STRESSED SKIN PANELS
FP 2.3.1

ALBERTA RESEARCH COUNCIL
INDUSTRIAL TECHNOLOGIES DEPARTMENT
FOREST PRODUCTS PROGRAM[1]

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[1]Edmonton, Alberta

DISCLAIMER

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SUMMARY

A stressed skin panel is an engineered, prebuilt component consisting of a frame of dimensional lumber, to which top and bottom flanges of plywood or other panel material are structurally glued. Stressed skin panels may be used as floor, wall or roof components in buildings -- they allow, for example, for much larger spans than regular flat plywood or OSB in traditional floor and roof construction.

The flanges of stressed skin panels have traditionally been made of Douglas-fir plywood. If, instead, flanges were made of Alberta spruce plywood and oriented strandboard, new markets could be developed for Alberta products.

The objectives of this study were:

1. to demonstrate that Alberta-made lumber and panels can be manufactured into competitive new structural components and

2. to verify established engineering design theories on stress skin panels when OSB and spruce plywood are used as the flange material and to study the effect of sustained loading (1000 day duration) on stressed skin panels made with OSB and softwood plywood.

Twenty-four stressed skin panels were designed, constructed and tested: six with flanges of Douglas-fir plywood, six with flanges of Alberta spruce plywood and twelve with flanges of oriented strandboard. Half the panels were tested to verify that established engineering design theories hold for stressed skin panels made with OSB and spruce plywood flange. The other half of the panels are being tested to study the effect of sustained loading (1000 day duration) on stressed skin panels made with OSB and spruce plywood flanges.

From this study, it can be concluded that the current structural design theory for stressed skin panels works effectively for panels with flanges of Alberta spruce plywood and oriented strandboard. The average ultimate flexural strength of panels with flanges of oriented strandboard was 81% of that of panels with flanges of Douglas-fir plywood, where panels were of identical design.

The study on the effect of sustained loading has begun. The study has not progressed to the point where results or conclusions can be published. Continued work on this portion of the project is required.

There are many questions still to be answered with respect to the use of oriented strandboard as an engineering material. Further investigation should focus on the response of oriented strandboard to loadings of pure tension and pure compression and on the effects of the composite layering system used in its manufacture.

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1. INTRODUCTION

1.1 General

This report is submitted to the B.4 Committee Canada/Aberta Forest Resource Development Agreement (C/A FRDA) by the Forest Products Program, Industrial Technologies Department, Alberta Research Council. It covers the activities for the year 1986/1987 under Study #2.3.1: Stressed Skin Panels.

1.2 Objectives and Goals

The following objectives and goals for the year ended March 31, 1987 are as set out in Proposal for Basic 1986/1987 Funding of the ARC Forest Products Program to the B.4 Canada/Alberta Forest Resources Development Agreement Committee, Document No. 86-PFP-8, March 10, 1986, and as agreed to by C/A FRDA.

Project #2.3: LUMBER/STRUCTURAL COMPONENTS

Objective of the Project:

To demonstrate that Alberta-made lumber and panels can be manufactured into competitive new structural components.

Study #2.3.1: STRESSED SKIN PANELS

Objective of this Study:

To verify established engineering design theories on stressed skin panels when OSB and spruce plywood are used as the flange material and to study the effect of sustained loading (1,000 day duration) on stressed skin panels made with OSB, spruce plywood and Douglas-fir plywood.

Goals for this Year:

To construct 24 stressed skin panels (12 with OSB flanges, 6 with spruce plywood flanges and 6 with Douglas-fir flanges). To verify, through short-term testing, that established engineering design theories hold for stressed skin panels made with OSB and spruce plywood flanges. To start long-term testing of stressed skin panels made with Douglas-fir plywood, OSB and spruce plywood flanges.

1.3 Background

A stressed skin panel consists of a frame, or web, constructed of solid lumber, to which top and bottom flanges of plywood or other panel material are structurally glued. A schematic diagram of a stressed skin panel is shown in Figure 1. There are stressed skin panels without bottom flanges or with T-flanges in place of the bottom flange, but those particular designs are not considered in this study.

As solid lumber is used for stringers in the web, the maximum length of the stressed skin panel is limited by the length of lumber available: up to 4880 mm (16'). The width of the stressed skin panel is typically 1220 mm (4'), which is normal panel width. The spacing of the stringers and the thicknesses of the top and bottom flanges are determined in each instance by design considerations. Headers (at the ends of the web) and blocking (within the web) serve to align the stringers, back up splice plates, stiffen the panel at points where concentrated loads are anticipated and support the flange edges.

Stressed skin panels are used as roof and floor components in building construction. They are much stiffer than traditional methods of floor and roof construction and can, therefore, cover greater spans. In addition, they offer the advantage of factory (pre) fabrication and they can be engineered to cost-effectively suit particular applications.

1.4 Scope of the Study

The flanges of stressed skin panels have traditionally been made of Douglas-fir plywood, and design guides have been written with this in mind. In this study flanges of Alberta spruce plywood and OSB are compared to flanges of Douglas-fir, to determine their suitability and to develop engineering data that may be used in the future design of stressed skin panels using Alberta materials.

The greater availability of engineering data will help to develp markets for Alberta forest products.

In this study, twelve stressed skin panels were tested for short-term (elastic) flexural behaviour -- three with flanges of Douglas-fir, three with flanges of Alberta spruce plywood and six with flanges of OSB.

Twelve stressed skin panels are being tested for long-term behaviour (creep) - three with flanges of Douglas-fir, three with flanges of Alberta spruce plywood and six with flanges of OSB.

