OSB *Performance by Design*™

Design Manual

Construction Sheathing and Design Rated Oriented Strand Board

Structural Board Association
Representing the OSB Industry

OSB Design Manual

Construction Sheathing and Design Rated Oriented Strand Board

2004

Structural Board Association
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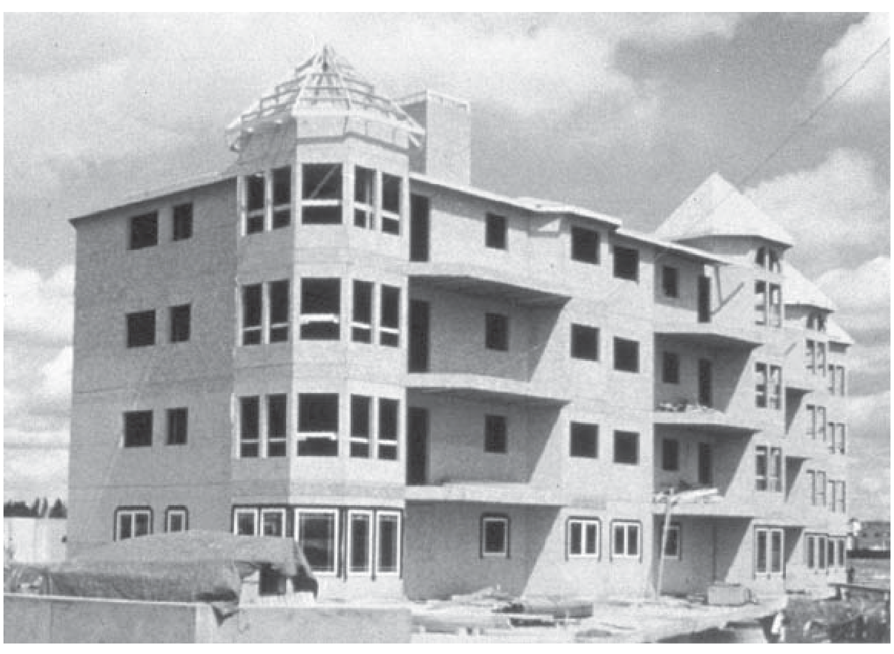
Preface

The Structural Board Association is a trade association of Oriented Strand Board (OSB) producers committed to the continuous enhancement of overall quality and services. SBA members are dedicated to end user recognition of OSB as the preferred structural wood panel.

The SBA is comprised of OSB manufacturing members, associate members, allied members and research members. We encourage you to visit our Web site, **www.osbguide.com**, where you will find an up-to-date members' list, as well as a list of affiliated organizations.

This is the second edition of a manual entirely devoted to designing with OSB. It was made possible with the introduction of a new series of CSA Standards, CSA O452-94 *Design Rated OSB*, and of design values and procedures for Design Rated and Construction Sheathing OSB in the Engineering Design in Wood standard, CSA O86-01.

SBA committed its technical resources and engaged the services of Quaile Engineering Ltd. (in particular Stephen J. Boyd, P.Eng.), and Ketchen Industrial Design. We would also like to acknowledge the participation of the Technical Committee and several reviewers who ensured the completeness of this publication.



Extensive use of OSB wall and roof sheathing provides structural strength and performance for this 3-storey residential complex.

1.0 Introduction

Oriented Strand Board (OSB) and its predecessor waferboard have been commercially available since the 1960s. Early testing of OSB and waferboard established their suitability for residential sheathing applications. Additional work demonstrated the strength of OSB and waferboard shearwalls and diaphragms.

In 1985 the Structural Board Association (SBA), then known as the Waferboard Association, embarked on a program to determine the full range of engineering design values for OSB. As part of this program, thirteen mills were intensively sampled and panels tested by Forintek Canada Corp. Forintek demonstrated that OSB could be produced in a number of stress grades with different mechanical properties (refer to Reference No. 1). This work culminated in the development of CSA Standard O452 *Design Rated Oriented Strand Board*. CSA O452 sets out the minimum basic strength capacities for various grades of OSB.

The traditional process of setting design values is to establish a level that accomodates the weakest panels being produced in the industry. While this process provides acceptance for all producers, it does not provide a means of recognizing the superior products being manufactured or permit improvements in the manufacturing process, until they have been adopted by the entire industry. The new CSA O452 Standard recognizes that the strength properties of OSB can be controlled by adjustments in the manufacturing processes and provides a mechanism whereby the design properties of a superior product can be recognized. This process encourages improvements in the manufacturing of OSB and allows individual manufacturers to reap the benefits.

Following a separate testing program, commissioned by the SBA in 1998, a second set of specified strengths and stiffness values for sheathing and single floor grades of Construction Sheathing OSB were proposed to and adopted by the Technical Committee on Engineering Design in Wood (see Reference 5).

As per CSA O86, the design provisions apply to panels that are qualified and identified in accordance with CSA O325, which pertains to wood-based panel products designed and manufactured for protected construction uses, such as roof sheathing, wall sheathing and floor sheathing in light frame construction applications, and shear walls and horizontal diaphragms.

Engineering design values for OSB are published in CSA O86-01, Engineering Design in Wood (Limit States Design) for both Design Rated OSB conforming to CSA O452 and Construction Sheathing OSB conforming to CSA O325.

The design procedures given in this manual are valid for both types of OSB.

2.0 OSB Products

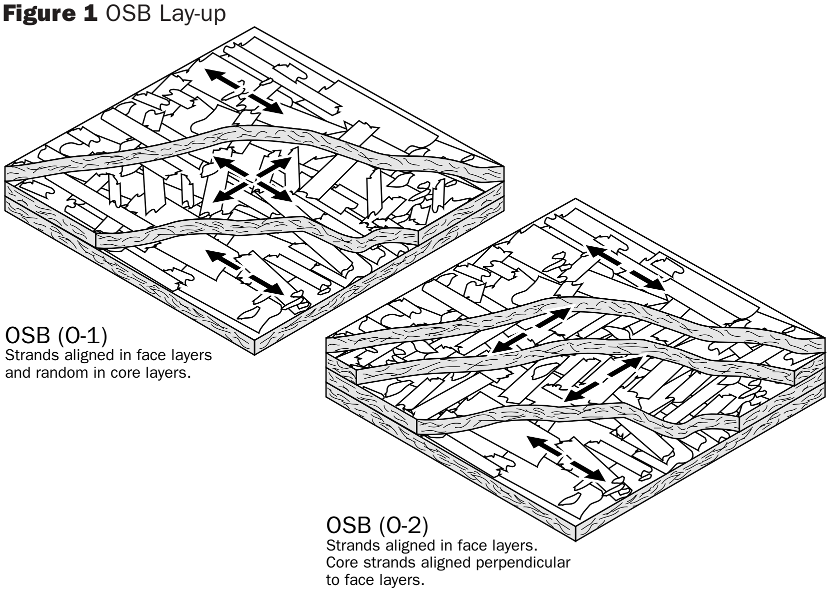
2.1 Description

Oriented Strand Board (OSB) is a structural panel suitable for a wide range of construction and industrial applications. It is a mat-formed panel made of strands sliced from small diameter, fast growing round wood logs and bonded with an exterior-type binder under heat and pressure.

OSB's considerable bending strength comes from uninterrupted wood fibre, interweaving of the long strands and orientation of strands in the surface layers. Typically, the surface layers are aligned in the long direction of the panel for superior bending strength and stiffness in this direction. The inner layers may be randomly oriented or cross-aligned to the surface layer (see Figure 1). The waterproof and boil-proof resin binders combined with the strands provide internal strength, rigidity and moisture resistance.

Reference 2 contains additional information about OSB products. Also some selected physical properties, such as thermal resistance, vapour permeance and flame spread rating, are given in Appendix A.1.

Figure 1 OSB Lay-up



2.2 Construction Sheathing OSB

CSA O325 pertains to wood-based panel products designed and manufactured for protected construction uses, such as roof sheathing, wall sheathing, subfloors and single-layer floors in light frame construction applications, or in shear walls and horizontal diaphragms. OSB in Canada is currently mostly produced to meet CSA O325, which is a performance-based standard that rates panels by performnace baselines such as load bearing capacities for designated end uses.

End-use marks identify panels for various applications, as indicated in Table 1. Table 2 provides a relationship between panels mark and nominal thickness. OSB panels marked to CSA O325 are technically equivalent to OSB panels rated to the U.S. standard DOC PS 2, which uses a slightly different span rating designation.

Table 1 Panel Marks for Construction Sheathing OSB

(a) Panel Marks	Span Marks					
	16	20	24	32	40	48
	Recommended Maximum Framing Member Spacing, mm					
End Use Marks	406	508	610	813	1016	1220
1F	1F16	1F20	1F24	1F32	x	1F48
2F	2F16	2F20	2F24	x	x	x
1R	1R16	1R20	1R24	1R32	1R40	1R48
2R	2R16	2R20	2R24	2R32	2R40	2R48
W	W16	W20	W24	x	x	x

x = not available

Notes:

1. Panel marks comprise an end use mark (see below) followed by an appropriate span mark, e.g. 2R24, or W16.
2. Multiple panel marks may be shown on panels qualified for more than one end use, e.g. 1R24/2F16, or 2R48/2F24.
3. The span mark relates to the centre-to-centre spacing of supports (test span in inches), used for qualification testing of Construction Sheathing OSB. These spans are based on assumed end use and framing member spacing normally found in wood-frame construction. The framing itself must be designed for the expected loads using recognized engineering practices.

(b) End Use Marks

For Panel Marked	Assumed End Use
1F	Subflooring (single layer)
2F	Subflooring used with panel type underlay
1R	Roof sheathing used without edge support
2R	Roof sheathing used with edge support
W*	Wall sheathing

* Panels marked W only are not permitted by CSA O86-01

Note:

1. Panels marked 1 are usually stiffer than panels marked 2.

Table 2 Relationship between Panel Mark and Nominal Thickness

	Nominal Thickness, mm											
Panel Mark	7.5	9.5	11	12	12.5	15	15.5	18	18.5	22	25	28.5
2R20	P											
2R24		P	A	A	A							
1R24/2F16			P	A	A							
2R32/2F16				P	A	A	A					
2R40/2F20						P	A					
2R48/2F24								P	A	A		
1F16						P	A					
1F20						P	A					
1F24								P	A			
1F32										P	A	
1F48												P

P – indicates the predominant nominal thickness for each panel mark.

A – indicates alternative nominal thicknesses that may be available for each panel mark. Check with suppliers regarding their availability.

Note:

1. Thicknesses of Construction Sheathing OSB may vary with type of product and span. Thicknesses are established at time of qualification and may be 0.5 mm less than the thicknesses shown above.

2.3 Design Rated OSB

There are three types of Design Rated OSB defined by CSA O452 including the following:

- Type 1 – STANDARD
- Type 2 – PLUS
- Type 3 – PROPRIETARY

As shown in Table 1 Type 1 – STANDARD consists of A, B and C grades that have engineering properties listed in CSA O86. These products will be the most commonly available type of Design Rated OSB.

Type 2 – PLUS Design Rated OSB are essentially STANDARD panels in which some of the properties are higher than listed in CSA O86. The PLUS panels will be marked with either A+, B+ or C+ grade and the higher design value will be listed as a percentage increase over the STANDARD values (Reference Para. 2.4.2).

