Wind-Rated Roofs

DESIGNING COMMERCIAL ROOFS TO WITHSTAND WIND UPLIFT FORCES

APA
THE ENGINEERED WOOD ASSOCIATION

WOOD
The Natural Choice

Engineered wood products are a good choice for the environment. They are manufactured for years of trouble-free, dependable use. They help reduce waste by decreasing disposal costs and product damage. Wood is a renewable, recyclable, biodegradable resource that is easily manufactured into a variety of viable products.

A few facts about wood.

▪ ***We're growing more wood every day.*** Forests fully cover one-third of the United States' and one-half of Canada's land mass. American landowners plant more than two billion trees every year. In addition, millions of trees seed naturally. The forest products industry, which comprises about 15 percent of forestland ownership, is responsible for 41 percent of replanted forest acreage. That works out to more than one billion trees a year, or about three million trees planted every day. This high rate of replanting accounts for the fact that each year, 27 percent more timber is grown than is harvested. Canada's replanting record shows a fourfold increase in the number of trees planted between 1975 and 1990.

▪ ***Life Cycle Assessment shows wood is the greenest building product.*** A 2004 Consortium for Research on Renewable Industrial Materials (CORRIM) study gave scientific validation to the strength of wood as a green building product. In examining building products' life cycles – from extraction of the raw material to demolition of the building at the end of its long lifespan – CORRIM found that wood was better for the environment than steel or concrete in terms of embodied energy, global warming potential, air emissions, water emissions and solid waste production. For the complete details of the report, visit www.CORRIM.org.

▪ ***Manufacturing wood is energy efficient.*** Wood products made up 47 percent of all industrial raw materials manufactured in the United States, yet consumed only 4 percent of the energy needed to manufacture all industrial raw materials, according to a 1987 study.

Material	Percent of Production	Percent of Energy Use
Wood	47	4
Steel	23	48
Aluminum	2	8

▪ ***Good news for a healthy planet.*** For every ton of wood grown, a young forest produces 1.07 tons of oxygen and absorbs 1.47 tons of carbon dioxide.

Wood: It's the natural choice for the environment, for design and for strong, lasting construction.

The roof system is an integral part of any structure, but designing and building commercial roofs for wind uplift resistance is particularly crucial in coastal and other high-wind areas. Many insurance companies require roof systems to be rated for wind uplift resistance before they will insure the building.

This publication from APA – The Engineered Wood Association provides assembly details for roof systems with APA wood structural panels used as the substrate. Each assembly contains a classification based on Underwriters Laboratories or FM Approvals testing that determines the maximum wind uplift the roof system can resist. By following the classifications required by the region in which the structure is built, commercial designers and builders can ensure wind uplift resistance and meet insurance requirements.

For additional information on wind uplift or roof design or for assistance with specific design problems, contact the APA Product Support Help Desk at (253) 620-7400 or help@apawood.org, or visit our web site at www.apawood.org.

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WIND UPLIFT RATINGS

Wind uplift-resistance ratings are based on a roofing system's performance in wind uplift tests. Underwriters Laboratories (UL) and FM Approvals (Factory Mutual or FM) are two agencies that do research and testing and assign wind uplift classifications that buildings must often meet to be insured. Because of the assemblies' structural merits, many commercial designers use UL or FM rated systems even when not required to do so.

UL assigns systems a semi-wind-resistive classification (Class 30 or 60) or fully-wind-resistive classification (Class 90). FM assigns systems Class 1 ratings based on the wind uplift pressure (not wind speeds) in pounds per square foot (psf) that the system resisted during testing, e.g., 1-90 or 1-105.

In 2004, APA participated in FM Approvals testing directed by the Asphalt Roofing Manufacturers Association (ARMA). APA designed the wood structural panel decking systems, and APA members provided plywood and oriented strand board (OSB) panels used for these tests over wood bases. FM conducted tests to evaluate the capability of the deck components of the roofing system to resist a minimum simulated wind uplift pressure for one minute. Tests began with 30 psf of pressure, with pressure increasing in increments of 15 psf after each minute of successful resistance until failure occurred in any component. FM assigned systems classifications based on the last successful one-minute pressure resistance, meaning a system that failed during the 135 psf pressure test would receive a 1-120 class rating.

It is important to note that a safety factor of two is required nationwide to receive FM insurance coverage on any building. Thus, to be insured in an area with wind loads of up to 45 psf, the structure's roof system must be built to a 1-90 classification. Many fire-rated wood roof assemblies can also qualify for wind uplift ratings. Tables 1 and 2 make a simplified comparison between the wind speeds, as shown in Figure 1609 of the 2003 International Building Code (IBC) and the design corner uplift pressures given in Table 1609.6.2.1(2) of the IBC.

TABLE 1

WIND SPEEDS AND PRESSURES[1]

Maximum Wind Velocity (mph, 3 second gust)	Roof Corner Uplift Design Pressure (psf)	Required FM Rating
85	33	1-75
90	37	1-75
100	45	1-90
110	55	1-120
120	65	1-135

[1] Exposure B, enclosed structure, Zone 3 of a flat roof, height 30 feet.

