

# WOOD-BASED PANELS FOR ROOF DECKS

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This paper describes wood-based structural panels used for roof decks and the system used to rate these products so they can be used successfully. The rating system utilizes performance tests which are related to the in-service conditions that must be satisfied. The performance tests are described. Supplemental tests to demonstrate performance under various roof coverings are also described. The identification on the panels directly shows the application recommendation in the form of a maximum span for the most common live load conditions in the United States.

## PLYWOOD ROOF DECKS

Construction plywood has been used as a roof deck in the United States under various types of roofing for more than 40 years. This product used as a roof deck is typically  $\frac{1}{2}$  inch or thicker, though  $\frac{3}{8}$ -inch and  $\frac{5}{8}$ -inch panels are sometimes used. Plywood, manufactured under U.S. Product Standard PS-1, Construction and Industrial Plywood\*, must meet certain requirements for the product to carry the PS-1 identification. The requirements relate to species of wood used in the various layers, veneer thicknesses, glue-bond durability, tolerances and many other details essential to satisfactory performance.

Plywood use recommendations have been developed by the American Plywood Association (APA)\*\*. These recommendations are based on technical data developed by the industry over many years, supplemented by information gained from long-term experience.

Plywood is easily fastened to wood supporting members and also readily receives mechanical fasteners used to attach roof coverings.

## SPAN RATING

Beginning in 1966 with the promulgation of U.S. Product Standard PS 1-66 for Softwood Plywood, Construction and Industrial, sheathing panels carry a two-part Span Rating or Identification Index. For example, a 32/16 number indicates that the panel is suitable for a roof span of 32 inches between supports and a floor span of 16 inches. This marking system is illustrated in Figure 1. This is a practical system that indicates to the user how the panel can be used in normal applications. This is an important concept since some species used in the manufacture of plywood are only about half as stiff as others, and therefore it is not sufficient to

simply specify panel thickness. PS 1-66 also established species groupings which facilitated their utilization in the structural panels. The rating system is based on the construction of the panel, including species used for face and back plies; that is, the thickness of the panel and the veneers, their location within the panel and the species.

This rating system has worked very well in the United States. Live roof loads in the United States vary typically from about 20 pounds per square foot to 40 or 50 pounds per square foot. That was the reason for establishing the rating system based on spacing between supports. For other parts of the world, perhaps a rating system based on loads for a fixed or most common span could also be used.

The Span Rating constitutes a performance rating because the span capability is related to the panel end use. Therefore, panels that carry a Span Rating are called Performance-Rated Panels.

## NEW PANEL PRODUCTS

During the last 10 years there has been rapid development in the production of wood-based structural panel products other than all-veneer plywood. Since 1980, the members of APA have produced, in addition to plywood, other structural panels such as COMPLY, oriented strand board and waferboard. These are illustrated in Figure 2.

There are several reasons for this. One is the availability of machinery to produce these types of products, particularly waferboard and oriented strand board. Second is the ability to use wood species which are now either underutilized or not used at all for structural purposes, thus increasing their value. With these products it is also possible to use much more of the tree than in the case of plywood or other solid wood products. The individual pieces or flakes of wood used in these new products can be oriented with regard to the major and minor panel dimensions and can be layered within the panel, tending to give the same performance as regular plywood. Thus, by selection of species, resin content, density and orientation, the properties desired in the final product can be achieved.

## IN-SERVICE LOADS

The next step in determining the suitability of these new products in typical sheathing applications was to establish the service loads and construction loads which they should be capable of supporting. An extensive amount of research was conducted to evaluate various service and construction loads likely to be encountered. The study involved roof decks, wall sheathing, subflooring and single-layer flooring, but the discussion here will be limited to the investigation of roof sheathing.

\*Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

\*\*Refer to Appendix for information on the American Plywood Association.

During construction, it's possible that concentrated loads can be placed on the roof. This may be in the form of roofing materials placed in a small area, including rolls of asphalt roofing, gravel or mechanical equipment temporarily placed in a location, or in a concentration, different from where it is finally installed. In addition, there can be mechanical equipment operating on the roof during the application of the roof covering (Figure 3).

In this investigation, felt layers, hot carriers, gravel spreaders and material carts were all considered. It was found that the greatest anticipated load concentrated in a small area is a hot carrier. This has a total weight of 700 pounds which, when in use, spreads that load to two wheels. Thus, a total load per wheel of 350 pounds can be expected. We increased this to 400 pounds and established that figure as a concentrated load requirement.

