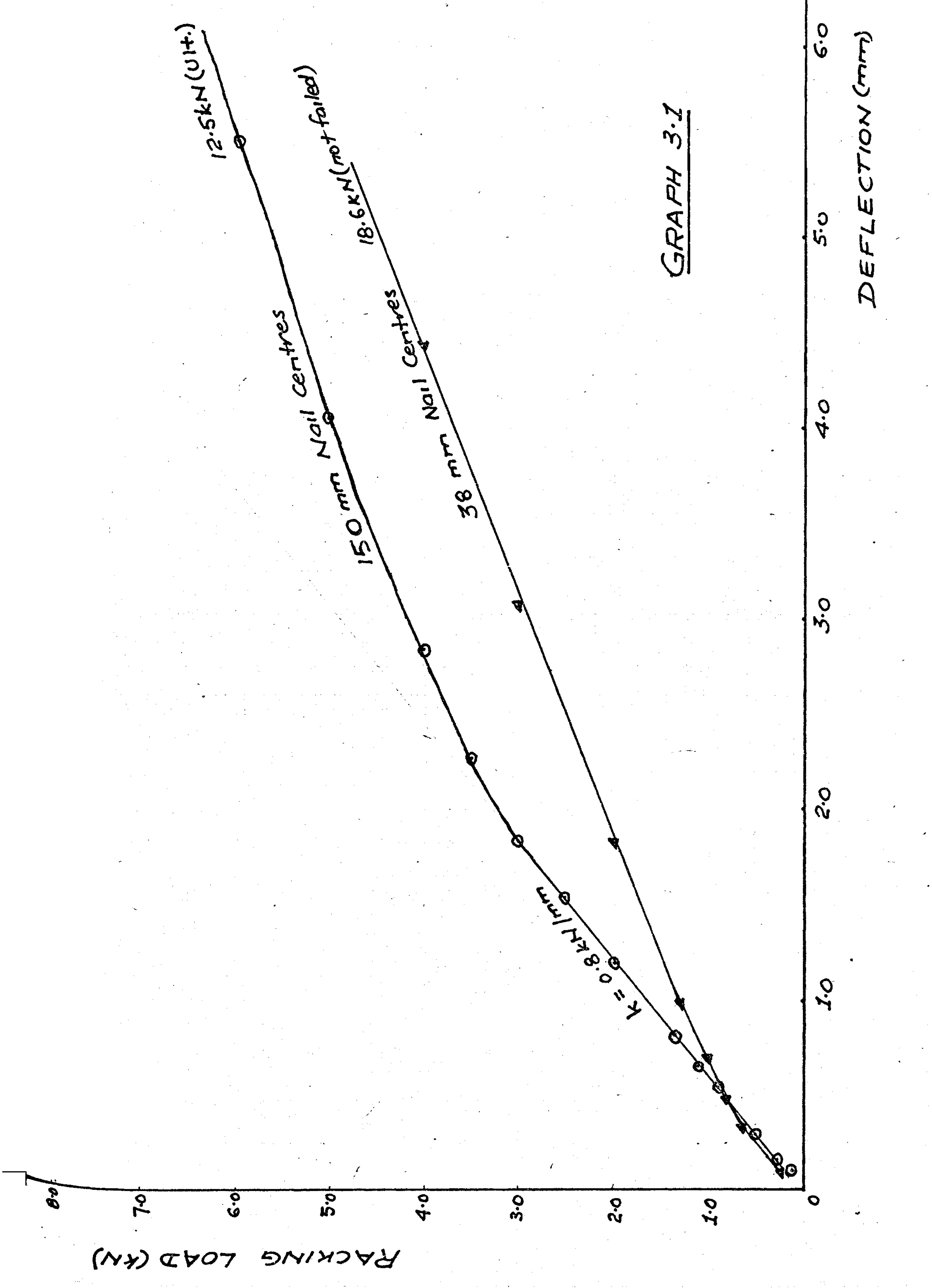
Nail Spacing 38 after being 150mm



TEST DATA (TEST 12)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defl. Δ (mm)	Strain Readings ×10⁻⁶ Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.2			0.09										0.09	0.0			
0.4			0.28										0.28	0.0			
0.6			0.32										0.33	0.01			
0.8			0.48										0.48	0.01			
1.0			0.69	S	T	R	A	I	N	ST	RAI	N	0.63	0.015	DI	AL	
1.3			0.99										0.91	0.025			
1.6			1.27							READ	IN	GS	1.17	0.025	GA	UG	ES
2.0			1.77	R	EA	D	IN	G	S				1.64	0.03			
3.0			3.09							NOT	TAK	EN	2.83	0.03	NOT	RE	AD
4.0			4.44							Load dropped off for some reason			4.09	0.055			
5.0			4.94	N	OT		TA	KE	N				4.60	0.15			
6.0			5.65										5.26	0.19			
7.0			6.40										5.96	0.23			
8.0			7.29										6.85	0.31			
9.0			8.17										7.92	0.59			
11.0			10.15										10.18	1.05			
13.0			10.75										12.55	1.46			
14.0	Dial gauges removed after this load. No signs of nail or sheathing distress at 18.6kN.												13.86	1.60			

Model panel base support channel was bent during this loading cycle.


GRAPH 3.1
RACKING LOAD (kN)
DEFLECTION (mm)
150 mm Nail Centres
38 mm Nail Centres
12.5kN (Ult.)
18.6kN (not failed)
k = 0.8kN/mm
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0

.3 7mm RADIATA PINEPLY TEST RESULTS

odel panel No. 6, after attachment of the sheathing with nails at 50 mm centres, was positioned in the loading frame as previously escribed.

ata Sheet 3 (Test 13) shows the racking load versus deflection esults. Strain and dial gauge readings were not taken during loading.

.3.1 Analysis of Results

e results for this test are straight forward.

.3.2 Failure Mode

e panel was loaded until connection failure was observed at 7.2 kN. e failure mode of the nails was the same as for the 9 mm Texpan eathing.

aph 3.2 shows a linear load-deflection response to about 3.5 kN ter which it becomes non-linear to failure. At low loads the effect f friction at the nails is apparent resulting in a fairly high itial stiffness.

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 15-11-83

PANEL IDENT. N°: 6 (PP 7)