Type 3 – PROPRIETARY is to permit the producer to manufacture products with different properties and thicknesses than STANDARD or PLUS types. These products may be developed for a specific customer who has special requirements (for instance, a manufacturer of engineered components).

The nominal thicknesses listed in Table 3A are a hard metric series of dimensions. The allowable tolerance on these dimensions is ±0.75 mm at time of shipment. However, the thickness on the job site may be slightly higher since the panels will absorb some moisture from the environment.

The panel sizes listed in Table 3A represent common industry practice. Other sizes and thicknesses may be available for special uses or markets. The sizes shown are nominal; the actual size is slightly less in order to accommodate the building code requirement for a 2 mm (3/32 in.) gap between panels to allow for possible expansion.

Table 3A Types of Design Rated OSB

Type	Grades	Nominal Thickness mm	Nominal Thickness in.	Nominal Panel Sizes
Type 1 – STANDARD	A, B or C	9.5 11.0 12.5 15.5 18.5 22.0 28.5	3/8 7/16 1/2 5/8 3/4 7/8 1-1/8	4 x 8 ft. imperial or 1220 x 2440 mm metric (other sizes can also be produced)
Type 2 – PLUS	A+, B+ or C+ (The same as Type 1 but with some higher properties)	Same as Type 1		Same as Type 1
Type 3 – PROPRIETARY	No set grades, thicknesses or panel sizes. Properties and dimensions developed for customers with special requirements			

2.3.1 Comparison of Design Rated OSB to CSA O437 OSB

Design Rated OSB is required to meet the requirements of O-2 grade OSB produced under product standard CSA O437.0 *OSB and Waferboard*. Also, the resin binder used in Design Rated OSB complies with CSA Standard O437.2.

The flexural stiffness of grade C Design Rated OSB closely approximates the flexural stiffness of O-2 grade. Therefore, Design Rated OSB can be thought of as regular O-2 OSB that has been stress-rated. Furthermore, Design Rated OSB can be substituted for O-1 or O-2 OSB (or R-1 waferboard) in any residential application covered by Part 9 of the National Building Code of Canada (NBCC).

2.3.2 Certification and Quality Control of Design Rated OSB

In order for an OSB manufacturer to produce Design Rated OSB the manufacturer must first have a third party independent certification organization conduct qualification testing as outlined in CSA Standard O452.1. This consists of sampling and testing large panel samples over a number of shifts of production in accordance with ASTM test standards. From the test results a grade is assigned so that the calculated capacities meet or exceed the requirements listed in CSA O452.0.

After the product has been qualified, regular quality assurance tests are carried out by the third party certification organization to assure that the strength capacities are being met. These tests are in addition to regular in-house quality control tests. The certification organization also reviews the in-house quality control records to ensure they are in order. Guidelines for quality assurance are contained in CSA Standard O452.2.

Ongoing OSB research activities provide the end-user with the assurance of consistent levels of quality and continuous product improvement.

2.4 Panel Marking

2.4.1 Construction Sheathing OSB

Construction Sheathing OSB panels will be stamped with a mark showing:

- The designation CSA O325.0.
- The panel mark denoting the span rating and end use.
- The nominal thickness.

- The certification agency's logo or name.
- The words Exterior Bond or EXT BOND.
- The name or logo of the manufacturer and the mill identification number.
- The date of manufacture or other code identifying the date.
- The direction of face strand alignment.
- Optional marks, such as tongue-and-groove edges, width, length, or other marks indicating conformance to other standards (such as O437 or PS 2).

Figure 2 shows an example of a typical OSB gradestamp.

2.4.2 Design Rated OSB

Design Rated OSB products will be stamped with a mark containing the following information:

- The designation CSA O452.
- The designation Design Rated OSB or DR OSB.
- The panel type; (ie. TYPE 1 – STD or TYPE 1).
- The rating grade.
- The nominal thickness.
- For Type 3 – PROPRIETARY products, the company designation for the product.
- For Type 2 – PLUS products, the notations shown in Table 3B as required.
- The words EXTERIOR BOND or EXT BOND.
- The direction of the major axis in such a manner that when the board is cut into sections as small as 600 x 600 mm, each section continues to show the directional marking (arrows, arrowheads or other marks).
- The name or logo of the Certification Organization.
- The mill identification number.
- The date of manufacture, or date code.
- Optional marks indicating that the Design Rated panel conforms to other panel Standards (such as CSA O437, CSA O325).

An example of typical panel markings is shown in Figure 3.

Table 3B Type 2 – PLUS Notation

	Symbol	Explanation
Property	EI	Bending stiffness
	MS	Bending moment resistance
	EA	Axial stiffness (tension and compression)
	TA	Axial resistance (tension and compression)
	GTT	Shear-through-thickness rigidity
	STT	Shear-through-thickness resistance
	SIP	Shear-in-plane resistance
Direction	//	Major axis (0°)
	⊥	Minor axis (90°)
Increase in Property	10	10% higher than Type 1
	15, etc.	15% higher than Type 1

Example: EI//15

Figure 2 Typical OSB Gradestamp

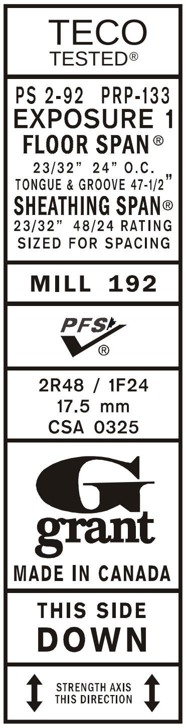


Figure 3 Typical Design Rated OSB Panel Markings

Type 1 – STANDARD

CSA O452 DR OSB TYPE 1 STD 15.5 B
EXT BOND

Type 2 – PLUS

CSA O452 DR OSB TYPE 2 PLUS 15.5 B+
EI∥15 EI⊥30 MS∥20 GTT24 STT29
EXT BOND

Type 3 – PROPRIETARY

CSA O452 DR OSB TYPE 3 PROPRIETARY 15.5
(Company Product designation)
EXT BOND

2.5 OSB and the Environment

Oriented Strand Board (OSB) is generally manufactured from aspen poplar in the northern part of North America and southern yellow pine in the south, however other hardwood and softwood species or combinations may also be used. Aspen poplar and northern hardwoods are harvested from naturally regenerated self-sustaining stands. Southern yellow pine is generally harvested from intensively managed plantation or wood lot stands. The thinnings are also utilized. Modern mills are designed to meet or exceed strict quality standards for air emissions by using collectors, precipitators or scrubbers to remove particulates from the discharge gases released into the atmosphere. Where log soaking ponds are used, the pond water is filtered, the ponds cleaned regularly and the sludge burned as fuel. The mills are designed to be self sufficient in terms of heat energy with all bark, screenings, sawdust and panel trim recycled as fuel for the dryers and the press heating system.

Oriented Strand Board (OSB) is bonded with thermo-setting phenol formaldehyde or isocyanate binders. Regular tests confirm formaldehyde emissions from phenolic bonded OSB panels are negligible or non-existent.

3.0 Applications

3.1 Sheathing

Oriented Strand Board (OSB) can be used for roof, floor and wall sheathing in engineered construction. These products can also be used in residential construction to improve floor performance. Design Rated Grade A panels have a higher bending stiffness than traditional sheathing products of the same thickness; therefore, substituting either Grade A or B for traditional sheathing will help reduce floor “bounciness” by increasing the stiffness derived from the greater composite action with the joists.

Further information regarding sheathing applications can be found in Reference 2.

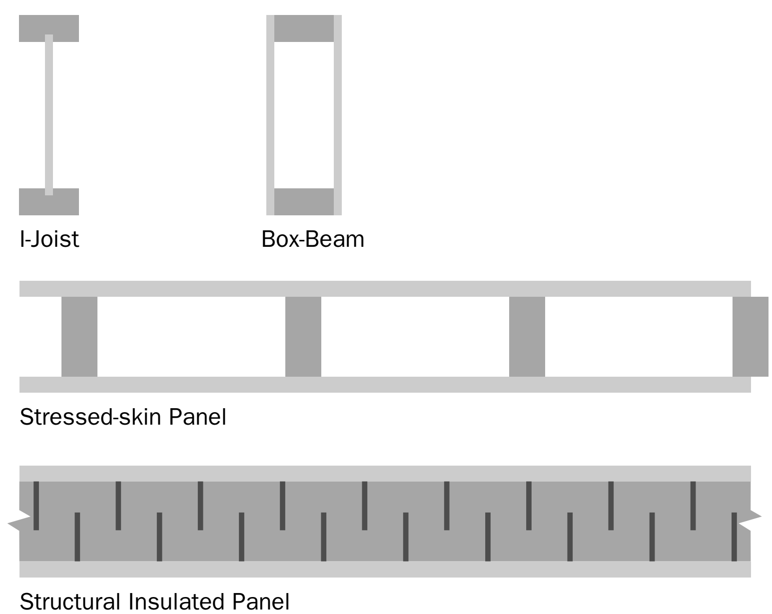
3.2 Engineered Components

OSB is extensively used for the webs of prefabricated wood I-joists (see Figure 4). Proprietary OSB could also be used for manufacture of box beams and stress-skin panels where the panel properties can be tailored to suit the product (see Figure 4). Stress-skin panels are constructed by gluing sheathing to lumber joists to form a composite panel. OSB manufacturers can make large panels (2400 x 7300 mm) so that joints are not required. Detailed design procedures for box beams or stressed-skin panels are given in Section 8 of CSA O86-01.

When gluing is required, tests have indicated that the shear strength of the glue bond exceeds the planar shear strength of the panel. This means that the glueability of OSB is excellent. Provisions are given in CSA O86 for glued scarf and butt OSB joints (OSB to OSB splice plates, for instance), with the appropriate stress-joint reduction factors to be applied to the specified strength capacity in tension, compression or shear-through-the-thickness.

Structural insulated panels are also commercially available (see Figure 4). These products typically have an OSB skin and rigid foam insulation cores.

Figure 4 Engineered Components



3.3 Shearwalls and Diaphragms

OSB can be fastened to wood floors and walls to create structural shearwalls and diaphragms capable of resisting lateral loads (wind or earthquake).

Engineering design values for OSB shearwalls and diaphragms are given in CSA O86 for various nailing arrangements. OSB panels have good nail holding power and fastening near the edge of the panel does not cause splitting since the core is cross-aligned with the surface layers.

3.4 Gussets for Frames and Trusses

OSB can be used as gussets for trusses or frames constructed with dimension lumber. Nails, screws, staples and/or adhesive can be used to fasten the gussets. This type of structural connection is also ideal for repairing or upgrading wood structures.

Where an adhesive is used it should meet the requirements of CSA Standard O122.7.

3.5 Formwork

Standard grades of OSB sheathing are sometimes used in applications where the forms are left in place after the concrete sets. This is the case in bridge decks with internal voids. Specialty products are now also offered by some OSB manufacturers with increased water and edge resistance for repeat concrete pours.

In this application the OSB panels should be designed for bending moment, shear and deflection. Conservative design values for this application can be obtained by reducing the standard term factored resistances given in Table 4 by 25 percent. The reduction is to account for the temporary wet service conditions.

