



Structural
Plywood

Design and Application Guide

INTRODUCTION

Plywood as we know it has been produced since early in the 20th century. It has been in widespread use as sheathing in residential and commercial construction for well over 50 years and has developed a reputation as a premium panel product for both commodity and specialty applications. Structural plywood products give architects, engineers, designers, and builders a broad array of choices for use as subfloors, combination floors (i.e. subfloor and underlayment), wall and roof sheathing. Besides the very important function of supporting, resisting and transferring loads to the main force resisting elements of the building, plywood panels provide an excellent base for many types of finished flooring and provide a flat, solid base upon which the exterior wall cladding and roofing can be applied.

This TECO Design and Application Guide is divided into four sections. Section 1 identifies some of the basics in selecting, handling, and storing plywood. Section 2 provides specific details regarding the application of plywood in single or multilayer floor systems, while Section 3 provides similar information for plywood used as wall and roof sheathing. Section 4 provides information on various performance issues concerning plywood.

The information provided in this guide is based on standard industry practice. Users of structural-use panels should always consult the local building code and information provided by the panel manufacturer for more specific requirements and recommendations.

TABLE OF CONTENTS

Panel Selection, Handling and Storage

Panel Selection	4
Panel Grades	
Bond Classification	
Span Rating	
Sizes and Availability	
Basic Specifications	
General Provisions	
Roof Sheathing	
Flooring	
Panel Handling and Storage	9

Floors

Plywood Floor Components	10
FLOOR SPAN Combination Subfloor/Underlayment	
Subflooring	
Non-Span-Rated Plywood	
Underlayment	
Installation	12
FLOOR SPAN, SHEATHING SPAN and Non-Span-Rated Plywood	
Underlayment	
Field-Glued Floor System	17
Installing the Field-Glued Floor System	
High-Performance Floor	
Finish Floors Over Plywood	20
Adhesive-Applied Flooring	
Lightweight Concrete	
Hardwood Flooring	
Ceramic Tile	
Stair Treads and Risers	

Walls and Roofs

Diaphragms and Shear Walls	23
Wall Sheathing	23
Fastening Wall Sheathing	
Installing SIDING SPAN Panels	
Roof Sheathing	26
Fastening Roof Sheathing	
Design Considerations	27
Narrow-Width Roof Panels	

Other Performance Issues

Flame Spread and "Smoke Developed" Rating For Softwood Plywood —	35
Plywood In Fire-Rated Assemblies	35
Formaldehyde Emissions From Plywood Panels	35
Preservative Treated Plywood	36
Thermal Resistance and Moisture Vapor Permeability of Plywood	36

Panel Selection, Handling and Storage

PANEL SELECTION

PANEL GRADES

Plywood panels used in typical construction applications in the United States must meet the requirements of the U.S. Department of Commerce/National Institute of Standards and Technology Voluntary Product Standard PS 1, *Construction and Industrial Plywood*, PS 2, *Performance Standard for Wood-Based Structural-Use Panels*, or an accepted industry standard such as TECO's PRP-133, *Performance Standards and Policies for Wood-Based Structural-Use Panels*. Panels conforming to one or more of these standards are identified with a gradestamp that includes the grademark-specified thickness, grade, group number or recommended span rating and bond classification for the panel. Panels manufactured by TECO client mills also include the **TECO TESTED®** trademark, which indicates that the product has been certified by a qualified third-party certification and testing agency in conformance to the appropriate standard(s).

Panels conforming to PS 1 must meet either thickness and species prescriptive requirements or performance testing requirements. Panel grade is identified by the veneer grade classification of the face and back veneers (e.g. A-C, B-C, etc.) or by a designation of intended end-use (i.e. sheathing, structural I sheathing or single-floor).

Panels identified by the grade of the face and back veneers typically are also identified by the species group of the face and back veneers. Species group is designated as 1, 2, 3, 4, or 5 and is based on elastic bending modulus and other important mechanical properties. Species included in Group 1 have the highest mechanical properties, whereas species in Group 5 have the lowest. Panels identified by veneer grade and group number are typically used in non-structural applications, but may be used in structural applications as well. Panels with face veneer grades of N, A or B are sanded and most often used in applications where a high quality surface is required.

Panels identified for an intended end-use such as sheathing or single-floor are further identified with a numerical span rating that indicates the maximum spacing of supports over which the panel should be placed under average loading conditions. These panels are manufactured with all C or C and D grade veneers and are either touch-sanded or unsanded.

Plywood panels conforming to either PS 2 or PRP-133 must meet or exceed the performance criteria of these standards. Panel grades are identified by intended end-use (i.e. sheathing, structural I sheathing or single-floor) and a

span rating is assigned based on performance test qualification. Plywood intended for these grades are typically manufactured with all C, C and D or all D grade veneers and are touch-sanded or unsanded.

Sheathing (SHEATHING SPAN®) grade panels are intended for use as covering material for roofs, subfloors, and walls. Structural I sheathing (Structural I SHEATHING SPAN®) panels meet additional requirements for cross-panel strength and stiffness and are typically used in panelized roof systems, diaphragms, and shearwalls, where additional cross panel strength is required. Single-floor (FLOOR SPAN®) grade panels are used as a combination subfloor and underlayment and may be used directly under several different types of finish flooring as well as subflooring in a two-layer floor system with underlayment.

There are other panel grades that TECO certifies as well. Panels designated as SPCL-PNL® meet U.S. Department of Housing and Urban Development (HUD) requirements for floors designed specifically for manufactured home construction. FORMALL® is TECO's designation for concrete forming panels that meet PS 1 specifications. PS 1 provides specifications for two types of concrete form panels based on species group requirements. Class I concrete form panels must be manufactured with faces of Group 1 species, crossbands of Group 1 or 2 species and centers of Group 1, 2, 3, or 4 species. Class II concrete form panels must be manufactured with faces of Group 1 or 2 species and crossbands and centers of Group 1, 2, 3, or 4 species, or faces of Group 3 species of 1/8-inch minimum thickness (before sanding), crossbands of Group 1, 2, or 3 species and centers of Group 1, 2, 3, or 4 species. FORMALL panels are designed to provide superior performance in light and heavy construction and in limited or maximum re-use applications. FORMALL concrete forming panels provide surfaces with an acceptable finish, minimum surface roughness and blemishes. More demanding smoothness requirements or special effects, such as texturing, can be met with FORMALL in conjunction with form liners or high-density overlaid concrete form plywood.

SIDING SPAN is a span rated panel intended to function as both sheathing and exterior covering for wall systems. SIDING SPAN panels are available with grooves and various face ply decorative treatments and shiplap edges.

Table 1 provides examples of gradestamps of several plywood products covered in this guide.

Panel Selection, Handling and Storage

Table 1. Examples of Gradestamps for Plywood Used in Various Structural Applications

Panel Gradestamps - Information and Application Recommendations	
TECO TESTED® PS 1-XX PRP-133 EXPOSURE 1 SHEATHING SPAN® 32/16" 15/32" C - D SIZED FOR SPACING MANUFACTURER'S NAME MILL NO.	SHEATHING SPAN® Appropriate for a broad range of construction and industrial applications, but specifically designed for wall and roof sheathing and subfloor. Available in thicknesses of 1/4, 5/16, 11/32, 3/8, 25/64, 7/16, 29/64, 15/32, 1/2, 19/32, 5/8, 11/16, 23/32, 3/4, 7/8, 1, and 1-1/8 inch.
TECO TESTED® PS 1-XX EXTERIOR B - B FORMALL® 3/4 INCH CLASS 1 MANUFACTURER'S NAME MILL NO.	FORMALL® Concrete form plywood panels manufactured in conformance with the requirements of PS 1. Formall is a Class 1 concrete form plywood designed to provide superior performance in the most demanding applications. Standard thicknesses include 19/32", 5/8", 23/32" and 3/4" in standard 4' x 8' sheets.
TECO TESTED® PRP-133 EXPOSURE 1 FLOOR SPAN® 24" O.C. 23/32" TONGUE AND GROOVE NET FACE 47-1/2" MANUFACTURER'S NAME MILL NO.	FLOOR SPAN® Designed for use as combination subfloor/underlayment. Provides high concentrated and impact load resistance and smooth surface for application under several types of finish flooring. Available in square edge or T&G, in thicknesses of 19/32, 5/8, 23/32, 3/4, 7/8, 1, 1-1/8, and 1-1/4 inch.
TECO TESTED® PS 1-XX PRP-133 EXTERIOR SIDING SPAN 15/32" 16" O.C. WALL MANUFACTURER'S NAME MILL NO.	SIDING SPAN SIDING SPAN is a span rated plywood panel intended to function as both sheathing and exterior covering for wall systems. These panels are intended for uses where the surface will be exposed and appearance is important. SIDING SPAN panels are available with grooves and various face ply decorative treatments. Standard thicknesses include 11/32", 15/32" and 19/32" in standard 4' x 8' sheets.

BOND CLASSIFICATION

Bond classification is related to the moisture resistance of the glue bond under intended end-use conditions and does not relate to the physical (e.g. erosion, ultraviolet, etc.) or biological (i.e. mold, fungal decay, insect, etc.) resistance of the panel*. PS 1, PS 2 or PRP-133 compliant panels must meet the bond classification requirements for Exposure 1 or Exterior.

Exposure 1 is defined in PS 1 and PS 2 as a bond classification for panels that are suitable for uses not permanently exposed to the weather. Panels classified as Exposure 1 are intended to resist the effects of moisture on structural performance due to construction delays or other conditions of similar severity*.

Exterior is defined in PS 1 and PS 2 as a bond classification for plywood panels that are suitable for repeated wetting and redrying or long term exposure to weather or other conditions of similar severity*. Exterior plywood is manufactured with a minimum C-grade veneer.

* U.S. Department of Commerce, National Institute of Standards and Technology, Voluntary Product Standard PS 1 — *Construction and Industrial Plywood* and U.S. Department of Commerce, National Institute of Standards and Technology, Voluntary Product Standard PS 2 — *Performance Standard for Wood-Based Structural-Use Panels*

Panel Selection, Handling and Storage

SPAN RATING

Span rating numbers for SHEATHING SPAN and FLOOR SPAN indicate the maximum spacing of supports over which the panels should be placed. The span rating provides a measure of the strength and stiffness in the direction parallel to the grain of the face and back veneers of the panel.

The span rating on SHEATHING SPAN panels appears as two numbers separated by a slash (e.g., 32/16 or 48/24). The first number is the maximum on center (o.c.) support spacing in inches for roof sheathing. The second number is the maximum o.c. support spacing when the panel is used for subflooring. A panel marked 32/16 may be used for roof sheathing over supports spaced up to 32 inches o.c. or for floor sheathing over supports spaced up to 16 inches o.c.

The span rating on FLOOR SPAN panels appears as a single number (e.g., 20 o.c.). FLOOR SPAN panels are designed for single-floor applications and are manufactured with span ratings of 16, 20, 24, 32, and 48 inches o.c.

In Canada, panels must comply with the Canadian Standards Association's CAN/CSA O325 "*Construction Sheathing*", CSA O121-M1978 (R1998), "*Douglas Fir Plywood*", CSA 0151-04, "*Canadian Softwood Plywood*", or CSA 0153-M1980 (R2003), "*Poplar Plywood*". Please refer to the appropriate CSA standard for a more detailed description of structural plywood used in Canada.

SIZES AND AVAILABILITY

Grademark-specified plywood panel thicknesses range from 1/4 inch to 1-1/4 inch. Not all thicknesses are readily available. Check with suppliers to determine availability.

Standard dimensions are nominal 4 feet by 8 feet. Because plywood is made with wood, which will expand or contract when subjected to changes in temperature and relative humidity, a tolerance on width and length is permitted for possible expansion after installation. Panels meeting the requirements of PS 1 are permitted a plus 0/minus 1/16-inch tolerance on width and length while panels meeting the requirements of PS 2 are permitted a plus 0/minus 1/8-inch tolerance on width and length. Sanded panels meeting the requirements of PS 1 are limited to a tolerance of $\pm 1/64$ -inch of the grademark-specified thickness of 3/4-inch and less and $\pm 3\%$ of the grademark-specified thickness for panels thicker than 3/4-inch. Unsanded, touch-sanded and overlaid panels meeting the requirements of PS 1 and all plywood panels meeting the requirements of PS 2 are limited to a tolerance of $\pm 1/32$ -inch of the grademark-specified thickness of 13/16-inch and less and $\pm 5\%$ of the grademark-specified thickness for panels thicker than 13/16-inch. Some mills also produce specialty sizes (e.g., smaller panels for the Japanese market). Panels 1/2-inch thick and thicker are manufactured with a square edge or tongue-and-groove (T&G) edge.

Table 2. Metric Equivalents of Panel Dimensions

PANEL WIDTH AND LENGTH	
English (foot)	S.I. (mm)
4 x 8	1220 x 2440
4 x 9	1220 x 2745
4 x 10	1220 x 3050
PANEL THICKNESS	
English (in.)	S.I. (mm)
1/4	6.5
5/16	8.0
11/32	9.0
3/8	9.5
7/16	11.0
15/32	12.0
1/2	12.5
19/32	15.0
5/8	16.0
23/32	18.5
3/4	19.0
25/32	20.0
7/8	22.0
1	25.5
1-1/8	28.5

Note: S.I. thicknesses are metric conversions derived from English measurements and are rounded to the nearest 0.5 mm. Refer to Canadian Standards for nominal thickness tolerances.

Panel Selection, Handling and Storage

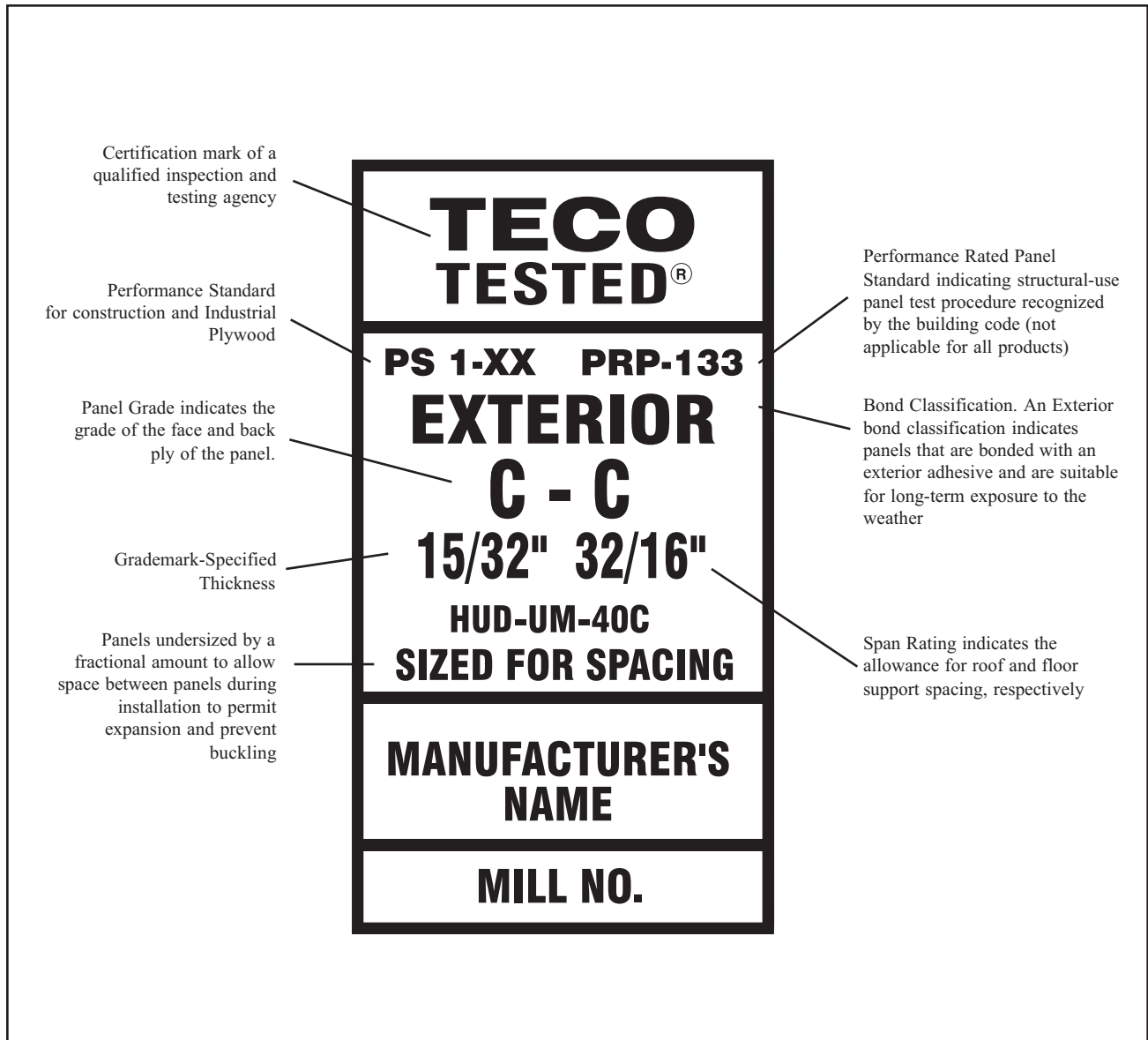


Fig. 1. Example gradestamp of a certified "Exterior" plywood panel

Most T&G panels are manufactured with a 47-1/2-inch net face width, although manufacturing practices vary.