FRAMING MEMBERS: Size 70 X 45

Species Radiata

Stress Grade F 8

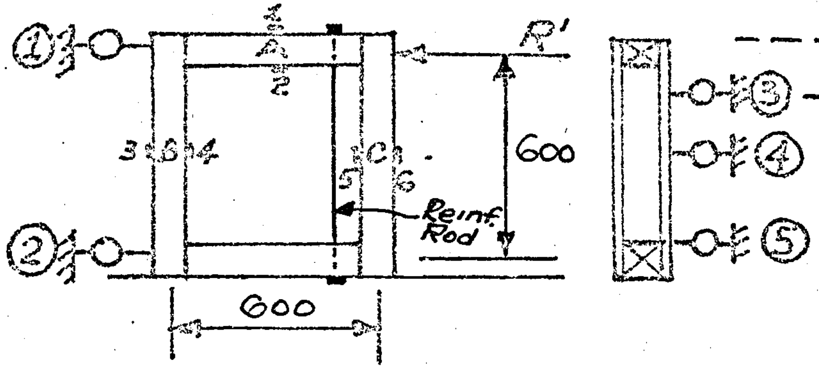
m.c. __ %

SHEATHING MATL.: Ident: Radiata Pine Plywood

Thick. 7 mm

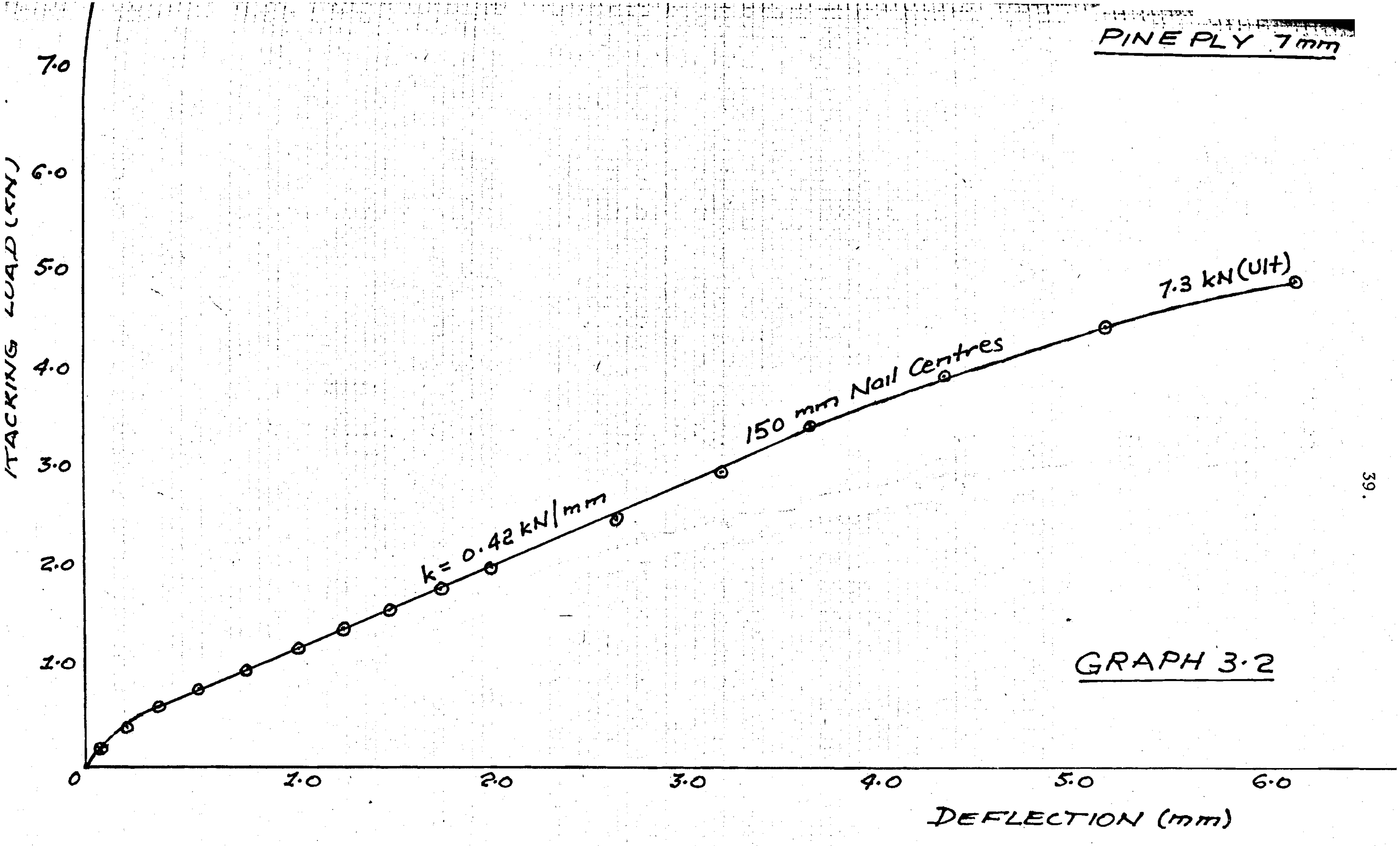
m.c. __ % Den. ____ kg/m³

Nail Spacing 150 mm



TEST DATA (TEST 13)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defln. Δ (mm)	Strain Readings ×10⁻⁶ Member A		B		C		Panel Rosette			Dial Gauge Readings (mm)				
				1	2	3	4	5	6	7	8	9	1	2	3	4	5
0.2			0.08										0.08	0.0			
0.4			0.22										0.22	0.0			
0.6			0.39										0.38	0.0			
0.8			0.59										0.56	0.0			
1.0			0.84	S	T R	A	I N			S T	R A	I N	0.79	0.0	D I	A L	
1.2			1.10										1.04	-0.005			
1.4			1.34										1.27	0.01			
1.6			1.58	R	E A	D	I N	G S		R E	A D I	N G S	1.49	0.015	G A	U G	E S
1.8			1.83										1.72	0.015			
2.0			2.10										1.98	0.02			
2.5			2.76	N O	T	T A	K E	N		N O T	T A	K E N	2.60	0.03	N O	T R E	A D
3.0			3.29										3.10	0.035			
3.5			3.74										3.53	0.055			
4.0			4.45										4.23	0.085			
4.5			5.27										5.03	0.11			
5.0			6.25										6.03	0.15			
6.0			8.87										8.64	0.23			
7.2	Ult.	Load															


PINE PLY 7mm
RACKING LOAD (kN)
7·0
6·0
5·0
4·0
3·0
2·0
1·0
0
1·0
2·0
3·0
4·0
5·0
6·0
DEFLECTION (mm)
7.3 kN (Ult)
150 mm Nail Centres
k = 0.42 kN/mm

GRAPH 3·2

3.4 4mm FINELINE TEST RESULTS

Model panel No. 7 was sheathed with nails at 150 mm centres and positioned in the loading frame.

Data Sheet 4 (Test 14) shows the racking load versus deflection results. Strain and dial gauge readings were not taken during loading.

3.4.1 Analysis of Results

The results for this test are again straight forward.

3.4.2 Failure Mode

The panel was loaded until material failure was observed at 4.5 kN.

The failure mode in this case differed from those previously described in that no visible nail movement occurred. However, tearing of the material was evidenced in the same general direction as the nail deformations of the thicker boards. The implication here is that the nail is stronger than the sheathing material and, for example, whilst the nail appears not to deform along the tension diagonal say, the material tears permitting the nail to move. This type of action is shown diagrammatically in Figure 3.1. A similar situation exists along the compression diagonal.

The direction of nail forces must be in the opposite direction to that of material tearing and therefore conform to the same sorts of deformations as those observed for the thicker boards.

Graph 3.3 shows the load/deflection response to be linear to about 1.5 kN at which stage it becomes non-linear to failure. As for the previous case the effect of friction is also in evidence at the lower load levels.

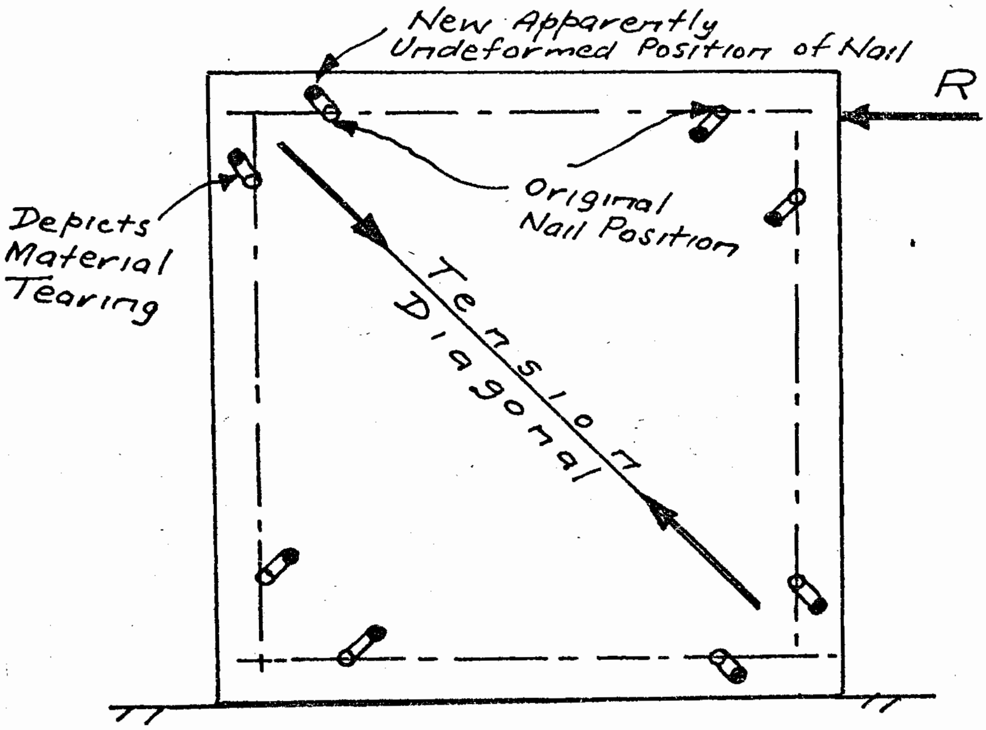

New Apparently Undeformed Position of Nail
R
Depicts Material Tearing
Original Nail Position
Tension Diagonal

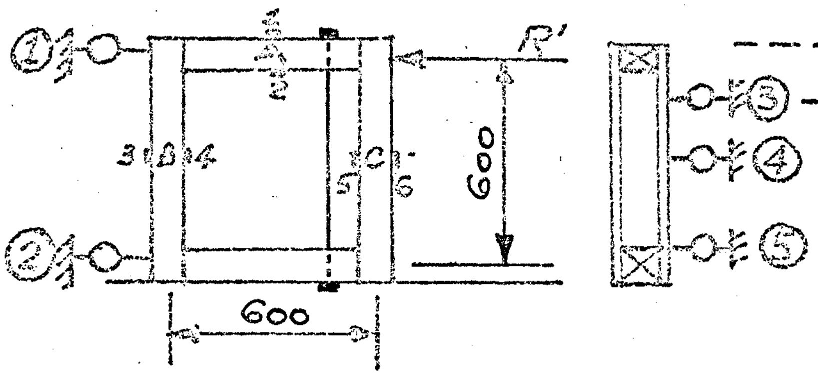
FIGURE 3.1

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 15-11-83

PANEL IDENT. No: 7 (FL4)