The versatility of these full-size OSB panels makes it possible to build commercial walls very efficiently.

4.0 Engineering Design

4.1 General Design

All of the design information contained herein is in accordance with CSA O86-01. This document is in limit states design format using the load factors stated in the National Building Code of Canada.

In general, Design Rated OSB must be designed to satisfy the following criteria:

Factored Resistance	≥	Effect of Factored Loads
Deformation due to service Loads	≤	Maximum Permissible Deformation

Tables 5A to 5C contain the factored resistance and rigidity capacities for Construction Sheathing OSB. Tables 5D to 5F contain the factored resistances and the stiffness and rigidity capacities for Type 1 – STANDARD Design Rated OSB. All the values are unit values. To determine the total resistance simply multiply the unit values by the width of panel. For the in-plane planar shear resistance, multiply by the contact area of the glued splice or gusset as shown in the table.

All of the values in Tables 5A, 5B, 5D and 5F are based on standard term duration of load, which includes dead plus snow or use and occupancy loads. For other loading conditions multiply the unit resistances by the duration of load factor shown in Table 4.

Design Rated OSB is presently intended for use in dry service conditions only; therefore, no modification for wet service is provided. Where a panel is treated with a fire retardant chemical, the resistance and stiffness of the material must be based on documented test results.

Table 4 Duration of Load Values for OSB

Duration of Load	K_D	Explanation
Short Term	1.15	Loading in which the specified load is not expected to last more than 7 days continuously or cumulatively throughout the life of the structure. Examples include wind, earthquake, falsework and formwork loads.
Standard Term	1.0	Loading condition where duration of specified loads exceeds that of short term but is less than permanent. Examples include snow, live loads due to use and occupancy and dead loads in combination with the above.
Permanent	0.65	Condition where OSB is subjected to more or less continuous specified load under moderate temperature and dry conditions. Examples of continuously applied load include dead loads, or permanent live loads such as loads in storage bins or loads on floors used for storage.
	0.45	Condition where OSB is subjected to permanently applied specified loads that exceed 50% of the design capacity (maximum permissible specified load), protected from direct exposure to water, but exposed to intermittent high temperature and humidity conditions. Examples include an open shed used for storage, or storage floors in some agricultural buildings.

Notes:
1. Selection of appropriate K_D factors requires professional judgement by the designer.
2. Capacities relative to major axis (orientation of applied force relative to panel length).

Table 5A Unit Factored Bending and Axial Resistances for **Construction Sheathing** OSB

Mark	Nominal Panel Thickness[3] mm	Bending Moment Resistance[1] M_r (N•mm/mm) Minimum		Axial Tensile Resistance[1] T_r (N/mm)		Axial Compressive Resistance[1,5] P_r (N/mm)	
		Orientation of applied force rel. to panel length		Orientation of applied force rel. to panel length		Orientation of applied force rel. to panel length	
		0°	90°	0°	90°	0°	90°
2R24	9.5	171	54	50	17	59	51
1R24/2F16	11	228	65	57	29	67	51
2R32/2F16	12	257	95	62	36	73	64
2R40/2F20	15	437	152	64	46	87	83
2R48/2F24	18	599	228	87	56	105	89
1F16	15	295	95	57	41	83	74
1F20	15	342	143	64	46	87	83
1F24	18	456	219	73	56	105	89
1F32	22	608	380	87	71	133	124
1F48	28.5	1140	684	124	105	171	143

Notes:
1. Multiply by the width of the panel, b (mm), to determine the total resistance. For T_r use the net width of the panel after cutting of holes etc.
2. The factored unit bearing resistance perpendicular to panel Q_r = 4.0 MPa. Multiply by bearing area (mm^2) to calculate the total resistance.
3. The minimum nominal thickness shown on the panel mark can be 0.5 mm less than the values shown here.
4. Values are factored and are for dry service conditions and standard term duration of loading. For other duration of load conditions multiply the unit resistances by the K_D values shown in Table 4.
5. Axial compressive resistance assumes full lateral support.
6. Tabulated design information is given in metric SI units. For conversion factors, refer to Appendix A.2.

Table 5B Unit Factored Shear Resistances for **Construction Sheathing** OSB

Panel Mark	Minimum Nominal Thickness[3] mm	Shear Through Thickness Resistance[1] V_r (N/mm) Orientation of applied force rel. to panel length 0° and 90°	Planar Shear Resistance: Due to bending[1] V_{rb} (N/mm) Orientation of applied force rel. to panel length 0°	90°	Due to in-plane shear[2] V_{rp} (MPa) Orientation of applied force rel. to panel length 0°	90°
2R24	9.5	40	3.6	2.3	0.57	0.36
1R24/2F16	11	44	4.2	2.3	0.57	0.31
2R32/2F16	12	48	4.6	2.9	0.57	0.36
2R40/2F20	15	52	5.8	3.6	0.58	0.36
2R48/2F24	18	57	7.4	4.2	0.62	0.35
1F16	15	45	4.9	3.1	0.49	0.31
1F20	15	51	5.8	3.7	0.58	0.37
1F24	18	56	7.4	4.3	0.62	0.35
1F32	22	61	8.7	6.1	0.60	0.42
1F48	28.5	81	13.3	9.5	0.69	0.52

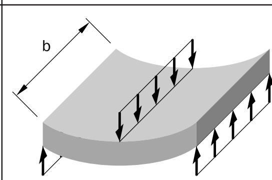
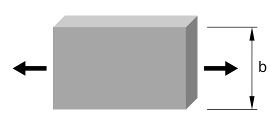
Notes:
1. Multiply by the width of the panel, b (mm), to determine the total resistance.
2. Multiply by the contact area of the glued splice or gusset plate (mm^2) to determine the total resistance.
3. The minimum nominal thickness shown on the panel mark can be 0.5 mm less than the values shown here.
4. The factored unit bearing resistance perpendicular to panel Q_r = 4.0 MPa. Multiply by bearing area (mm^2) to calculate the total resistance.
5. Values are factored and are for dry service conditions and standard term duration of loading. For other duration of load conditions multiply the unit resistances by the K_D values shown in Table 4.
6. Tabulated design information is given in metric SI units. For conversion factors, refer to Appendix A.2.

Table 5C Unit Stiffness and Rigidity Capacities for **Construction Sheathing** OSB

Panel Mark	Nominal Thickness[2] mm	Bending Stiffness[1] EI (N·mm^2/mm) Minimum Orientation of applied force rel. to panel length 0°	90°	Axial Stiffness[1] EA (N/mm) Orientation of applied force rel. to panel length 0°	90°	Shear Through Thickness Rigidity[1] G (N/mm) Orientation of applied force rel. to panel length 0° and 90°
2R24	9.5	560000	100000	33000	19000	10000
1R24/2F16	11	730000	140000	38000	22000	11000
2R32/2F16	12	1100000	220000	43000	25000	11000
2R40/2F20	15	2100000	500000	53000	31000	12000
2R48/2F24	18	3800000	820000	64000	37000	13000
1F16	15	1400000	300000	53000	31000	11000
1F20	15	2000000	360000	53000	31000	11000
1F24	18	2800000	720000	64000	37000	12000
1F32	22	6100000	2100000	76000	44000	15000
1F48	28.5	11000000	4400000	98000	51000	20000

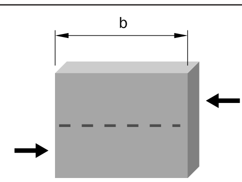
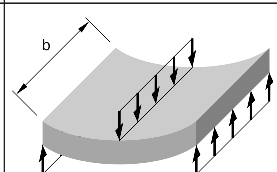
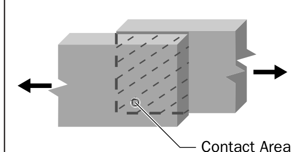
Notes:
1. Multiply by the width of the panel, b (mm), to determine the total stiffness and rigidity.
2. The minimum nominal thickness shown on the panel mark can be 0.5 mm less than the values shown here.

Table 5D Unit Factored Bending and Axial Resistances for **Type 1 – STANDARD Design Rated** OSB

Design Rating		Bending Moment Resistance [1] M_r (N·mm/mm)		Axial Tensile Resistance [1] T_r (N/mm)		Axial Compressive Resistance [1, 5] P_r (N/mm)	
Nominal Thickness mm	Rating Grade	Orientation of applied force rel. to panel length 0°	90°	Orientation of applied force rel. to panel length 0°	90°	Orientation of applied force rel. to panel length 0°	90°
9.5	A	276	86	75	36	75	36
	B	228	86	60	36	60	36
	C	181	86	45	36	45	36
11.0	A	371	114	86	42	86	42
	B	304	114	69	42	69	42
	C	247	114	52	42	52	42
12.5	A	475	152	95	48	95	48
	B	399	152	79	48	79	48
	C	314	152	59	48	59	48
15.5	A	732	228	124	59	124	59
	B	608	228	95	59	95	59
	C	485	228	73	59	73	59
18.5	A	1045	323	143	70	143	70
	B	865	323	114	70	114	70
	C	684	323	87	70	87	70
22.0	A	1520	456	171	84	171	84
	B	1235	456	143	84	143	84
	C	950	456	105	84	105	84
28.5	A	2470	770	228	105	228	105
	B	2090	770	181	105	181	105
	C	1615	770	133	105	133	105
							

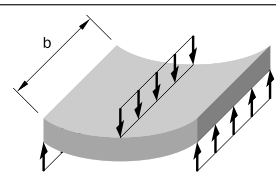
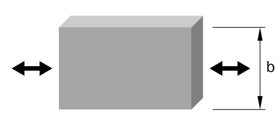
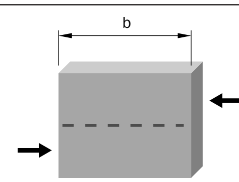
Notes:
1. Multiply by the width of the panel, b (mm), to determine the total resistance. For T_r use the net width of the panel after cutting of holes etc.
2. Multiply by the contact area of the glued splice or gusset plate (mm^2) to determine the total resistance.
3. The factored unit bearing resistance perpendicular to panel Q_r = 4.0 MPa. Multiply by bearing area (mm^2) to calculate the total resistance.
4. Values are factored and are for dry service conditions and standard term duration of loading. For other duration of load conditions multiply the unit resistances by the K_D values shown in Table 4.
5. Axial compressive resistance assumes full lateral support.
6. Tabulated design information is given in metric SI units. For conversion factors, refer to Appendix A.2.