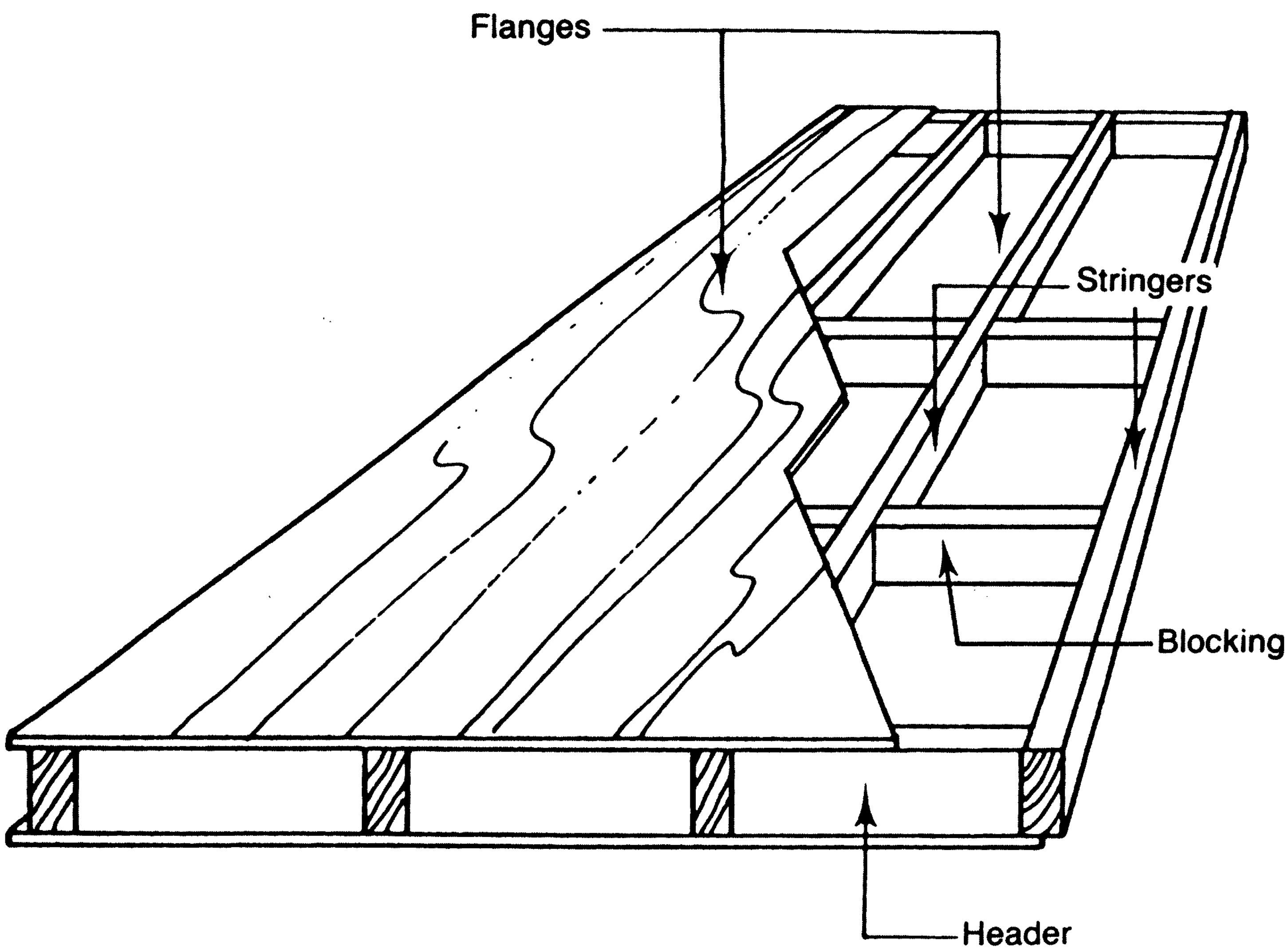


Figure 1 Schematic Diagram of a Stressed Skin Panel

2. PROCEDURE

2.1 Design Considerations

To ensure maximum stiffness of the stressed skin panel, flanges must be rigidly glued to the web. Then the whole panel assembly will behave as a composite unit, with direct transfer of forces between flanges and web, the flanges taking most of the bending stress, the web the shear stresses.

Where flanges are made of plywood, joints should be scarfed or tongued and grooved, glued and supplemented with splice plates. Panels of oriented strandboard can be made to be the exact length of the stringers so that no joints are required.

For purposes of design calculation, it can be assumed that the stressed skin panel will behave like a composite beam. General flexural formulations can be applied to design the cross-section. In calculating section properties for the stressed skin panel, the designer must take into account the fact that not all materials will have similar moduli of elasticity. These may be reconciled by the use of a transformed section, which is a section of uniform modulus of elasticity. Sections should be designed in such a way that each material is not stressed beyond the safety limits stipulated in the appropriate design codes. For bending, deflection and rolling shear, the panel is "normalized" to the material of the flanges; for horizontal shear, to a material with the properties of the web.

Stressed skin panels are designed by the "cut and try" method. A trial section is assumed and then checked for its ability to do the job intended; if the section does not meet the design criteria, it is modified and the process repeated. The design criteria include deflection, bending stress on the bottom flange, bending stress on the top flange, bending stress on the tension splices, rolling shear and horizontal shear. In-plane buckling and shear lag are beyond the scope of this study.

Owing to the structural efficiency possible with stressed skin panels, whereby relatively shallow panels prove adequate for strength, the design is likely to be controlled by the allowable deflection. The first aspect of the assumed section to be checked, therefore, will be deflection. Moment will be checked next, and shear last -- since it is least likely to govern.

It is normal for calculations to indicate that the bottom flange, which will be under tension, may be thinner than the top flange. This is due to the fact that the top, or compression, flange carries the imposed load.

2.2 Design Assumptions

Normally, stressed skin panels are designed to carry a uniformly distributed live load, which in this case would be 1.9 kPa (40 p.s.f.). However, because the testing setup calls for third point loading, the panel design was modified so that it would sustain a minimum of 4350 N of line load. (This is equivalent to a uniformly distributed load of 2.0 kPa).

The ratio between the live load deflection and the beam span is limited to (length/360).

As indicated in Table 1, deflection criteria govern the design, regardless of the material used for the flange. It was, therefore, not necessary to modify the design to accommodate bending mment or shear stresses.

TABLE 1

RESULTS OF DESIGN CALCULATIONS

Flange Material	EI Calculated $kN\text{-}mm^2$	Governing Load (N) Based on		
		Live Load Deflection	Bending Moment	Shear
Douglas-fir Plywood	1552.4	5217	7598*	10912
Spruce Plywood	1288.6	4330	5642*	11171
Oriented Strandboard	1414.0	4762	5787**	9050

* At location of tension splice plate.
** Compression flange.

A sample set of design calculations for a stressed skin panel, using oriented strandboard as flange material, is given in Appendix A.

2.3 Fabrication of Stressed Skin Panels

Twenty-four (24) stressed skin panels were constructed at Western Archrib from materials purchased at lumber yards in Edmonton. The webs of all twenty-four panels were identical in terms of material and design. Only the flanges differed -- six of the stressed skin panels had flanges of Douglas-fir, which originated in British Columbia; six had flanges of Alberta spruce plywood; and twelve had flanges of OSB, which was also an Alberta product.

The stressed skin panels were assembled according to the standards of the American Plywood Association and the construction diagrams in Figure 2 and Figure 3, with the following dimensions:

* overall length: 4880 mm,
* overall width: 1220 mm,
* top flange thickness: 15.5 mm,
* bottom flange thickness: 9.5 mm,
* web constructed from 38 mm x 140 mm (2" x 6") lumber.