TABLE 2

MINIMUM WOOD STRUCTURAL PANEL REQUIREMENTS FOR PANELIZED ROOF SYSTEMS (Panel Strength Axis Parallel to Supports)[1]

FM Class[2]	Minimum Panel Thickness (in.) and Span Rating	Additional Requirements
1-60	15/32 – 32/16	5-Ply Plywood or OSB
1-75	15/32 – 32/16	5-Ply Plywood or OSB
1-90	19/32 – 40/20	4-Ply Plywood or OSB
1-105	19/32 – 40/20	5-Ply Plywood or OSB
1-120	19/32 – 40/20	5-Ply Plywood or OSB
1-135	19/32 – 40/20	5-Ply Plywood or OSB

[1] Minimum thickness is critical due to fastener holding requirements. For additional cross-panel strength, stiffness and fastener-holding capacity without additional thickness, specify APA Structural I Rated Sheathing.

[2] Based on roof corner uplift design pressures from the IBC and ASCE 7-05 for Enclosed, Exposure B and roof height 30 feet.

WOOD STRUCTURAL PANEL BENEFITS

Wood structural panels provide a solid substrate to which the built-up or modified bitumen roofing is applied. When adequately attached to walls, supports and other roofing layers, plywood and OSB contribute to one of the most solid and stable roof systems available.

Plywood and OSB are light and easy to work with, making the construction process easier and more time efficient. The lightness in weight does not compromise the panels' strength; on the contrary, one of the greatest benefits of plywood and OSB is their diaphragm shear strength. In addition, panels are less expensive than other options, allowing builders to pass cost savings on to the owners.

UL ROOF ASSEMBLIES

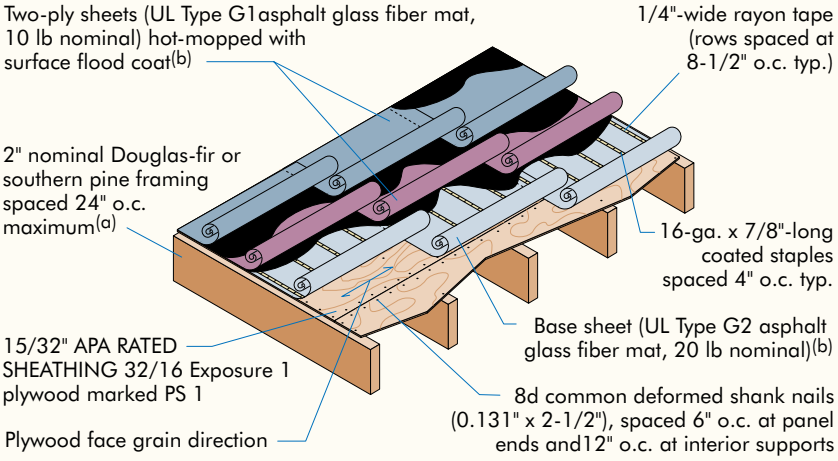
Two UL-Rated plywood roof systems with hot-mopped built-up roofing over a mechanically fastened roofing base sheet are qualified for fully-wind-resistive ratings (Class 90).

One of these systems, UL Construction No. NM519, is illustrated in Figure 1. It uses 15/32-inch APA RATED SHEATHING Exposure 1 marked PS 1 (C-D Exposure 1 plywood), installed across nominal 2-inch wood joists spaced a maximum of 24 inches o.c. For a fully-wind-resistive rating (Class 90), the three-ply built-up roofing consists of a fiberglass mat base sheet (UL Type G2) that is mechanically fastened to the plywood roof deck at lapped edges and along three intermediate rows with a staple/tape system and two plies of fiberglass mat ply sheets (UL Type G1) that are hot-mopped to the base sheet.

The second, illustrated in Figure 2, is UL Construction No. NM520, a panelized roof deck of 15/32-inch APA RATED SHEATHING Exposure 1 marked PS 1 (C-D Exposure 1 plywood). The panels are installed parallel to 2x4 joists spaced a maximum of 24 inches o.c., framed into glulam beams. For a fully-wind-resistive (Class 90) rating, the three-ply built-up roofing is installed as described above for NM519 construction, with the rayon tape spaced a maximum of 8-1/2 inches o.c. If the roofing base sheet is fastened to the plywood roof deck at lapped edges and along two intermediate rows with a staple/tape system spaced a maximum of 11-1/3 inches o.c., the roofing system qualifies for a semi-wind-resistive rating (Class 60).

Panelized roofs are commonly used on the West Coast for seismic or wind resistance and are becoming increasingly popular in Texas and Gulf Coast regions where wind-rated roofing systems can be used with the diaphragm shear strength of wood roof decks to provide economical, wind-resistant structures. Panelized roof systems are also fast and economical to assemble and install. Because the panelized sections are assembled on the

FIGURE 1
FULLY-WIND-RESISTIVE ROOF ASSEMBLY — UL CLASS 90 (NM519)



(a) Design in accordance with local building code requirements for roof loads and anchorage. All framing must have 2" nominal or greater width for plywood deck nailing.