Table 5E Unit Factored Shear Resistances for **Type 1 – STANDARD Design Rated** OSB

Design Rating		Shear Through Thickness Resistance [1] V_r (N/mm)	Planar Shear Resistance: Due to bending [1] V_{rb} (N/mm)	Planar Shear Resistance: Due to in-plane shear [2] V_{rp} (MPa)
Nominal Thickness mm	Rating Grade	Orientation of applied force rel. to panel length 0° and 90°	Orientation of applied force rel. to panel length 0° and 90°	Orientation of applied force rel. to panel length 0° and 90°
9.5	A	29	3.9	0.61
	B	29	3.9	0.61
	C	29	3.9	0.61
11.0	A	33	4.5	0.61
	B	33	4.5	0.61
	C	33	4.5	0.61
12.5	A	38	5.0	0.61
	B	38	5.0	0.61
	C	38	5.0	0.61
15.5	A	48	6.3	0.61
	B	48	6.3	0.61
	C	48	6.3	0.61
18.5	A	56	7.5	0.61
	B	56	7.5	0.61
	C	56	7.5	0.61
22.0	A	67	8.9	0.61
	B	67	8.9	0.61
	C	67	8.9	0.61
28.5	A	86	11.4	0.61
	B	86	11.4	0.61
	C	86	11.4	0.61
				

Notes:
1. Multiply by the width of the panel, b (mm), to determine the total resistance. For T_r use the net width of the panel after cutting of holes etc.
2. Multiply by the contact area of the glued splice or gusset plate (mm^2) to determine the total resistance.
3. The factored unit bearing resistance perpendicular to panel Q_r = 4.0 MPa. Multiply by bearing area (mm^2) to calculate the total resistance.
4. Values are factored and are for dry service conditions and standard term duration of loading. For other duration of load conditions multiply the unit resistances by the K_D values shown in Table 4.
5. Axial compressive resistance assumes full lateral support.

Table 5F Unit Stiffness and Rigidity Capacities for **Type 1 – STANDARD Design Rated** OSB

Design Rating		Bending Stiffness [1] EI (N·mm²/mm)		Axial Stiffness [1] EA (N/mm)		Shear Through Thickness Rigidity [1] G (N/mm)
Nominal Thickness mm	Rating Grade	Orientation of applied force rel. to panel length 0°	90°	Orientation of applied force rel. to panel length 0°	90°	Orientation of applied force rel. to panel length 0° and 90°
9.5	A	590 000	170 000	46 000	19 000	9 500
	B	490 000	170 000	39 000	19 000	9 500
	C	390 000	170 000	33 000	19 000	9 500
11.0	A	920 000	270 000	53 000	22 000	11 000
	B	760 000	270 000	46 000	22 000	11 000
	C	610 000	270 000	38 000	22 000	11 000
12.5	A	1 300 000	390 000	60 000	25 000	12 000
	B	1 100 000	390 000	52 000	25 000	12 000
	C	900 000	390 000	43 000	25 000	12 000
15.5	A	2 600 000	740 000	75 000	31 000	15 000
	B	2 100 000	740 000	64 000	31 000	15 000
	C	1 700 000	740 000	53 000	31 000	15 000
18.5	A	4 400 000	1 300 000	89 000	37 000	18 000
	B	3 600 000	1 300 000	77 000	37 000	18 000
	C	2 900 000	1 300 000	64 000	37 000	18 000
22.0	A	7 300 000	2 100 000	110 000	44 000	22 000
	B	6 100 000	2 100 000	91 000	44 000	22 000
	C	4 900 000	2 100 000	76 000	44 000	22 000
28.5	A	16 000 000	4 600 000	140 000	57 000	28 000
	B	13 000 000	4 600 000	120 000	57 000	28 000
	C	11 000 000	4 600 000	98 000	57 000	28 000
						

Note:
1. Multiply by the width of the panel, b (mm), to determine the total stiffness and rigidity.

4.2 Sheathing

Sheathing must be designed to satisfy the following criteria:

Factored Moment Resistance	≥	Factored Bending Moment
Factored Planar Shear Resistance due to bending	≥	Factored Shear Force
Deflection Under Specified Loads	≤	Maximum Permissible Deflection

Tables 6A, 6B and 6C provide the recommended thickness of Construction Sheathing OSB for roof and floor applications.

Tables 7A, 7B and 7C provide the recommended thickness of Design Rated OSB for roof and floor applications.

The values for residential buildings have been developed using the following load cases, which generate the same sheathing thicknesses given in Part 9 of the NBCC for other sheathing products:

(a) Uniform dead plus live loads

- maximum permissible floor sheathing deflection of span/360 under live load.
- roof sheathing designed for a uniform load over 3 spans.
- floor sheathing designed for the most critical condition of 2 or 3 span continuous with full or partial load.

(b) Concentrated load

- 0.89 kN (200 lb) point load at centre of a sheathing panel.
- maximum deflection as follows using the formulae in Appendix A.3 for a simply supported plate:
  - 3.2 mm (1/8") for floor sheathing
  - 12.7 mm (1/2") for roof sheathing with edges unsupported
  - 19.0 mm (3/4") for roof sheathing with all edges supported

For non-residential buildings, the following additional concentrated load cases were considered in accordance with Part 4 of the NBCC:

(a) 9 kN load over a 750 x 750 mm area (Floors of offices only).

(b) 1.3 kN load over a 750 x 750 mm area (Roofs only).

Using these criteria, the recommended thicknesses for C grade Design Rated OSB on residential floors and roofs are identical to those given in Part 9 of the NBCC for O-2 grade OSB. Note that for roof sheathing with supported edges, the NBCC thicknesses allow 25 mm deflection under the 0.89 kN concentrated load using the formulae in Appendix A.3; however, the SBA recommends 19 mm maximum for enhanced performance.

For other design cases, Tables 8A and 8B can be used to determine the required thickness for the maximum uniform design loads shown.

Table 6A Minimum Required Roof Sheathing Thickness in Residential Buildings for **Construction Sheathing** OSB

Panel Edges	Maximum Support Spacing mm	in.	Panel Mark
Unsupported	305	12	1R16
	406	16	1R16
	488	19.2	1R20
	610	24	1R24
Supported	305	12	2R16
	406	16	2R16
	488	19.2	2R20
	610	24	2R24

Notes:
1. This table is for buildings conforming to Part 9 of the NBCC.
2. Edge support must consist of 38 mm framing, H-clips or T&G edges.
3. Panels to be continuous over 2 or more spans.
4. Major axis (or panel length) spanning across supports (roof trusses or rafters).
5. For roofs used as a walking deck, sheathing thickness should be no less than that shown in the Floor Sheathing Table (Table 6C).

Table 6B Minimum Required Roof Sheathing Thickness in Commercial Buildings for **Construction Sheathing** OSB

Panel Edges	Uniform Specified Roof Snow Load kPa	Specified Concentrated Load kN	Maximum Support Spacing mm	in.	Panel Marks
Supported or Unsupported	2.8 or less	1.3	305	12	2R24
			406	16	2R24
			488	19.2	2R24
			610	24	2R32/2F16/1F16
			813	32	2R48/2F24/1F24
Supported or Unsupported	3.6 or less	1.3	305	12	2R24
			406	16	2R24
			488	19.2	2R24
			610	24	2R40/2F20/1F16
			813	32	2R48/2F24/1F24

Notes:
1. This table is for buildings falling under Part 4 of the NBCC with any roof slope.
2. Concentrated load acts over an area of 750 x 750 mm and is a seperate load case.
3. Panels to be continuous over 2 or more spans.
4. Major axis (or panel length) spanning across supports (roof trusses or rafters).
5. Dead load of 0.3 kPa included in calculation of thickness.
6. For roofs used as a walking deck, sheathing thickness should be no less than that shown in the Floor Sheathing Table (Table 6C).

Table 6C Minimum Required Floor Sheathing Thickness for **Construction Sheathing** OSB

Type of Floor	Uniform Specified Live Load kPa	Specified Concentrated Live Load kN	Maximum Support Spacing mm	in.	Panel Marks
Residential – OSB sheathing used with panel-type underlay	1.9 or less	Not Applicable	305	12	2F16
			406	16	2F16
			488	19.2	2F20
			610	24	2F24
Residential – OSB subfloor without underlay (single floor)	1.9 or less	Not Applicable	305	12	1F16
			406	16	1F16
			488	19.2	1F20
			610	24	1F24
Commercial	Up to 4.8	Not Applicable	305	12	1F16
			406	16	1F16
			488	19.2	1F20
			610	24	1F32
			813	32	1F48
Commercial	Up to 4.8	9	305	12	1F16
			406	16	1F24
			488	19.2	1F32
			610	24	1F48
			813	32	Not Recommended

Notes:
1. Residential floor refers to Part 9 of the NBCC.
2. Commercial floor refers to floors falling under Part 4 of the NBCC.
3. Dead load of 0.3 kPa included in calculation of thickness.
4. Concentrated load acts over an area of 750 x 750 mm and is a seperate design case.
5. Panels to be continuous over 2 or more spans.
6. Major axis (or panel length) spanning across supports (floor joists).
7. Edge support is required except in a residential floor where a separate panel-type underlay is applied to a subfloor. Edge support must consist of not less than 38 x 38 mm blocking securely nailed between framing members, or tongue and groove edge joint.

Table 7A Minimum Required Roof Sheathing Thickness in Residential Buildings for **Type 1 – STANDARD Design Rated** OSB

Panel Edges	Maximum Support Spacing mm	in.	Sheathing Thickness mm Grade C	B	A
Unsupported	305	12	9.5	9.5	9.5
	406	16	9.5	9.5	9.5
	488	19.2	11.0	9.5	9.5
	610	24	12.5	11.0	11.0
Supported	305	12	9.5 [6]	9.5 [6]	9.5 [6]
	406	16	9.5 [6]	9.5 [6]	9.5 [6]
	488	19.2	9.5	9.5	9.5
	610	24	11.0 [7]	11.0 [7]	11.0 [7]

Notes:
1. These tables are for buildings conforming to Part 9 of the NBCC.
2. Edge support must consist of 38 mm framing, H-clips or T&G edges.
3. Panels to be continuous over 2 or more spans.
4. Major axis (or panel length) spanning across supports (roof trusses or rafters).
5. The thicknesses are governed by the concentrated load case in order to be consistent with the NBCC. These thicknesses will provide a deflection of L/180 for uniform live loads up to 1.8 kPa for supported edges and 2.2 kPa for unsupported edges.
6. 7.5 mm Sheathing is permitted by NBCC in some cases; however, Design Rated OSB is not produced in this thickness.
7. NBCC permits the use of 9.5 mm sheathing on a 610 mm span with supported edges; however, the SBA recommends the use of 11.0 mm for enhanced performance.
8. For roofs used as a walking deck, sheathing thickness should be no less than that shown in the Floor Sheathing Table (Table 7C).

Table 7B Minimum Required Roof Sheathing Thickness in Commercial Buildings for **Type 1 – STANDARD Design Rated** OSB

Panel Edges	Uniform Specified Roof Snow Load kPa	Specified Concentrated Load kN	Maximum Support Spacing mm	in.	Sheathing Thickness mm Grade C	B	A
Supported or Unsupported	2.8 or less	1.3	305	12	9.5	9.5	9.5
			406	16	9.5	9.5	9.5
			488	19.2	11.0	9.5	9.5
			610	24	12.5	12.5	11.0
			813	32	18.5	15.5	15.5
Supported or Unsupported	3.6 or less	1.3	305	12	9.5	9.5	9.5
			406	16	9.5	9.5	9.5
			488	19.2	11.0	11.0	9.5
			610	24	15.5	12.5	12.5
			813	32	18.5	18.5	18.5

Notes:
1. These tables are for buildings falling under Part 4 of the NBCC with any roof slope.
2. Concentrated load acts over an area of 750 x 750 mm and is a separate load case.
3. Panels to be continuous over 2 or more spans.
4. Major axis (or panel length) spanning across supports (roof trusses or rafters).
5. Dead load of 0.3 kPa included in calculation of thickness.
6. For roofs used as a walking deck, sheathing thickness should be no less than that shown in the Floor Sheathing Table (Table 7C).