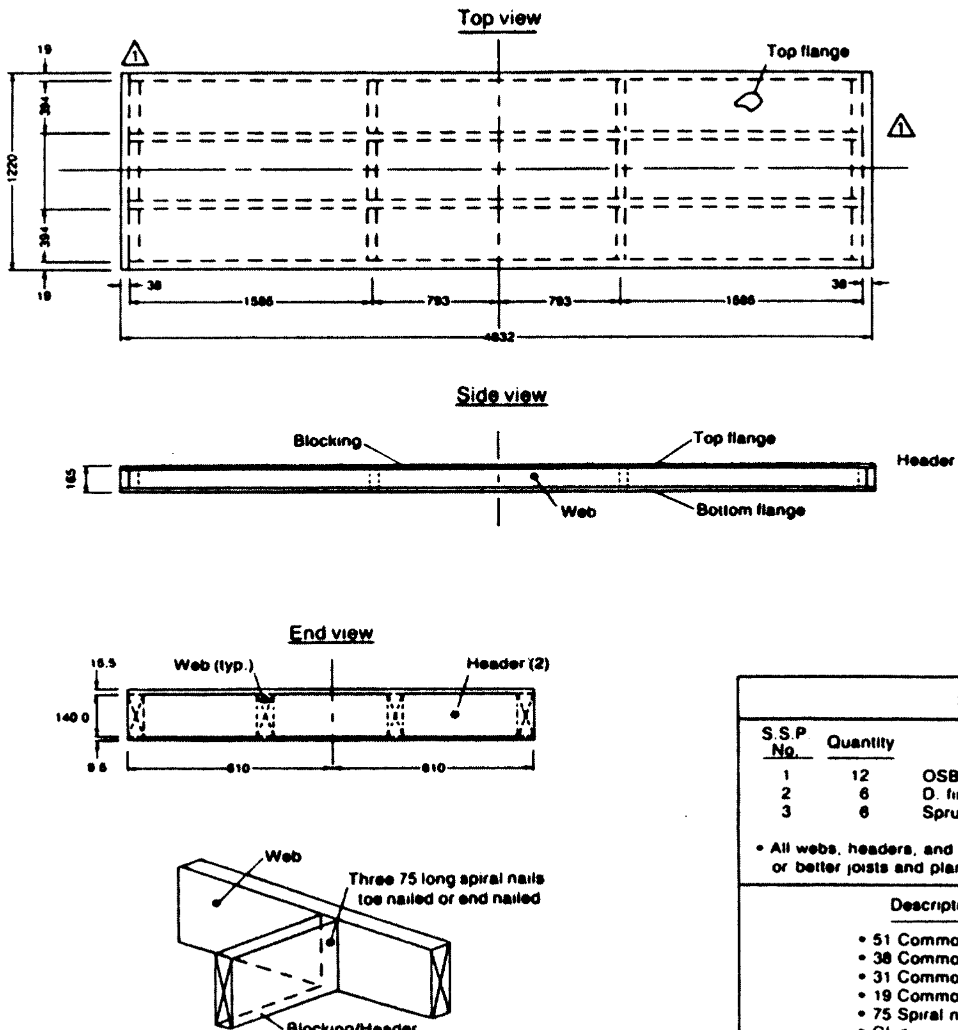
The plywood joints were tongued and grooved, glued and supported with splice plates. The oriented strandboards were manufactured specifically to match the overall dimensions of the stressed skin panels; therefore, no jointing in the flange sections was required.

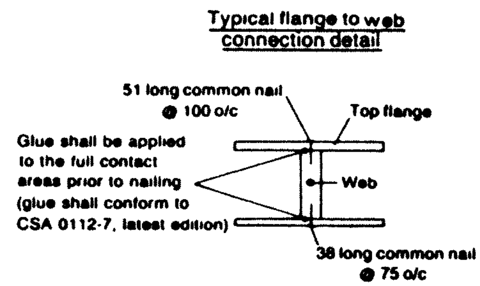
All pieces of lumber and all panels were machine stress rated to determine moduli of elasticity. These values were used to calculate the overall stiffness of the panels, as set out in Table 2.

TABLE 2

MODULUS OF ELASTICITY DATA

Flange Material	Modulus of Elasticity, MPa			Calculated EI N-mm^2
	Top Flange	Bottom Flange	Web	
Douglas-fir Plywood	16582	15126	11665	1552×10^9
Spruce Plywood	16371	13401	11665	1289×10^9
Oriented Strandboard	9486	9754	11665	1414×10^9





Schedule of materials

S.S.P. No.	Quantity	Top flange	Bottom flange
1	12	OSB 15.5 thick	OSB 9.5 thick
2	6	D. fir ply. 15.5 thick	D. fir ply. 9.5 thick
3	6	Spruce ply. 15.5 thick	Spruce ply. 9.5 thick

• All webs, headers, and blocking shall be 38 x 140 (2" x 6") SPF grade no. 2 or better joists and planks.

Description	Quantity
• 51 Common nail	4800
• 38 Common nail	6150
• 31 Common nail	610
• 19 Common nail	1210
• 75 Spiral nail	1820
• Glue	50 m² surface area

General notes

1. All stressed skin panels shall be assembled and manufactured in accordance with the drawings and written instruction from the engineer.
2. Flanges and webs shall be the specified size and grade.
3. The moisture content for each component shall be between 7 and 16 percent with a variation of not more than 5 percent between components, at time of gluing.
4. Prior to gluing, the gluing surfaces shall be free of dust, oil or any deterious substances which may cause defect in the bonding of parts.
5. The gluing surfaces shall not be sanded flat such that the variation is less than 1.0 mm
6. The usage of glue shall be in accordance with the exact instruction supplied by the glue manufacturer. Any deviation shall be subjected to the engineers written approval. The fabricater shall use positive mechanical means to ensure the proper bonding of materials (suggested contact pressure: 700 kPa to 1000 kPa).
7. Care shall be taken in the storage and handling of all parts (especially the wood panels for the flanges) so that permanent deformation does not result due to bending or other means.
8. All dimensions are in mm or noted otherwise.

Stressed skin panel (S.S.P.) construction drawing - general	
Revisions	△1 Reduce from six to three nails; Change header configuration
Alberta Research Council	
Approved by: L. B.	
Drawn by: A A	Date drawn: 86-07-08
Designed by: P. W.	Dwg no
Date issued: July 14, 1986	
Scale: N T S.	81
Project no.: 2.3.1	