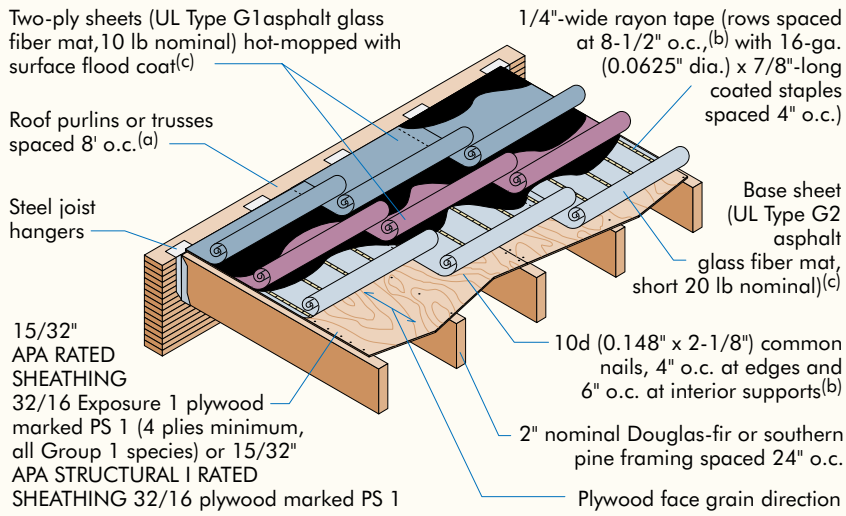
(b) Install roofing base and ply sheets with roll direction parallel to plywood face grain direction, as with a panelized roof system.

ground and lifted into the place with a forklift, worker time on the roof deck is minimized, increasing worker safety on the job site.

Another type of wind-rated roof construction uses proprietary metal roofing panels, available from several sources, installed over plywood roof sheathing as shown in Figure 3. These constructions use APA RATED SHEATHING Exposure 1 marked PS 1 (C-D Exposure 1 plywood), installed across wood or steel framing spaced up to 24 inches o.c. Plywood thickness depends on details of the proprietary construction, with a minimum of 15/32 inch (Span Rating 32/16) for some constructions, and 5/8 or 3/4 inch (Span Rating 40/20 or 48/24, respectively) for others. Metal roofing panels are fastened to the plywood roof sheathing or framing with special clips and screws.

Other types of proprietary roofing products, such as prepared roof covering or steel tile or shake panels, also are rated for wind uplift resistance when installed over 15/32-inch plywood roof sheathing. Other constructions use a single-ply roofing membrane over minimum 7/16-inch OSB panels as roofing substrate over steel roof decking, or 15/32-inch plywood roof sheathing. For details, consult the UL *Building Materials Directory* under Product Categories TGIK and TGKX.

FIGURE 2
FULLY-WIND-RESISTIVE ROOF ASSEMBLY — UL CLASS 90 (NM520)

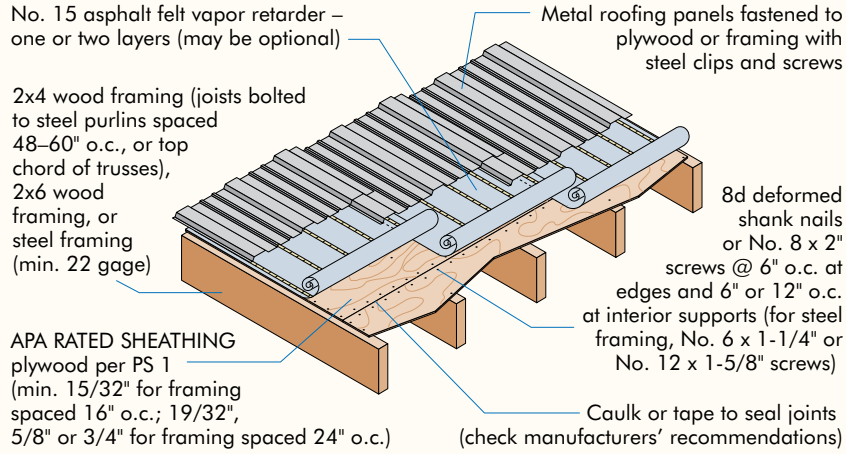


(a) Trusses or I-joists used for purlins must have chords or flanges of 1-3/4" minimum depth for plywood deck nailing.

(b) For semi-wind-resistive assemblies (Class 60), plywood deck nailing spaced 6" o.c. at all supports and roofing base sheet attached with rayon tape rows spaced 11-1/3" o.c.

(c) Install roofing base and ply sheets with roll direction parallel to plywood face grain direction, as with a panelized roof system.

FIGURE 3
METAL ROOFING PANELS — UL CLASS 90(a)



(a) Some rated assemblies and constructions incorporate OSB sheathing and proprietary products. When designing and specifying, check the Underwriters Laboratories (UL) Roofing Materials and Systems Directory (Category TGKX) for complete details on a particular assembly in UL Construction Nos. 200-500 (series). A change in details may affect the wind uplift classification of the assembly.