Table 8A Maximum Uniform Load (kPa) for **Construction Sheathing** OSB

Maximum Support Spacing mm	in.	Load kPa	Panel Mark 2R24	1R24 or 2F16	2R32 or 2F16	2R40 or 2F20	2R48 or 2F24	1F16	1F20	1F24	1F32	1F48
305	12	w_f	14.7	19.6	22.1	30.4	38.9	25.3	29.4	38.9	45.8	69.8
		w – L/180	11.9	15.5	23.4	44.7	80.9	29.8	42.6	59.6	130	234
		w – L/360	5.96	7.77	11.7	22.3	40.4	14.9	21.3	29.8	64.9	117
406	16	w_f	8.30	11.1	12.4	21.2	29.0	14.3	16.6	22.1	29.5	52.4
		w – L/180	5.05	6.59	9.93	18.9	34.3	12.6	18.0	25.3	55.0	99.3
		w – L/360	2.53	3.29	4.96	9.47	17.1	6.32	9.02	12.6	27.5	49.6
488	19.2	w_f	5.74	7.66	8.62	14.7	20.1	9.89	11.5	15.3	20.4	38.3
		w – L/180	2.91	3.79	5.72	10.9	19.7	7.27	10.4	14.5	31.7	57.2
		w – L/360	1.45	1.90	2.86	5.46	9.87	3.64	5.20	7.27	15.8	28.6
610	24	w_f	3.68	4.90	5.51	9.40	12.9	6.33	7.35	9.80	13.1	24.5
		w – L/180	1.49	1.94	2.93	5.59	10.1	3.72	5.32	7.45	16.2	29.3
		w – L/360			1.46	2.79	5.05	1.86	2.66	3.72	8.11	14.6
813	32	w_f			3.10	5.29	7.24	3.56	4.14	5.52	7.36	13.8
		w – L/180			1.24	2.36	4.27	1.57	2.25	3.15	6.86	12.4
		w – L/360				1.18	2.14		1.12	1.57	3.43	6.18

Notes:
See Table 8B notes.

Table 8B Maximum Uniform Load for **Type 1 – STANDARD Design Rated** OSB

Grade	Maximum Support Spacing mm	in.	Load kPa	Thickness mm 9.5	11	12.5	15.5	18.5	22	28.5
C	305	12	w_f	15.5	21.2	26.4	32.9	39.4	46.8	59.8
			w – L/180	8.30	13.0	19.2	36.2	61.7	104	234
			w – L/360	4.15	6.49	9.58	18.1	30.9	52.1	117
	406	16	w_f	8.76	12.0	15.2	23.5	29.6	35.2	45.0
			w – L/180	3.52	5.51	8.12	15.3	26.2	44.2	98.8
			w – L/360	1.76	2.75	4.06	7.67	13.1	22.1	49.6
	488	19.2	w_f	6.06	8.30	10.5	16.3	23.0	29.3	37.4
			w – L/180	2.03	3.17	4.68	8.83	15.1	25.5	57.2
			w – L/360		1.58	2.34	4.42	7.53	12.7	28.6
	610	24	w_f	3.88	5.31	6.74	10.4	14.7	20.4	29.9
			w – L/180	1.04	1.62	2.39	4.52	7.72	13.0	29.3
			w – L/360			1.20	2.26	3.86	6.52	14.6
	813	32	w_f			3.79	5.86	8.28	11.5	19.5
			w – L/180			1.01	1.91	3.26	5.51	12.4
			w – L/360					1.63	2.75	6.18

continued

Table 7C Minimum Required Floor Sheathing Thickness for **Type 1 – STANDARD Design Rated** OSB

Type of Floor	Uniform Specified Live Load kPa	Specified Concentrated Live Load kN	Maximum Support Spacing mm	in.	Sheathing Thickness mm Grade C	B	A
Residential	1.9 or less	Not Applicable	305	12	12.5	11.0	11.0
			406	16	15.5	15.5	12.5
			488	19.2	15.5	15.5	15.5
			610	24	18.5	18.5	18.5
			813	32	22.0	22.0	22.0
Commercial	Up to 4.8	Not Applicable	305	12	12.5	11.0	11.0
			406	16	15.5	15.5	12.5
			488	19.2	18.5	15.5	15.5
			610	24	22.0	22.0	18.5
			813	32	28.5	28.5	28.5
Commercial	Up to 4.8	9	305	12	15.5	15.5	12.5
			406	16	18.5	18.5	18.5
			488	19.2	22.0	22.0	22.0
			610	24	28.5	28.5	28.5
			813	32	Not Recommended		

Notes:
1. Residential floor refers to Part 9 of NBCC.
2. Commercial floor refers to floors falling under Part 4 of NBCC.
3. Dead load of 0.3 kPa included in calculation of thicknesses.
4. Concentrated load acts over an area of 750 x 750 mm and is a separate design case.
5. Sheathing to be continuous over at least 2 spans.
6. Major axis (or panel length) spanning across supports (floor joists).
7. All panel edges to be supported by 38 mm framing or T&G edge.

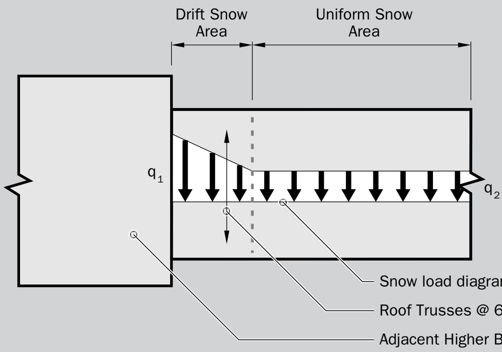
Table 8B *continued:*

Grade	Maximum Support Spacing mm	in.	Load kPa	Thickness mm 9.5	11	12.5	15.5	18.5	22	28.5
B	305	12	w_f	19.6	23.4	26.4	32.9	39.4	46.8	59.8
			w – L/180	10.4	16.2	23.4	44.7	76.6	130	277
			w – L/360	5.21	8.09	11.7	22.3	38.3	64.9	138
	406	16	w_f	11.0	14.8	19.4	24.7	29.6	35.2	45.0
			w – L/180	4.42	6.85	9.88	19.0	32.5	55.1	117
			w – L/360	2.21	3.43	4.96	9.48	16.2	27.5	58.7
	488	19.2	w_f	7.66	10.2	13.4	20.4	24.6	29.3	37.4
			w – L/180	2.55	3.95	5.72	10.9	18.7	31.7	67.6
			w – L/360		1.97	2.86	5.46	9.35	15.8	33.8
	610	24	w_f	4.90	6.54	8.58	13.1	18.6	23.4	29.9
			w – L/180	1.30	2.02	2.93	5.59	9.58	16.2	34.6
			w – L/360			1.46	2.79	4.79	8.11	17.3
	813	32	w_f			4.83	7.36	10.5	14.9	22.4
			w – L/180			1.24	2.36	4.05	6.86	14.6
			w – L/360					2.02	3.43	7.30
A	305	12	w_f	20.4	23.4	26.4	32.9	39.4	46.8	59.8
			w – L/180	12.6	19.6	27.7	55.3	93.7	155	341
			w – L/360	6.28	9.79	13.8	27.7	46.8	77.7	170
	406	16	w_f	13.4	17.4	19.7	24.7	29.6	35.2	45.0
			w – L/180	5.32	8.30	11.7	23.5	39.7	65.9	145
			w – L/360	2.66	4.15	5.87	11.7	19.8	32.9	72.2
	488	19.2	w_f	9.25	12.4	16.0	20.6	24.6	29.3	37.4
			w – L/180	3.07	4.78	6.76	13.5	22.9	37.9	83.1
			w – L/360	1.53	2.39	3.38	6.76	11.4	19.0	41.6
	610	24	w_f	5.92	7.97	10.2	16.4	19.7	23.4	29.9
			w – L/180	1.57	2.45	3.46	6.92	11.7	19.4	42.6
			w – L/360			1.73	3.46	5.85	9.71	21.3
	813	32	w_f		4.48	5.75	12.3	12.6	17.6	22.4
			w – L/180		1.03	1.46	2.92	4.94	8.20	18.0
			w – L/360				1.46	2.47	4.10	8.99

Notes:
1. w_f is the maximum factored uniform load based on moment and shear resistance.
2. w – L/180 is the maximum specified load for a deflection limit of span/180.
3. w – L/360 is the maximum specified load for a deflection limit of span/360.
4. For L/240 deflection limit, multiply w – L/180 values by 0.75. For L/480 deflection limit, multiply w – L/360 values by 0.75.
5. Values are for standard term load and dry service conditions. For other load duration situations multiply w_f by K_D (see Table 4).
6. Values are for sheathing continuous over 2 or more spans with full and partial loading.
7. Major axis (or panel length) spanning across supports.

EXAMPLE

Determine the thickness of Grade C Design Rated OSB Sheathing for the roof shown below:



Roof Plan

Loads

kPa	q_1	q_2
Spec. dead load	0.3	0.3
Spec. live load	1.5	4.0
Total spec. load	1.8	4.3
Total factored load	2.63	6.38

- Non-residential Building
- Loads as shown above plus a separate concentrated load case consisting of 1.3 kN over 750 x 750 mm area

(a) Uniform Snow Area

As shown in Table 8B, a thickness of 12.5 mm is required in the uniform snow area.

(b) Drift Snow Area

In the triangular snow drift area it is advantageous to decrease the support spacing so that the same thickness can be used. From Table 8B, 12.5 mm C-grade sheathing can support the following loads when the support spacing is decreased to 488 mm:

Maximum factored load based on strength resistance

$$w_f = 10.5\ \text{kPa} > 6.38\ \text{kPa} \qquad \textit{Acceptable}$$

Maximum specified total load for deflection of span/180

$$w - \frac{L}{180} = 4.7\ \text{kPa} > 4.3\ \text{kPa} \qquad \textit{Acceptable}$$

Therefore, 12.5 mm C-grade Design Rated OSB is acceptable with spacing of supports reduced to 488 mm in the snow drift area.

Note that as an alternative, one could select a 15.5 mm thick panel instead, with spacing of supports at 610 mm.

4.3 Shearwalls and Diaphragms

Shearwall and diaphragm sheathing must be designed so that the factored shear resistance per unit length v_r is greater than or equal to the maximum factored shear force per unit length v_f . Tables 9 and 10 provide values of v_r for OSB panels with various species of lumber, nail sizes and spacings. Values are not given for different grades of OSB since the strength of the diaphragm or shearwall depends on the nailed connection.

Values are provided for blocked and unblocked diaphragms. Shearwalls must always be blocked. Blocking should consist of no less than 38 mm framing at all panel edges.

The values are for shearwalls and diaphragms framed with spruce-pine-fir lumber and subject to short term (wind or earthquake) loads. For other conditions the values must be adjusted as indicated in the notes of the Tables.

Diaphragms and shearwalls must also have adequate chord members and must be properly anchored to the supporting structure. For a complete review of shearwall and diaphragm design and detailing, please refer to Reference 3.

Use of OSB in shearwalls is recognized by the model building code in Canada and the U.S.