In some areas, certain panel thicknesses or span ratings may be difficult to obtain. Plywood suppliers can verify the availability and details of the products they carry. To order plywood panels, the specifier should designate thickness, grade, span rating, bond classification, dimensions, "square edge" or "T&G" (as desired for

thicker floor panels), and number of pieces. For example:

15/32-inch SHEATHING SPAN, 32/16
Exposure 1, 48 x 96 inches, square-edge, 200 pcs.

The specifier is wise to identify an alternate panel in the specifications in the event that a certain dimension is not readily available. Fig. 1 illustrates a typical gradestamp that is applied to a certified panel, while Table 2 contains metric equivalents for panel thicknesses.

Panel Selection, Handling and Storage

BASIC SPECIFICATIONS

The use of plywood-panels is governed by several basic guidelines. Details regarding application are presented in later sections of this Guide.

GENERAL PROVISIONS

1. When used structurally, each panel shall conform to the requirements of the appropriate standard as referenced in the building code. PS 1 panels must indicate the grade name or the veneer grade of face and back (i.e. C-C, C-D, C-C Plugged, etc.). Each panel shall be identified by the trademarks of an approved testing and grading agency.
2. Plywood panels with an Exposure 1 bond classification are not to be used where they will be permanently exposed to the weather, except where roof sheathing is exposed on the underside such as with open soffits.
3. Panel applications shall meet the minimum requirements of the applicable building code and comply with the manufacturer's recommendations.

ROOF SHEATHING

Plywood panels used in roof sheathing applications are typically designated as sheathing (e.g. SHEATHING SPAN or Structural I SHEATHING SPAN) with a span rating appropriate for the intended design conditions. Panels designated by the species group may also be used as roof sheathing if they are properly designed to support the intended loads. Panels used as roof sheathing must have an Exposure 1 or Exterior bond classification.

All panel ends must be joined over framing. Suitable edge support must be provided as specified by the building code or in recommendations by the manufacturer or TECO through use of panel clips, T&G edges, or lumber blocking between joists. Spacing of 1/8 inch is recommended between all panel ends and edges, although occasionally the panel manufacturer may recommend an alternative*.

FLOORING

Subflooring is applied directly to the floor framing and under an additional layer of structural material such as underlayment, hardwood flooring or concrete topping. Plywood panels used in subfloor applications are typically designated as “sheathing” or “single floor” (e.g. SHEATHING SPAN, Structural I SHEATHING SPAN or FLOOR SPAN) with a span rating appropriate for the intended design conditions. Panels designated by species group may also be used as subflooring if they are properly designed to support the intended loads. Panels used as subflooring must have an Exposure 1 or Exterior bond classification.

Spacing of 1/8 inch is recommended at panel ends and edges, though a panel manufacturer may recommend an alternative*. Before underlayment or finish flooring is installed, subfloor joints should be sanded to a smooth surface.

Combined subfloor/underlayment plywood panels are typically designated as “single floor” (e.g. FLOOR SPAN) with a span rating appropriate for the intended design conditions, or by species group. Plywood panels used in single floor applications must have an Exposure 1 or Exterior bond classification.

Plywood single floor panels meeting the requirements of PS 1 must include a grade designation such as Underlayment or C-C Plugged.

Panel edges should be tongue-and-groove edged or supported on nominal 2-inch lumber blocking between joists. The tongue-and-groove edges must be protected against damage until the finish floor is installed. Panel ends should meet over framing and joints should be staggered. Spacing of 1/8 inch is recommended at panel ends and edges during installation, although the panel manufacturer may recommend an alternative*.

All edge joints must be thoroughly filled and sanded. The manufacturer of the finish flooring may recommend light sanding of any surface roughness, particularly around fasteners.

* Under in-plant construction conditions, such as manufactured housing, a spacing of 1/16-inch between the edges and ends of panels is acceptable.

Panel Selection, Handling and Storage

PANEL HANDLING AND STORAGE

PANEL HANDLING AND STORAGE

Like all building materials, plywood panels should be properly stored and handled carefully to prevent damage and assure reliable performance.

Edges and ends of all panels must be protected. Panels to be moved by a forklift should be placed on pallets or lumber stringers when received to avoid damage by fork tines. When stacking units of panels, ensure that stringers are aligned vertically. Panels to be transported on open truck beds should be covered for protection from weather exposure.

Plywood panels should preferably be stored under a roof. The top panel in a stack should be weighted down to

minimize warpage from uneven moisture absorption. If moisture absorption is expected, the steel banding on panel bundles should be cut to prevent edge damage.

As illustrated in Fig. 2, panels to be stored outside should be stacked on a level surface supported by lumber stringers or blocking. Panels should never be in direct contact with the ground. At least three full-width supports should be placed along the 8 foot length of the bundle — one centered and the others 12 to 16 inches from each end. The stack should be covered loosely with plastic sheets or tarps. The covering should be anchored at the top of the stack, but kept open and away from the sides and bottom to allow ventilation.

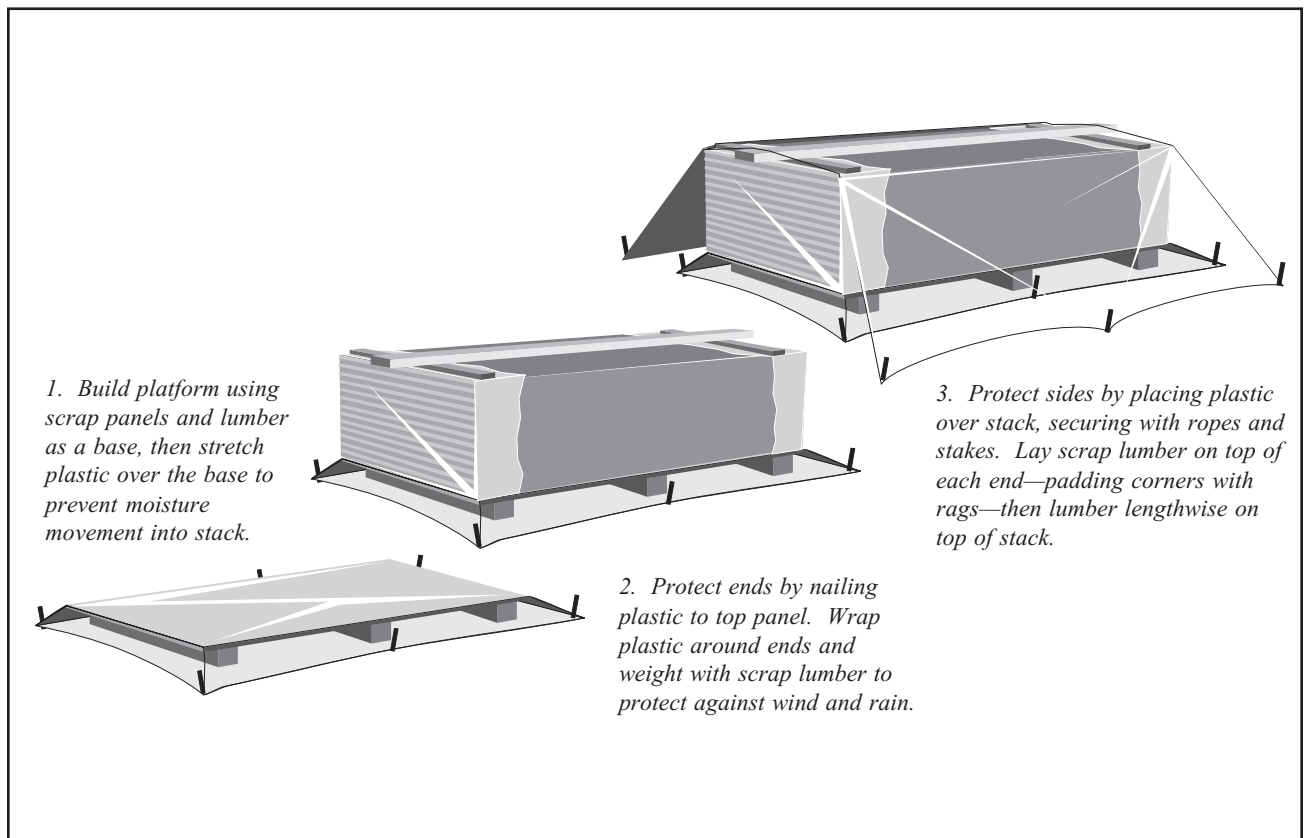


Fig. 2. Panel storage recommendations

Floors

PLYWOOD FLOOR COMPONENTS

FLOOR SPAN - COMBINATION SUBFLOOR / UNDERLAYMENT

FLOOR SPAN is a span-rated product designed specifically for economy and performance in single-layer floor construction. FLOOR SPAN is manufactured with a smooth side (i.e., a sanded or touch-sanded face) ready for several types of finish flooring. It is commonly used beneath carpet and pad and is also used as "subflooring" under hardwood flooring, lightweight concrete and ceramic tile. FLOOR SPAN panels are manufactured with span ratings of 16, 20, 24, 32 and 48 inches oc, indicating the maximum recommended spacing of floor joists when the panel is installed with its strength axis across two or more supports.

Glue-nailing is recommended for FLOOR SPAN panels, although panels can be nailed only (see fastening recommendations for glued and nailed and nailed only floor systems in Table 4). The field-glued floor system is further described on page 17.

When greater stiffness in residential and light-frame commercial floors is desired, the addition of solid blocking will increase stiffness considerably. However, some manufacturers of engineered wood I-joists do not recommend this practice as the blocking can potentially create floor squeaks if not properly installed. For higher performance, FLOOR SPAN 32 oc and 48 oc installed over framing spaced at 24 inches on center can provide an improved floor system. Table 5 provides allowable floor live loads for FLOOR SPAN panels installed over various support spacings. Installation guidelines are provided on page 12.

SUBFLOORING

SHEATHING SPAN subfloors are intended to be installed in combination with an additional layer of material such as an underlayment, hardwood flooring, or concrete topping. Floor vibration or "bounciness" usually results from a combination of maximum floor joist span and spacing, with minimum subfloor thickness or lack of bracing or blocking. To increase floor stiffness and significantly improve overall floor performance, several options are available:

- increasing the subfloor thickness beyond the minimum code requirements;
- nailing and field-gluing the subfloor to the joists;
- reducing the joist spacing or limiting the joist spans

to a smaller deflection criteria to account for live load (e.g., $L/480$ or $L/600$); or

- installing an approved bracing system.

The span ratings for SHEATHING SPAN are the maximum recommended for the spans indicated. Spans are limited (Fig. 3) because of the possible effect of concentrated loads.

Heavier concentrated loads and greater traffic may require panel capacity and/or performance in excess of the minimums required. Additional stiffness and strength can be gained by using panels with a floor span rating greater than the support spacing (for example, 40/20 or 48/24 SHEATHING SPAN with floor joists at 16 inches on center). For beams or joists 24 or 32 inches o.c., 1-inch-thick or thicker panels may provide the needed stiffness.

NON-SPAN-RATED PLYWOOD

Non-span-rated plywood meeting the requirements of PS 1 is often used in structural floor applications. Products include the "sanded appearance" grades such as A-A, A-B, A-C, B-D, etc., and the touch-sanded grades such as underlayment, C-C Plugged and C-D Plugged plywood. These products are typically identified by the grade and species group of the face and back veneers. Using this information, the engineer or architect can design and specify the appropriate product for the specific application using the applicable section and stress information provided in the *Plywood Design Specification*, published by APA - The Engineered Wood Association. This document is referenced by virtually all of the model building codes in the U.S. and is applicable to plywood meeting the requirements of PS 1 and certified by an accredited inspection and testing agency.

UNDERLAYMENT

Several different grades of plywood meeting the requirements of PS 1 are ideal for use as the non-structural underlayment layer directly beneath finish flooring products such as carpet, resilient floor coverings, ceramic tile or hardwood flooring. Used in this type of application, the plywood can provide a hard, smooth and uniform surface to which the finish flooring is attached. The underlayment layer also restores a smooth surface over panels that may have been scuffed or roughened during construction, or over panels that may not have received an adequately sanded surface.

Floors

Plywood panels meeting the Underlayment or C-C Plugged grade requirements of PS 1 are manufactured with special restrictions on the grade, group classification, thickness and size of open characteristics of the face veneer and the veneer immediately adjacent to the face. These special requirements ensure that the panels provide a hard, smooth surface that is ideal for use under resilient floor coverings. Certain “Appearance” grade products meeting the requirements of PS 1 can also be used as underlayment beneath resilient flooring as long as they are manufactured with “plugged” inner plies.

Plywood panels used as underlayment should be at least 1/4 inch thick when installed over subfloors supported on framing spaced up to 24 inches on center. When framing is spaced greater than 24 inches on center, 11/32 inch or thicker panels should be used.

Table 3. Nail Information

PENNY WEIGHT	LENGTH (inches)	DIAMETER (inch)
<i>Bright, common wire nails</i>		
6d	2	0.113
8d	2 -1/2	0.131
10d	3	0.148
12d	3 -1/4	0.148
16d	3 -1/2	0.162
20d	4	0.192
<i>Deformed¹ Shank Nails</i>		
6d	2	0.120
8d	2 -1/2	0.120
10d	3	0.135
12d	3 -1/4	0.135
16d	3 -1/2	0.148
20d	4	0.177

1. A deformed shank nail shall have either a helical (screw) shank or an annular (ring) shank.

Table 4. FLOOR SPAN Fastening Recommendations¹

SPAN RATING	NOMINAL PANEL THICKNESS ² (inch)	GLUED AND NAILED ⁶				NAILED ONLY	
		Nail size and type ³	Maximum nail spacing (inches)		Nail size and type ³	Maximum nail spacing (inches)	
			Supported panel edges	Intermediate supports		Supported panel edges	Intermediate supports
16 oc	19/32, 5/8	6d deformed shank ⁴	12	12	6d deformed shank	6	12
20 oc	19/32, 5/8						
24 oc	23/32, 3/4						
24 oc	7/8	8d deformed shank ⁴	6	(7)	8d deformed shank		(7)
32 oc	7/8, 1						
48 oc	1-1/8, 1-1/4	8d deformed shank ^{4,5}			8d deformed shank ⁵		

1. Fastening guidelines assume application of standard uniform loads. For heavy traffic, concentrated loads, or other special conditions, construction in excess of minimums shown may be required.
2. Panels of a given thickness may be produced in multiple span ratings. Panels with a span rating greater than a given joist spacing may be substituted for panels of the same thickness whose span rating matches the joist spacing. For example, 19/32-inch-thick, 20 oc rated FLOOR SPAN may be used over joists spaced at 16 or 20 inches on center. 19/32-inch-thick, 16 oc FLOOR SPAN may be used over joists spaced at 16 inches on center.
3. Other code approved fasteners may be used.
4. If deformed shank nails are not available, common nails providing equal or greater withdrawal and lateral resistance may be substituted.
5. If supports are well seasoned, 10d common nails may be substituted to attach 1-1/8-inch-thick FLOOR SPAN panels.
6. Adhesives must be applied according to manufacturer recommendations and must conform to ASTM D3498 (or Specification AFG-01).
7. For supports spaced 48-inch on center, space nails a maximum of 6 inches.