FM APPROVALS-TESTED ROOF ASSEMBLIES

FM Approvals (FM) tested the decking and the finish systems together and assigned uplift classification ratings for the wood roof decking and base sheet/insulation/cover board/cap-sheet combinations separately. The wood panel decking system and the finish roofing system above the wood decks were assigned different Class 1 wind uplift ratings based on that assessment. The test results were used to assign each wood structural panel system a classification that specified minimum panel thickness, maximum support spacing, minimum nail size and maximum nail spacing. Figures 4–10 of this publication show wood decking systems meeting FM classes ranging from 1-60 to 1-135.

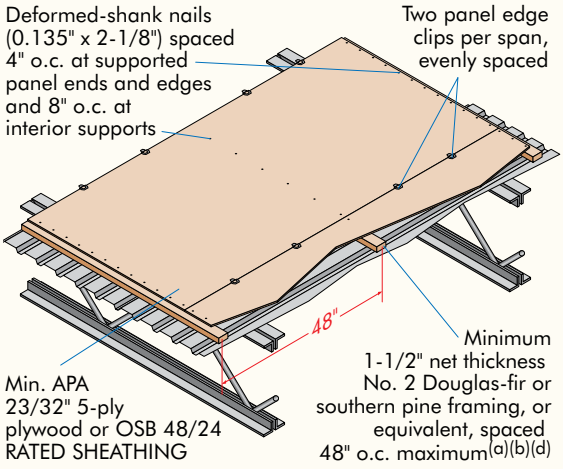
Any of the wood panel systems will work with any of the finish roofing combinations shown in Figures 11–15. The overall uplift classification of the decking system plus finish roofing system will be the lower of the two system ratings. Thus, a wood deck meeting Class 1-105 with an insulation/cover board combination meeting Class 1-90 would be rated 1-90, or a wood deck meeting Class 1-105 on an insulation/cover board combination meeting Class 1-120 would be rated 1-105.

Decks

The type of framing supports used is the designer's choice. The figures in this publication depict different framing options with each figure to show the range of choices available. The spacing of the framing in relation to the wood deck is important, however, and spacing must be followed as dictated in the figures to meet the FM classes listed. Framing supports must also be designed in accordance with local building code requirements for roof loads and anchorage. All framing must be minimum net thickness of 1-1/2 inches No. 2 Douglas-fir or southern pine or equivalent. For wood I-joists, follow manufacturer's recommendations for minimum nail spacing.

Figure 4 shows a wood deck that meets FM Class 1-60. It uses a minimum of APA 23/32-inch 5-ply plywood or OSB 48/24 RATED SHEATHING installed over framing spaced at a maximum of 48 inches o.c. The sheathing should be secured to supports using deformed-shank nails (minimum 0.135 x 2-1/8 inches) spaced a maximum of 4 inches o.c. along supported ends and edges and 8 inches o.c. along interior supports. Unsupported panel edges should be clipped using two metal panel clips evenly spaced between supports.

FIGURE 4
FM CLASS 1-60 WITH ARMA ROOF COVERING[c]



(a) Design in accordance with local building code requirements for roof loads and anchorage. All framing must be minimum net thickness of 1-1/2 inches No. 2 Douglas-fir or southern pine or equivalent. For wood I-joists, follow manufacturer's recommendations for minimum nail spacing.

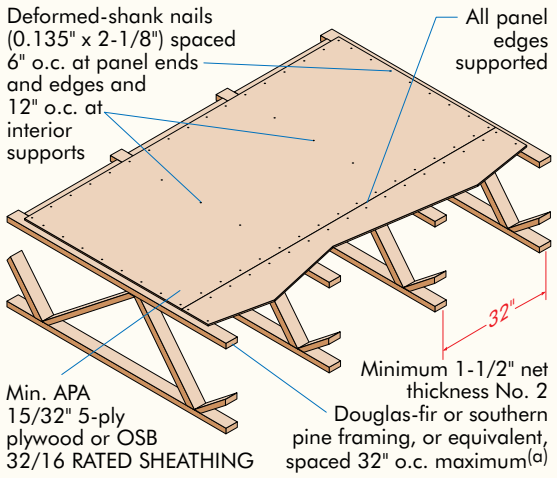
(b) Attach wood framing to min. 22 ga., 1-1/2" deep wide-rib steel roof deck with screws at 6" o.c.

(c) Panel strength axis across supports for direct-to-support spacing as shown. To install panels with strength axis parallel to supports spaced 24" o.c., as in panelized roof systems, see minimum panel requirements listed in Table 2.

(d) Wood glulams, I-joists or trusses can be used in place of the bar joists illustrated. The steel decking can be used over the wood members.

Figure 5 depicts a wood deck meeting FM Class 1-75, with a minimum 15/32-inch 5-ply APA plywood or OSB 32/16 RATED SHEATHING. Sheathing should be installed over minimum 2x framing spaced at a maximum of 32 inches o.c. using deformed-shank nails (minimum 0.135 x 2-1/8 inches) spaced a maximum of 6 inches o.c. along panel edges and 12 inches o.c. over interior supports.