Table 9 Factored Shear Resistance of Diaphragms Sheathed with OSB

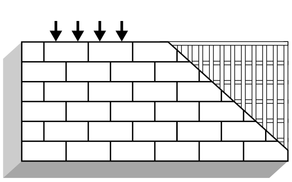
Common Nail Size Length in.	Common Nail Size Dia. mm	Minimum Nail Penetration in Framing mm	Panel Mark	Minimum Nominal Thickness mm	Minimum Width of Framing Member mm	Factored Shear Resistance of Diaphragms v_r (kN/m): Blocked				Unblocked	
						Nail Spacing (mm) at Diaphragm Boundaries (all cases) and at Cont. Panel Edges Parallel to Load (Cases 3 and 4)				Nails Spaced at 150 mm Maximum at Supported Panel Edges	
						150	100	64	50[6]	Load Perp. to Edges and Continuous Panel Joints (Case 1)	All other Configurations (Cases 2, 3 and 4)
						Nail Spacing at Other Panel Edges (mm): 150	150	100	75		
2	2.8	31	2R20	7.5	38	2.96	3.93	5.86	6.63	2.64	1.93
					64	3.35	4.38	6.63	7.53	2.96	2.19
			2R24	9.5	38	3.22	4.38	6.57	7.34	2.90	2.19
					64	3.67	4.89	7.34	8.31	3.22	2.45
2-1/2	3.3	38	2R24	9.5	38	4.19	5.60	8.44	9.53	3.80	2.83
					64	4.70	6.31	9.47	10.69	4.19	3.16
			1R24/2F16	11	38	4.44	5.92	8.82	10.05	4.06	2.96
					64	5.02	6.63	9.98	11.27	4.44	3.35
			2R32/2F16	12.5	38	4.70	6.31	9.27	10.50	4.19	3.16
					64	5.28	7.02	10.50	11.85	4.64	3.48
3[7]	3.7	41	2R32/2F16 or 1F20	12.5	38	5.09	6.76	10.05	11.46	4.44	3.35
					64	5.67	7.53	11.40	12.88	5.09	3.80
			2R40/1F20 or 2F20	15.5	38	5.60	7.47	11.20	12.75	5.02	3.80
					64	6.31	8.37	12.62	14.36	5.60	4.19
			2R48/2R24 or 1R24	18.5	64		11.27[8]	16.36[8]			
					89		13.14[8]	18.80[8]			

Notes:

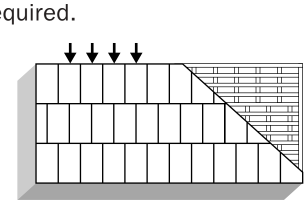
1. **OSB to meet CSA standards O325, O437 or O452.** Check for availability before specifying. For Construction Sheathing OSB (O325), the minimum nominal thickness may be 0.5 mm less than the thickness shown above. No adjustment to the tabulated shear strength values is required.
2. **Values are for short term duration of load, dry service conditions and common nails only.** For other loading or nail type conditions, refer to CSA O86-01.
3. Nails spaced at 300 mm on centre along intermediate framing members. Nails placed not less than 9 mm from panel edge. Panels apply directly to framing.
4. Values are for lumber that has a moisture content of 15% or less prior to nailing. For unseasoned lumber, multiply the values by 0.8.
5. **Values are for S-P-F framing lumber.** For other species multiply the values by the following factors:

D.Fir-Larch	1.25
Hem-Fir	1.13
Northern Species	0.88

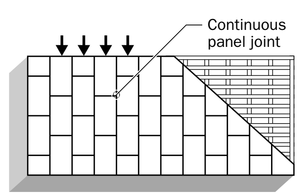
6. Framing at adjointing panel edges shall be 64 mm nominal (or a built-up column composed of two 38 mm nominal width framing members connected to transfer the factored shear force), or wider and nails shall be staggered where nails are spaced 50 mm on centre.
7. Framing at adjointing panel edges shall be 64 mm nominal (or two 38 mm nominal width framing members connected to transfer the factored shear force), or wider and nails shall be staggered where nails of 3.66 mm diameter penetrating more than 41 mm into framing are spaced 75mm or less on centre.
8. Two lines of fasteners are required.



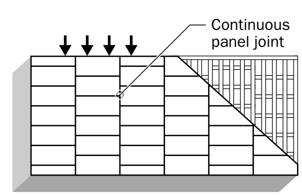
Case 1
Vertical framing
horizontal blocking, if used



Case 2
Horizontal framing
vertical blocking, if used



Case 3
Horizontal framing
vertical blocking, if used



Case 4
Vertical framing
horizontal blocking, if used

Table 10 Factored Shear Resistance of Shearwalls Sheathed with OSB

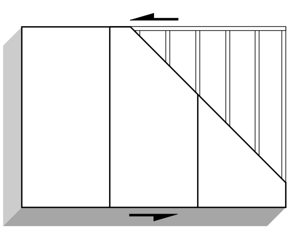
Panel Mark	Nominal Panel Thickness mm	Minimum Nail Penetration in Framing mm	Common Nail Size Length in.	Common Nail Size Diameter mm	Factored Shear Resistance of Shearwalls (kN/m) Nail spacing at panel edges mm 150	100	75	50 [9]
2R24	9.5	31	2	2.84	3.48	5.28	6.83	8.95
2R24 [7]	9.5	38	2.5	3.25	3.86	5.60	7.15	9.27
1R24/2F16 [7]	11	38	2.5	3.25	4.19	6.12	7.86	10.2
2R32/2F16 or 1F16	12.5	38	2.5	3.25	4.57	6.63	8.57	11.2
2R32/2F16 or 1F16	12.5	41	3 [10]	3.66	5.41	8.05	10.5	13.46
2R40/2F20	15.5	41	3 [10]	3.66	5.92	8.95	11.66	15.26

Notes:

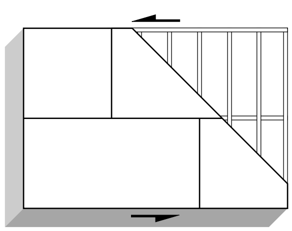
1. **OSB to meet CSA standards O325, O437 or O452.** Check for availability before specifying. For Construction Sheathing OSB (O325), the minimum nominal thickness may be 0.5 mm less than the thickness shown above. No adjustment to the tabulated shear strength values is required.
2. Sheathing installed either horizontally or vertically. Space nails at 300 mm on centre along intermediate members. All panel edges backed with 38 mm or wider framing. For horizontal unblocked panels, consult CSA O86-01.
3. **Values are for short term duration of load, dry service conditions and common nails only.** For other loading or nail type conditions, consult CSA O86-01.
4. Values are for lumber that has a moisture content of 15 percent or less prior to nailing. For unseasoned lumber, multiply the values by 0.8.
4. Where panels are applied on both faces of a wall and nail spacing is less than 150 mm on centre on either side, panel joints shall be offset to fall on different members or framing shall be 76 mm nominal or thicker and nails on each side shall be staggered.
5. **Values are for S-P-F framing lumber.** For other species multiply the values by the following factors:

D.Fir-Larch	1.25
Hem-Fir	1.13
Northern Species	0.88

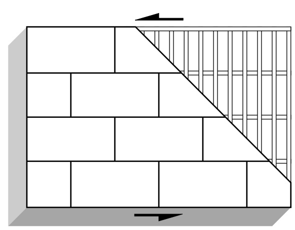
6. Where panels are applied on both faces of a wall and nail spacing is less than 150 mm on centre on either side, panel joints shall be offset to fall on different members or framing shall be 76 mm nominal or thicker and nails on each side shall be staggered.
7. The values for 2R24 and 1R24/2F16 mm panels applied directly to framing may be increased to values shown, respecively for 1R24/2F16 and 2R32/2F16/1F16 panels, provided studs spaced at a maximum of 406 mm on centre.
8. For panels applied over 12.7 mm or 15.9 mm gypsum wallboard, specified shear strength for the same thickness panel applied directly to framing may be used as long as minimum nail penetration is satisfied.
9. Framing at adjoining panel edges shall be 64 mm nominal lumber (or two 38 mm nominal width framing members connected to transfer the factored shear force), or wider and nails shall be staggered.
10. Framing at adjointing panel edges shall be 64 mm nominal (or two 38 mm nominal width framing members connected to transfer the factored shear force), or wider and nails shall be staggered where nails are spaced 75mm or less on centre.
11. Values are for shearwalls with hold-down connections at the end of the walls and adjacent to all openings. For shearwalls without hold-downs, see CSA O86-01 design procedures.



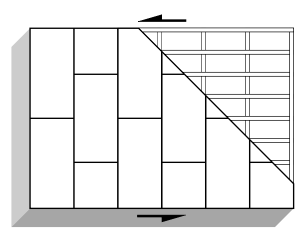
Vertical Framing,
Vertical Sheathing



Vertical Framing,
Horizontal Sheathing



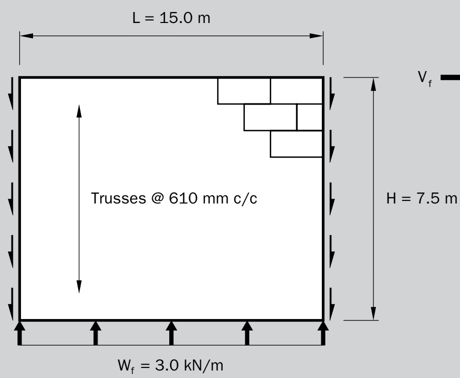
Vertical Framing,
Horizontal Sheathing
with blocking



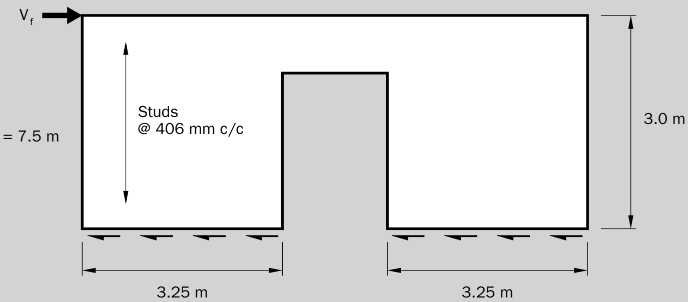
Horizontal Framing,
Vertical Sheathing
with blocking

EXAMPLE

Determine the Design Rated OSB thickness required for the roof diaphragm and shearwall shown below:



Roof Plan



Elevation of Shearwall

- Single Storey Commercial building. SPF lumber. Design roof snow load (specified) = 2.0 kPa.
- Specified concentrated load = 1.3 kN on 750 x 750 mm roof area.