Because roofing rolls and other building materials can be dropped on the roof, there is also an impact load requirement. In addition, there's a requirement that panels support at least a 150-pound-per-square-foot uniform load when tested in a two-span condition, and a deflection limit is imposed under a 35-pound-per-square-foot load. This satisfies requirements of most areas of the country for snow loads when panels are used at their full rated span. For one reason or another, panels are often used at a lesser span and, of course, are then able to carry a much higher uniform load.

The effect of workmen walking on the roof was also considered. The 400-pound test load was judged to be an entirely adequate requirement. This is also well above building code requirements in the United States.

## LABORATORY TESTS

Considerable research went into studies to establish reasonable laboratory tests that would have effects comparable to those induced by actual service loads. For example, tests to establish uniform load capacity have always been awkward. Dead weight loading has the disadvantage of covering up the panel under test and creating a dangerous situation at time of failure. It is also slow. Therefore, a vacuum box was selected. In this system, the framework is sealed to the laboratory floor. The panel under test is placed over supports in the open top of the framework, and the surface sealed using 6-mil polyethylene. We found that the polyethylene can be adequately sealed simply by using wide masking tape around its perimeter. Following this, a vacuum is drawn on the undersurface of the panel. This allows air pressure to apply a uniform load to the upper surface. If there is a failure, the panel fails down into the box without hazard to the operator. Furthermore, it's possible to observe the upper surface of the panel since it's readily visible through the clear polyethylene.

The method for applying concentrated loads was submitted to ASTM and has now become a standard test method (Figure 4). The procedure for conducting impact tests has also been incorporated in the same ASTM test method.

## CRITERIA

Studies were made of the performance of plywood other panel products which have been used successfully in these applications for many years. Criteria were established which resulted in performance comparable to that of other

materials which have performed satisfactorily under roof coverings.

## QUALIFICATION

The process of qualifying new products to determine whether they meet the performance standards is an essential element of the program. The following steps are included in the APA qualification program.

### Selection of the Samples

APA employees, whom we call quality supervisors, go to the mill during the production run and make a random selection. Up to 60 panels of each thickness are required for qualification. The sample is not entirely random since we require that near-minimum panels be selected. The reason for this is that the Mill Specification, which includes control values for production, is based on the sample. Thus, if the sample selected is near the high end of the typical product produced, it would be impossible for the production panels to meet the Mill Specification control values. That's the reason for selecting near-minimum panels in terms of grade, density and thickness. These panels are then shipped to Tacoma, Wash. to the APA Research Center for performance testing.

### Testing

The testing procedure for these wood-based structural panels requires that, to qualify, all 10 panels tested must support the 400-pound concentrated load and the 150-pound-per-square-foot uniform load. However, there is a procedure in which if one of the 10 specimens fails, a second group of 10 panels can be tested. To qualify for the Span Rating, all of the second group must support the required load. This means that only one out of 20 panels could fail to come up to the 400-pound concentrated or the 150-pound-per-square-foot uniform load. This is an extremely severe requirement.

### Mill Specification

If the panels meet the APA Performance Standards, a Mill Specification is issued. This provides control numbers for use by the mill and the APA quality supervisor in controlling the product.

## QUALITY ASSURANCE

The APA quality supervisor makes weekly unannounced visits to the mill to audit the work of the in-plant quality control manager. He also collects product samples for testing at one of the seven regional APA laboratories. If the results of the APA lab tests do not agree with the in-plant quality control work, or if the production panels fail to meet the control numbers in the Mill Specification, further intensive sampling is conducted. If the mill is unable to maintain the level of quality required, the APA trademarks are withdrawn and may not be reinstated until the product has been requalified or until quality is again at the required level.

## ACCEPTANCES

Since the APA program was initiated in 1980, 459 Mill Specifications for plywood products and 62 Mill Specifications for composite board, waferboard, oriented strand board and structural particleboard have been issued. The products are recognized throughout the United States

through National Evaluation Service Report No. 108. The National Evaluation Service is a joint activity of the Council of American Building Officials which is made up of the three building official organizations that promulgate model building codes. NER reports are recognized in the same way as reports issued by the individual official building organizations. In addition, the Federal Housing Administration is using APA qualification reports and issuing material releases on individual products.

### UNDERWRITERS LABORATORIES TESTS

Roof coverings are rated according to their ability to retard the spread and penetration of an external fire which may be caused by flames along the edge of a roof or by burning brands landing on the roof. When roof coverings are tested, they are tested over a specific roof deck. In the past, Class A and B roofs have been tested over  $\frac{1}{2}$ -inch plywood. Recently Underwriters Laboratories has conducted a series of tests for the American Plywood Association which demonstrated that Class A and B roof coverings can be used over  $\frac{3}{4}$ -inch plywood. This is a new thickness plywood panel which, when made with specific layups and certain species can be rated  $\frac{3}{4}$ —the same as  $\frac{1}{2}$ -inch Group 1 plywood under Product Standard PS 1. Because PS 1-83 includes performance language for plywood, these panels can now be identified with the PS 1-83 mark.