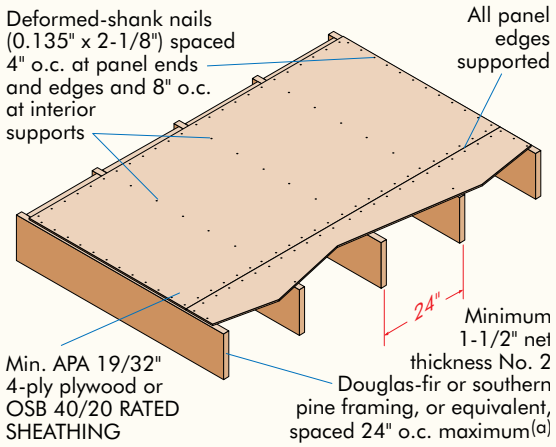
FIGURE 5
FM CLASS 1-75 WITH ARMA ROOF COVERING[b]



(a) Design in accordance with local building code requirements for roof loads and anchorage. All framing must be minimum net thickness of 1-1/2 inches No. 2 Douglas-fir or southern pine or equivalent. For wood I-joists, follow manufacturer's recommendations for minimum nail spacing.

(b) Panel strength axis across supports for direct-to-support spacing as shown. To install panels with strength axis parallel to supports spaced 24" o.c., as in panelized roof systems, see minimum panel requirements listed in Table 2.

FIGURE 6
FM CLASS 1-90 WITH ARMA ROOF COVERING[b]



(a) Design in accordance with local building code requirements for roof loads and anchorage. All framing must be minimum net thickness of 1-1/2 inches No. 2 Douglas-fir or southern pine or equivalent. For wood I-joists, follow manufacturer's recommendations for minimum nail spacing.

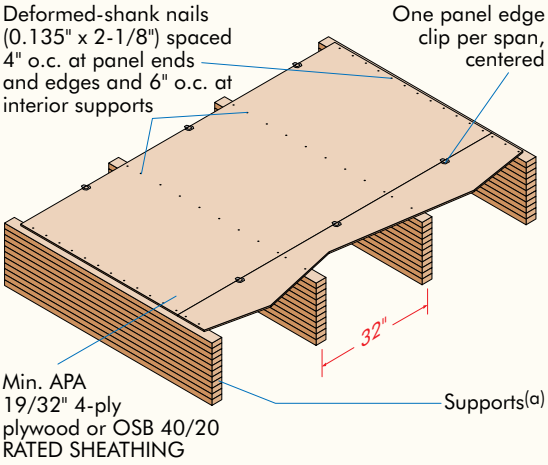
(b) Panel strength axis across supports for direct-to-support spacing as shown. To install panels with strength axis parallel to supports spaced 24" o.c., as in panelized roof systems, see minimum panel requirements listed in Table 2.

The wood deck in Figure 6 meets FM Class 1-90 by using a minimum of 19/32-inch APA 4-ply plywood or OSB 40/20 RATED SHEATHING secured to supports using deformed-shank nails (minimum 0.135 x 2-1/8 inches) spaced a maximum of 4 inches o.c. along the perimeter ends and edges and at 8 inches o.c. along interior supports. The panels are supported on framing spaced a maximum of 24 inches o.c.

FM Class 1-105 can be achieved by using the deck illustrated in Figure 7. A minimum of 19/32-inch 4-ply APA plywood or OSB 40/20 RATED SHEATHING over framing spaced a maximum of 32 inches o.c. The sheathing is attached to supports using deformed-shank nails (minimum 0.135 x 2-1/8 inches) spaced a maximum of 4 inches o.c. along supported panel edges and at a maximum of 6 inches o.c. along interior supports. Unsupported panel edges are clipped using one metal panel edge clip centered between the supports.

Figure 8 shows a wood deck meeting FM Class 1-120 using a minimum of 19/32-inch 4-ply plywood or OSB 40/20 APA RATED SHEATHING secured to supports using deformed-shank nails (minimum 0.135 x 2-1/8

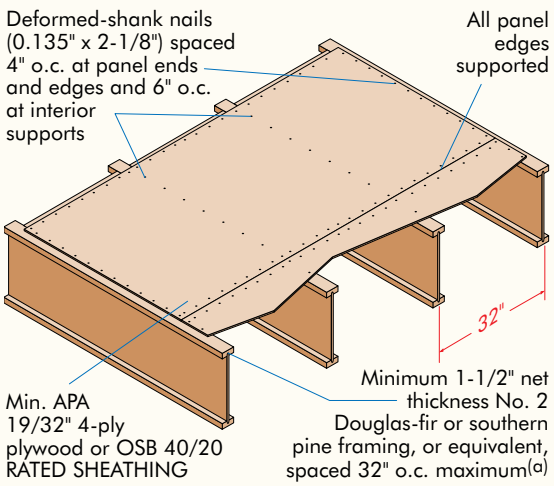
FIGURE 7
FM CLASS 1-105 WITH ARMA ROOF COVERING[b]



(a) Design in accordance with local building code requirements for roof loads and anchorage. All framing must be minimum net thickness of 1-1/2 inches No. 2 Douglas-fir or southern pine or equivalent. For wood I-joists, follow manufacturer's recommendations for minimum nail spacing.