Floors

INSTALLATION

FLOOR SPAN, SHEATHING SPAN AND NON-SPAN-RATED PLYWOOD

Plywood panels used in structural floor applications should be installed continuously over two or more spans with the strength axis perpendicular to the supports. FLOOR SPAN panels should also be installed with the side marked “THIS SIDE DOWN” towards the supports. Non-span-rated plywood should be installed with the face ply (i.e. the highest grade veneer) away from the supports. End joints must be over the supports and should be staggered at least one support in adjacent panels. Plywood panels should have ends and edges spaced 1/8 inch, unless specific spacing recommendations are provided by the manufacturer. The long edges of the plywood panels should be tongue-and-groove or supported with blocking with the following exceptions:

- where a separate underlayment (1/4 inch minimum thickness) (see previous page) is to be installed with its joints offset from those in the subfloor;
- a minimum of 1-1/2 inch of lightweight concrete is to be applied over the subfloor;
- 3/4-inch-thick wood-strip flooring is to be installed over the subfloor.

Fig. 3 shows the recommended installation details for plywood along with the maximum support spacing for subfloors and combination subfloor/underlayment. Table 6 provides the allowable spans for various thicknesses of sanded non-span-rated plywood based on species group classification.

Power-driven nails can be used to fasten the panels as long as the nails are not over-driven. Standard nail sizes and lengths are given in Table 3. Fastening recommendations for FLOOR SPAN panels are provided in Table 4. Fastening recommendations for SHEATHING SPAN subflooring are in Table 7, while fastening recommendations for non-span-rated plywood are provided in Table 8. Wood screws are acceptable and other code-approved fasteners can also be used. Subflooring can be glued to improve performance and to reduce squeaks.

FLOOR SPAN 32 oc panels can be installed over dimension lumber joists or engineered wood I-joists spaced up to 32 inches o.c. (Fig. 4). FLOOR SPAN 48 oc can be installed over supports up to 48 inches o.c. (Fig. 5). Supports can be multiple 2x_ joists spiked together, 4x_ lumber, glulams, lightweight steel beams, wood I-joists or floor trusses. Girders of doubled 2x_ members should

Table 5. Recommended Uniform Floor Live Loads for FLOOR SPAN With Strength Axis of Panel Perpendicular to Supports ¹

SPAN RATING	NOMINAL PANEL THICKNESS (inch)	MAXIMUM SPAN (inches)	ALLOWABLE LIVE LOAD ² (psf)								
		With edge support ³	Spacing of supports center-to-center (inches)								
			12	16	19.2	24	32	40	48	54	60
16 oc	19/32, 5/8	16 ⁴	185	100							
20 oc	19/32, 5/8, 3/4	20 ^{4, 5}	270	150	100						
24 oc	23/32, 3/4	24		240	160	100					
32 oc	7/8, 1	32			295	185	100				
48 oc	1-1/8, 1-1/4	48				290	160	100	65		

For SI units: 1 inch = 25.4 mm; 1 psf = 47.9 Pa

1. Panels shall be a minimum of 24 inches wide.
2. The allowable spans were determined using a dead load of 10 psf. If the dead load exceeds 10 psf then the live load shall be reduced accordingly. Limits live load deflection to 1/360 of span.
3. Tongue-and-groove edges or lumber blocking (see also exceptions on page 10). Only lumber blocking will satisfy blocked diaphragm requirements of ER-5637 or IBC 2003 Tables 2306.3.1 and 2306.3.2.
4. Is permitted to be 24 inches on center where 3/4-inch wood strip flooring is installed perpendicular to the supports.
5. Is permitted to be 24 inches on center where 1-1/2 inches of cellular or lightweight concrete is applied over the panels.

Floors

have top edges flush to permit smooth panel end joints.

If it is desired to have the panels bear directly on the sill plate, the support members can be set in foundation pockets or on ledgers. If 4x_ lumber girders are used, they should be air dried and/or set higher than the sill plate to allow for shrinkage.

When floor members are dry, fasteners should be installed with the heads set flush with, or slightly below, the surface of the panels. If framing is green, it could present nail popping problems upon drying; in such a case, fasteners should be re-set. Nail holes need not be filled, but edge joints must be filled and thoroughly sanded. This step may not be necessary under certain types of carpet or some other finished flooring products. Check with the flooring manufacturer for further recommendations. Any other damaged or open areas should be filled and all surface roughness sanded.

UNDERLAYMENT

The following information provides general industry guidelines for installing plywood panels as underlayment.

When installed over subfloors, plywood panels should be applied with the face ply up, immediately prior to installation of the finished flooring.

Before the underlayment is applied, the subfloor must be dry and thoroughly swept or vacuumed. All popped nails must be re-set and any loose panels must be re-nailed.

Plywood underlayment must be protected against physical damage or water prior to installation. Individual panels should be placed on edge for several days before installation to equalize with surrounding temperature and relative humidity conditions. Panel faces and edges need to be protected from damage prior to and during installation. The surface of the underlayment should also be protected after installation to ensure a clean, smooth surface for application of the finish flooring.

The plywood underlayment thickness required to bridge an uneven floor will depend on roughness and loads applied.

Underlayment recommendations for thin flooring products are provided in Table 10. Nailing should begin at the contact corner of the underlayment panels and work should progress diagonally across the panels. Fig. 7 provides the recommended installation details for

underlayment along with fastener size and type. Panels must be in firm contact with the subfloor as fasteners are driven. As each panel is determined to be uniformly flat, workers can continue to fully fasten panels toward the opposite edge. End joints of underlayment panels should be offset by at least 4 inches from joints of subfloor panels. Edge joints of subfloor panels should be offset one joist space from the subfloor joint. Nails should be spaced a maximum of 6 inches o.c. along panel edges and 12 inches o.c. within the field of the panel (see Table 10 for recommended spacing with thin flooring). When underlayment is glued to the subfloor, only solvent-based adhesives are to be used.

In some cases, underlayment panels are applied over lumber board subfloors. In such situations, the panels should be laid parallel to the joists if the boards are perpendicular to the joists. Underlayment panels may be applied in either direction if boards are at an angle less than 75 degrees to joists.

Table 6. Maximum Support Spacing for Sanded, Non-Span-Rated Plywood With Strength Axis of Panel Perpendicular to Supports^{1, 2, 3}

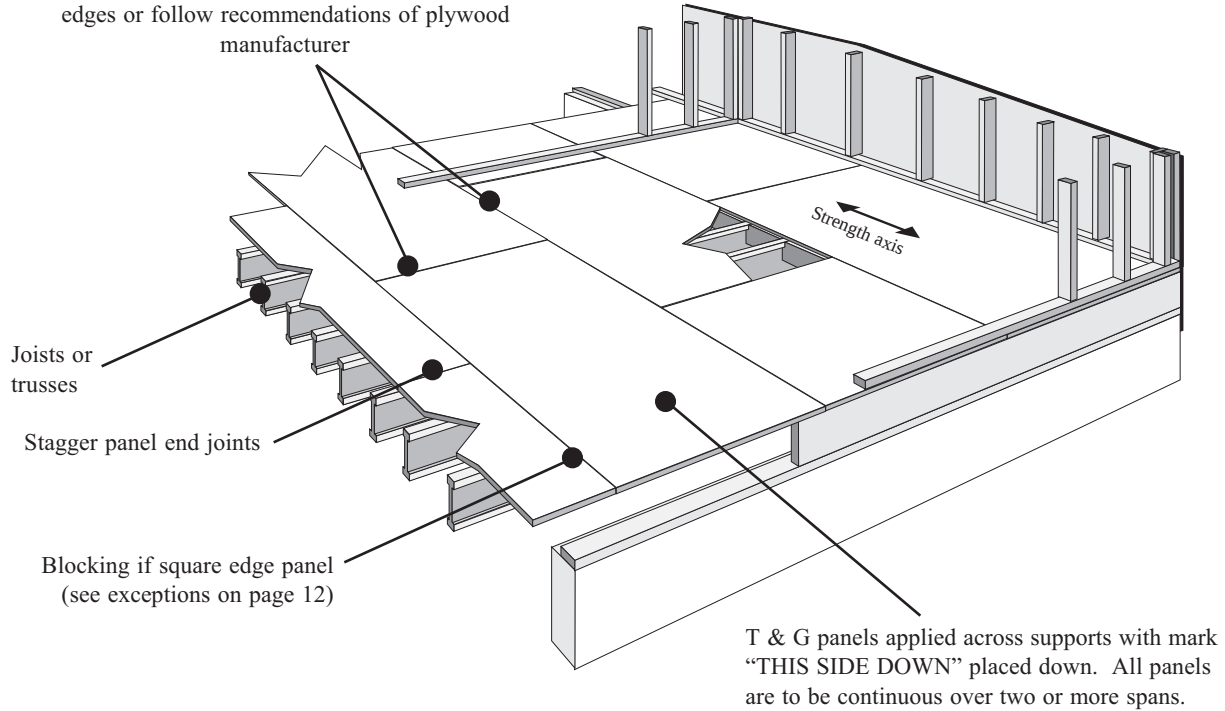
MAXIMUM CENTER-TO-CENTER SUPPORT SPACING ⁴ (inches)	SPECIES GROUP		
	1	2, 3	4
	MINIMUM PANEL THICKNESS (inches)		
16	1/2	5/8	3/4
20	5/8	3/4	7/8
24	3/4	7/8 ⁵	1

For SI units: 1 inch = 25.4 mm; 1 psf = 47.9 Pa

- Table applies to sanded plywood meeting the requirements of PS 1 with an Exterior or Exposure 1 Bond Classification.
- Panels shall be a minimum of 24 inches wide and continuous over two or more spans.
- Panel edges shall have approved tongue-and-groove joints or shall be supported with lumber blocking unless overlaid with a) 1/4-inch minimum thickness underlayment, b) 1-1/2 inches of approved cellular or lightweight concrete, or c) 3/4-inch minimum wood strip finish flooring.
- Support spacing, unless otherwise noted, assumes a uniform live load of 100 psf and uniform dead load of 10 psf. Uniform load deflection limits are 1/240 times span for total load (i.e. live plus dead load) and 1/360 times span for live load. Spans are further limited due to possible effects of concentrated loads.
- Limited to a uniform live load of 90 psf and a uniform dead load of 10 psf.

Floors

For combination subfloor/underlayment or subfloor panels, leave a 1/8 inch minimum gap at panel ends and edges or follow recommendations of plywood manufacturer



Note:

In crawl spaces, provide adequate ventilation and an approved moisture retarder as ground cover.

Maximum Support Spacing

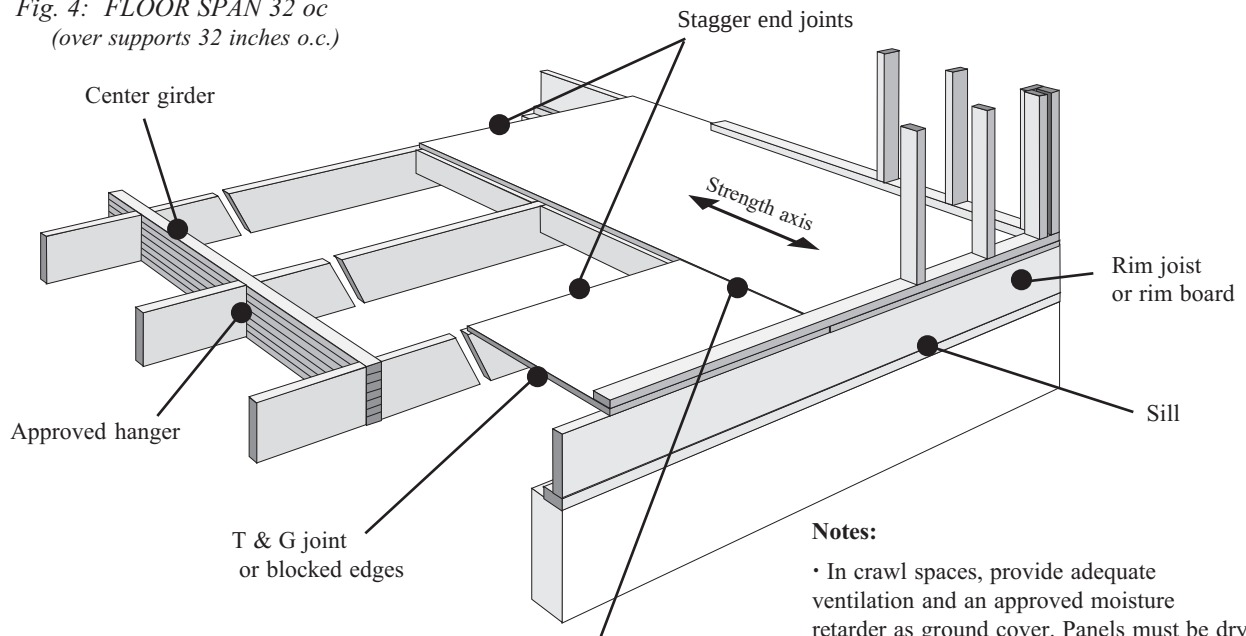
SHEATHING SPAN Subfloor: Sheathing and Structural I			FLOOR SPAN Combination Subfloor / Underlayment		
Support Spacing (inches)	Span Rating	Nominal Panel Thickness (inch)	Support Spacing (inches)	Span Rating	Nominal Panel Thickness (inch)
16 ¹	24/16	7/16, 15/32, 1/2	16 ¹	16 oc	19/32, 5/8
	32/16	15/32, 1/2, 19/32, 5/8	20	20 oc	19/32, 5/8
19.2, 20	40/20	19/32, 5/8, 23/32, 3/4	24	20 oc ²	19/32, 5/8
24	40/20 ²			24 oc	23/32, 3/4
	48/24			32 oc	7/8, 1
			48	48 oc	1-1/8, 1-1/4

1. Is permitted to be 24 inches on center for panels with span ratings of 32/16 or 16 oc where 3/4-inch wood strip flooring is installed perpendicular to the supports.
2. Acceptable where 3/4-inch wood strip flooring is installed perpendicular to supports or where 1-1/2 inches of cellular or lightweight concrete is applied over the panels.