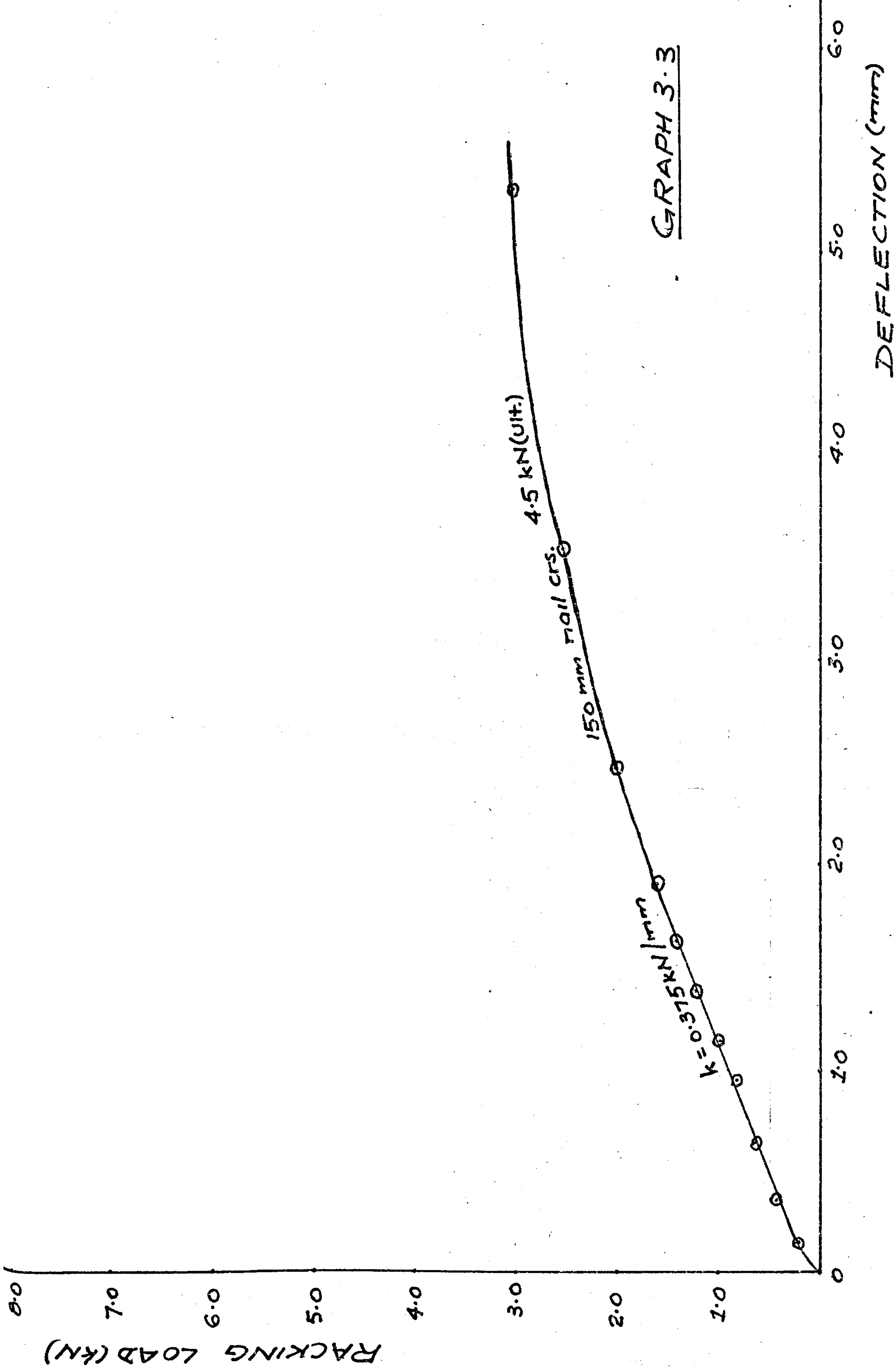
FRAMING MEMBERS: Size 70 x 45
Species Radiata
Stress Grade F8
m.c. ___ %

SHEATHING MAT'L: Ident: FINELINE
Thick. 4 mm
m.c. ___ % Den. ___ kg
Nail Spacing 150mm

TEST DATA (TEST 14)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defln. Δ (mm)	Strain Readings x10⁻⁶ Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.2			0.15										0.15	0.0			
0.4			0.36										0.35	0.01			
0.6			0.64										0.64	0.015			
0.8			0.96										0.96	0.02			
1.0			1.16	S	T	R	A	I	N	ST	RA	IN	1.15	0.03	DI	AL	
1.2			1.39										1.37	0.035			
1.4			1.62										1.59	0.04			
1.6			1.93	R	E	AD	I	NG	S	RE	ADI	NGS	1.88	0.045	GA	UG	ES
1.8			2.17										2.10	0.055			
2.0			2.48										2.40	0.06			
2.5			3.55	NO	T	T	AK	EN		NOT	TA	KEN	3.45	0.085	NO	TR	EAD
3.0			5.34										5.20	0.11			
3.5			8.19										8.03	0.14			
4.0													Dial	Gauge	Removed		
4.5																	

SHEET 4 OF 9


GRAPH 3·3
DEFLECTION (mm)
RACKING LOAD (kN)
4·5 kN(ult.)
150 mm nail crs.
k = 0·375 kN/mm
0
1·0
2·0
3·0
4·0
5·0
6·0
7·0
8·0

3.5 10 mm PINEBOARD TEST RESULTS

Model panel No. 8 was sheathed with nails at 75 mm centres and positioned in the loading frame.

Data Sheet 5 (Test 15) shows the strain and dial gauge readings for 0.1 kN load increments to 1 kN and 0.2 kN load increments from 1.0 kN to 2.4 kN. The load was then released and residual values of strain and displacement record.

Data Sheet 6 (Test 16) shows the racking load and corresponding horizontal deflection of the panel. During this loading strain readings were not taken and dial gauges 3, 4 and 5 were removed.

Data Sheet 9 (Test 19) which shows the test data obtained for model panel No. 11 is included here since it pertains to Pineboard. These results were obtained after sheathing the timber frame using nails at 150 mm centres and racking the panel.

3.5.1 Analysis of Results

For model panel No. 8, which has nails at 75 mm centres, the strain readings in members A and B show these member to be subjected to axial compression combined with bending. Member C is subjected mainly to bending with the axial force varying between being a low compressive to a low tensile force.

Strain rosette readings show tensile forces to exist in the direction of gauge 9 and compressive forces in the direction of gauge 7.

Dial gauges 3, 4 and 5 show negative readings indicating a tendency for the sheathing to buckle concave in towards the framing members in a half sine wave.

3.5.2 Failure Mode

For both model panels No's. 8 and 11 connector failure occurred resulting in the nails assuming the deformed pattern shown in Figure 2.4. The respective failure loads were 16.5 kN and an estimated 15 kN. There was no evidence of sheathing distress at failure.

Graph 3.4 shows the initial stiffness to be approximately halved by doubling the distance between nail centres. Both curves display the same tendency to soften and then regain stiffness for some inexplicable reason.

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 15-11-83

PANEL IDENT. Nº: 8 (PB 10)