(b) Panel strength axis across supports for direct-to-support spacing as shown. To install panels with strength axis parallel to supports spaced 24" o.c., as in panelized roof systems, see minimum panel requirements listed in Table 2.

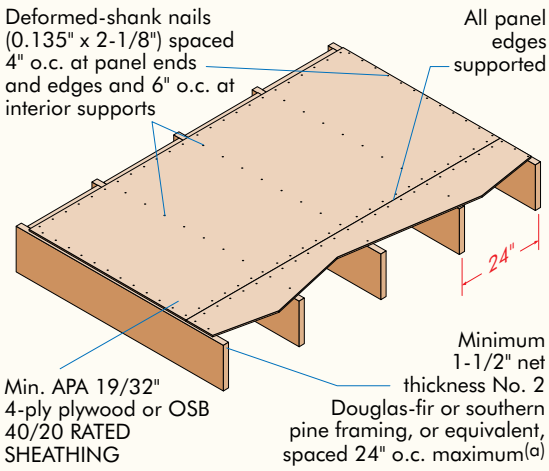
FIGURE 8
FM CLASS 1-120 WITH ARMA ROOF COVERING[b]



(a) Design in accordance with local building code requirements for roof loads and anchorage. All framing must be minimum net thickness of 1-1/2 inches No. 2 Douglas-fir or southern pine or equivalent. For wood I-joists, follow manufacturer's recommendations for minimum nail spacing.

(b) Panel strength axis across supports for direct-to-support spacing as shown. To install panels with strength axis parallel to supports spaced 24" o.c., as in panelized roof systems, see minimum panel requirements listed in Table 2.

FIGURE 9
FM CLASS 1-135 WITH ARMA ROOF COVERING[b]



(a) Design in accordance with local building code requirements for roof loads and anchorage. All framing must be minimum net thickness of 1-1/2 inches No. 2 Douglas-fir or southern pine or equivalent. For wood I-joists, follow manufacturer's recommendations for minimum nail spacing.

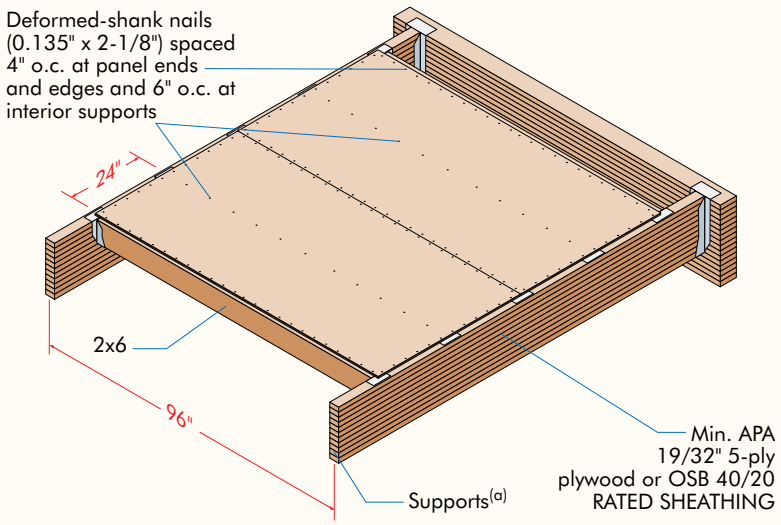
(b) Panel strength axis across supports for direct-to-support spacing as shown. To install panels with strength axis parallel to supports spaced 24" o.c., as in panelized roof systems, see minimum panel requirements listed in Table 2.

inches) spaced a maximum of 4 inches o.c. along panel edges and 6 inches o.c. along interior supports. Framing should be spaced at a maximum of 32 inches o.c.

In Figure 9, the wood deck meets FM Class 1-135. A minimum of 19/32-inch 4-ply plywood or OSB 40/20 APA RATED SHEATHING is secured to supports using deformed shank nails (minimum 0.135 x 2-1/8 inches) spaced a maximum of 4 inches o.c. along panel edges and 6 inches o.c. along interior supports. The sheathing is supported on framing spaced at a maximum of 24 inches o.c.

Figure 10 illustrates a panelized roof system that meets the panel attachment requirements for the various FM Windstorm Classifications. See Table 2 for the minimum panel thickness and number of plies

FIGURE 10
FM CLASS 1-135 WITH ARMA ROOF COVERING[b]



(a) Design in accordance with local building code requirements for roof loads and anchorage. All framing must be minimum net thickness of 1-1/2 inches No. 2 Douglas-fir or southern pine or equivalent. For wood I-joists, follow manufacturer's recommendations for minimum nail spacing.