Figure 2 Stressed Skin Panel Construction Drawing: General

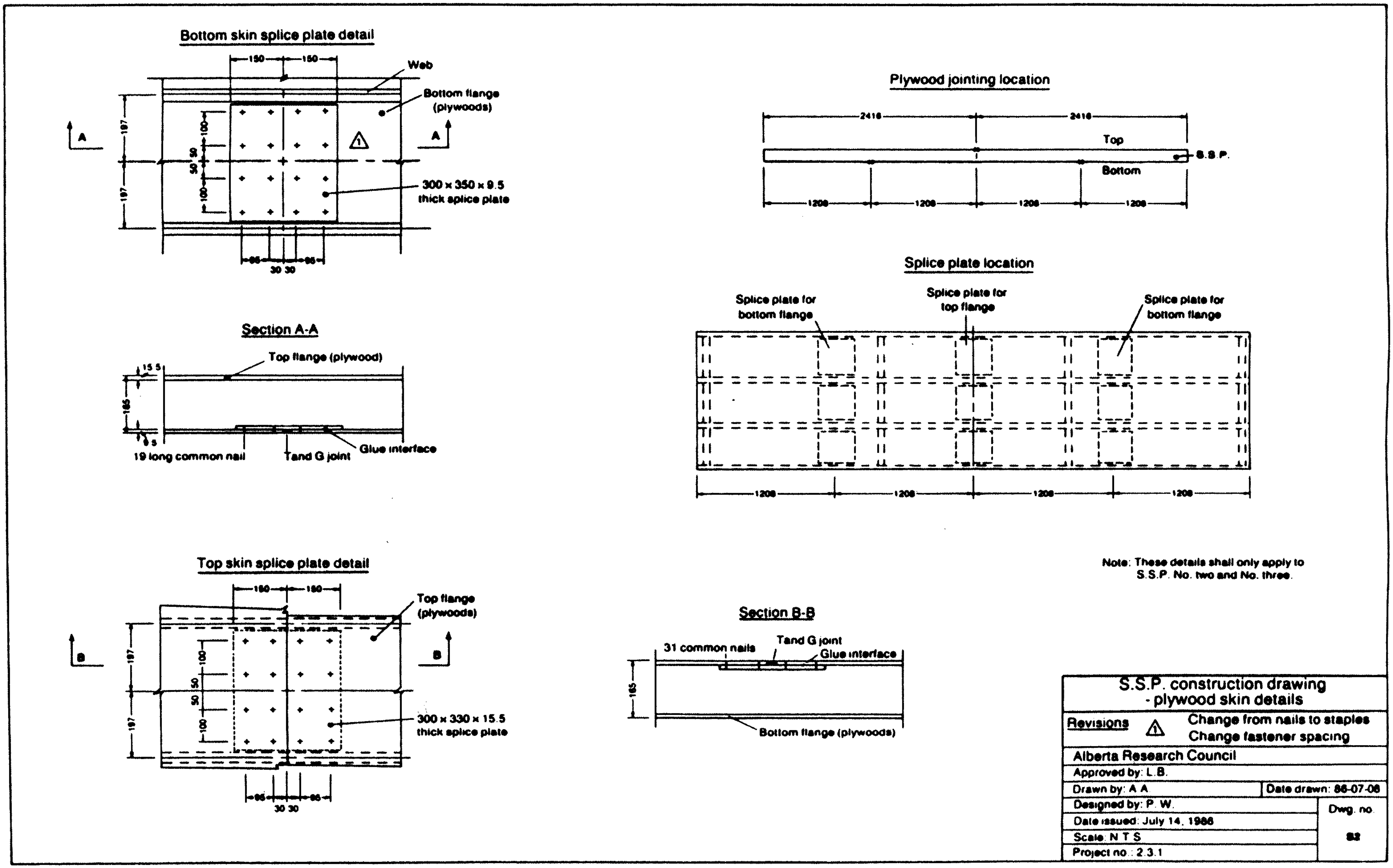


Figure 3 Stressed Skin Panel Construction Drawing: Plywood Flange Details

Any pieces of lumber with a moisture content over 15% were rejected.

Resorcinol resin adhesive was used to glue the flanges to the webs. As there was not a press large enough to handle the stressed skin panels, the flanges were nailed tightly to the webs to allow sufficient time for a solid bond to form.

Blocking was provided at the points where concentrated loads were to be applied.

2.4 Test Methods

Testing for the short-term was conducted according to ASTM E72 -80: Standard Methods of Conducting Strength Tests of Panels for Building Construction. The load test setup is shown in Figure 4. This is a third point loading arrangement using an airbag. The pressure created inside the airbag was transformed into two line loads that were superimposed onto the test panel. Each panel was subjected to a loading rate of 4410 N per minute. Deflection was measured and plotted against total load.

A photograph of the Stressed Skin Panel Tester is shown in Figure 5.

All panels were tested to failure. Points of failure were noted and photographs taken where fractures occurred.

Upon completion of each test, moisture samples were taken from webs and flanges.

Indoor temperature and relative humidity were monitored throughout testing.

Attempts to determine the radius of curvature in the central span of the stressed skin panel (where the panel is subject to pure bending only) were unsuccessful.

Testing for the long-term was begun and is being conducted according to ASTM E 72-80. The test setup is shown in Figure 4. The third point loading arrangment uses four water-filled drums. The weight of the drums is transformed into two line loads across the test panel. The load was applied quickly to reduce the effects of the rate of loading on the time-deflection curve. Deflection will be measured and plotted against elapsed time.

Indoor temperature and relative humidity are being monitored through the testing.

Moisture samples taken from the same material as the individual elements of the stressed skin panels are being weighed weekly to determine moisture content of the elements at any given week. The temperature, humidity and moisture content measurements will provide a basis for a relation between the deflection and the stiffness of the stressed skin panels.