Fig. 3. Floor panel installation and maximum recommended support spacing

Floors

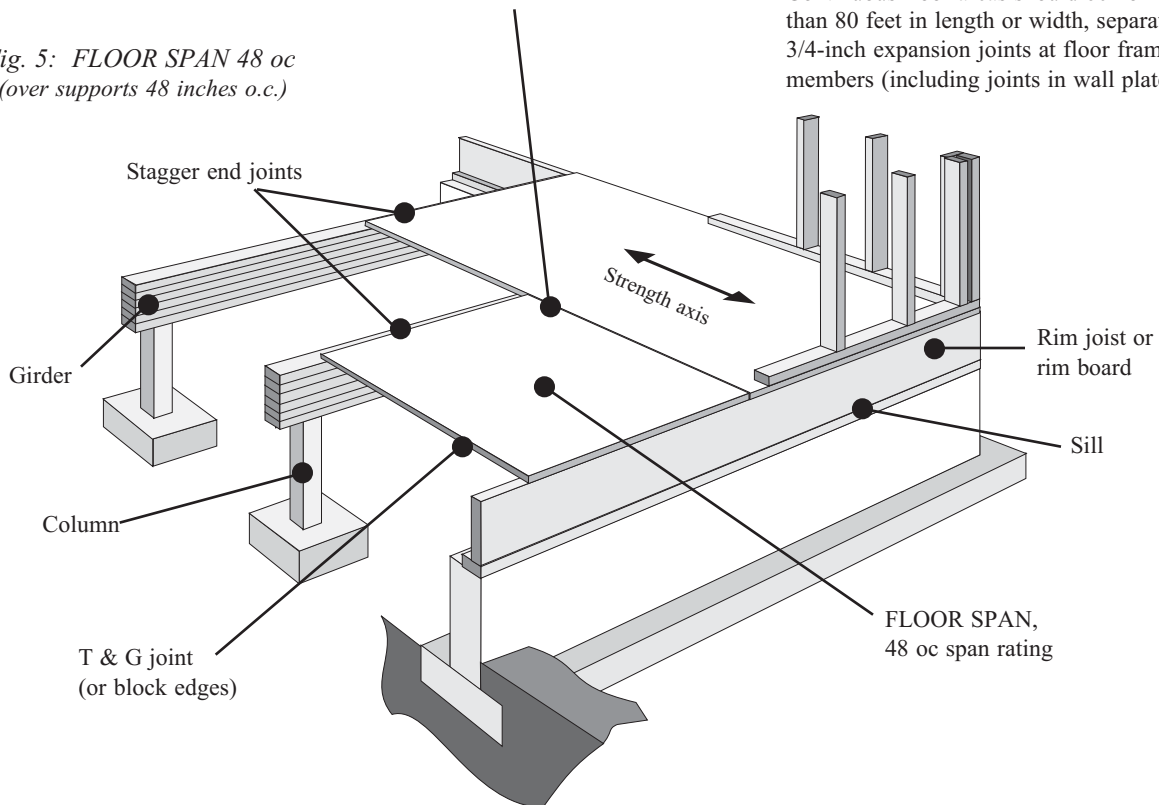
Fig. 4: FLOOR SPAN 32 oc
(over supports 32 inches o.c.)



Notes:

- In crawl spaces, provide adequate ventilation and an approved moisture retarder as ground cover. Panels must be dry before applying finish floor material.
- Accumulated expansion of panels may occur during construction in wet weather if expansion joints are not incorporated into buildings with wood- or steel-framed walls. Continuous floor areas should be no more than 80 feet in length or width, separated by 3/4-inch expansion joints at floor framing members (including joints in wall plates).

Fig. 5: FLOOR SPAN 48 oc
(over supports 48 inches o.c.)



Figs. 4 and 5. Installation of 32 oc and 48 oc FLOOR SPAN

Floors

Table 7. SHEATHING SPAN Subfloor and Underlayment Fastening Recommendations ^{1,2}

SPAN RATING	NOMINAL PANEL THICKNESS (inch)	MAXIMUM SPAN ³ (inches)	NAIL TYPE AND SIZE ⁴	MAXIMUM NAIL SPACING (inches)	
				Supported panel edges	Intermediate supports
24/16	7/16	16	6d common or deformed shank	6	12
32/16	15/32, 1/2	16 ⁵			
40/20	19/32, 5/8	20 ^{5,6}	8d common or 6d deformed shank		
48/24	23/32, 3/4	24			
60/32 ⁷	7/8	32	8d common or deformed shank		

1. Refer to Table 11 for subfloor recommendations under ceramic tile. Contact the manufacturer of gypsum concrete for subfloor recommendations.
2. When span rating is equal to or greater than maximum number shown, FLOOR SPAN panels may be substituted.
3. Tongue-and-groove edges or lumber blocking (see also exceptions on page 12). Only lumber blocking will satisfy blocked diaphragm requirements of ER-5637 or IBC 2003 Tables 2306.3.1 and 2306.3.2.
4. Other code-approved fasteners may be used.
5. Is permitted to be 24 inches on center where 3/4-inch wood strip flooring is installed perpendicular to the supports.
6. Is permitted to be 24 inches on center where 1-1/2 inches of cellular or lightweight concrete is applied over the panels.
7. Check with supplier for availability.

Table 8. Fastening Recommendations for Non-Span-Rated Plywood

NOMINAL PANEL THICKNESS (inch)	FASTENER TYPE ¹
≤ 1/2	6d ² common or 6d deformed shank nail 2-3/8" x 0.113 nail ³ 1-3/4" 16 gage staple ^{4,5}
19/32 - 3/4	8d common or 6d deformed shank nail 2-3/8" x 0.113 nail ⁶ 2" 16 gage staple ⁶
7/8 - 1	8d common or deformed shank nail

1. Nails spaced at 6 inches on center at edges and 12 inches on center at intermediate supports, unless otherwise noted. Nails for wall sheathing are permitted to be common, box or casing. Refer to the requirements in the building code for diaphragm and shear walls.
2. 8d nails are the minimum required for roof sheathing applications.
3. Space at 4 inches on center at edges and 8 inches on center at intermediate supports for roof sheathing applications.
4. Minimum crown width of 7/16 inch.
5. Space at 4 inches on center at edges and 8 inches on center at intermediate supports for subfloor and wall sheathing applications. Space at 3 inches on center at edges and 6 inches on center at intermediate supports for roof sheathing applications.
6. Space at 4 inches on center at edges and 8 inches on center at intermediate supports.

Floors

FIELD-GLUED FLOOR SYSTEM

The field-glued floor system is based on proven gluing techniques and field-applied construction adhesives. Floor stiffness is increased appreciably over conventional construction, particularly when the tongue-and-groove joints of the panel are glued. Gluing also helps eliminate squeaks, floor vibration, bounce, and nail-popping.

The system is normally used with FLOOR SPAN panels (Fig. 6), although multi-layer floors incorporating

plywood with a separate underlayment or with structural finish flooring are also candidate systems.

Only adhesives conforming to ASTM D3498 or AFG-01 are recommended for use with the field-glued floor system. Construction adhesives meeting this specification are available from building supply dealers. Specific application recommendations of the adhesive manufacturer must be followed.

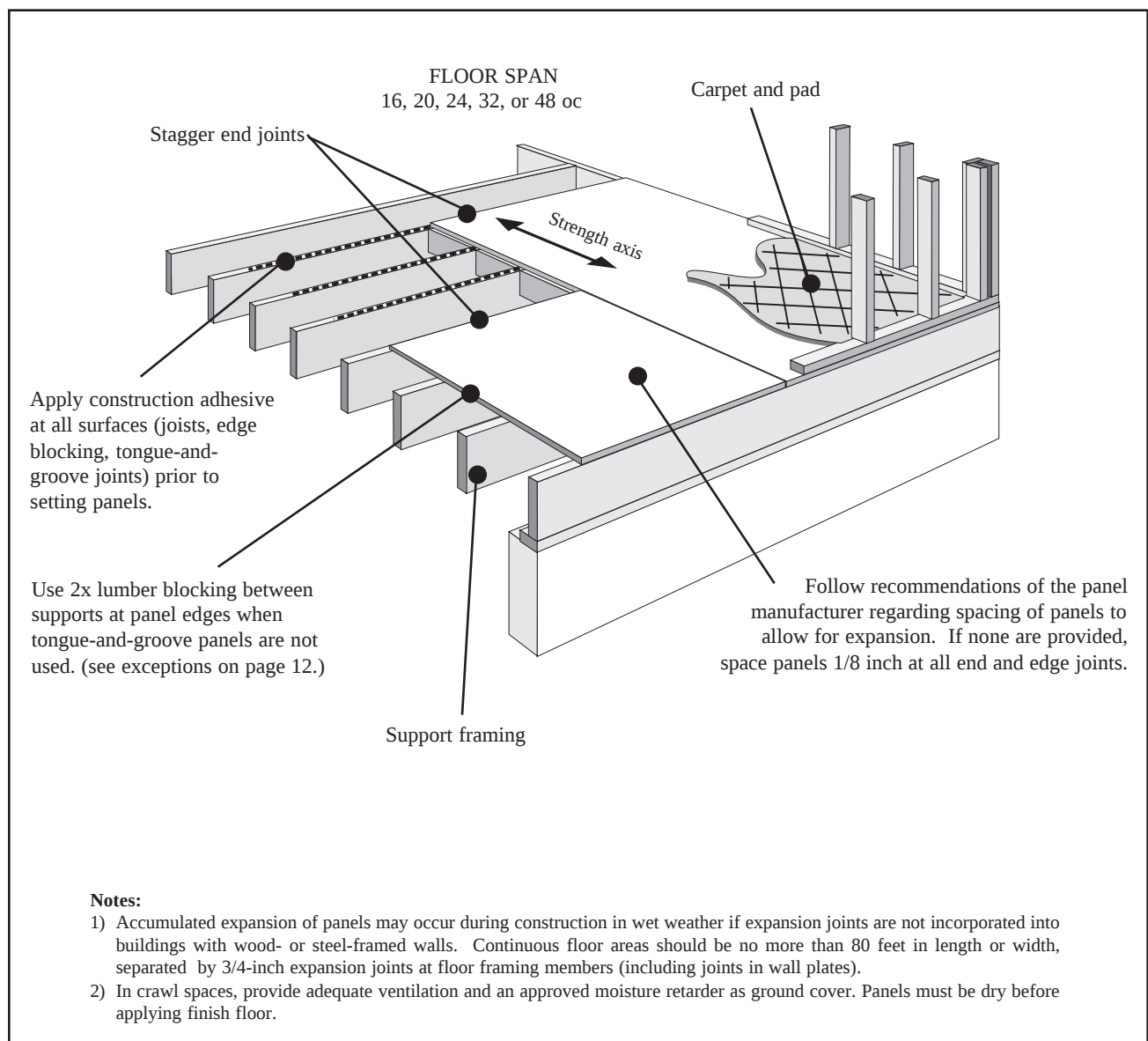


Fig. 6. Glued floor system

Floors

INSTALLING THE FIELD-GLUED FLOOR SYSTEM

The following installation instructions for the field-glued floor are appropriate for all structural plywood floor systems:

1. Snap a chalk line across joists 4 feet in from the wall for panel edge alignment and to serve as a boundary for spreading the glue.
2. Wipe any dirt from joists before gluing. Spread only enough glue to lay one or two panels at a time.
3. Lay the first panel with the tongue side to the wall and nail into place. This protects the tongue of the next panel from damage when gently tapped into place with block and sledgehammer.
4. Apply a continuous bead of glue (about 1/4 inch diameter) to framing members. Apply glue in a snake-like pattern on wide surfaces.
5. Apply two beads of glue on joists where panel ends butt to assure proper gluing of each end.
6. After the first row of panels is in place, spread glue in the groove of one or two panels at a time before laying the next row. Apply a thin bead (1/8 inch) to avoid squeeze-out.
7. Gently tap the second row of panels into place, using a block to protect the groove edges.
8. Stagger the end joints in each succeeding row. An 1/8 inch space between all end joints and an 1/8 inch space at all edges, including tongue-and-groove, is recommended. (Use a spacer tool to assure accurate and consistent spacing.)
9. Complete all nailing of each panel before glue sets. Check the manufacturer's recommendations for allowable setting time.

Note: Do not attempt to glue panels when it is raining or when joists are wet.

Table 9. Maximum Recommended Support Spacing for Plywood Panels Used with Hardwood Flooring

FLOOR SPAN	SHEATHING SPAN	Recommended maximum support spacing (inches)
20 oc	40/20	12
24 oc	48/24	19.2
32 oc		24
48 oc		32

Note: 23/32-inch or thicker panels are recommended for best performance

Table 10. Underlayment Application Recommendations for Thin Flooring¹

Application	Thickness (inch)	Fastener size and type (minimum required)	Maximum Fastener Spacing (inches)	
			Panel edges ²	Intermediate
Over smooth subfloor	1/4	3d x 1-1/4 inch ring-shank nails	3	6, each way

1. See Table 11 for underlayment recommendations under ceramic tile.
2. Fasten underlayment 3/8 inch from panel edges.

Floors

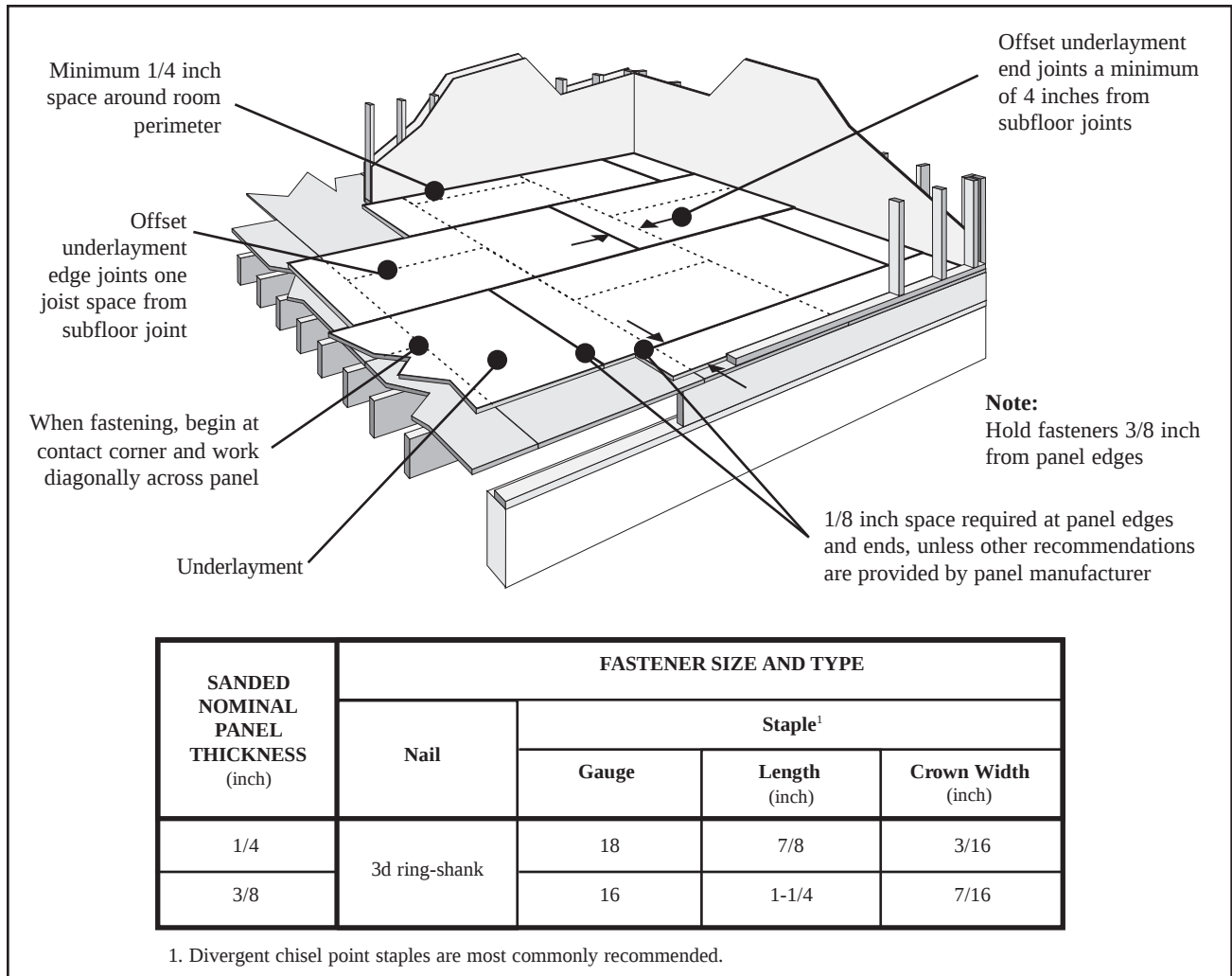


Fig. 7. Floor underlayment installation

HIGH-PERFORMANCE FLOOR

Floors constructed with plywood in accordance with minimum code provisions provide acceptable performance. For improved performance in subfloors, TECO recommends the following additional practices to create a High-Performance Floor:

- Span rated panels must be at least 24 oc for floor joist spacing up to 20 inches o.c. and 32 oc for joists spaced 24 inches o.c. Non-span-rated panels should be over-sized accordingly.
- Panels are to be installed with the field-glued floor system (page 17 and Fig. 6).
- Panels are to be fastened with 8d nails or other code-approved fasteners spaced 6 inches o.c. at edges, 12 inches at intermediate supports except 6 inches at all supports where spans are 48 inches or more. Nail size and spacing may vary depending on span and sheathing thickness. Deformed shank nails provide superior performance.
- Panels are to be installed on framing that is dry (moisture content equal to or less than 12%) and is designed to upgraded deflection criteria (e.g., L/480, live load, floor; L/360, live load, roof etc.).