(b) To install panels with strength axis parallel to supports spaced 24" o.c., as illustrated, see minimum panel requirements listed in Table 2.

required (for plywood) to meet the minimum strength and attachment requirements for each FM Windstorm Classification using a typical panelized roof system installation with panel strength axis parallel to supports. The maximum support spacing is 24 inches o.c. for a typical panelized roof system.

The minimum panel thickness is based on the panels tested by FM or the minimum bending capacity required to resist the design uplift pressures, whichever requirement is more restrictive. For instance, if the tested system were a 4-ply plywood panel with the panel strength axis across supports, a panelized roof system with the panel strength axis parallel to supports may require a 5-ply panel because of its superior cross-panel strength. The design uplift pressures are based on International Building Code Table 1609.6.2.1(2) for components and cladding at corner locations and ASCE 7-05 (3-second gust).

Insulation/Cover Boards

The insulation/cover boards fill a layer of the roof system between the wood deck and the roof covering. For all the FM tested figures illustrated here, an Asphalt Roofing Manufacturers Association (ARMA) roof covering[1] must be applied using hot asphalt. ARMA roof coverings can be built up or modified bitumen. For more information on roof coverings, consult the ARMA web site www.asphaltroofing.org.

Figure 11 illustrates an insulation/cover board combination that meets FM Class 1-90. A minimum thickness of 1-1/2 inches is required for the foam insulation, which is attached to the wood deck using 3-inch stress plate fasteners applied at a maximum tributary area of 1.45 square feet per fastener (a maximum of 14 inches o.c.). A minimum 1/2-inch fiberboard cover board, adhered with hot asphalt and walked in, covers the insulation.

In Figure 12, which also meets FM Class 1-90, an ARMA base sheet is secured to the wood deck with rayon tape and staples. Strips of base sheet overlap for a minimum of 2 inches, and one strip of rayon tape is placed along the center of the overlap. Additional tape is placed in three evenly spaced rows between the laps. Staples (7/16-inch crown x 7/8-inch 16 gage) are spaced a maximum of 5 inches o.c. along each row of rayon tape. Hot asphalt adheres an ARMA ply sheet to the base sheet.

FIGURE 11
FM CLASS 1-90

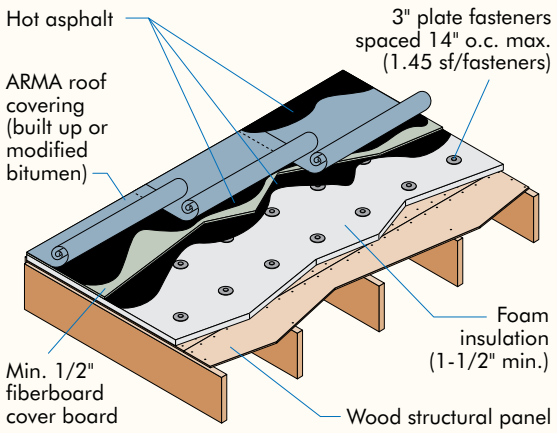
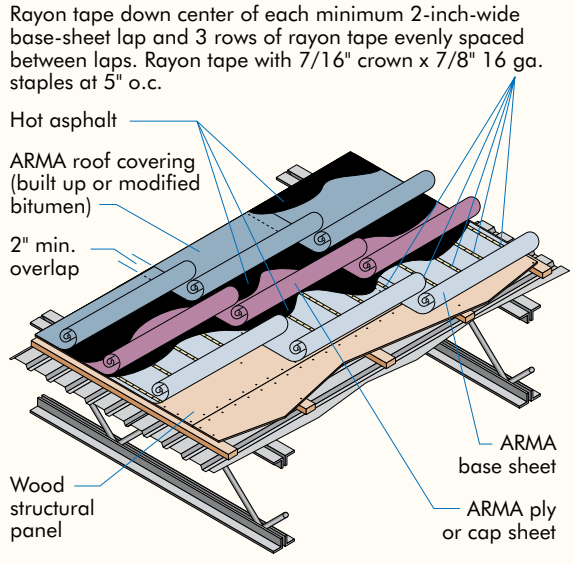


FIGURE 12
FM CLASS 1-90



[1] ARMA roof coverings consist of minimum 3-ply built-up roof or minimum 2-ply modified bitumen roof coverings. The bottom sheet is mechanically fastened or is adhered to the substrate with hot asphalt. Additional sheets are adhered with hot asphalt.

An ARMA base sheet is also used in Figure 13, which meets FM Class 1-105. In this case, the base sheet overlaps a minimum of 2 inches, and 3-inch plate fasteners should be spaced a maximum of 9 inches o.c. at the center of the base sheet overlap. Evenly spaced between the laps are three rows of 3-inch plate fasteners spaced a maximum of 9 inches o.c. on each row.