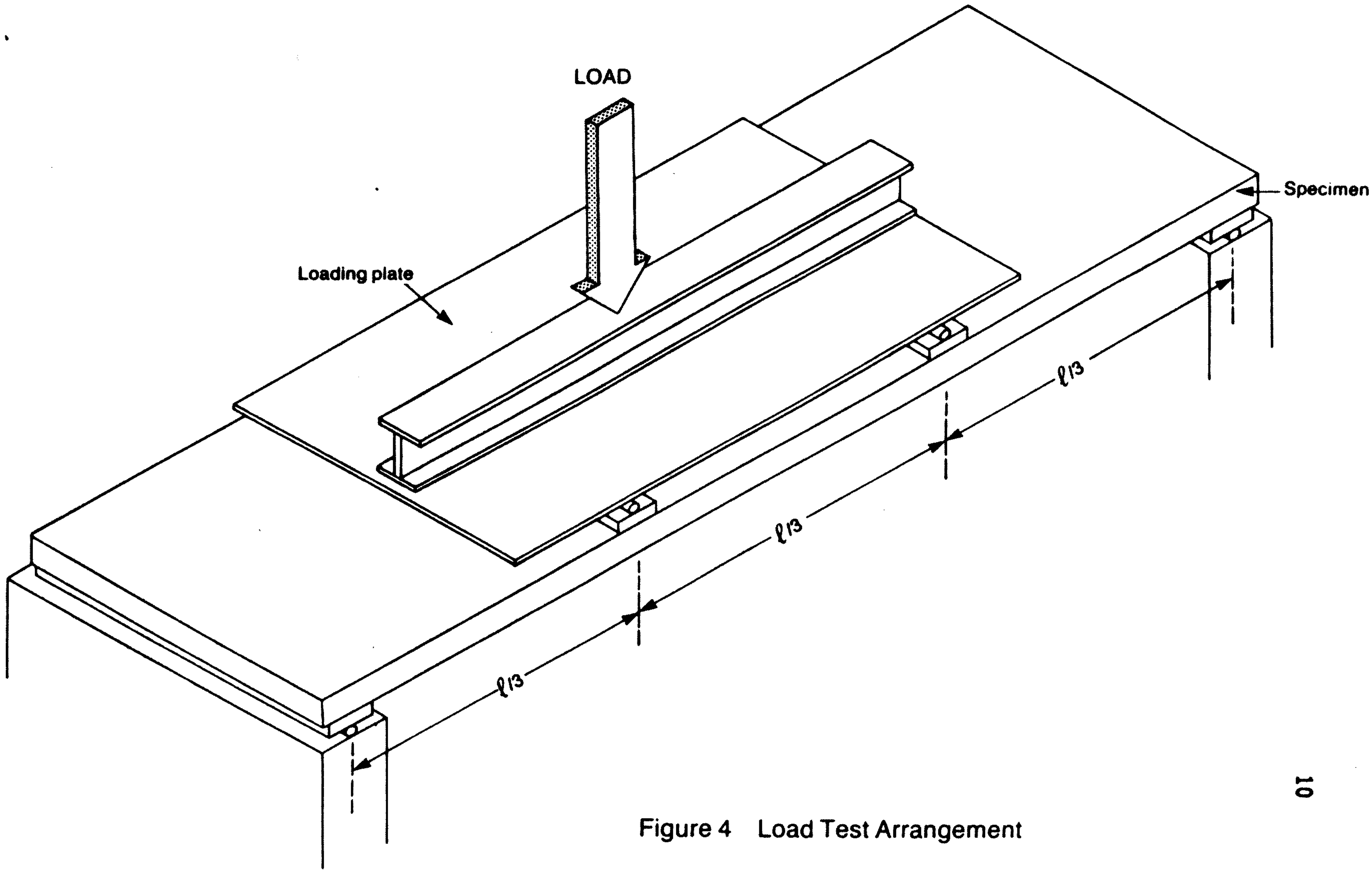


Figure 4 Load Test Arrangement

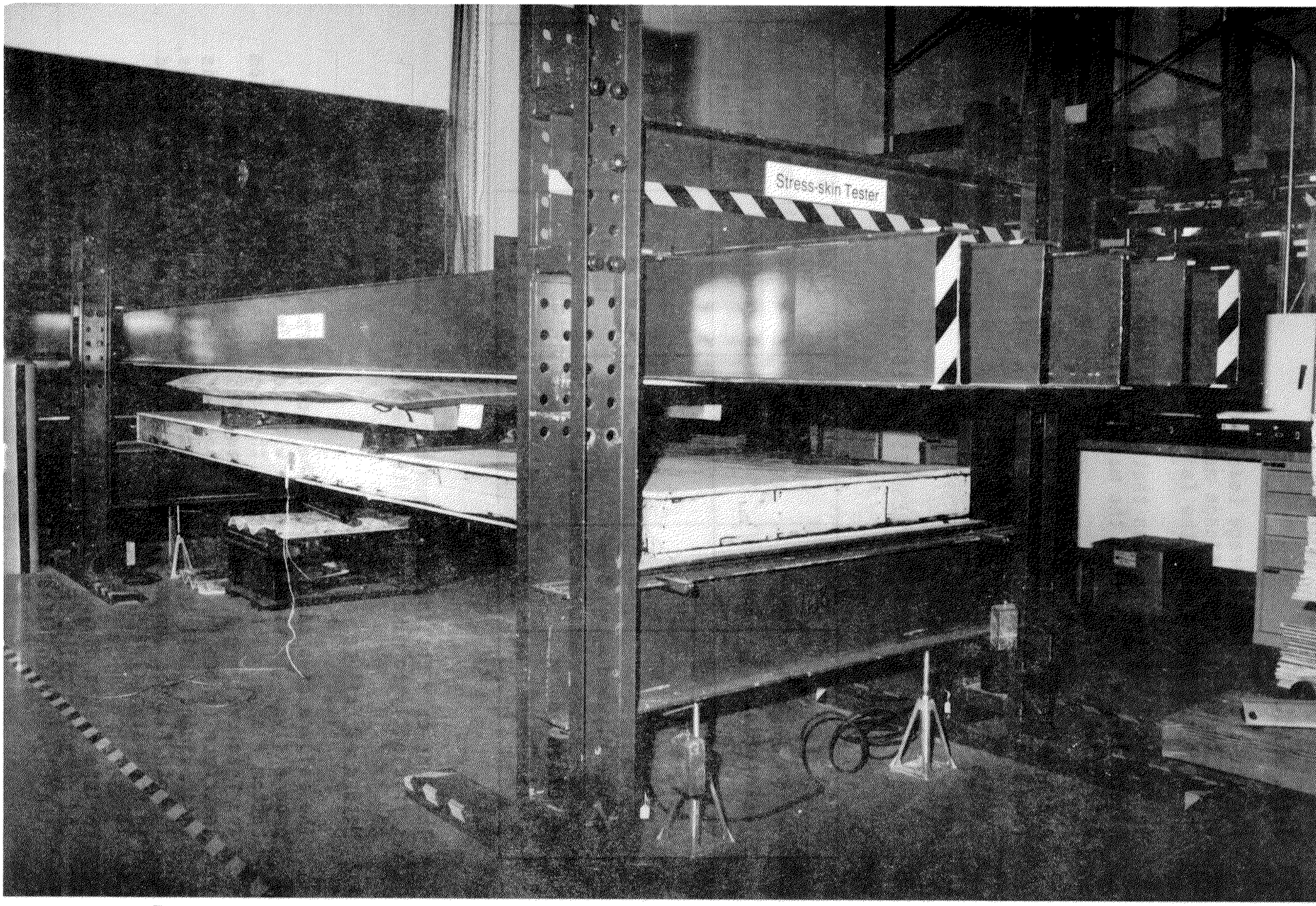


Figure 5 Stressed Skin Panel Tester

3. RESULTS AND DISCUSSION

3.1 Test Results

For the short-term, average Load/Deflection curves for panels made of the three different flange materials are given in Figure 6. These do not extend into the failure region.

In Figure 7, it can be seen that panels made of all three flange materials are well within the maximum allowable live load deflection limit.

Average Ultimate Moments and Average Flexural Stiffness calculated from Load/Deflection curves are given in Table 3.

TABLE 3

RESULTS OF TESTING

Flange Material	No. of Samples	Average Ultimate Moment N.m	Flexural Stiffness $kN\text{-}mm^2$	
			Predicted	Average Actual
Douglas-fir Plywood	3	50,540	1,552	1,765
Spruce Plywood	3	46,160	1,289	1,560
Oriented Strandboard	6	41,160	1,414	1,320

The long-term testing has begun but has not yet advanced sufficiently to make any results available.

3.2 Nature of Failure

The failure of a panel during the short-term testing is progressive. It usually begins with tensile fracture across the bottom flange. The web members then begin to fail from the bottom and fracture longitudinally. Shear failure along the bottom interface (which is material failure, rather than glue failure) is also evident. All top flanges remain intact. Many fracture lines, in both flanges and webs, intersect knots and initial cracks found in the material.

Failure of the plywood flanges is characterized by a very sudden and dramatic collapse. Two of the stressed skin panels sheathed with plywood exhibited failure at tensile splice points.