Floors

FINISH FLOORS OVER PLYWOOD

After the building is closed in and heated and just before the finish floor is laid, plywood panels must be swept and/or vacuumed. The floor surface must be checked for protruding nail heads and all panels must be securely nailed. If the floor became wet during construction, it must be allowed to dry before applying the finish floor. If moisture caused some panel edge swelling, those edges must be sanded. The floor should be checked again for flatness, especially at joints, after it is dry. If panels were subjected to severe moisture conditions during construction, it may be necessary to level the entire surface with a light sanding.

ADHESIVE-APPLIED FLOORING

For adhesive-applied flooring, use an adhesive recommended by the flooring manufacturer. Carpet and parquet flooring may be installed on top of touch-sanded or sanded plywood following good practice and the flooring manufacturer's directions.

LIGHTWEIGHT CONCRETE

Structural plywood that has either an Exposure 1 or Exterior bond classification provides an excellent base for lightweight concrete floors. Concrete toppings are often used over subfloors to increase the sound insulation properties and fire resistance of the floor system. Lightweight gypsum concrete manufacturers typically recommend using 3/4 inch of concrete over 23/32- or 3/4-inch-thick tongue-and-groove subfloor with the joists spaced at 16 inches to 24 inches o.c. However, 3/4 inch of lightweight concrete over 19/32-inch-thick (40/20) subfloor with joists at 19.2 inch o.c., or 1-1/2 inches of lightweight concrete for joists at 24 inch o.c., is often acceptable to local building officials.

Panels should be installed continuously over two or more spans with the strength axis across supports. A moisture retarder or seal coat is often recommended by the concrete or plywood manufacturer.

HARDWOOD FLOORING

Because hardwood flooring is sensitive to moisture, it is important that the subfloor be dry when the hardwood is installed. The moisture in a "wet" subfloor will migrate into the drier hardwood flooring causing the flooring to buckle and create squeaks. The moisture content of the panels should be checked with a moisture meter to assure that they are within limits acceptable to the hardwood flooring manufacturer. If the construction is built over a crawl space, the crawl space must be dry, and well drained and ventilated. A minimum 6-mil polyethylene vapor retarder should be installed as ground cover in the crawl space.

The subfloor should be level, especially at the joints between panels. Any ridges at panel edges should be sanded smooth before hardwood installation using a heavy-duty floor sander and a moderately coarse grit sandpaper. Following sanding, any areas of the subfloor that squeak should be re-nailed.

The National Wood Flooring Association (NWFA)* and the Wood Flooring Manufacturers Association (NOFMA)* recognize the use of 19/32-inch-thick (5/8) and 23/32-inch-thick (3/4) plywood subfloor or single-layer floor panels under hardwood flooring, although thicker panels can most certainly be used. Recommended support spacings for various span ratings are shown in Table 9. To help eliminate floor squeaks and improve stiffness when hardwood flooring is installed, follow construction recommendations for High-Performance Floors (see page 19).

NWFA and NOFMA provide recommendations for storage, handling, acclimatizing, and installing hardwood on subflooring. Where possible, the hardwood strips should be oriented perpendicular to the floor framing.

* Contact either the National Wood Flooring Association, Manchester, MO, (800) 422-4556, web site: www.woodfloors.org; or The Wood Flooring Manufacturers Association, Memphis, TN, (901) 526-5016, web site: www.nofma.org.

Floors

CERAMIC TILE

For long-term performance of ceramic tile, it is important that the floor system be as stiff as possible. Table 11 provides a summary of several installation methods using plywood as subflooring and/or underlayment with ceramic tile.

The use of thicker subfloor (e.g., 23/32-inch-thick 48/24 span rating), cross bracing, or underlayment along with

closer fastener spacing will enhance the performance of the floor. To avoid cracking, the tile should have no traffic until the mortar or adhesive and grout has set.

Note: For more specific information related to the requirements of ceramic tile, contact the Tile Council of America (Anderson, SC; (864) 646-8453, www.tileusa.com) or the National Tile Contractors Association (Jackson, MS; (601) 939-2071, www.Tile-Assn.com).

Table 11. Recommended Floor Sheathing Systems for Ceramic Tile Flooring ^{1,2}

Minimum Panel Subfloor Requirements	On-center Support Spacing (inches)	Total Load Deflection Criteria ³	Underlayment Requirements ⁴	Tile Council of America Installation Method No.
19/32 " Plywood with exterior glue	16	1/360 of the span	1-1/4 to 2-inch mortar bed with reinforcing and cleavage membrane	F141-03
			Minimum 19/32" plywood with exterior glue	F142-03
			15/32" plywood with exterior glue for Residential	F143-03, 150-03
			19/32" plywood with exterior glue for Light Commercial	
			Cementitious backer unit or fiber cement underlayment with dry-set mortar	F144-03
			Coated glass mat backerboard with dry-set or latex-portland cement mortar	F146-03
			Fiber-reinforced gypsum backerboard with dry-set or latex-portland cement mortar	F170-03
23/32 " plywood with exterior glue	16		Mortar bed with metal lath and cleavage membrane	F145-03
	24		19/32" plywood with exterior glue	F149-03
23/32 " tongue & groove plywood with exterior glue	24		Minimum 3/8" plywood with exterior glue	F147-03, 152-03
	19.2		Specialty uncoupling system with latex-portland cement mortar	F148-03
7/8 " tongue & groove plywood with exterior glue	24		Coated glass mat backerboard with dry-set or latex-portland cement mortar	F151-03

1. Based on 2003-2004 Handbook for Ceramic Tile Installation published by the Tile Council of America.

2. Install plywood with face grain perpendicular to supports for maximum stiffness.

3. The deflection limit of 1/360 of the span is based on a 300 lb. concentrated load as determined per ASTM test standard C627.

4. Underlayment fasteners should not penetrate the joists below.

Floors

STAIR TREADS AND RISERS

Plywood can be used for treads and risers of both site-fabricated and prefabricated stairs in open- or closed-riser stairways. Risers support the front and back of the tread, creating a short effective span. Plywood stair treads may be used interchangeably with boards when the system is to include closed risers.

Maximum span between stringers is 42 inches, unless further restricted by local code requirements. Rounded nosing can be machined into the tread, but should be covered by a finish flooring material such as carpet and pad to prevent excessive wear or damage to plies

exposed by rounding. Risers can be specified for any available plywood panel grade at least 19/32-inch thick. Treads should be at least 19/32-inch-thick 20 oc FLOOR SPAN if they are glue-nailed and 23/32-inch-thick 24 oc if treads are nailed only. As specified for other plywood floor construction, gluing is recommended to improve the stiffness of connections and to eliminate squeaks. A construction adhesive that meets the requirements of ASTM D3498 or AFG-01 should be applied to all joints, with particular attention to the connection at the riser. Regardless of where glue is used, all edges of treads must be carefully nailed (see Fig. 8).

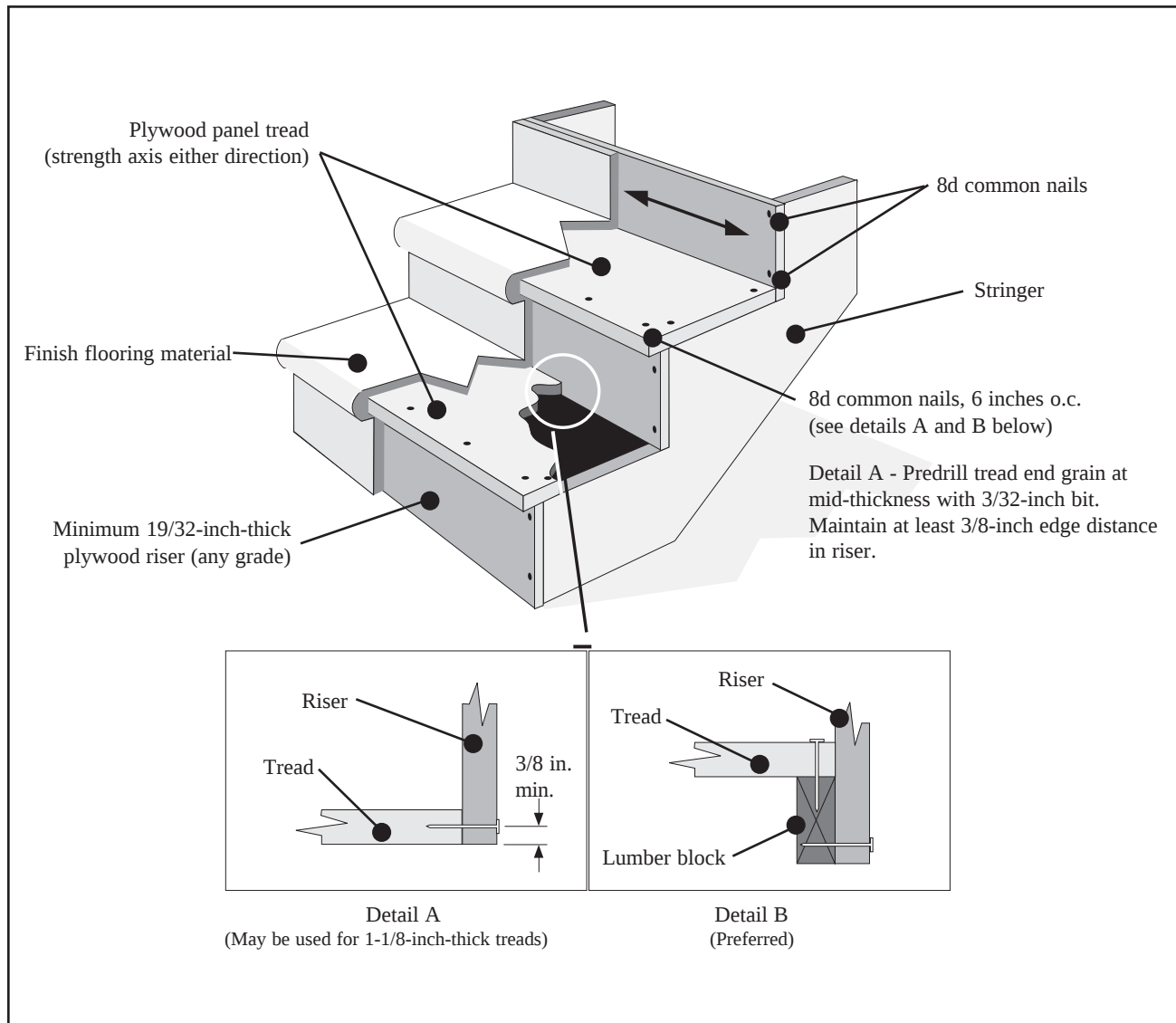


Fig. 8. Plywood stair construction recommendations

Walls and Roofs

DIAPHRAGMS AND SHEAR WALLS

Wind and seismic forces are the primary lateral forces that structural building systems must resist and transfer to the building foundation. Structural-use panels such as plywood serve as a principal component of the diaphragms and shear walls that comprise the building system. Diaphragms are horizontal or slanted planes that can be designed to act as deep beams that carry lateral forces applied to walls between floors and roofs. When

the building walls are parallel to an applied lateral force, they act as shear walls to transfer the force down to the foundation (see Fig. 9). Specific design and construction requirements are often necessary in order for a wall system to be designed and behave as a shear wall, while the same is true for a roof or floor system designed as a diaphragm. Basic design and construction methods and recommendations for each of these two systems follow.

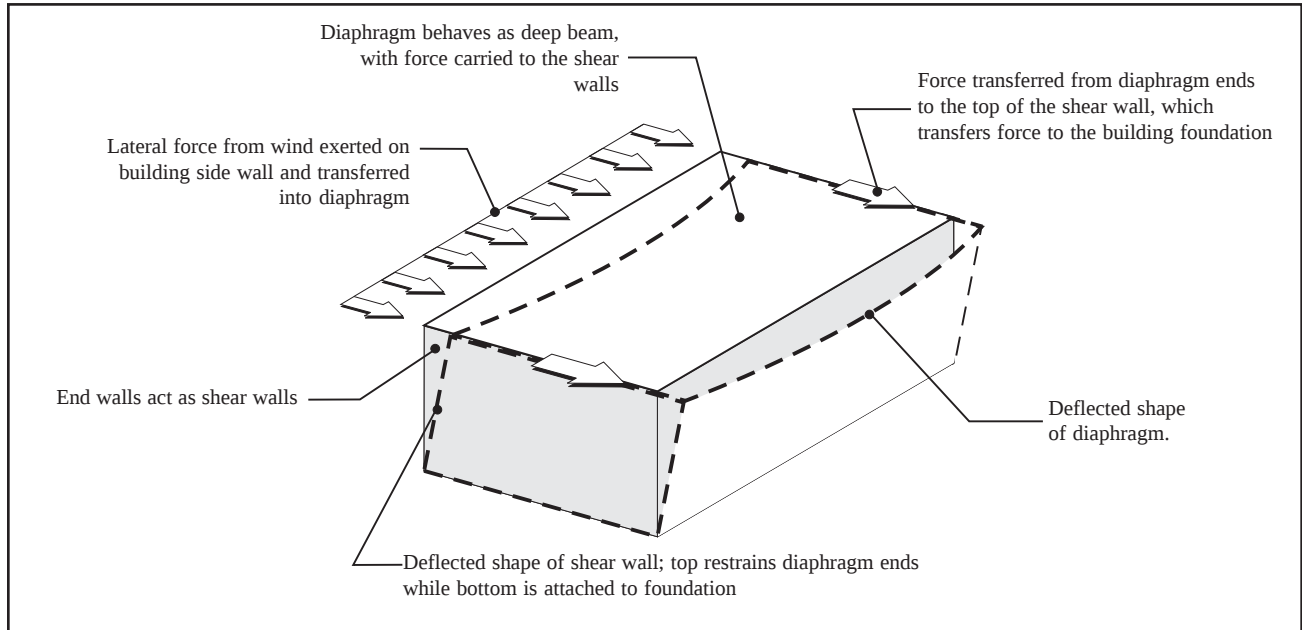


Fig. 9. Illustration of diaphragm and shear wall interaction

WALL SHEATHING

Span rated plywood that is certified to PS 1, PS 2 or PRP-133 and used for wall sheathing is permitted to be installed with the strength axis either perpendicular or parallel to the studs. Panels rated for wall spans, such as Wall-16, must be installed over studs spaced no farther apart than the span rating. When panels rated for roof spans are used for wall sheathing, the maximum stud spacing is 16 inches for panels with span ratings of 12, 16 and 20 inches, and 24 inches for 24 inch and greater span ratings. For example, plywood with a 20/0 span rating could be applied as wall sheathing when studs are spaced at 12 or 16 inches, but not 24 inches. Span rated plywood panels meet or exceed the corner bracing requirements and do not require additional let-in bracing (see Fig. 10).