FIGURE 13
FM CLASS 1-105

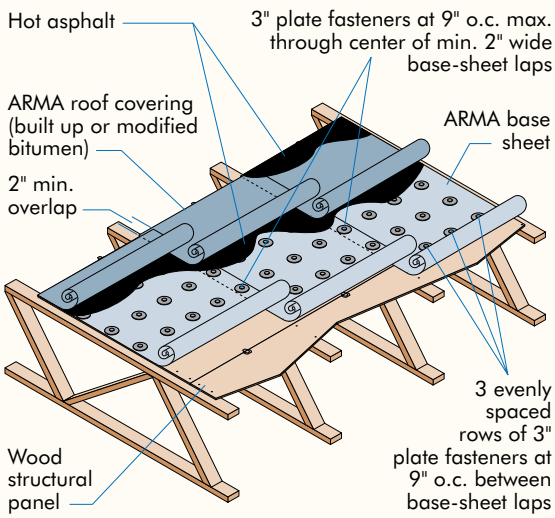


Figure 14 provides an insulation/cover board combination that meets FM Class 1-120. A layer of foam insulation, ranging between 2 and 12 inches thick, is adhered to the wood structural panels using 3-inch plate fasteners applied at a maximum contributory area of 1.45 square feet per fastener (a maximum of 14 inches o.c.). The insulation is covered with a minimum 1/2-inch fiberboard cover board, adhered with hot asphalt and walked in.

The assembly in Figure 15 meets FM Class 1-135. In this assembly, a foam insulation base layer directly above the wood sheathing is optional, but a minimum of a 2-inch composite or foam nail base is required. The maximum thickness of the optional foam insulation and the foam nail base – the total insulation thickness – is 12 inches. The nail base and optional insulation attach to the sheathing with 3-inch plate fasteners applied at a rate of 1.45 square feet per fastener (a maximum of 14 inches o.c.).

FIGURE 14
FM CLASS 1-120

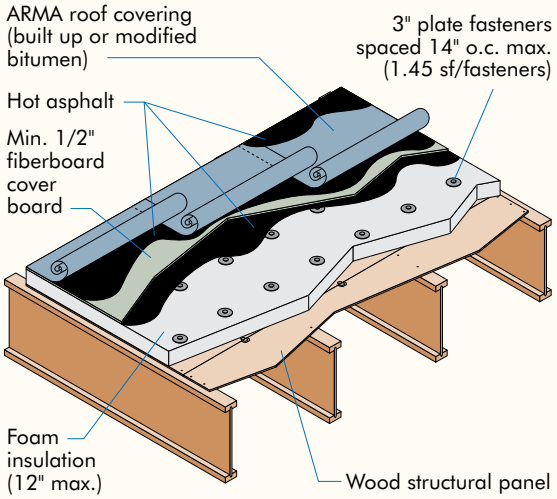
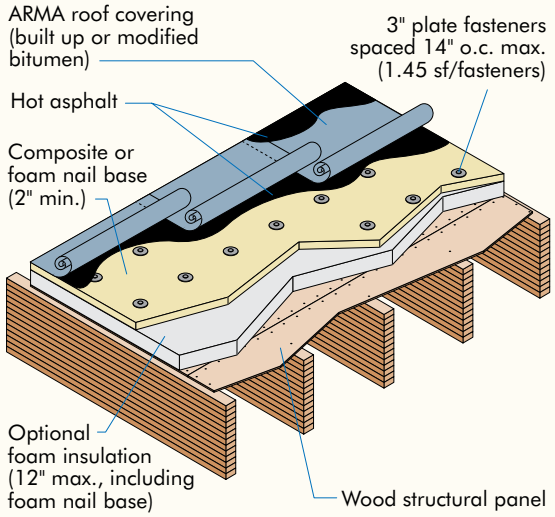


FIGURE 15
FM CLASS 1-135



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APA – The Engineered Wood Association is a nonprofit trade association of and for structural wood panel, glulam timber, wood I-joist, laminated veneer lumber and other engineered wood product manufacturers. Based in Tacoma, Washington, APA represents approximately 150 mills throughout North America, ranging from small, independently owned and operated companies to large integrated corporations.

Always insist on engineered wood products bearing the mark of quality – the APA or *APA EWS* trademark. Your APA engineered wood purchase is not only your highest possible assurance of product quality, but an investment in the many trade services that APA provides on your behalf. The Association's trademark appears only on products manufactured by member mills and is the manufacturer's assurance that the product conforms to the standard shown on the trademark.

For panels, that standard may be an APA performance standard, the Voluntary Product Standard PS 1-95 for Construction and Industrial Plywood or Voluntary Product Standard PS 2-04, Performance Standards for Wood-Based Structural-Use Panels. Panel quality of all APA trademarked products is subject to verification through APA audit.

APA's services go far beyond quality testing and inspection. Research and promotion programs play important roles in developing and improving plywood and other panel construction systems, and in helping users and specifiers to better understand and apply engineered wood products. For more information on wood construction systems, contact *APA – The Engineered Wood Association*, 7011 S. 19th St., Tacoma, Washington 98466, or visit the Association's web site at www.apawood.org.

We have field representatives in many major U.S. cities and in Canada
who can help answer questions involving APA trademarked products.
For additional assistance in specifying engineered wood products, contact us:

APA – THE ENGINEERED WOOD ASSOCIATION

HEADQUARTERS

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