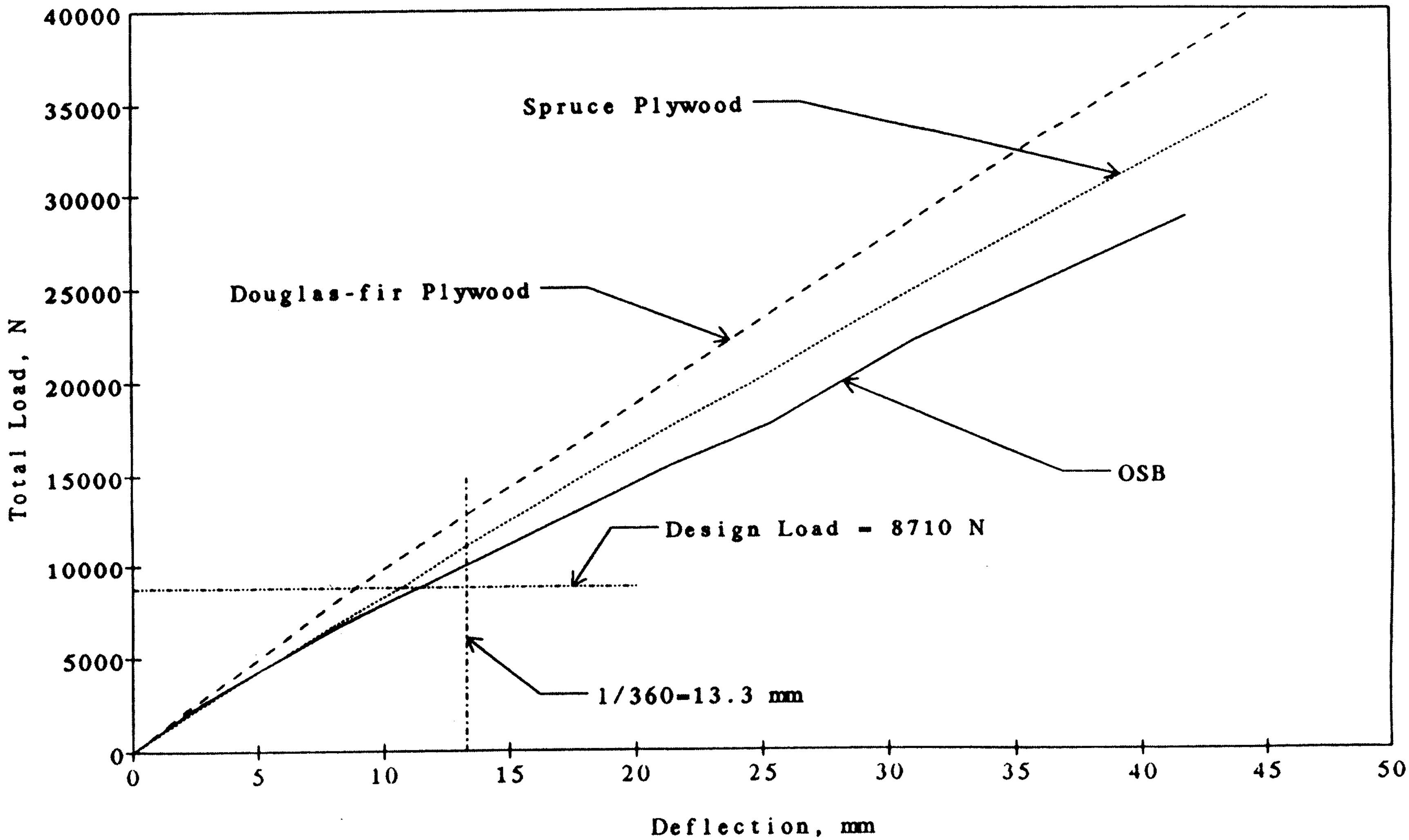


Figure 6 Average Load/Deflection Curves for Stressed Skin Panels Made With Flanges of Different Materials

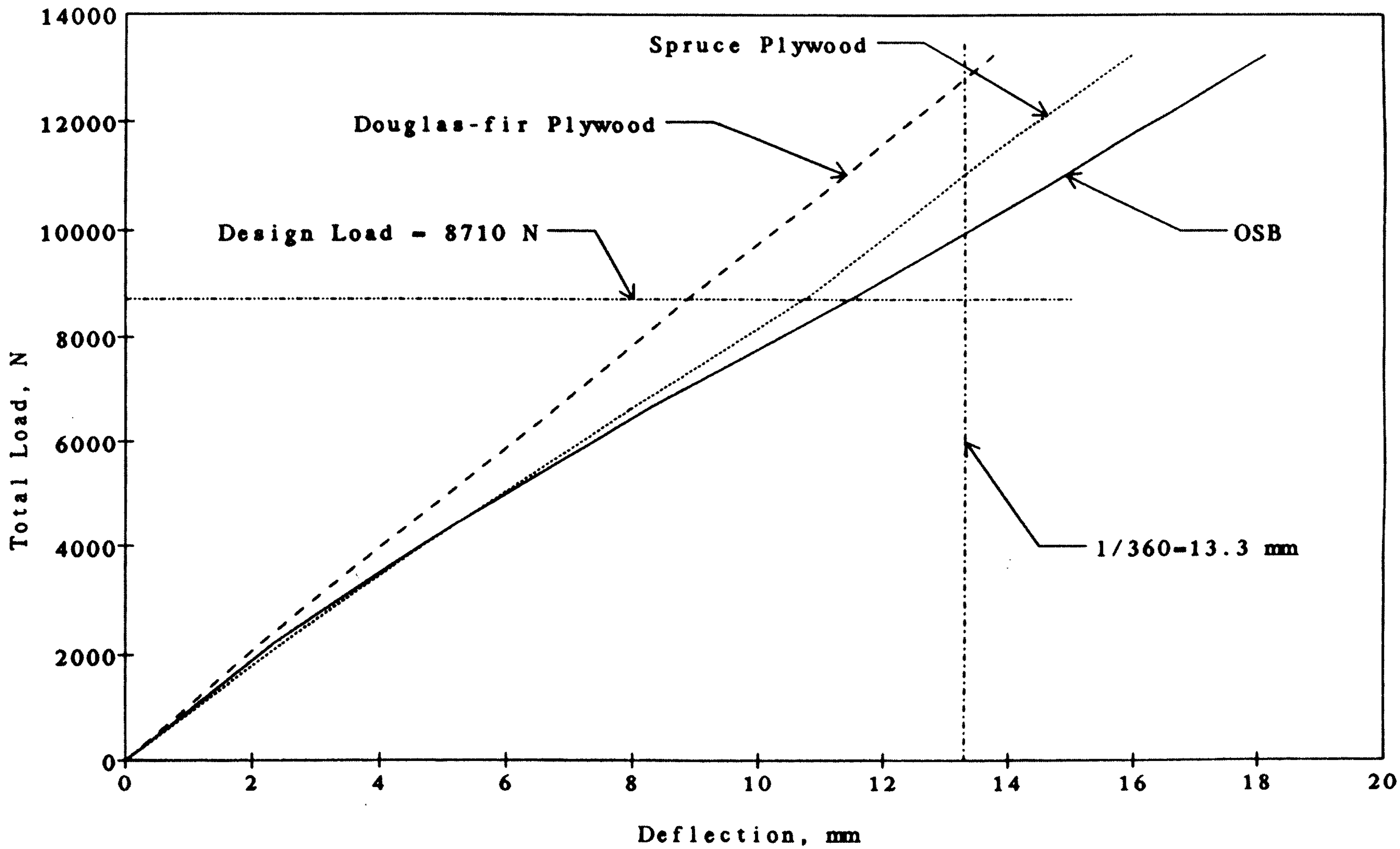


Figure 7 Design Load and Allowable Deflection (Detail of Figure 6)

All fractured panels exhibit some sort of rebound after the failure load is released from the system.

3.3 Comparison of Actual Results to Design Calculations

The comparison in Table 3 indicates that the stressed skin panels made with flanges of oriented strandboard performed slightly less well than expected, whereas the stressed skin panels made with flanges of plywood performerd better than expected.