(a) Diaphragm Sheathing

From Table 6C, 12.5 mm Grade C Design Rated OSB is required for the vertical loading on the roof (11 mm Grade A could also be used). The factored shear force per unit length is calculated as follows:

$$V_f = \frac{w_f\ L}{2} = \frac{3 \times 15}{2} = 22.5\ \text{kN}$$

$$v_f = \frac{V_f}{H} = \frac{22.5}{7.5} = 3.0\ \text{kN/m}$$

From Table 9 choose an unblocked diaphragm with 12.5 mm OSB and 2-1/2 in. nails at 150 mm along supported panel edges (Case 1). The factored shear resistance is:

$$v_r = 4.19\ \text{kN/m} > 3.0\ \text{kN/m} \qquad \textit{Acceptable}$$

(b) Shearwall sheathing

The factored shear force per unit length is calculated as follows:

$$v_f = \frac{22.5\ \text{kN}}{3.25 \times 2} = 3.21\ \text{kN/m}$$

From Table 10 use 9.5 mm Design Rated OSB fastened with 2-1/2" nails at 150 mm on centre along panel edges. The factored shear resistance is:

$$v_r = 3.86\ \text{kN/m} > 3.21\ \text{kN/m} \qquad \textit{Acceptable}$$

Note that chord members must be provided around the perimeter of the diaphragm and shearwall. Also, the diaphragm must be adequately connected to the shearwall and the shearwall fastened to the foundation to resist overturning and shear.

4.4 Gussets for Trusses and Frames

OSB gussets must be designed to meet the following criteria:

Factored Shear Through Thickness Resistance	≥	Factored Shear Force through the thickness of the gusset
Factored Planar Shear Resistance	≥	Factored Shear Force on glued area of the gusset
Factored Tensile Resistance	≥	Factored Tensile Force on gusset
Factored Bending Moment Resistance	≥	Factored Bending Moment on gusset
Factored Lateral Resistance of fasteners	≥	Factored Lateral Force on fasteners

The factored unit tensile and shear resistances of the gusset are given in Tables 5A and 5B for Construction Sheathing OSB, and in Tables 5D and 5E for Design Rated OSB. The factored lateral resistance for nailed OSB connections is given in Table 11 and the minimum nail spacing requirements are shown in Table 12.

Table 11 Factored Resistance for Nailed OSB Connections

Type	Length in.	Diameter mm	Minimum Penetration into Main Member mm	Minimum Thickness of OSB Gusset mm	Factored Lateral Resistance per nail, N_r kN S-P-F, North.	Hem-Fir	D.Fir-L	Factored Withdrawal Resistance for nails in S-P-F Lumber N/mm
Common Wire Nails	2-1/2	3.25	26	9.8	0.46	0.55	0.66	2.22
	3	3.66	29	11.0	0.60	0.72	0.84	2.46
	3-1/2	4.06	33	12.2	0.72	0.90	1.02	2.76
	4	4.88	39	14.6	1.02	1.20	0.72	3.30
Common Spiral Nails	2-1/2	2.77	22	8.3	0.31	0.36	0.43	1.85
	3	3.10	25	9.3	0.41	0.47	0.55	2.10
	3-1/2	3.86	31	11.6	0.66	0.78	0.96	2.61
	4	4.33	35	13.0	0.84	0.96	1.20	3.04

Notes:

1. Multiply tabulated values by the number of nails to determine the total resistance.
2. Lateral values are for standard load duration and dry service conditions. For permanent or short term loads multiply the lateral values by the K_D factor in Table 4.
3. For withdrawal resistance multiply the tabulated values by the length of penetration of the nail into the lumber member to obtain the total resistance per nail. Nails are permitted to be used in withdrawal for wind or earthquake loads only (values given for short term load duration).
4. Where the lumber will not be dried to a moisture content of 19 percent or less prior to nailing, multiply the lateral values by 0.8 and the withdrawal values by 0.25.
5. Where the nails are clinched on the far side of a two member joint the tabulated values may be multiplied by 1.6.
6. For a three member joint consisting of a centre lumber member and a gusset each side with the nails fully penetrating all members to obtain double shear, the lateral values may be multiplied by the factor shown below. Note that the nails have to be either clinched or driven alternately from both sides.

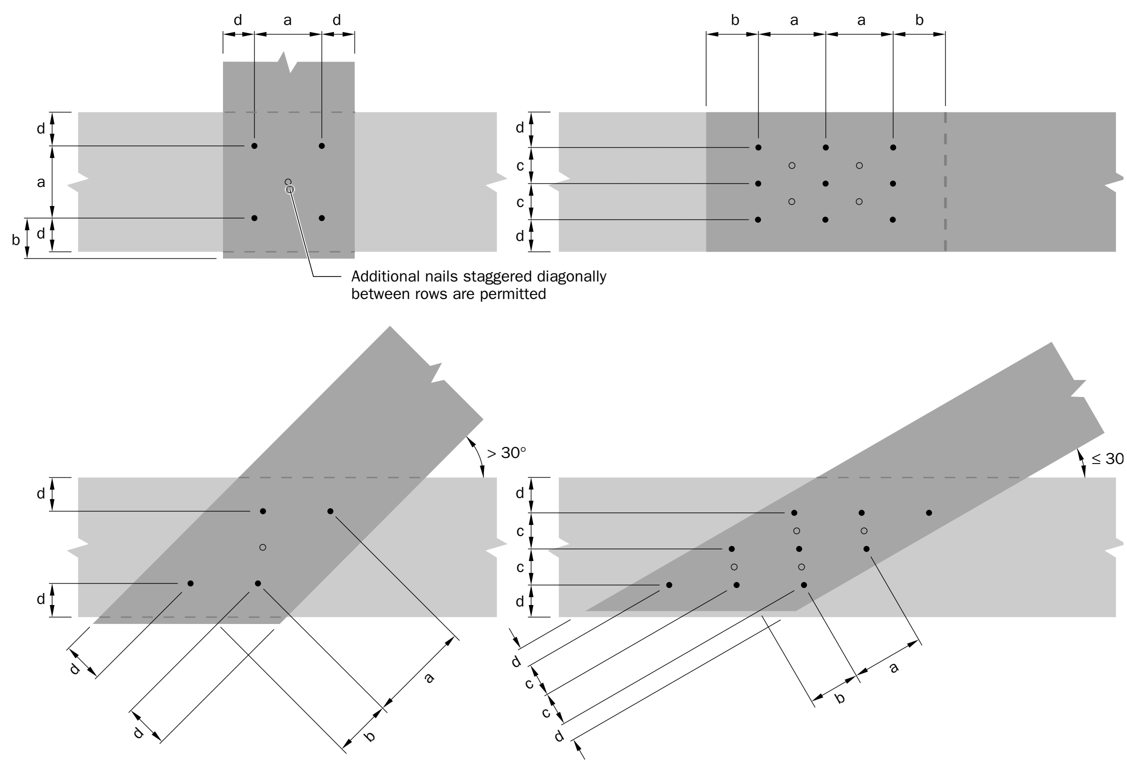
Thickness of centre member	Factor for 3 member double shear joint
11 x nail dia	2.0
8 x nail dia.	1.8

7. Values in the table are based on CSA O86-01. Background information is contained in Reference 4.

Table 12 Minimum Required Spacing, End and Edge Distances for Nails

		S-P-F and Northern				D.Fir-L and Hem-Fir			
Nail Type	Length in.	Min. Spacing Parallel to Grain a mm	Min. End Distance b mm	Min. Spacing Perp. to Grain c mm	Min. Edge Distance d mm	Min. Spacing Parallel to Grain a mm	Min. End Distance b mm	Min. Spacing Perp. to Grain c mm	Min. Edge Distance d mm
Common Wire Nails	2-1/2	52	39	26	13	65	49	33	16
	3	59	44	29	15	73	55	37	18
	3-1/2	65	49	32	16	81	61	41	20
	4	78	59	39	20	98	73	49	24
Common Spiral Nails	2-1/2	44	33	22	11	55	42	28	14
	3	50	37	25	12	62	47	31	16
	3-1/2	62	46	31	15	77	58	39	19
	4	69	52	35	17	87	65	43	22

Note:
1. For sheathing applications 10 mm is an acceptable end and edge distance.



Wood screws conforming to ANSI Standard B18.6.1 can also be used to fasten gussets. The design value for a screw of a given diameter may be taken as equal to a nail of the same diameter.

Bending moments in gussets act about an axis perpendicular to the plane of the panel (bending on edge). For this orientation the bending moment resistance is calculated as follows:

$$M_r = \frac{T_r\ b^2}{6}$$

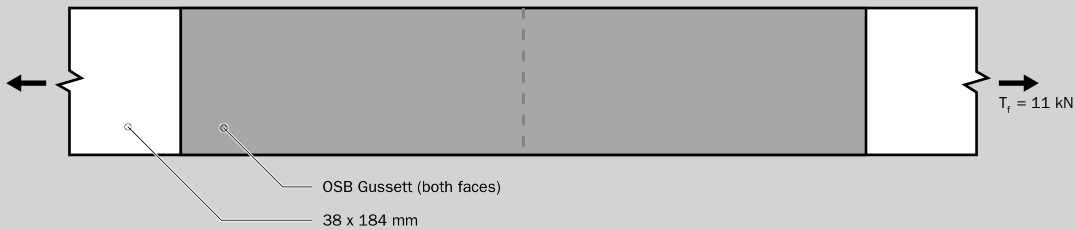
where:

T_r = factored tensile resistance per unit width from Tables 5A and 5B, or 5D and 5E.

b = width of panel subjected to bending.

EXAMPLE

Determine the size of gusset and the required nailing for the following connection:



- Factored tensile force of 11 kN due to Dead plus Snow load
- SPF lumber

The thickness and size of gusset is often governed by length and number of nails required. Typically, it is convenient to use a nail length that is equal to the total thickness of the member and the gussets. In this way the nail will be in double shear and will have a higher resistance.

For 38 mm truss members it is convenient to use 12.5 mm OSB with 2-1/2" nails or 18.5 mm OSB with 3" nails. Longer nails can be used where required, but they have to be clinched on the far side.

(a) Design of Gusset:

Try 12.5 mm Design Rated C-grade OSB with 2-1/2" spiral nails. The factored tensile resistance of the OSB is as follows:

$$T_r = 2 \times 184 \times \frac{59}{1000} = 21.7\ \text{kN} \ > \ 11\ \text{kN} \quad \textit{Acceptable}$$

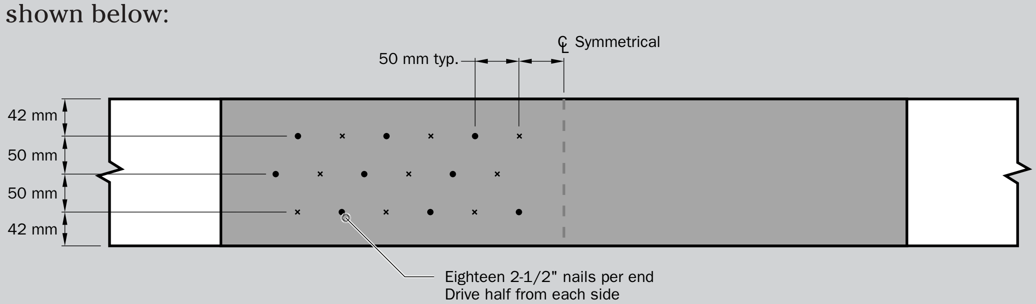
(b) Design of Nails:

The number of nails required is as follows using a factor of 2 for a 3 member, double shear joint:

$$N_r = 0.31 \times 2.0 = 0.61\ \text{kN per nail}$$

$$n_F\ \text{req'd.} = \frac{11}{1.61} = 18\ \text{nails}$$

Using the spacing requirements shown in Table 12 the final connection geometry is shown below:



5.0 Guide Specifications

Construction specifications for Oriented Strand Board (OSB) would generally be part of Section 06100 – Rough Carpentry. Following are some example specifications that could be included in 06100 to cover OSB materials and installation. Optional specifications are shown in square brackets. Please check with the SBA regarding the availability of grades and thicknesses before completing specifications.