FRAMING MEMBERS: SIZE 70 x 45

Species Radiata

Stress Grade F 8

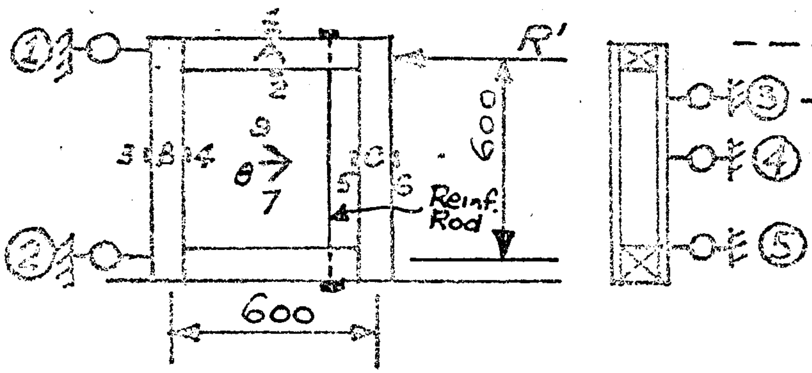
m.c. ___ %

SHEATHING MAT'L.: Ident. PINEBOARD

Thick. 10 mm

m.c. ___ % Den. ___ kg/m³

Nail Spacing 75 mm



TEST DATA (TEST 15)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defl. Δ (mm)	Strain Readings x10⁻⁶ Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette (120°) 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.1			0.0	-4	-6	0.0	-6	-4	0.0	-10	-2	+6	0.0	0.0	0.0	0.0	0.0
0.2			0.0	0.0	-7	0.0	-4	-6	+4	-14	0.0	+7	0.0	0.0	0.0	0.0	0.0
0.3			0.0	0.0	-6	0.0	-6	-4	+3	-14	+4	+14	0.03	0.05	0.0	0.0	0.0
0.4			0.04	0.0	-6	+2	-6	-2	+4	-16	+4	+18	0.05	0.01	0.0	0.0	0.0
0.5			0.07	-2	-8	+2	-7	-4	+4	-20	+5	+23	0.08	0.01	0.0	0.0	0.0
0.6			0.12	-4	-7	+2	-7	-6	+2	-26	+4	+24	0.125	0.01	0.0	0.0	0.0
0.7			0.18	-3	-10	-3	-10	-8	+4	-30	+4	+30	0.165	0.01	-0.02	0.0	0.0
0.8			0.24	-6	-14	-3	-10	-8	+4	-36	+2	+34	0.220	0.015	-0.05	+0.005	0.0
0.9			0.27	-6	-15	-4	-10	-6	+5	-40	+2	+39	0.250	0.015	-0.08	+0.010	0.0
1.0			0.34	-8	-16	-4	-10	-8	+6	-43	+4	+44	0.300	0.015	-0.13	-0.01	0.0
1.2			0.46	-6	-18	-4	-12	-6	+7	-50	+8	+50	0.410	0.020	-0.22	-0.04	0.0
1.4			0.61	-8	-24	-8	-14	-10	+6	-60	+6	+60	0.550	0.020	-0.34	-0.09	-0.01
1.6			0.66	-8	-32	-6	-14	-7	+7	-66	+7	+69	0.670	0.025	-0.49	-0.16	-0.02
1.8			0.92	-5	-28	-4	-9	-4	+10	-66	+12	+73	0.825	0.025	-0.68	-0.26	-0.04
2.0			1.07	0.0	-39	-6	-16	-6	+10	-81	+14	+85	0.965	0.030	-0.92	-0.37	-0.05
2.2			1.23	+2.0	-44	-6	-16	-6	+10	-90	+18	+95	1.100	0.035	-1.03	-0.43	-0.06
2.4			1.43	+7.0	-54	-7	-14	-2	+12	-94	+26	+110	1.290	0.040	-1.29	-0.52	-0.07
0.0			0.14	+12	-26	+4	-6	-7	+4	+5	0.0	+13	0.150	0.010	-0.33	-0.16	-0.05

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 15-11-83

PANEL IDENT. Nº: 8 (PB10)

FRAMING MEMBERS: Size 70 x 45

Species Radiata

Stress Grade F 8

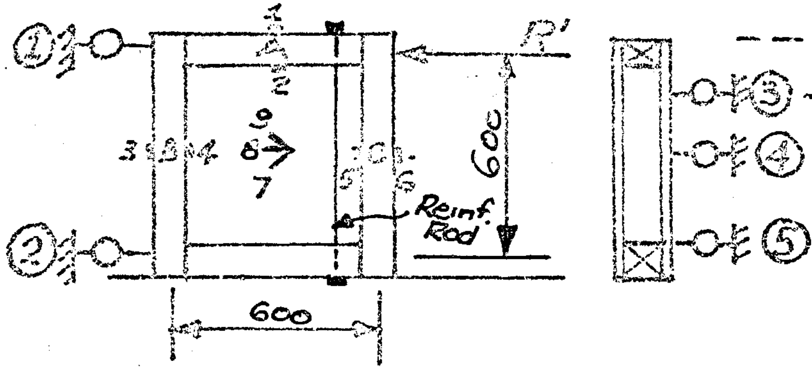
m.c. ___ %

SHEATHING MATL.: Ident. PINEBOARD

Thick. 10 mm

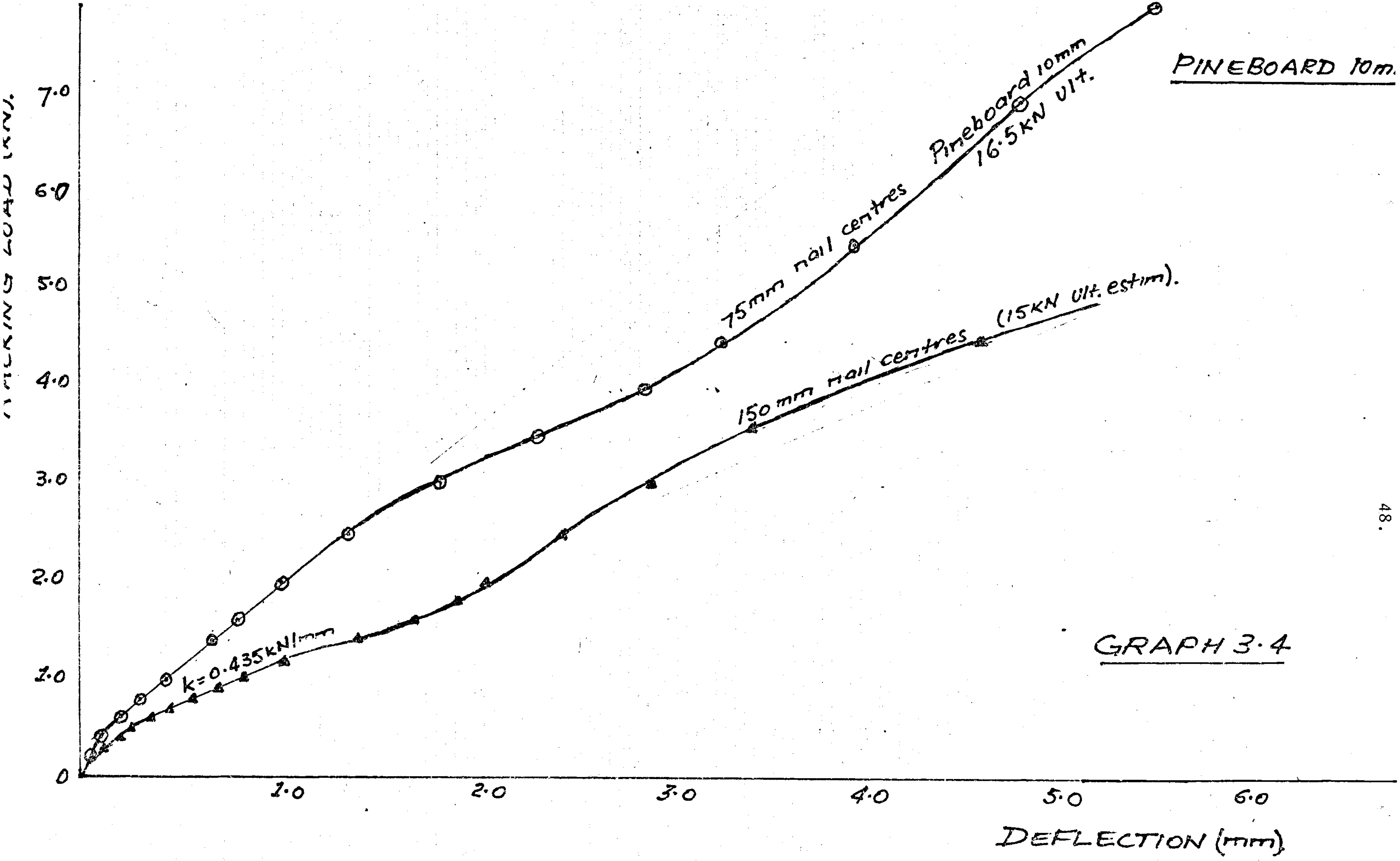
m.c. ___ % Den. ___ kg

Nail Spacing 75 mm



TEST DATA (TEST 16)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defln. Δ (mm)	Strain Readings x10⁻⁶ Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.2			0.061										0.06	0.0			
0.4			0.120										0.115	0.005			
0.6			0.220										0.19	0.01			
0.8			0.310										0.27	0.01			
1.0			0.450										0.38	0.015			
1.2			0.550	S	T	R	A	I	N	ST	RA	IN	0.47	0.015	DI	A	L
1.4			0.680										0.585	0.02			
1.6			0.810										0.70	0.02			
1.8			0.950	R	EA	D	I	NG	S	RE	ADI	NGS	0.82	0.025	GA	UG	ES
2.0			1.04										0.90	0.025			
2.5			1.39										1.215	0.03			
3.5			2.37	NO	T	T	AK	EN		NOT	TA	KEN	2.125	0.06	NO	T R	EAD
4.5			3.33										3.02	0.09			
5.5			4.00										3.60	0.15			
7.0			4.86										4.50	0.25			
9.0			6.34										5.93	0.39			
12.0			9.41										9.12	0.77			
16.5	ULT.												22.4				



PINEBOARD 10m.
RACKING LOAD (KN).
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
6.0
DEFLECTION (mm)
Pineboard 10mm
16.5KN ult.
75mm nail centres
(15KN ult. estim).
150mm nail centres
k=0.435kN/mm

GRAPH 3.4

3.6 6mm TEXPAN TEST RESULTS

Model panel No. 9 was sheathed with nails at 150 mm centres and positioned in the loading frame.

Data Sheet No. 7 (Test 17) shows the racking load and corresponding horizontal deflection of the panel. During this loading strain readings were not taken, however the readings of dial gauges 3, 4 and 5 were recorded.

Model panel No. 10 was sheathed using Araldite glue to attach the sheathing to the timber frame. The glue was spread over the full width of the members but only over the length bounded by the two extreme nails for a member.

Data sheet No. 8 (Test 18) shows the strain and dial gauge readings for 0.1 kN load increments to 1.0 kN, 1.0kN load increments to 4 kN and 2 kN load increments to 10 kN.

3.6.1 Analysis of Results

For panel no. 9 readings from dial gauges 3, 4 and 5 indicate that the sheathing buckles in a half sine wave up to aload of 2.5 kN and then assumed the form of a full sine wave.