It should be noted that, in design, it was assumed that the core section of the OSB makes no contribution to the stiffness of the stressed skin panel.

4. CONCLUSIONS AND RECOMMENDATIONS

The current structural design theory for stressed skin panels works effectively for panels with flanges of Alberta spruce plywood and oriented strandboard.

The average ultimate flexural strength of stressed skin panels with flanges of OSB was 81% and 89% of that of stressed skin panels of identical design with flanges of Douglas-fir and Alberta spruce plywood, respectively.

Useful preliminary engineering design data for stressed skin panels made with flanges of Alberta spruce plywood and OSB have been provided by this study.

There are many questions still to be answered with respect to the use of OSB as an engineering material. Further investigation should focus on the response of OSB to loadings of pure tension and pure compression and on the effects of the composite layering system used in its manufacture.

As the long-term creep behaviour testing has not been completed, and is not far enough advanced at the time of writing, no conclusions can be made.

It is recommended that the long-term study continue so that creditable results and conclusions can be published.

5. COMMERCIAL SIGNIFICANCE

The use of oriented strandboard has become increasingly acceptable for structural purposes. However, its application in the stresssed skin panels has not been fully developed due to the lack of data on stressed skin panels made with oriented strandboard.

The goal of the Forest Products Program of the Alberta Research Council is to increase and improve the utilization of Alberta-produced structural lumber and panel products. The Canada-Alberta Forest Resource Development Agreement is funding the Forest Products section to achieve their goal. One project being carried out to help achieve that goal is the testing of stressed skin panels made from Alberta-produced wood products.

This project is separated into two parts; one is to test the short-term bending strength of stressed skin panels made from Alberta-products wood products and the other is to study the creep behavior of these stressed skin panels.

Through these studies, the understanding of the behavior of these stressed skin panels will increase and useful engineering design data will be published. Design engineers will then have the necessary information to use stressed skin panels made with OSB and Alberta spruce plywood flanges.

This new usage for these Alberta-produced panels will increase the market demand.

6. ACKNOWLEDGEMENTS

The financial contribution to the Alberta Research Council's Forest Products Research and Development Program from the Alberta Forest Service (Alberta Forestry) and the Canadian Forestry Service (Agriculture Canada) is greatly appreciated.

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APPENDIX A

SAMPLE DESIGN CALCULATIONS FOR STRESSED SKIN PANELS WITH SKINS OF ORIENTED STRANDBOARD

APPENDIX A

SAMPLE DESIGN CALCULATIONS FOR STRESSED SKIN PANELS WITH SKINS OF ORIENTED STRANDBOARD

1. Values of Material Properties

Variable	Oriented Strandboard		Web
	Top Flange	Bottom Flange	
Thickness	15.5 mm	9.5 mm	
$A_{//}$	15.5x1220x0.6[a] $=11,350mm^2$	9.5x1220x0.6[a] $=6,954mm^2$	140x38x4 $=21,280mm^2$
E	9,486MPa[b]	9,754MPa[b]	11,670MPa
I	$380.7 \times 10^3 mm^4$ [b]	$34.76 \times 10^6 mm^4$ [b]	$81.6 \times 10^3 mm^4$ [b]
f	4.9MPa[b]	6.5MPa[b]	7.7MPa[c]

a: it is assumed that the core contributes nothing to the stiffness of the flanges.

b: values for oriented strandboard are taken from unpublished Forest Products Program data.

c: CAN3-086-M

2. Design Load

The following values are used:

$P = 4355$ N (line load)

$W = 0.61$ kN/m (dead load)

$V_w = 0.46$ MPa

$V_r = 0.448$ MPa

3. Locate Neutral Axis

The following equation is used:

$$\bar{y} = \frac{\Sigma A_{//} E y}{\Sigma A_{//} E}$$

See Figure 8.

Element	E (MPa)	$A_{//}$ (mm^2)	EA	y (mm)	E A y
Top Flange	9,486	11,350	107.6×10^6	157.25	$16,920 \times 10^6$
Web	11,670	21,280	248.2×10^6	79.5	$19,730 \times 10^6$
Bottom Flange	9,754	6,954	67.8×10^6	4.75	322×10^6
			$\Sigma = 423.6 \times 10^6$		$\Sigma = 36,972 \times 10^6$

$$\bar{y} = \frac{36,972 \times 10^6}{423.6 \times 10^6} = 87.3 \text{ mm}$$

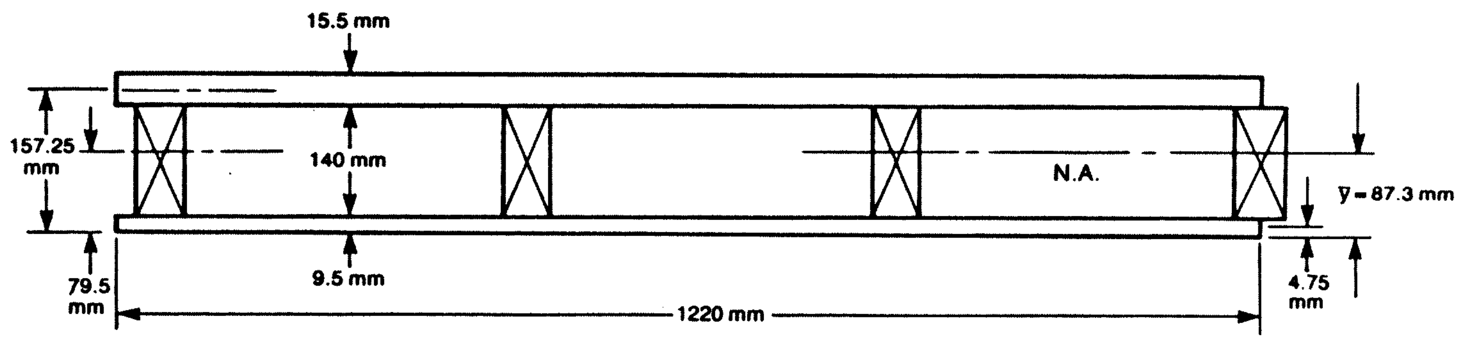

Figure 8   Location of Neutral Axis

4. Calculate Bending Stiffness

The following equation is used:

$$(EI)_g = \Sigma E (I + A_{//} d^2)$$

See Figure 9.

Element	E (MPa)	I (mm^4)	$A_{//}$ (mm^2)	d (mm)	$E(I + Ad^2)$
Top Flange	9,486	$3,80.7x10^3$	11,350	69.95	$530.2x10^9$
Web	11,670	$34.76x10^6$	21,280	7.8	$420.6x10^9$
Bottom Flange	9,754	$81.6x10^3$	6,954	82.55	$463.0x10^9$
					$(EI)_g$=$1,414x10^9$ N.mm^2

5. Calculate Horizontal Shear

Only the lumber and the parallel plies in compression are considered.

The following equation is used:

$$EQ_g = \Sigma E A y$$

See Figure 9.