Part 1 – General

1.1 Related Work Specified Elsewhere
1.1.1 Prefabricated Wood Trusses Section 06192
1.1.2 Finish Carpentry Section 06200
1.2 Source Quality
1.2.1 Construction Sheathing OSB identification: by panel mark in accordance with CSA Standard O325 [or Design Rated OSB in accordance with CSA O452].
1.3 Storage and Delivery
1.3.1 Ship OSB panels in original lift load where possible.
1.3.2 Panels shall be stored level on the site and shall be raised off the ground with sufficient supports so that panels remain flat. Cover with waterproof material and provide air circulation around panels by keeping cover open and away from sides and bottom of lift loads.

Part 2 – Products

2.1 Panel Standards
2.1.1 Construction Sheathing OSB: to CSA Standard CSA O325 [or Design Rated OSB to CSA O452].
2.2 Panel Materials End Uses
2.2.1 Roof Sheathing: OSB [T&G edge] [square edge], grade and thickness as indicated on drawings.
2.2.2 Floor Sheathing: OSB T&G edge, grade and thickness as shown on drawings.
2.2.3 Wall Sheathing: OSB, square edge, grade and thickness as shown on drawings.

Part 3 – Execution

3.1 Sheathing
3.1.1 Unless indicated otherwise install in accordance with Section 9.23 of NBCC.
3.1.2 Install OSB so that directional marks (ie. arrow heads) are perpendicular to direction of supports.
3.1.3 Unless indicated otherwise fasten sheathing to supports in accordance with Table 9.23.3B of NBCC.
3.1.4 [Provide edge support for OSB roof sheathing panels with H-clips or 38x38 mm blocking securely nailed between framing members].

6.0 References

6.1 Cited References

1. **Karacabeyli, et.al.** 1994. *Design Rated OSB-Summary of Short-term Test Results* (Submitted to Canadian Journal of Civil Engineering).
2. **Structural Board Association.** 2004. *OSB in Wood Frame Construction*. Structural Board Association, Markham, Ontario, 28 pp.
3. **Canadian Wood Council.** 2001. *Wood Design Manual*, Canadian Wood Council, Ottawa, Ontario, 928 pp.
4. **Mohammad, M. and I. Smith.** 1993. *Load-slip Response of Nailed OSB-to-Lumber Joints as Influenced by Moisture Conditioning*. Wood Science and Technology Centre, University of New Brunswick Report.
5. **Karacabeyli, E. and Lum, C.** 1999. *CSA O325 OSB Design Values: Strength and Stiffness Capacities (Final Report)*, Forintek Canada Corp., confidential report prepared for the Structural Board Association, Markham, Ontario.

6.2 Standards

1. **Canadian Standards Association.** 1974. *Wire Nails, Spikes and Staples*. CSA Standard B111 – 1974.
2. **Canadian Standards Association.** 2001. *Engineering Design in Wood (Limit States Design)*. CSA Standard CSA O86-01, and *Supplement 1*. CSA O86S1-04.
3. **Canadian Standards Association.** 1992. *Construction Sheathing*. CSA Standard CAN/CSA O325.0-92.
4. **Canadian Standards Association.** 1993. *OSB and Waferboard*. CSA Standard O437.0-93.
5. **Canadian Standards Association.** 1994. *Design Rated OSB*. CSA Standard O452 Series-94.
6. **National Research Council Canada.** 2005. *National Building Code of Canada*. NRCC, Ottawa, Ontario.
7. **US Department of Commerce.** 2004. *Performance Standard for Wood-Based Structural-Use Panels*. PS 2-04. NIST, Gaithersburg, Maryland.

Appendix A

A.1 Physical Properties of OSB

Nominal Panel Thickness mm	Dead Load kPa	Thermal Resistance $\frac{m^2\ °C}{w}$	Vapour Permeance $\frac{ng}{Pa \cdot s \cdot m^2}$	Flame Spread Rating [1]	Smoke Developed Index [1]
9.5	0.060	0.08	145	148	137
11.0	0.069	0.09	120	148	137
12.5	0.079	0.11	85	148	137
15.5	0.10	0.13	65	148	137
18.5	0.12	0.16	- [2]	148	137
22.0	0.14	0.19	- [2]	148	137
28.5	0.18	0.24	- [2]	148	137

Notes:

1. These numbers are average test values obtained by APA, The Engineered Wood Association on several thicknesses of OSB. The test numbers fall within the Class C or 3 range used in the US model codes for interior finishes. This is equivalent to the 150 maximum permitted for flame spread rating in the NBCC.
2. Panel thicknesses greater than 15.5 mm were not tested, but can be assumed to provide a permeability resistance equal to or better than that of 15.5 mm panels. Panels with a permeance of 60 or less are considered to act as vapour retarders. Panels with a permeance of 118 or more are considered to pass sufficient water vapour that a wall cavity will dry out when constructed with green lumber. Vapour permeance values are given for 50% relative humidity (R.H.), and increase slightly with increasing R.H.

A.2 Conversion Factors

$$1\ \text{mm} = 0.03937\ \text{in}$$

$$1\ \text{m} = 3.2808\ \text{ft}$$

$$1\ \text{kPa} = 20.885\ \text{psf}$$

$$1\ \text{MPa} = 145.04\ \text{psi}$$

$$1\ \text{N} = 0.22481\ \text{lb}$$

$$1\ \frac{\text{N} \cdot \text{mm}^2}{\text{mm}} = 0.1062\ \frac{\text{lb} \cdot \text{in}^2}{\text{ft width}}$$

$$1\ \frac{\text{N} \cdot \text{mm}}{\text{mm}} = 2.6976\ \frac{\text{lb} \cdot \text{in}}{\text{ft width}}$$

$$1\ \frac{\text{N}}{\text{mm}} = 68.522\ \frac{\text{lb}}{\text{ft width}}$$

$$1\ \frac{\text{m}^2 \cdot °\text{C}}{\text{w}} = 5.6783\ \frac{\text{Btu}}{\text{ft}^2 \cdot \text{hr} \cdot °\text{F}}\quad [\text{R value}]$$

$$1\ \frac{\text{ng}}{\text{Pa} \cdot \text{s} \cdot \text{m}^2} = 0.01739\ \text{perm}$$

Note:

1. Numbers are shown to five significant digits maximum.

A.3 Engineering Formulae for Sheathing Design

FORMULAE

3 Span Continuous – full uniform load:

$$M_f = \frac{w_f \; L^2}{10}$$

$$V_f = \frac{w_f \; L}{1.67}$$

$$\Delta = \frac{w \; L^4}{144.9 \; EI}$$

Critical condition for 2 or 3 span continuous with full load or one span loaded:

$$M_f = \frac{w_f \; L^2}{8}$$

$$V_f = \frac{w_f \; L}{1.6}$$

$$\Delta = \frac{w \; L^4}{108.7 \; EI}$$

Deflection under a concentrated load at the centre of a panel with four supported edges; major axis perpendicular to supports (from *Wood Handbook*, USDA Forest Service, 1998):

$$\Delta = K \left[\frac{P \; L^2}{48 \; EI_0}\right] \cdot \left[\frac{EI_0}{EI_{90}}\right]^{1/4}$$

where:

K = approximately 1.0 for 1220 mm wide panel on spans of 813 mm or less
EI_0 = unit bending stiffness along major axis
EI_{90} = unit bending stiffness along minor axis
w = uniform specified load, w_f = uniform factored load
L = centre to centre span between supports
M_f = factored bending moment
V_f = factored shear force
Δ = deflection
P = concentrated load

Appendix B

B.1 Symbols

a	Minimum nail spacing parallel to grain, mm
b	Width of panel, or minimum end distance, mm
c	Minimum nail spacing perpendicular to grain, mm
d	Minimum edge distance, mm
EA	Axial stiffness, N/mm
EI	Bending stiffness, N·mm^2/mm
G	Shear-through-thickness rigidity, N/mm
K_D	Duration of load factor
L	Centre-to-centre span between supports, mm
M_f	Factored bending moment, N·mm
M_r	Bending moment resistance, N·mm/mm
n_F	Number of required nails
N_r	Factored lateral nail resistance, kN
P_r	Axial compressive force, N/mm
T_f	Factored tensile force, N
T_r	Axial tensile resistance, N/mm
V_f	Factored shear force, N
v_r	Factored shear resistance (of diaphragms and shear walls), kN/m
V_r	Shear-through-thickness resistance, N/mm
V_{rb}	Planar shear resistance due to bending, N/mm
V_{rp}	Planar shear resistance due to in-plane shear, MPa
w	Maximum specified load, kPa
w_f	Maximum factored uniform load, kPa
Δ	Deflection, mm

B.2 Glossary of Terms

Basic Structural Capacity The numeric result of calculations specified in CSA O452 to characterize the short term mechanical properties of a product, based on test results for a sample undergoing qualification testing.

Certification Organization (C.O.) An impartial body possessing the necessary competence and reliability to operate a certification system, and accredited as such by an agency having a national mandate to accredit certification organizations.

Certificate of Conformance A document issued by a C.O. confirming that identified PROPRIETARY OSB Products meet the requirements of CSA O452, and listing the specified design capacities.

Construction Sheathing OSB OSB that has been certified to CSA standard CAN/CSA O325.0 for protected construction uses such as roof sheathing, wall sheathing, and floor sheathing in light frame construction applications and other permitted engineering applications.

Deflection The amount a panel deflects between two supports when carrying a load. Maximum deflection for roof loads is usually L/240 for live load only or L/180 for total load. For floor loads, maximum deflection is usually L/360 for live load plus dead load.

Design Rated OSB An OSB panel qualified for a specific design rating, or to which specified design capacities have been assigned, and certified and grade marked in accordance with CSA O452.

Design Rating A classification mark consisting of a nominal thickness and a rating grade that indicates a specific set of basic structural capacities for that panel.

Exterior Bond Panel A panel bonded with a thermosetting binder and with the quality of the adhesive bond controlled in production by means of a specified bond durability test

Major Axis (Strength Axis) The axis with the greater stiffness and strength in bending. For OSB, the direction of alignment of the strands in the face layers of the panel.

Minor Axis The axis with the lesser stiffness and strength in bending. For OSB, the direction at right angles to alignment of the strands in the face layers of the panel.

Nominal Thickness The trademark-specified thickness marked on the panel.

Rating Grade A classification based on minimum basic structural capacity levels established in CSA O452 for the designated nominal thickness of a Product. There are three levels for each nominal thickness.

OSB An acronym for Oriented Strand Board; a type of mat-formed panel with oriented or aligned strands, resulting in directional properties. OSB conforms to standards such as CSA O437, O325 or O452.

Specified Design Capacity The assigned value for use in limit states design calculations, derived from the basic structural capacity and after adjustment to normal design conditions in accordance with CSA O86.

Strand A specialized knife cut wood flake of controlled thickness and a length along the grain orientation of at least twice and usually many times its width.

Thermosetting Binder An adhesive or binder which when fully cured is not softened by heat, and will not break down in the presence of moisture.

For further details regarding OSB codes and specifications, contact:

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