Model panel No. 10 strain readings show members A and B to be subjected axial compression combined with bending. Member C is subjected to bending with axial compression at the higher values of racking load. This presence of axial compression is no doubt due to the restraining effect offered to member C by the reinforcing bolt.

Strain rosette readings show the usual trend of a compression and tension field however the compression effect seems fairly significant. However, since the strain readings of gauge 8 are significant the implication is that the principal strain directions are not in the directions of the main diagonals of the panel. To what extent these strains are effected by out of plane bending due to sheathing buckling is also a point of conjecture.

Dial gauges 3, 4 and 5 show the buckled mode of the glued panel to be of the same form as that for the panel with nails at 150 mm centres.

3.6.2 Failure Mode

For model panel No. 9 connection failure occurred resulting in the nails assuming the typically classical deformed pattern associated with the thicker sheathings. The failure load was 10.5 kN.

For model panel No. 10 failure was sudden and accompanied by a loud "bang" as the sheathing on one side of the panel failed in tension. This failure is shown schematically in Figure 3.2.

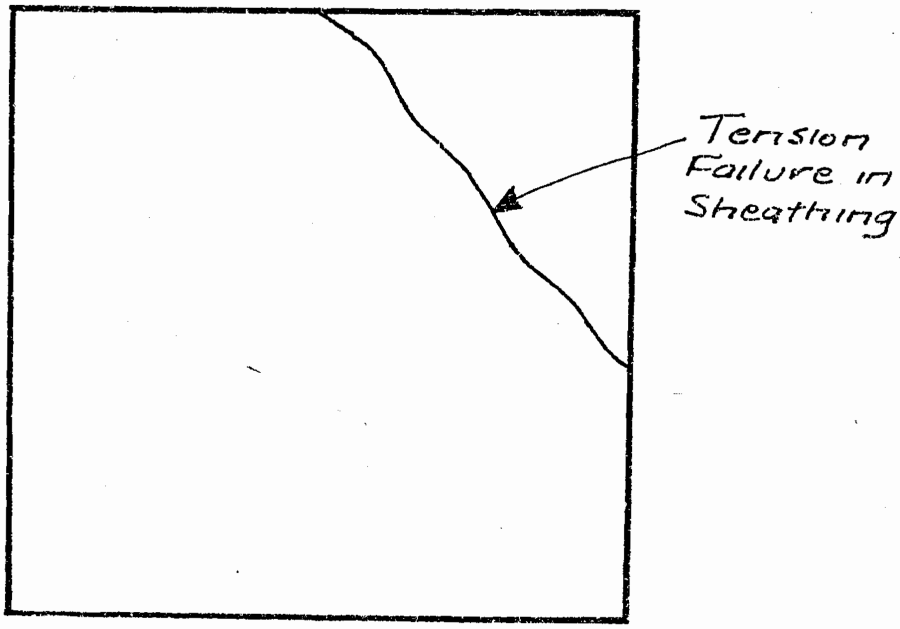


FIGURE 3.2

The racking load at which failure occurred was in excess of 20kN.

Graph 3.5 shows the significant increase in panel stiffness due to gluing the sheathing to the timber framing.

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 22-11-83

PANEL IDENT. No: 9 (TP6)

FRAMING MEMBERS: Size 70 X 45

Species Radiata

Stress Grade F8

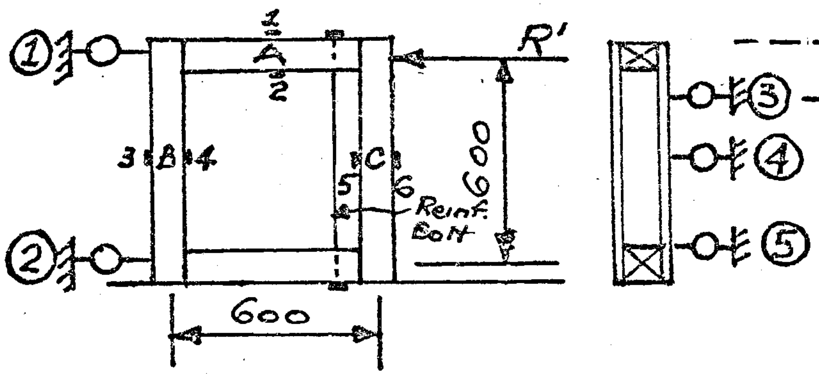
m.c. ___ %

SHEATHING MATL.: Ident. TEXPAN

Thick. 6 mm

m.c. ___ % Den. Low kg/m³

Nail Spacing 150 mm



TEST DATA (TEST 17)

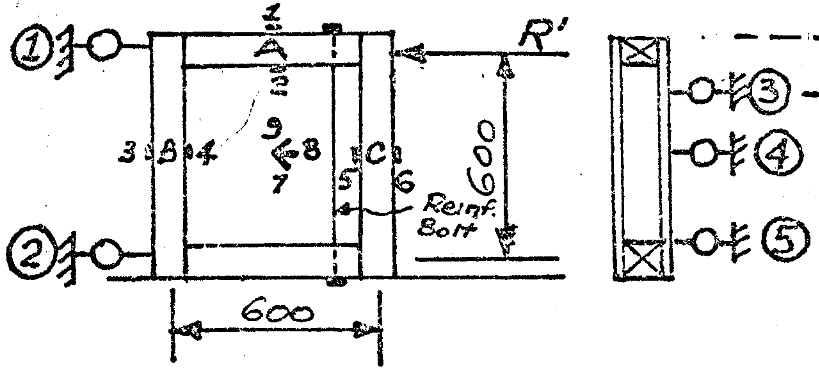
R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defln. Δ (mm)	Strain Readings ×10⁻⁶ Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.1			0.04										0.04	0.0	0.0	0.0	0.0
0.2			0.09										0.10	0.01	0.0	0.0	0.0
0.3			0.16										0.16	0.00	+0.055	0.0	0.0
0.4			0.23										0.24	0.01	+0.150	+0.015	+0.01
0.5			0.30										0.31	0.01	+0.200	+0.040	+0.02
0.6			0.39	S	T	R A	I	N		ST	RA	IN	0.40	0.01	+0.280	+0.070	+0.03
0.7			0.49										0.49	0.015	+0.500	+0.110	+0.04
0.8			0.60	R	E	A	D I	N G	S	RE	ADI	NGS	0.60	0.01	+0.540	+0.220	+0.04
0.9			0.75										0.75	0.02	+0.550	+0.250	+0.07
1.0			0.81	N	O T	T	A K	E	N	NOT	TA	KEN	0.81	0.02	+0.550	+0.260	+0.07
1.4			1.25										1.20	0.03	+0.550	+0.320	+0.09
1.8			1.82										1.76	0.04	+0.485	+0.390	+0.12
2.5			2.48										2.37	0.05	+0.20	+0.43	+0.13
3.5			3.69										3.50	0.07	-0.41	+0.73	+0.18
4.5			5.45										5.24	0.11	-3.10	+0.24	+0.22
5.5			7.66										7.40	0.17	-3.27	-0.31	+0.34
6.5			10.44										10.19	0.24	-2.24	-1.95	+0.42
10.5	Nail	Failure	Load														

SHEET 7 OF 9

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI — DATE OF TEST: 22-11-83

PANEL IDENT. N°: 10 (TP6)