Element	E (MPa)	$A_{//}$ (mm^2)	y (mm)	E A y
Top Flange	9,486	11,346	69.95	$7.53x10^9$
Web	11,670	9,454	31.10	$3.43x10^9$
				Σ=$11.0x10^9$ N.mm

Where $A_{//}$ (web) = 4(38)(157.25 - 15.5/2 - 87.3) = 9,454 mm^2

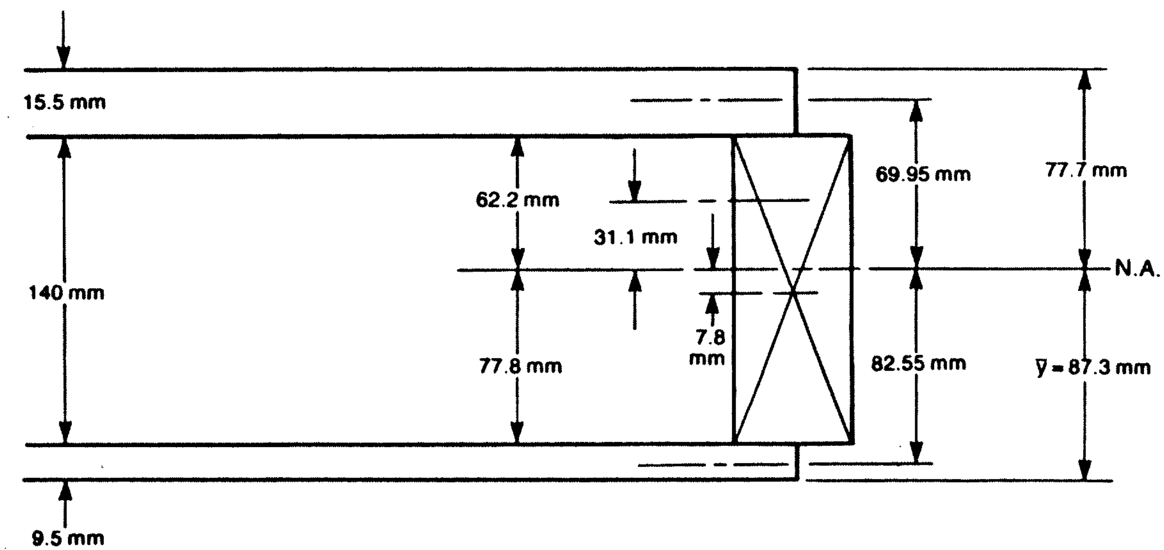

Figure 9 Distances from Neutral Axis to Midpoints and Outer Surfaces of Each Element

6. Planar Shear

This is the value of horizontal shear for the top flange, taken from the preceding equation.

$$EQ_r = 7.53\times10^9 \text{ N.mm}$$

7. Correction Coefficient

$$K_c = 1 - \frac{4.8}{(L/L_s)^2} \quad \text{(dimensionless)}$$

$$K_c = 1 - \frac{4.8}{(4775/356)^2} = 0.973$$

Where $L_s = \dfrac{1200 - 4(38)}{3} = 356$ mm

8. Flange-Web Shear Factor

	a_{min}/a_{max}	$b_r k_{rs}$	N	$(N)(b_r k_{rs})$
outside longitudinal (left)	0	38(0.86)	1	32.68
inside longitudinal	1	38(1.68)	2	127.68
outside longitudinal	0	38(0.86)	1	32.68
				$\Sigma\, b_r k_{rs} = 193.04$

9. Live Load Deflection

The deflection criteria are:

Given a design load, the deflection must not exceed:

* 1/360 for live load only, or
* 1/240 for live load plus dead load.

Normally, there are two components to deflection -- bending load deflection and shear deflection. Shear deflection is not specifically catered for in these calculations because, for panels with long spans, shear deflection seldom approaches even 10% of total deflection.

The equation for live load deflection is:

$$\Delta_{L.L.} = \frac{23\ P\ L^3}{648\ (EI)_g}$$

$$\Delta_{L.L.} = \frac{23\ (4355)\ (4775)^3}{648\ (1{,}414 \times 10^9)} = 11.9\ mm$$

Total live load deflection is 11.9 mm, which compares with L/360 of 13.3 mm.

10. Live Load Plus Dead Load Deflection

The equation for dead load deflection is:

$$\Delta_{D.L.} = \frac{5\ w\ L^4}{384\ (EI)_g}$$

$$\Delta_{D.L.} = \frac{5\ (0.61)\ (4775)^4}{384\ (1{,}414 \times 10^9)} = 2.9\ mm$$

Total live load plus dead load deflection is 16.2 mm, which compares with L/240 of 19.9 mm.

11. Allowable Load - Moment

The approach is to calculate the allowable load under three conditions:

* assuming the top skin governs,
* assuming the web governs, and
* assuming the bottom skin governs.

The lowest of these must exceed the design load.

Top Skin Moment (Compression Flange)

$$P = \frac{f_{c//}\ 3\ (EI)_g\ (K_c)}{(L)(E)(C_c)}$$

$$P = \frac{(4.9)(3)(1414 \times 10^9)(0.973)}{(4775)(9486)(77.7)} = 5{,}787\ N$$

Bottom Skin Moment (Tension Flange)

$$P = \frac{f_{t//}\ 3\ (EI)_g\ (K_c)}{(L)(E)(C_t)}$$

$$P = \frac{(6.5)(3)(1414 \times 10^9)(0.973)}{(4775)(9754)(87.3)} = 6{,}645\ N$$

Web Moment

$$P = \frac{f_{bw}\ 3\ (EI)_g\ (K_c)}{(L)(E)(C_w)}$$

$$P = \frac{(7.7)(3)(1414 \times 10^9)(0.973)}{(4775)(11670)(77.8)} = 7{,}386\ N$$

All values exceed the design load.

12. Allowable Load - Shear

Planar Shear

$$P = \frac{V_r\ (EI)_g(\Sigma\ b_r k_{rs})}{EQ_r}$$

$$P = \frac{(0.448)(1414\text{x}10^9)(193.04)}{(7.53\text{x}10^9)} = 16{,}355\ \text{N}$$

Horizontal Shear

$$P = \frac{V_w\ (EI)_g(\Sigma\ b_w)}{EQ_w}$$

$$P = \frac{(0.46)(1414\text{x}10^9)(4\text{x}38)}{(11.0\text{x}10^9)} = 9050\ \text{N}$$

Both values exceed the design load.

APPENDIX B

INITIAL AND 24 HOUR DEFLECTION DATA FOR STRESSED SKIN PANELS FOR 1000 DAY DURATION OF LOADING

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INITIAL AND 24 HOUR DEFLECTION DATA FOR STRESSED SKIN PANELS FOR 1000 DAY DURATION OF LOADING

PANEL NUMBER	FLANGE TYPE	AVERAGE INITIAL DEFLECTION (mm)	24 HOUR DEFLECTION (mm)
1	OSB	10.00	10.75
8	OSB	10.00	11.50
9	OSB	10.00	11.25
10	OSB	9.75	11.00
11	OSB	10.50	11.75
12	OSB	13.25	14.00
14	D-fir	8.75	9.00
15	D-fir	8.25	8.75
16	CSP	9.75	11.00
17	CSP	8.50	9.00
18	CSP	8.25	9.50
22	D-fir	8.00	8.50