Building codes often require that wall sheathing be at least 1/2 inch thick when stucco is to be applied (unless the lath is fastened directly to the wall studs). Sheathing

rated as Structural I has greater cross-panel load carrying capacity and is ideal in shear wall and diaphragm applications.

Plywood panels used for wall sheathing should have either an Exposure I or Exterior bond classification. Panels identified as Exposure I are not intended for permanent exposure to the weather and need to be covered by an exterior wall covering complying with the applicable code. Panels identified as Exterior, such as SIDING SPAN, are designed to be permanently exposed in outdoor applications and need not be covered.

To prevent problems associated with expansion of panels due to an increase in moisture content, wall sheathing should be installed with 1/8-inch gaps at panel ends and edges and around window and door openings, unless specific spacing recommendations are provided by the panel manufacturer.

Walls and Roofs

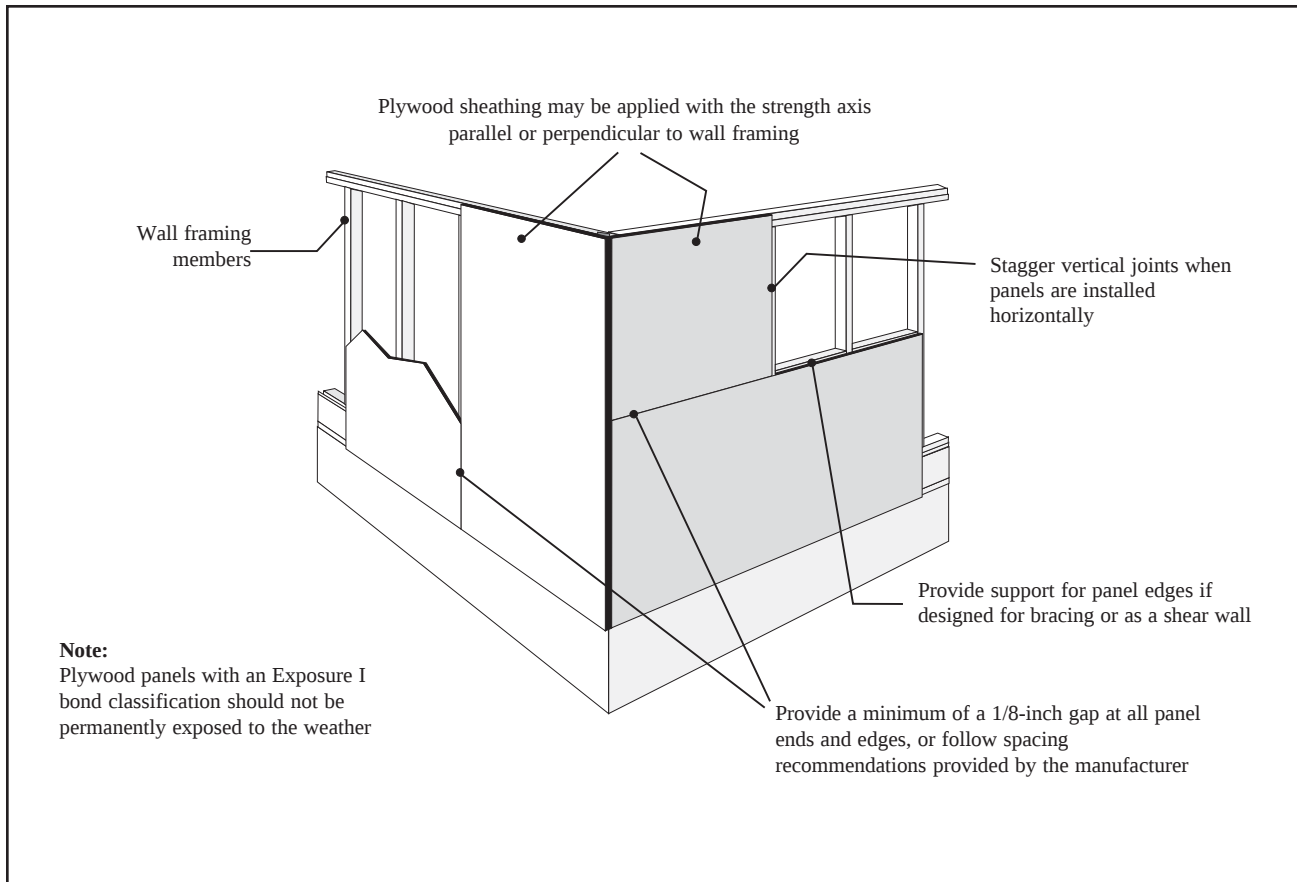


Fig 10. Wall sheathing installation recommendations

FASTENING WALL SHEATHING

Field investigations conducted after several hurricanes in the past two decades have confirmed that improper fastening of sheathing, siding, shingles, and other wall and roof covering has been a primary source of failure and damage resulting from the high winds of hurricanes. Using the correct fastener, whether nail, screw, staple or others, and applying them where and as often as required is the first step in preventing and limiting damage from high-wind events.

Wall sheathing panels 1/2 inch thick or less should be fastened with 6d common nails or deformed shank nails.

Panels greater than 1/2 inch but less than 7/8 inch thick should be fastened with 6d deformed shank or 8d common nails. Eight penny common or deformed shank nails should be used to attach panels 7/8 inch to 1 inch thick. Panels 1-1/8 inch thick and greater should be attached with 8d deformed shank or 10d common nails. In all cases, other nails, staples, or screws can be substituted for common nails when their capacity is sufficient for the intended purpose and local code allows such substitution. Some plywood manufacturers mark lines on each panel corresponding to support spacing of 12, 16 or 24 inches as guides for workers fastening the panels.

Walls and Roofs

INSTALLING SIDING SPAN PANELS

SIDING SPAN is a span rated panel intended to function as both sheathing and exterior covering for wall systems. When SIDING SPAN is applied directly to studs, the studs shall be spaced no further apart than the span rating indicated in the grade stamp on the panel. Panels with a span rating of 16 or 24 inches on center are permitted to be applied over studs spaced 24 inches on center when applied with face grain horizontal or when applied over nailable sheathing. Nailable sheathing includes the following three types:

- 1) Nominal 1-inch boards applied over studs spaced 16 or 24 inches on center.
- 2) Sheathing panels with roof span ratings of 24 inches or greater applied with the strength axis parallel or perpendicular to studs spaced 16 to 24 inches on center (Note - 3-ply plywood panels must be applied with the strength axis perpendicular to studs spaced 24 inches on center).
- 3) Sheathing panels with roof span ratings less than 24 inches applied with the strength axis parallel or perpendicular to studs spaced 16 inches on center (Note - plywood panels 3/8 inch thick or less must be applied with the strength axis perpendicular to studs).

Fasteners for attaching siding should be non-staining, corrosive resistant box, siding, or casing nails. For panels 1/2-inch thick or less use 6d nails, and 8d for thicker panels unless more restrictive nailing is required by the building code for shear walls. For 3/8 inch and thinner lap siding use 6d nails, and 8d for thicker lap siding.

SIDING SPAN panels are intended to be applied without a weather-resistive barrier (such as building paper), either directly to framing or over sheathing, provided that all

siding joints occur over framing and are protected with a continuous wood batt, approved caulking, flashing, vertical or horizontal shiplaps, or are otherwise made waterproof. A weather resistive barrier, such as building paper, shall be applied when required by the applicable building code. Where grooved siding is applied horizontally directly to framing, vertical butt joints shall be backed with a weather resistive barrier. Horizontal joints must be flashed to prevent water penetration. Siding shall be fastened directly to framing in accordance with the applicable provisions of the code. Siding installed over foam sheathing shall be in accordance with the relevant provisions of the applicable building code.

SIDING SPAN panels may be used as wall bracing in accordance with the requirements of the applicable building code. Allowable shear values for plywood siding applied directly to studs or over 1/2- or 5/8-inch gypsum sheathing are provided in Table 16.

Lap siding is applied either directly to framing or over nailable sheathing as defined above. When lap siding is installed either directly to framing or over boards, a weather resistive barrier is required. The vertical end joints of the lap siding shall be either caulked or otherwise installed in accordance with recommendations of the manufacturer. Siding joints, if staggered, are allowed to occur away from studs when applied over nailable sheathing. When lap siding is installed over nailable sheathing, space nails 8 inches on center along the top edge. If siding is wider than 12 inches, it must also be fastened to intermediate studs with nails spaced 8 inches on center.

Walls and Roofs

ROOF SHEATHING

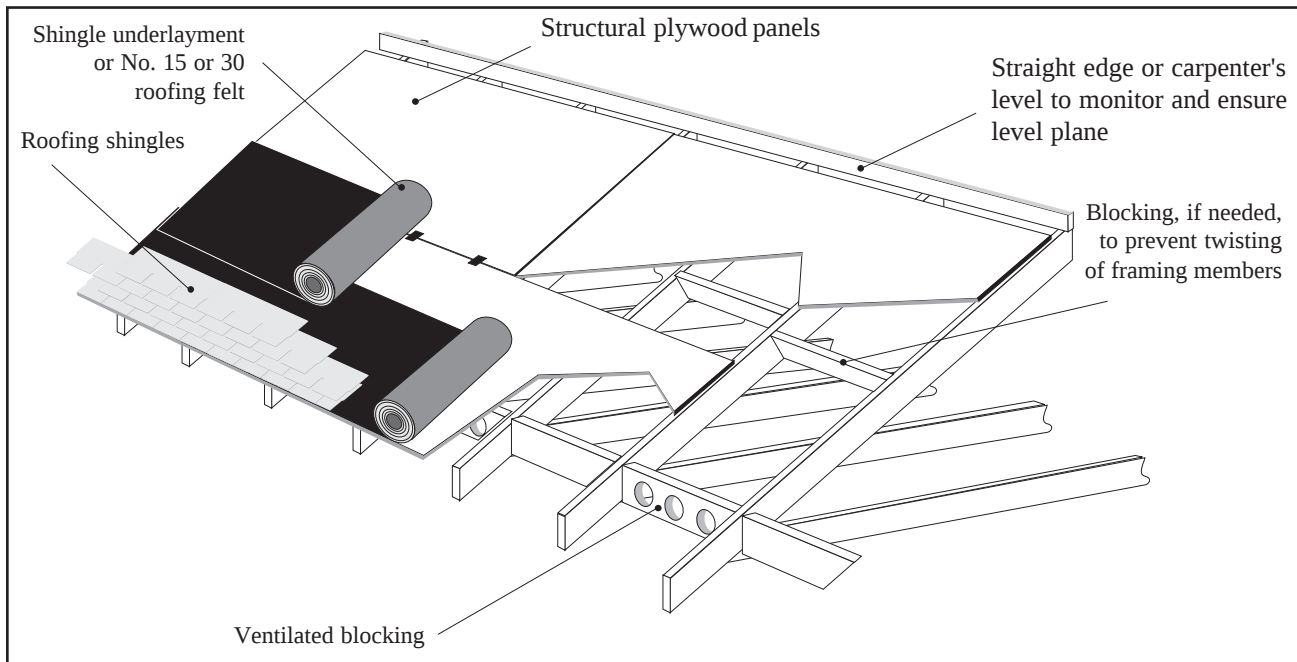


Fig.11. Installation of roof sheathing with felt and shingles

SHEATHING SPAN panels are the primary structural sheathing component of roof systems and are effective under a variety of roof coverings including wood, asphalt, or fiberglass shingles, tiles, wood shakes, or built-up roofing. Fig. 11 illustrates a typical roof system with recommendations that will enhance performance of the entire roof structure. Additionally, the surface of the roof sheathing should be dry prior to installing any portion of the roof covering

Follow these steps when installing the roof:

- Step 1** Install the roof framing and ensure that it provides a level surface; add blocking if needed to fix any twisted areas of framing.
- Step 2** Ensure proper ventilation that meets or exceeds all applicable building codes.
- Step 3** Space and fasten panels; place panel ends over supports; space panels 1/8 inch (the diameter of a 10d box nail) apart to allow for possible moisture expansion; install fasteners 3/8 inch from the edge of the panel at the appropriate on-center spacing. Install panel clips when required*.
- Step 4** Install shingle underlayment or No. 15 roofing felt to minimize exposure to weather prior to

applying shingles (use No. 30 roofing felt if prolonged exposure is expected); apply evenly, leaving a smooth surface.

- Step 5** Install shingles or other roof covering according to the manufacturer's recommendations; heavyweight, laminated and textured shingles create the best appearance.

FASTENING ROOF SHEATHING

It is recommended that roof sheathing less than 1-1/8 inch thick be fastened with a minimum of 8d common or deformed shank nails (although some code jurisdictions allow the use of 6d common or deformed shank nails); for panels that are 1-1/8 inch thick or greater, use 10d common nails.

Fastener spacing requirements may vary with building codes that recognize the potential for high-wind and seismic forces. Consult with your local code authority for these requirements. In all cases, other nail types, staples, or screws can be substituted for common nails when their capacity is sufficient for the intended purpose and local codes allow such substitution.

* Refer to footnote 3 of Table 12 for edge support requirements for panels used as roof sheathing.

Walls and Roofs

DESIGN CONSIDERATIONS

Tables 12, 13, 14, 15, and 16 are taken from either TECO's Evaluation Report ER-5637 or the 2003 International Building Code® and contain allowable load information for structural plywood panels when used as roof or wall sheathing. Table 12 contains allowable roof live loads when panels are oriented with their strength axis perpendicular to supports, as is typically the case. Table 13 provides similar load information when the strength axis of the panel is installed parallel to supports. Tables 14 and 15 provide allowable shear values when panels are used in diaphragm applications, while shear wall allowable loads are provided in Table 16. The values in these tables are applicable to panels that comply with the requirements of PRP-133, PS 1 or PS 2.

The allowable loads provided in Tables 12 and 13 are derived assuming a dead load of 10 psf. Applications with heavier dead loads must be considered appropriately.

As an example, let's assume that an architect is designing a roof system for a commercial structure. It is determined that the sheathing panels must support 60 psf of live load and 15 psf of dead load, i.e., a total load of 75 psf. What are the choices if a panel with supports spaced no more than 32 inches on center is to be specified?

Since the allowable roof live loads in Table 12 assume a dead load of 10 psf and the design requires a 15 psf dead load, the architect must increase the design live load by an equal amount (specifically 5 psf) to 65 psf. Doing so will ensure that the chosen panel is capable of carrying a total load of 75 psf.

Entering the table, our architect has the following choices:

- 7/16" 24/16 panels with supports at 19.2" o.c.
- 15/32" 32/16 panels with supports at 24" o.c.
- 23/32" 48/24 panels with supports at 32" o.c.

Notice that the first of these choices is the most efficient since the panels are rated for 65 psf and therefore utilize their entire structural capacity. Still, other considerations, like the choice of the supporting trusses or joists (due to cost or appearance, for instance), may lead to one of the other options.

Notice also that if the architect had not made the adjustment for excess dead load, he or she may have chosen 19/32-inch panels rated at 40/20, which have a

tabular live load capacity of 60 psf at a support spacing of 32 inches on center. This choice would have resulted in panels that exceeded their capacity by 5 psf, or more than 7 percent.

Looking at the diaphragm and shear wall tables (Tables 14, 15 and 16 respectively), notice that the top section of each table applies to Structural I SHEATHING SPAN, while the lower section applies to regular sheathing, FLOOR SPAN and other grades covered in PS 1 or PS 2. Notice too that when framing species such as Spruce-Pine-Fir are used, shear values must be adjusted to account for the difference in density between those species and Douglas Fir-Larch or Southern Pine.