FRAMING MEMBERS: Size 70 X 45

Species Radiata

Stress Grade F 8

m.c. ___ %

SHEATHING MATL.: Ident. TEXPAN

Thick. 6 mm

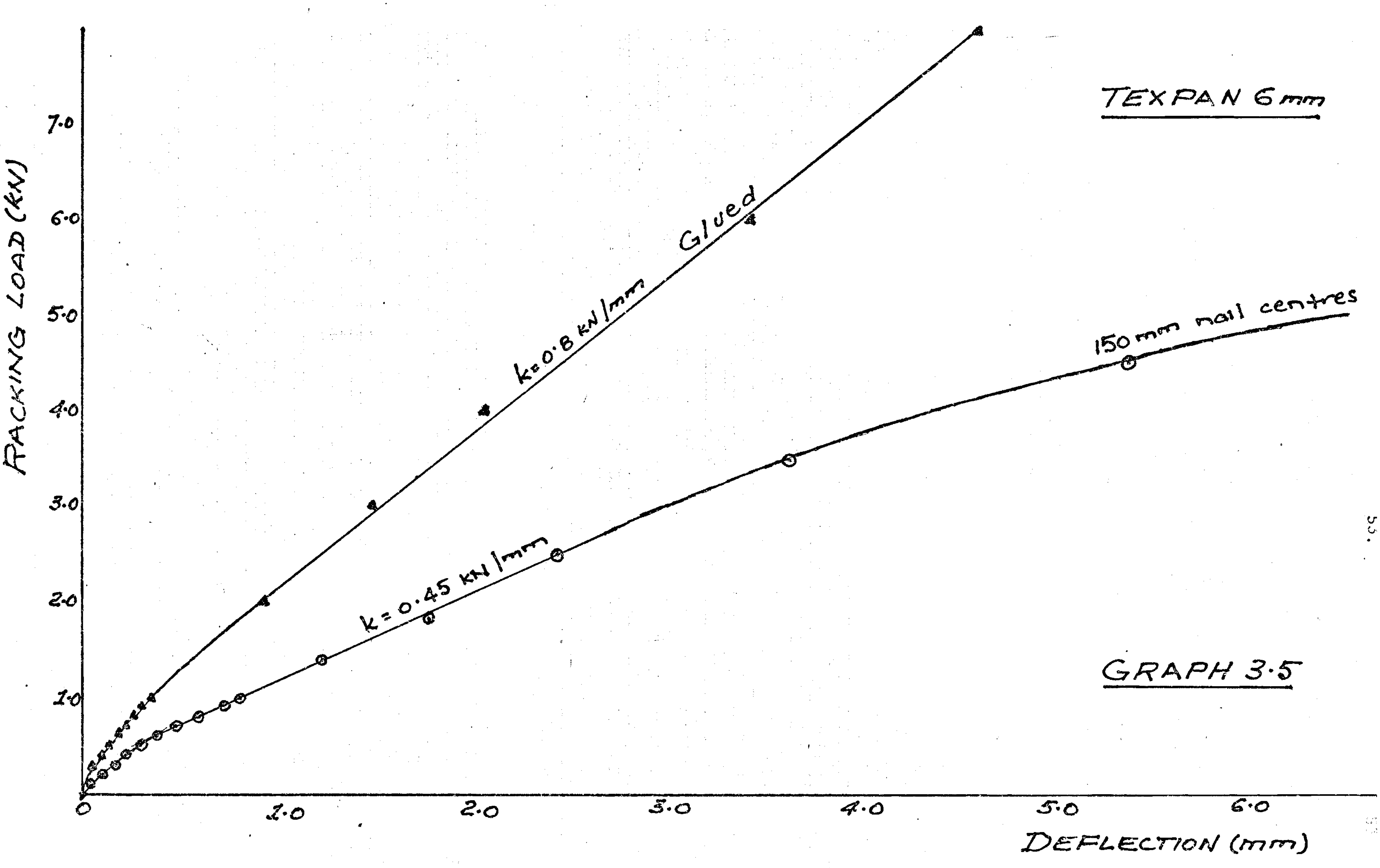
m.c. ___ % Den. Low kg/m³

Nail Spacing (Glued)

TEST DATA (TEST 18)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Defl^n. Δ (mm)	Strain Readings ×10⁻⁶: Member A: 1	A: 2	B: 3	B: 4	C: 5	C: 6	Panel Rosette: 7	8	9	Dial Gauge Readings (mm): 1	2	3	4	5
0.1			-0.01	+1.0	0.0	+2.0	+2.0	+2.0	+2.0	-4.0	-1.0	-2.0	-0.01	0.0	-0.01	0.0	0.0
0.2			+0.01	-2.0	-2.0	-1.0	0.0	-2.0	0.0	-6.0	-2.0	-5.0	+0.01	0.0	-0.06	0.0	0.0
0.3			0.05	-3.0	-3.0	-2.0	-2.0	-2.0	0.0	-6.0	-3.0	-8.0	+0.05	0.0	-0.13	-0.02	0.0
0.4			0.10	-2.0	-2.0	-1.0	0.0	-2.0	+3.0	-6.0	-3.0	-14.0	0.10	0.0	-0.18	-0.05	0.0
0.5			0.13	-2.0	-3.0	-2.0	-2.0	-2.0	0.0	-4.0	-6.0	-6.0	0.13	0.005	-0.25	-0.07	0.0
0.6			0.18	-2.0	-4.0	-2.0	0.0	-2.0	+2.0	+2.0	-4.0	-6.0	0.18	0.010	-0.31	-0.10	0.0
0.7			0.23	-2.0	-5.0	-4.0	-2.0	-3.0	+4.0	+2.0	-4.0	-7.0	0.23	0.010	-0.39	-0.13	0.0
0.8			0.27	-4.0	-5.0	-4.0	-2.0	-4.0	+3.0	0.0	-7.0	-12.0	0.27	0.010	-0.48	-0.16	0.0
0.9			0.30	-4.0	-6.0	-4.0	-2.0	-4.0	0.0	-3.0	-10.0	-16.0	0.30	0.010	-0.52	-0.18	0.0
1.0			0.36	-5.0	-7.0	-5.0	-2.0	-5.0	+2.0	-2.0	-10.0	-20.0	0.35	0.010	-0.58	-0.21	-0.01
2.0			0.95	-6.0	-14.0	-8.0	-3.0	-9.0	+4.0	+8.0	-14.0	-52	0.86	0.02	-1.33	-0.50	-0.03
3.0			1.51	-9.0	-18.0	-14.0	-4.0	-12.0	+6.0	+18.0	-24.0	-80	1.35	0.04	-1.75	-0.67	-0.04
4.0			2.10	-9.0	-24.0	-13.0	-4.0	-14.0	+8.0	+26.0	-28.0	-110	1.88	0.07	-2.0	-0.76	-0.03
6.0			3.49	-3.0	-37.0	-20.0	-2.0	-18.0	+12.0	+44.0	-40.0	-162	3.18	0.17	-2.10	-0.75	+0.04
8.0			4.68	+4.0	-52.0	-30.0	0.0	-26.0	+14.0	+58.0	-68.0	-200	4.29	0.30	-2.04	-0.64	+0.09
10.0			5.66	+12.0	-64.0	-37.0	+6.0	-33.0	+16.0	+70.0	-100.0	-244	5.33	0.55	-1.94	-0.52	+0.12
13.0			8.60	+27.0	-96.0	-45.0	0.0	-64.0	+5.0	+66.0	-182.0	-320	7.60	-0.12	-1.65	-0.11	+0.19

SHEET 8 OF 9


TEXPAN 6 mm
RACKING LOAD (kN)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
5.0
6.0
DEFLECTION (mm)
Glued
k=0.8 kN/mm
k=0.45 kN/mm
150 mm nail centres

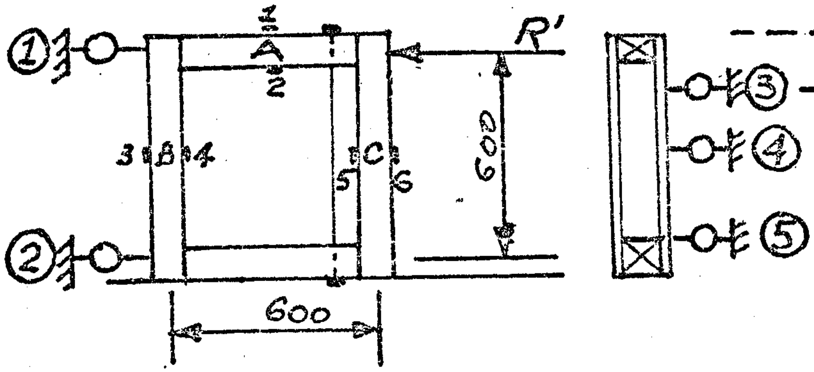
GRAPH 3.5

RACKING MODEL PANEL TEST RESULTS

TEST PERFORMED FOR: APRI

DATE OF TEST: 24-11-83

PANEL IDENT. Nº: 11 (PB 10)



FRAMING MEMBERS: Size 70 X 45

Species Radiata

Stress Grade F 8

m.c. ___ %

SHEATHING MAT^L.: Ident. PINEBOARD

Thick. 10 mm

m.c. ___ % Den. ____ kg/m³

Nail Spacing 150

TEST DATA (TEST 19)

R (kN)	R' (kN)	R'' = R'/2 (kN)	Horiz. Deflⁿ. Δ (mm)	Strain Readings ×10⁻⁶ — Member A 1	A 2	B 3	B 4	C 5	C 6	Panel Rosette 7	8	9	Dial Gauge Readings (mm) 1	2	3	4	5
0.1			0.015										0.015	0.0	-0.01	0.0	0.0
0.2			0.80										0.08	0.0	-0.08	0.0	0.0
0.3			0.14										0.14	0.0	-0.15	-0.02	0.0
0.4			0.21										0.21	0.0	-0.23	-0.05	0.0
0.5			0.27	S	T	R	A	I	N	ST	RA	IN	0.27	0.0	-0.31	-0.08	0.0
0.6			0.37										0.37	0.0	-0.38	-0.10	0.0
0.7			0.47										0.46	0.0	-0.49	-0.14	0.0
0.8			0.59	R	E	A	D	I	NG S	RE	AD	INGS	0.58	0.0	-0.57	-0.17	0.0
0.9			0.71										0.69	0.0	-0.66	-0.20	0.0
1.0			0.81										0.79	0.0	-0.75	-0.24	0.0
1.4			1.46	NO	T	T	AK	EN		NOT	TA	KEN	1.41	-0.01	-1.30	-0.43	-0.01
1.8			1.94										1.85	-0.01	-1.62	-0.59	-0.015
2.5			2.50										2.35	-0.015	-1.66	-0.61	-0.02
3.0			2.90										2.77	-0.030	-1.67	-0.61	-0.01
3.5			3.48										3.28	-0.060	-1.64	-0.61	+0.005
4.5			4.71										4.46	-0.070	-1.61	-0.60	+0.05
9.0				First	sign	of	nail	move	ment								

SECTION 4

CONCLUSIONS & RECOMMENDATIONS

4.1 INTRODUCTION

In making conclusions from observations of tests and test results, only data obtained from the Final Testing Programme will be considered. This does not imply that the Preliminary Testing Programme was of no benefit but rather that problems were identified and rectified in this phase.