NARROW-WIDTH ROOF PANELS

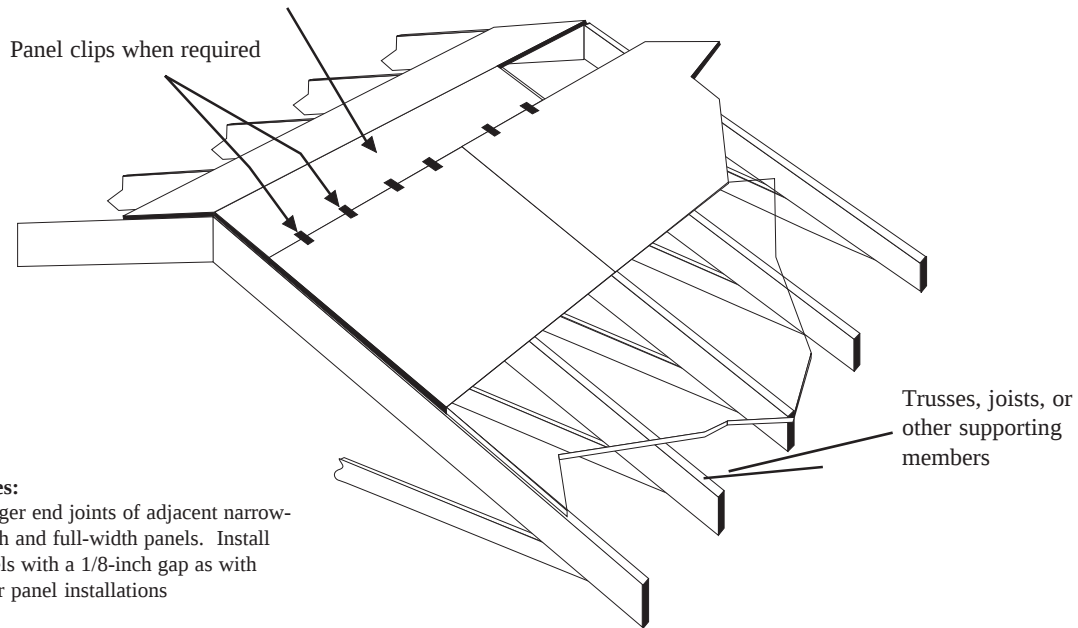
The overwhelming majority of structural-use panels used in construction today are four feet wide. Yet plywood panels must often be cut to a width less than four feet to accommodate the size and shape of the roof system. Fig. 12 illustrates this situation, where full-width panels are installed beginning at the soffit, continuing up the roof and creating the need for a run of narrow-width panels at the ridge. It is not uncommon, especially in specialized industrial construction, for these narrow-width panels to be less than 12 inches in width.

Allowable uniform roof live loads in Table 12 apply to panels that are at least 24 inches wide. Whenever possible, panels should be laid out so that the minimum panel is 24 inches, even if it creates two panels less than full width. It is further recommended to install the narrow-width panels away from the ridge at intermediate locations within the roof system, with both edges supported as recommended in the table in Fig. 12.

However, if panels must be cut to less than 24 inches in width, the recommendations in Fig. 12 are suggested to provide sufficient edge support to ensure adequate panel performance. These recommendations apply to panels installed over two or more spans (i.e., three or more supports) with the strength axis of the panel perpendicular to the supports. When panel clips are recommended, one clip should be centered between supports for support spacing 16 inches on center or less; use at least two clips, equally spaced, when support spacing is greater than 16 inches on center. If lumber blocking is recommended, a 2x4 or greater (any grade except Utility) may be installed edge- or flat-wise, adequately attached to supporting members.

Walls and Roofs

Narrow-width panel. When feasible, intersperse narrow width panels at intermediate locations within the roof system and support both edges as recommended in the Table below.



Panel Width, PW	Support Recommendations
$16'' \leq PW < 24''$	Panel clips or lumber blocking as described above. If the edge adjacent to a full-width panel is supported as recommended, the edge adjacent to a ridge or valley need not be supported, unless specifically required by code.
$12'' \leq PW < 16''$	Lumber blocking as described above on edge adjacent to full-width panel; support opposite edge if required by code.
$PW < 12''$	Lumber blocking as described above on both edges, even if one is adjacent to a ridge or valley. Both edges are considered blocked by a single piece of lumber when each edge is no further than 1-1/2" from the lumber edge (e.g., a single nominal 2x4 lumber block on edge centered under a 4-1/2-inch-wide panel is considered sufficient for support).

Note: Panel section widths are nominal and may be 1/8 inch less than specified to allow for saw kerf.

Fig.12. Illustration of narrow-width roof panels with recommendations for support

Walls and Roofs

Table 12. Allowable Uniform Roof Live Load for SHEATHING SPAN and FLOOR SPAN Panels with Strength Axis Perpendicular to Supports¹

SHEATHING SPAN

SPAN RATING	NOMINAL PANEL THICKNESS (inch)	MAXIMUM SPAN (inches)		ALLOWABLE LIVE LOAD ² (psf)								
		With edge support ³	Without edge support	Spacing of supports center-to-center (inches)								
				12	16	19.2	24	32	40	48	54	60
20/0	5/16, 11/32	20	20	120	50	30						
24/0	3/8	24	20	190	100	60	30					
24/16	7/16	24	24	190	100	65	40					
32/16	15/32, 1/2	32	28		180	120	70	30				
40/20	19/32, 5/8	40	32			205	130	60	30			
48/24	23/32, 3/4	48	36				175	95	45	35		
54/32	7/8, 1	54	40					130	75	50	35	
60/32	7/8, 1	60	40					165	100	70	50	35
60/48	7/8, 1, 1-1/8	60	48					165	100	70	50	35

FLOOR SPAN

SPAN RATING	NOMINAL PANEL THICKNESS (inch)	MAXIMUM SPAN (inches)		ALLOWABLE LIVE LOAD ² (psf)								
		With edge support ³	Without edge support	Spacing of supports center-to-center (inches)								
				12	16	19.2	24	32	40	48	54	60
16 oc	19/32, 5/8	24	24	185	100	65	40					
20 oc	19/32, 5/8, 3/4	32	32	270	150	100	60	30				
24 oc	23/32, 3/4	48	36		240	160	100	50	30	25		
32 oc	7/8, 1	48	40			295	185	100	60	40		
48 oc	1-1/8, 1-1/4	60	48				290	160	100	65	50	40

SI units: 1 inch = 25.4 mm; 1 psf = 47.9 Pa

1. Panels shall be a minimum of 24 inches wide.
2. The allowable spans were determined using a dead load of 10 psf. If the dead load exceeds 10 psf then the live load shall be reduced accordingly.
3. Tongue-and-groove edges, panel edge clips (one between each support, except two between supports 48 inches on center), lumber blocking or other. Only lumber blocking will satisfy blocked diaphragm requirements of ER-5637 or IBC 2003 Tables 2306.3.1 and 2306.3.2.

Walls and Roofs

Table 13. Allowable Uniform Roof Live Loads for SHEATHING SPAN Panels with Primary Axis Parallel to Supports^{1, 2, 3}

SPAN RATING	NOMINAL PANEL THICKNESS (inch)	STRUCTURAL I ⁴ SHEATHING SPAN		SHEATHING SPAN	
		Maximum span with edge support ⁵ (inches)	Live load ⁶ (psf)	Maximum span with edge support ⁵ (inches)	Live load ⁶ (psf)
24/16	7/16	24	20	16	40
32/16	15/32	24	35 ⁷	24	20 ⁸
32/16	1/2	24	40 ⁷	24	25 ⁸
40/20	19/32	24	70	24	40 ⁷
	5/8				45 ⁷
48/24	23/32, 3/4	24	90	24	60 ^{7, 8}

* Values per 2003 International Building Code®

SI units: 1 inch = 25.4 mm; 1 psf = 47.9 Pa

1. Panels shall be continuous over two or more spans.
2. Assumes plywood structural panels are minimum 5-ply/5-layer unless otherwise noted.
3. Uniform load deflection limitations are 1/180 times span under total load (i.e. live plus dead) and 1/240 times span under live load only. Edges shall be blocked with lumber or other approved type of edge supports.
4. Structural I rated panels have greater stiffness in the cross panel direction than sheathing panels.
5. Tongue-and-groove edges, panel edge clips (one between each support, except two between supports 48 inches on center), lumber blocking or other.
6. The allowable spans were determined using a dead load of 10 psf unless otherwise noted. If the dead load exceeds 10 psf then the live load shall be reduced accordingly.
7. Reduce load by 15 psf if 4-ply plywood structural panels.
8. The allowable spans were determined using a dead load of 5 psf. If the dead load exceeds 5 psf then the live load shall be reduced accordingly.

Walls and Roofs

Table 14. Allowable Shear (pounds per foot) for Plywood Panel Diaphragms with Framing of Douglas Fir-Larch or Southern Pine¹ for Wind or Seismic Loading

PANEL GRADE ²	COMMON NAIL SIZE OR STAPLE ⁸ LENGTH AND GAGE	MINIMUM FASTENER PENETRATION IN FRAMING (inches)	MINIMUM NOMINAL PANEL THICKNESS (inch)	MINIMUM NOMINAL WIDTH OF FRAMING MEMBER (inches)	BLOCKED DIAPHRAGMS				UNBLOCKED DIAPHRAGMS	
					Fastener spacing (in.) at diaphragm boundaries (all Cases) at continuous panel edges parallel to load (Cases 3 and 4) and at all panel edges (Cases 5 and 6) ³				Fasteners spaced 6 inches maximum at supported edges ³	
					6	4	2½ ⁴	2 ⁴	Case 1 ⁵	Cases 2, 3, 4, 5 and 6
					Fastener spacing (inches) at other panel edges (Cases 1, 2, 3 and 4) ³					
					6	6	4	3		
Structural I SHEATHING SPAN®	6d ⁷	1-1/4	5/16	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	1-1/2 16 Gage	1		2 3	155 175	205 230	310 345	350 390	135 155	105 115
	8d	1-3/8	3/8	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	1-1/2 16 Gage	1		2 3	175 200	235 265	350 395	400 450	155 175	115 130
	10d ⁶	1-1/2	15/32	2 3	320 360	425 480	640 720	730 820	285 320	215 240
	1-1/2 16 Gage	1		2 3	175 200	235 265	350 395	400 450	155 175	120 130
SHEATHING SPAN®, FLOOR SPAN® and other grades covered in PS 1 or PS 2	6d ⁷	1-1/4	5/16	2 3	170 190	225 250	335 380	380 430	150 170	110 125
	1-1/2 16 Gage	1		2 3	140 155	185 205	275 310	315 350	125 140	90 105
	6d ⁷	1-1/4	3/8	2 3	185 210	250 280	375 420	420 475	165 185	125 140
	8d	1-3/8		2 3	240 270	320 360	480 540	545 610	215 240	160 180
	1-1/2 16 Gage	1		2 3	160 180	210 235	315 355	360 400	140 160	105 120
	8d	1-3/8	7/16	2 3	255 285	340 380	505 570	575 645	230 255	170 190
	1-1/2 16 Gage	1		2 3	165 190	225 250	335 375	380 425	150 165	110 125
	8d	1-3/8	15/32	2 3	270 300	360 400	530 600	600 675	240 265	180 200
	10d ⁶	1-1/2		2 3	290 325	385 430	575 650	655 735	255 290	190 215
	1-1/2 16 Gage	1		2 3	160 180	210 235	315 355	360 405	140 160	105 120
	10d ⁶	1-1/2	19/32	2 3	320 360	425 480	640 720	730 820	285 320	215 240
	1-3/4 16 Gage	1		2 3	175 200	235 265	350 395	400 450	155 175	115 130

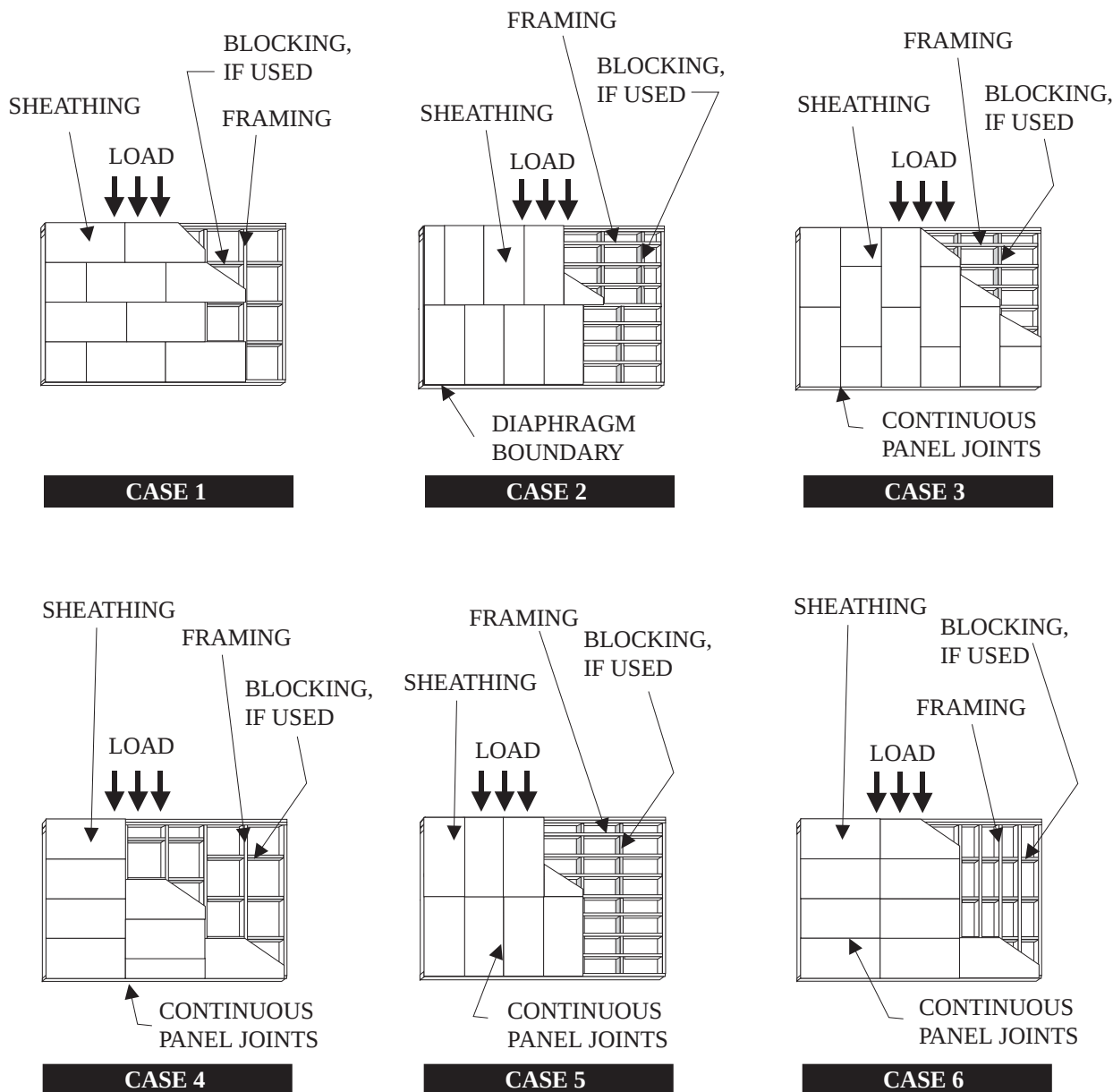
* Values per 2003 International Building Code®

Walls and Roofs

Table 14. (continued)

For SI: 1 inch = 25.4 mm, 1 pound = 14.5939 N/m

- For framing of other species: (a) find specific gravity for the species of lumber in the AF&PA National Design Specification; (b) For staples find shear value from above table for Structural I panels (regardless of actual grade) and multiply value by 0.82 for species with specific gravity of 0.42 or greater, or multiply by 0.65 for all other species; (c) for nails find shear value from above table for nail size for actual grade and multiply value by the following factor: Specific Gravity Adjustment Factor = $[1 - (0.5 - SG)]$, where SG = Specific Gravity of the framing lumber. This adjustment factor shall not be greater than 1.
- Panels conforming to PS 1, PS 2 OR PRP-133.
- Space fasteners maximum 12 inches o.c. along intermediate framing members (6 inches o.c. when supports are spaced 48 inches o.c.).
- Framing at adjoining panel edges shall be 3-inches nominal or wider and nails shall be staggered where nails are spaced 2 inches o.c. or 2-1/2 inches o.c.
- No unblocked edges or continuous joints parallel to load.
- Framing at adjoining panel edges shall be 3-inches nominal or wider and nails shall be staggered where both of the following conditions are met: (a) 10d nails having a penetration into framing of more than 1-1/2 inches and (b) nails are spaced 3 inches o.c. or less.
- 8d is recommended minimum for roofs due to negative pressures of high winds.
- Staples shall have a minimum crown width of 7/16-inch.



Walls and Roofs

Table 15. Allowable Shear in pounds per foot for Horizontal Blocked Diaphragms Utilizing Multiple Rows of Fasteners (High Load Diaphragms) with Framing of Douglas Fir-Larch or Southern Pine¹ for Wind or Seismic Loading²

PANEL GRADE ³	FASTENER AND SIZE	MINIMUM NAIL PENETRATION IN FRAMING (inches)	MINIMUM NOMINAL PANEL THICKNESS (inch)	MINIMUM NOMINAL WIDTH OF FRAMING MEMBER ⁵ (inches)	LINES OF FASTENERS	BLOCKED DIAPHRAGMS					
						Cases 1 and 2 ⁴					
						Fastener spacing per line at boundaries (inches)					
						4		2½		2	
						Fastener spacing per line at other panel edges (inches)					
6	4	4	3	3	2						
Structural I SHEATHING SPAN®	10d common nails	1-1/2	15/32	3	2	605	815	875	1150	—	—
				4	2	700	915	1005	1290	—	—
				4	3	875	1220	1285	1395	—	—
			19/32	3	2	670	880	965	1255	—	—
				4	2	780	990	1110	1440	—	—
				4	3	965	1320	1405	1790	—	—
			23/32	3	2	730	955	1050	1365	—	—
				4	2	855	1070	1210	1565	—	—
				4	3	1050	1430	1525	1800	—	—
	14 gage staples	2	15/32	3	2	600	600	860	960	1060	1200
				4	3	860	900	1160	1295	1295	1400
			19/32	3	2	600	600	875	960	1075	1200
4	3	875	900	1175	1440	1475	1795				
SHEATHING SPAN®, FLOOR SPAN® and other grades covered in PS 1 or PS 2	10d common nails	1-1/2	15/32	3	2	525	725	765	1010	—	—
				4	2	605	815	875	1105	—	—
				4	3	765	1085	1130	1195	—	—
			19/32	3	2	650	860	935	1225	—	—
				4	2	755	965	1080	1370	—	—
				4	3	935	1290	1365	1485	—	—
			23/32	3	2	710	935	1020	1335	—	—
				4	2	825	1050	1175	1445	—	—
				4	3	1020	1400	1480	1565	—	—
	14 gage staples	2	15/32	3	2	540	540	735	865	915	1080
				4	3	735	810	1005	1105	1105	1195
			19/32	3	2	600	600	865	960	1065	1200
				4	3	865	900	1130	1430	1370	1485
			23/32	4	3	865	900	1130	1490	1430	1545

* Values per 2003 International Building Code®

For SI: 1 inch = 25.4 mm

- For framing of other species: (a) find specific gravity for the species of lumber in the AF&PA National Design Specification, (b) Find shear value from table above for nail size of actual grade, and (c) Multiply value by the following adjustment factor = $[1 - (0.5 - SG)]$, where SG = Specific Gravity of the framing lumber. This adjustment factor shall not be greater than 1.
- Fastening along intermediate framing members: Space fasteners 12 inches on center, except 6 inches on center for spans greater than 32 inches.
- Panels conforming to PS 1, PS 2 or PRP-133.
- This table gives shear values for Cases 1 and 2 as shown in Table 14. The values shown are applicable to Cases 3,4, 5 and 6 as shown in Table 14, providing fasteners at all continuous panel edges are spaced in accordance with the boundary fastener spacing.
- The minimum depth of framing members shall be 3 inches.

Walls and Roofs

Table 16. Allowable Shear (pounds per foot) for Plywood Panel Shear Walls with Framing of Douglas Fir-Larch or Southern Pine¹ for Wind or Seismic Loading^{2,8,9,10}

PANEL GRADE	MINIMUM NOMINAL PANEL THICKNESS (inch)	MINIMUM FASTENER PENETRATION IN FRAMING (inches)	PANELS APPLIED DIRECT TO FRAMING					PANELS APPLIED OVER 1/2 or 5/8 -INCH GYPSUM SHEATHING				
			Nail (Common, galvanized box) or (Staple size ¹¹)	Fastener Spacing at Panel Edges (inches)				Nail (Common, galvanized box) or (Staple size ¹¹)	Fastener Spacing at Panel Edges (inches)			
				6	4	3	2 ⁵		6	4	3	2 ⁵
Structural I SHEATHING SPAN[®]	5/16	1-1/4	6d	200	300	390	510	8d	200	300	390	510
		1	1-1/2 16 Gage	165	245	325	415	2 16 Gage	125	185	245	315
	3/8	1-3/8	8d	230 ⁴	360 ⁴	460 ⁴	610 ⁴	10d	280	430	550 ⁶	730
		1	1-1/2 16 Gage	155	235	315	400	2 16 Gage	155	235	310	400
	7/16	1-3/8	8d	255 ⁴	395 ⁴	505 ⁴	670 ⁴	10d	280	430	550 ⁶	730
		1	1-1/2 16 Gage	170	260	345	440	2 16 Gage	155	235	310	400
	15/32	1-3/8	8d	280	430	550	730	10d	280	430	550 ⁶	730
		1	1-1/2 16 Gage	185	280	375	475	2 16 Gage	155	235	300	400
		1-1/2	10d	340	510	665 ⁶	870	10d	-	-	-	-
SHEATHING SPAN[®] SIDING SPAN^{7,12}	5/16 or 1/4 ³	1-1/4	6d	180	270	350	450	8d	180	270	350	450
		1	1-1/2 16 Gage	145	220	295	375	2 16 Gage	110	165	220	285
	3/8	1-1/4	6d	200	300	390	510	8d	200	300	390	510
		1-3/8	8d	220 ⁴	320 ⁴	410 ⁴	530 ⁴	10d	260	380	490 ⁶	640
		1	1-1/2 16 Gage	140	210	280	360	2 16 Gage	140	210	280	360
	7/16	1-3/8	8d	240 ⁴	350 ⁴	450 ⁴	585 ⁴	10d	260	380	490 ⁶	640
		1	1-1/2 16 Gage	155	230	310	395	2 16 Gage	140	210	280	360
	15/32	1-3/8	8d	260	380	490	640	10d	260	380	490 ⁶	640
		1-1/2	10d	310	460	600 ⁶	770	-	-	-	-	-
		1	1-1/2 16 Gage	170	255	335	430	2 16 Gage	140	210	280	360
	19/32	1-1/2	10d	340	510	665 ⁶	870	-	-	-	-	-
		1	1-3/4 16 Gage	185	280	375	475	-	-	-	-	-
			Nail Size (Galvanized Casing)					Nail Size (Galvanized Casing)				
	5/16 ³	1-1/4	6d	140	210	275	360	8d	140	210	275	360
	3/8	1-3/8	8d	160	240	310	410	10d	160	240	310 ⁶	410

* Values per 2003 International Building Code[®]

For SI: 1 inch = 25.4 mm, 1 pound = 14.5939 N/m

- For framing of other species: (a) find specific gravity for the species of lumber in the AF&PA National Design Specification; (b) For staples find shear value from above tables for Structural I panels (regardless of actual grade) and multiply value by 0.82 for species with specific gravity of 0.42 or greater, or multiply by 0.65 for all other species; (c) for nails find shear value from above table for nail size for actual grade and multiply value by the following factor: Specific Gravity Adjustment Factor = $[1 - (0.5 - SG)]$, where SG = Specific Gravity of the framing lumber. This adjustment factor shall not be greater than 1.
- Panel edges backed with 2-inch nominal or wider framing. Install panels either horizontally or vertically. Space fasteners a maximum of 6 inches o.c. along intermediate framing members for 3/8- and 7/16-inch panels installed on studs spaced 24 inches o.c. For other conditions and panel thicknesses, space fasteners a maximum of 12 inches o.c. on intermediate supports.
- 3/8-inch panel thickness or siding with a span rating of 16 inches on center is the minimum recommended where applied direct to framing as exterior siding.
- Shears may be increased to values shown for 15/32-inch sheathing with same nailing, provided (1) studs are spaced a maximum of 16 inches o.c. or (2) if panels are applied with long dimension across studs.
- Framing at adjoining panel edges shall be 3-inch nominal or wider and nails shall be staggered where nails are spaced 2 inches o.c.
- Framing at adjoining panel edges shall be 3-inch nominal or wider, and nails shall be staggered where both of the following conditions are met: (a) 10d nails having penetration into framing of more than 1-1/2 inches and (b) nails are spaced 3 inches o.c.
- Thickness at point of fastening on panel edges governs shear values.
- Where panels are applied on both faces of a wall and nail spacing is less than 6 inches o.c. on either side, panel joints shall be offset to fall on different framing members or framing shall be 3-inch nominal or thicker and nails on each side shall be staggered.
- In seismic Design Category D, E, or F where shear design values exceed 490 plf (LRFD) or 350 plf (ASD) all framing members receiving edge nailing from abutting panels shall not be less than a single 3-inch nominal member. Panel joint and sill plate nailing shall be staggered in all cases. Refer to building code for sill plate size and anchorage requirements.
- Galvanized nails shall be hot-dipped or tumbled.
- Staples shall have a minimum crown width of 7/16-inch.
- Group 5 species are not permitted.

Other Performance Issues

FLAME SPREAD AND "SMOKE DEVELOPED" RATING FOR SOFTWOOD PLYWOOD

ASTM E84 is used to determine a product's tendency to permit the travel of a flame along its surface as well as provide a measure of how much smoke is developed when it burns. A gas flame is applied to the underside of products at one end of a 25-foot-long tunnel. The rate of flame spread and the amount of smoke developed are measured. Each is given a separate rating, with the following standardized scale being used for both. The higher the flame spread rating, the higher the tendency for the material being tested to spread flames during a fire. Similarly, a higher smoke developed rating means that a material tends to generate more smoke when subject to fire. Inorganic reinforced cement board is assigned a flame spread and smoke developed rating of zero, while red oak is rated a 100 for both.

Rating classes:

- 0 to 25 - Class I (or A)
- 26 to 75 - Class II (or B)
- 76 to 200 - Class III (or C)

Test results for softwood plywood panels, with or without factory overlay finishes, indicate that softwood plywood falls into the Class III (or C) rating for both flame spread and smoke developed*. A Class III (or C) rating is typical for most untreated wood products. Fire-retardant coatings that can be applied to the surface of the panels are also available from various coating manufacturers. These coatings reduce the flame spread and smoke development characteristics of the panels, thereby improving the rating class to Class I or II.

* Refer to "Design for Code Acceptance No. 1 - Flame Spread Performance of Wood Products" - published by the American Forest and Paper Association, 1111 Nineteenth Street, NW, Suite 800, Washington DC 20036. (202) 463-2766, web site: www.awc.org

PLYWOOD IN FIRE-RATED ASSEMBLIES

Architects and engineers specify fire-rated assemblies extensively in structures where one- and two-hour fire protection is required. Detailed information on tested floor, roof and wall assemblies, using plywood as the covering, are available from sources such as Underwriters Laboratories (UL)*, the Gypsum Association*, the American Forest & Paper Association* and many others. The plywood used in these assemblies must be manufactured to meet the requirements of PS 1

and PS 2 and be certified by a code recognized inspection and testing agency. As an alternate to PS 1 and PS 2, UL permits wood structural panels that have been evaluated in accordance with APA - The Engineered Wood Association Standard PRP-108, *Performance Standards and Policies for Structural-Use Panels*, or TECO Standard PRP-133, *Performance Standards and Policies for Wood-Based Structural-Use Panels*, and meet the description for the panel type in the individual designs.

*For specific information regarding fire rated assemblies contact Underwriters Laboratories Inc. (Northbrook, IL, 847-272-8800, www.ul.com); Gypsum Association, (Washington DC, 202-289-5440, www.gypsum.org); American Forest & Paper Association, (Washington DC, 202-463-4713, www.awc.org).

FORMALDEHYDE EMISSIONS FROM PLYWOOD PANELS

Wood structural panels, such as plywood, manufactured with an exterior type phenol formaldehyde adhesive do not "off gas" like other types of wood-based panels and therefore do not require certification for formaldehyde emissions. Phenolic-based adhesives are specifically exempted in Section II.C.3 of HUD Rule 24 CFR 3280 (of the August 9, 1984 Federal Register), which states

that HUD "has decided to exempt products that are formulated exclusively with phenol-formaldehyde resins and surface finishes from the testing and certification provision of the rule." The amount of formaldehyde emitted from panels using phenolic-based adhesives is considered too small to be significant and has therefore been exempted.

Other Performance Issues

PRESERVATIVE TREATED PLYWOOD

For use in certain applications, plywood can be treated with preservative chemicals to avoid attack by decay causing organisms and insects. Preservative treated panels make up a relatively large portion of the plywood market. Common uses include concrete forming and all-weather wood foundations. When plywood is to be treated with a water borne preservative for use in a particular application, the user should specify the preservative retention level and after-treatment moisture content desired. Building codes require that the treating must be conducted in accordance with requirements of the American Wood Preservers Association (AWPA) and that the treated panels bear the mark of an agency certified to inspect preservative treated wood products.

Both Exposure 1 and Exterior plywood can be treated with preservative chemicals, although certain applications, such as permanent wood foundations, are limited to Exterior plywood only. Exterior plywood grades used for treating must consist of no less than “C” grade veneer and use only species classified as Group 1 or Group 2.

Treaters should be aware that some methods of pressure treatment exceed the pressures used in PS 1 for quality control bond durability tests. Span ratings are typically qualified before treatment and may not apply to panels after treatment. Consumers should contact the treatment company for specific information regarding the treatment used and the effects on panel strength and stiffness properties.

THERMAL RESISTANCE AND MOISTURE VAPOR PERMEABILITY OF PLYWOOD PANELS

The thermal resistance, or R-value of several common thicknesses of structural plywood panels are listed in Table 17. For wood panels such as plywood, the R-value provides a measure of the insulating value and is proportional to the density and the thickness of the panel.

Moisture vapor permeance refers to the rate of water vapor diffusion through a material. The moisture vapor permeability of a material is measured in “perms”. One perm is equal to the transfer of 1 grain (i.e. 1/7000 lb.) of water per square foot of material per hour under a pressure difference of 1 inch of mercury.

Table 17. Thermal Resistance of Plywood

Plywood thickness (inch)	R-value (in ft ² -hr-°F/BTU)
3/8	0.47
15/32	0.59
1/2	0.63
19/32	0.74
5/8	0.77
23/32	0.9
3/4	0.94
1	1.25

Plywood, as with all wood products, is hygroscopic (i.e. it readily absorbs moisture from the atmosphere). The permeability characteristics of hygroscopic materials change as the relative humidity increases. Plywood used in typical “protected” applications, where the moisture content is less than 12% is relatively impermeable (i.e. < 1 perm). If the plywood becomes wet, however, it becomes relatively permeable (i.e. > 1 and < 10 perms). Most U.S. building codes consider materials with a permeability of 1 perm or less to be “vapor retarders”.