Connector stiffnesses for the various mechanically fastened boards are evaluated for comparative purposes. The basis for comparison is the performance of the Radiata pine plywood sheathing panel.

Conclusions are listed and briefly discussed and recommendations regarding the project presented.

4.2 MODEL PANEL CONNECTOR STIFFNESSES

Using the Nail Force analysis equation (1) and applying it to the model wall panels having the nailing pattern shown in Figure 4.1:

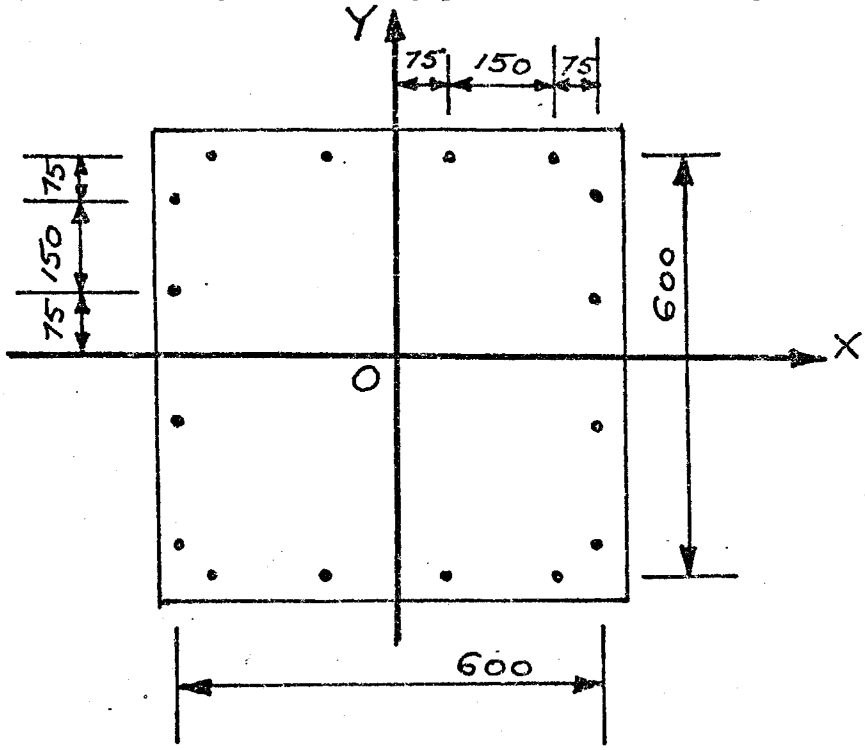


FIGURE 4.1

From symmetry:

$$\Sigma xi^2 = \Sigma yi^2 = 4(300^2 + 300^2 + 225^2 + 75^2)$$

$$= 945{,}000 \text{ mm}^2$$

From graphs 3.1, 3.2, 3.3, 3.4 and 3.5:

$k_{FL4} = 375\text{N}/^{\text{mm}}$; $k_{TPG} = 450\text{N/mm}$; $K_{TP9} = 800\text{N/mm}$;

$k_{PB10} = 435\text{N/mm}$; $k_{PP\&} = 420\text{N/mm}$

Also:

$h = 600$ mm

$$k = \frac{c}{h^2} \quad \frac{\Sigma x_i^2 \ \Sigma y_i^2}{\Sigma x_i^2 + \Sigma y_i^2}$$

$k = 1.31c$

$$\therefore \quad c = \frac{k}{1.31} \text{ N/mm for all above cases}$$

Hence:

$$C_{FL4} = \frac{375}{1.31} = 286 \text{ N/mm}$$

$$C_{TP6} = \frac{450}{1.31} = 344 \text{ N/mm}$$

$$C_{TP9} = \frac{800}{1.31} = \text{G11 N/mm}$$

$$C_{PB10} = \frac{435}{1.31} = 332 \text{ N/mm}$$

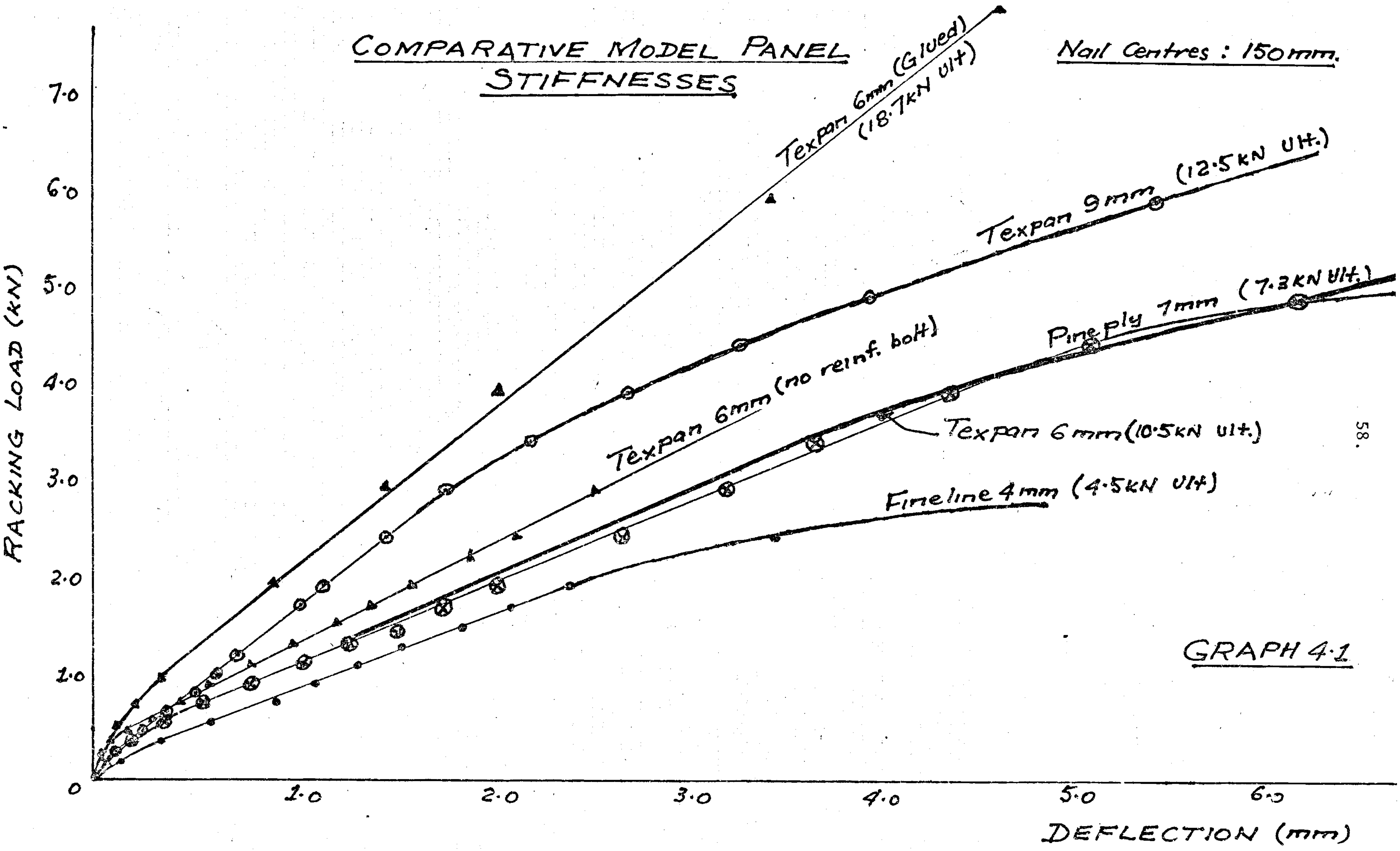
$$C_{PP7} = \frac{420}{1.31} = 321 \text{ N/mm}$$

Graph 4.1 shows a plot of Racking Load versus Deflection for all of the sheathing materials except the 10 mm Pineboard which has an initial panel stiffness slightly less than the 6mm Texpan. It can be seen that all model panel stiffnesses are bounded by 6mm Texpan glued (upper) and the 4mm Fineline with nails at 150mm centres (lower).

For ease of reference Table 4.1 sets out relevant information pertaining to the test results. From the proportional limit column it can be seen that the Pineply remains linear elastic to the highest load and for the largest deflection with the 6mm Texpan being the next best. However, it can also be seen that all particleboard sheathing materials except the 4mm Fineline attain a considerably higher ultimate load to connection failure than does the plywood.

Observations of tests would tend to indicate that nails in the plywood sheathed panel all attain their maximum load carrying capacity at about the same time resulting in a fairly instantaneous gross rotation of the sheathing relative to the timber framing. However, with the particleboard sheathed panels the tendency is to have certain nails becoming highly loaded resulting in sufficiently large local deformations to cause load transfer to the next most highly loaded nail group. This mechanism, although resulting in the same deformed nail pattern as the plywood sheathing at failure, prolongs the ability of the panel to sustain load.

Comparison of connector stiffnesses shows all boards, except the 4mm Fineline, to have a greater connector stiffness than the Pineply. Hence, for a given nail geometry, etc. all of these boards would provide greater racking resistance than the Pineply on the basis of calculations.


COMPARATIVE MODEL PANEL STIFFNESSES
Nail Centres : 150mm.
Texpan 6mm (Glued) (18.7kN Ult)
Texpan 9mm (12.5kN Ult.)
Texpan 6mm (no reinf. bolt)
Pineply 7mm (7.3kN Ult.)
Texpan 6mm (10.5kN Ult.)
Fineline 4mm (4.5kN Ult)
RACKING LOAD (kN)
DEFLECTION (mm)
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0

GRAPH 4.1

Sheathing Material	Thick (mm)	Fastener Spacing	Connector Stiffness	Proportional Limit		Ult. Racking Load (kN)	Failure Mode
				Load (kN)	Defln (mm)		
Fineline	4	150	286	2.0	2.5	4.5	Material tearing at connectors
Texpan	6	150	344	3.50	3.75	10.5	Nail rotation
Texpan	9	150	611	3.0	1.85	12.5	Nail rotation
Pineboard	10	150	332	1.2	1.10	15	Nail rotation
Pineply	7	150	321	4.5	5.2	7.3	Nail rotation

TABLE 4.1

4.3 CONCLUSIONS FROM MODEL PANEL TESTS

The following conclusions have been reached on the basis of observations of tests and analysis of test results.

(i) The load response characteristics of panel sheathing depends on the relative strength and stiffness of the connector compared to sheathing materials in-plane tensile and compressive strength.

A consequence of connector strength exceeding that of the sheathing material results in the sheathing tearing behind the fastener rather than the connector deforming excessively.

(ii) Loading panels such that bending is induced into member C results in half of the panel being ineffective in load transfer and the mechanism of load response of the panel being of the form shown in Figure 4.2(a).

It could be expected that for thinner sheathing which fails in accordance with (i) the mechanism of load transfer would be of the type shown in Figure 4.2(b) whilst for the case of the thicker materials it would be of the form shown in Figure 4.2(c).

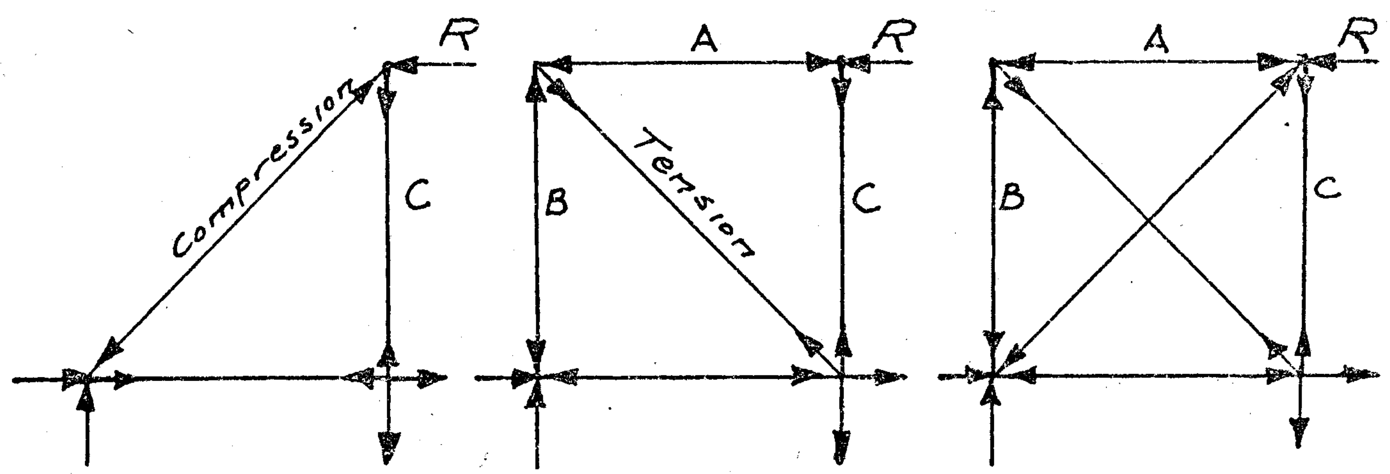


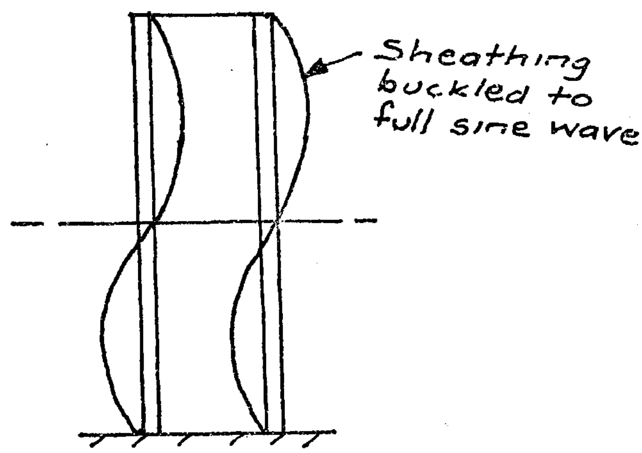
Figure 4.2(a) Figure 4.2(b) Figure 4.2(c)

LOAD TRANSFER MECHANISMS

FIGURE 4.2

(iii) Even for the thicker sheathing materials load transfer is dependent upon the sheathing buckling. For thick boards the buckling mode is a half sine wave at low loads tending to a full sine wave at higher loads.

As a result of this type of sheathing buckling the panel tends to assume the unsymmetric buckled shape shown in Figure 4.3.



BUCKLED SHAPE

FIGURE 4.3

(iv) Gluing the sheathing to the timber framing members, in the case of the thinner boards, has the following effects:

(a) significantly increases panel stiffness
(b) promotes sheathing failure rather than connection failure
(c) failure is rapid and without warning

(v) Strain rosette readings must be viewed with some caution, particularly for the thinner boards where buckling out of plane must induce high bending stresses thus preventing the in-plane tension and compressive stresses from being correctly evaluated. To eliminate this problem would require a strain rosette either side of the sheating material to enable bending strains to be isolated.

For this reason the strain rosette readings have been used qualitatively rather than quantitatively.

(vi) The real effect of increasing the number of fasteners is not particularly clear, i.e. doubling the number does not necessarily double panel stiffness. However, there is little doubt that it does increase ultimate load carrying capacity of the panel.

(vii) For the same nailing pattern thicker boards have a higher panel stiffness, at least initially, than their thinner counterparts.

4.4 RECOMMENDATIONS

4.4.1 Regarding Particleboard as sheathing

From test results obtained from the model panels it is evident that all of the boards tested have some racking resistance.

Also from the testing programme it can be seen that the 6mm Texpan board offers the greatest potential as a sheathing material when compared to the 7mm Pineply. Reasons for this observation are:

(i) it is of similar thickness to the Pineply

(ii) its racking load/deflection response characteristics are similar to those of Pineply and its calculated connector stiffness is slightly greater

(iii) its ultimate load carrying capacity for nails at 150mm centres is greater than that for Pineply.

4.4.2 Regarding Project

It is recommended that the next stage of the project i.e. the testing of full size wall panels (project 4-01-03) continue using the 6mm Texpan board as the sheathing material.

5. REFERENCE

1. Floor - Wall - Ceiling Interaction of Domestic Dwellings under Simulated Wind Loadings, N.T. McKee, Final Year Civil Engineering Project Report, CIAE, 1979

APPENDIX 1

MOISTURE CONTENTS & DENSITIES

Board Ident. No.	Dimensions (mmxmmxmm)	Mass (grams)	Dried Mass (grams)	M.C. (%)	Nominal Density	Density (kg/m^3)
TP1(6)	201x201x5.8	182.08	167.13	8.2	Std.	777.03
2(6)	201x201x5.8	199.97	184.10	7.9	Std.	853.38
3(6)	201x201x5.9	173.06	159.83	7.6	Low	726.03
4(6)	201x201x6.0	173.07	160.30	7.4	Low	713.96
5(9)	201x201x8.7	231.80	212.75	8.2	650	659.48
6(9)	201x201x9.0	249.06	230.32	7.5	Std.	684.96
7(9)	201x201x8.7	260.16	239.34	8.0	Std.	723.53
8(9)	201x201x8.1	210.30	196.06	6.7	600	642.63
9(9)	201x201x8.5	205.94	189.54	7.9	550	599.69
FL1(4)	201x201x4.0	108.66	98.08	9.7	-	672.38
PB1(10)	201x201x10.4	286.59	258.34	9.8	-	682.08