### APA TESTS

The APA has also conducted tests to evaluate the performance of two roof coverings when applied over  $\frac{1}{2}$ -inch plywood and  $\frac{3}{4}$ -inch nonveneer panels over supports 24-inch on center. This is a very common construction in the United States, and one in which there is a great deal of interest on the part of roofing manufacturers.

One test involved rolling loaded wheels across unsupported panel edges. This is illustrated in Figure 5. Weights were placed on the platform so that the wheel load was 200 pounds. This was increased to 300 pounds in subsequent testing. The wheel track is perpendicular to the panel joint, and the plywood strip on which the wheel rolls is jointed immediately over the panel joint. This causes the full differential deflection to occur from one panel edge to the next.

Two types of roofing were tested. One involved a base sheet and two ply sheets, the other a base sheet, a ply sheet and a cap sheet. The wheel traversed each joint a total of

4,000 times. Following application of the repetitive loading, the roof was tested for leaks using an open bottom cylinder with a head of 12 inches of water. No leaks were observed. There was some indication of distress to the base sheet. However, the damage was not sufficient to cause leakage. Four thousand passes of loads up to 300 pounds is extremely severe and would represent a very unusual situation. Furthermore, lumber framing or metal "H" clips were not used to help transfer load from one panel edge to the next.

### SUMMARY

There are many wood-base structural panels being used for roof decks. These structural-use panels include plywood, composite board, waferboard, oriented strand board and structural particleboard. These panels vary widely in their composition and performance capability. The APA Performance Standards provide a logical means for rating these panels in terms of their span capability, and are a method that can be conveniently used by specifiers of roof decks to assure that performance will be consistent with application requirements.

### APPENDIX

#### The American Plywood Association

The American Plywood Association began in 1933 as a trade association representing the softwood plywood industry. Until 1980, products produced by members of the American Plywood Association were structural plywood panels. These are used widely in building construction for roof sheathing, wall sheathing, subflooring, single-layer flooring and structural components. Industrial applications include containers, pallets, industrial shelving and a myriad of other applications.

Upon promulgation of performance standards for wood-based structural-use panels in 1980, APA members began producing a variety of nonveneer products. These include COMPLY (veneer in combination with reconstituted wood), oriented strand board (OSB), waferboard—both oriented and non-oriented—and structural particleboard.

In addition to conducting research on new applications of structural-use panels, the American Plywood Association engages in promotion, quality assurance and seeks acceptance for these products by regulatory bodies, including building codes and the federal government.

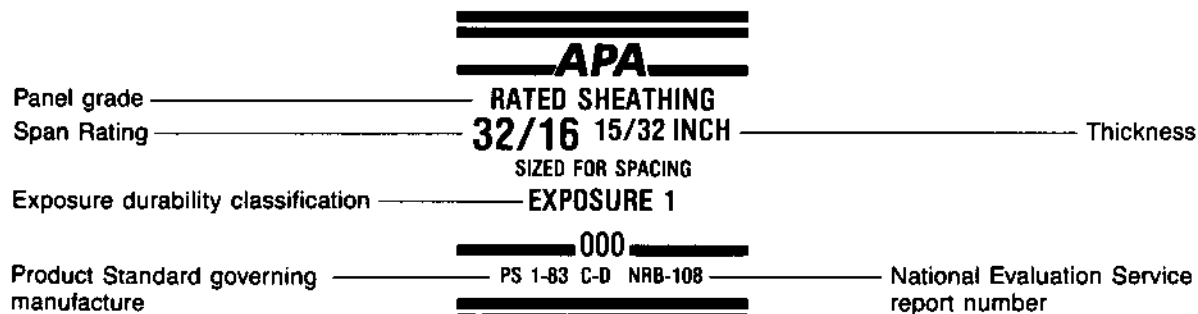


Figure 1 Typical trademark showing Span Rating

**PLYWOOD****COMPOSITE (COMPLY®)**

Panels of reconstituted wood cores bonded between veneer face and back plies.

**WAFERBOARD**

Panels of compressed wafer-like particles or flakes randomly or directionally oriented.

**ORIENTED STRAND BOARD**

Panels of compressed strand-like particles arranged in layers (usually three to five) oriented at right angles to one another.

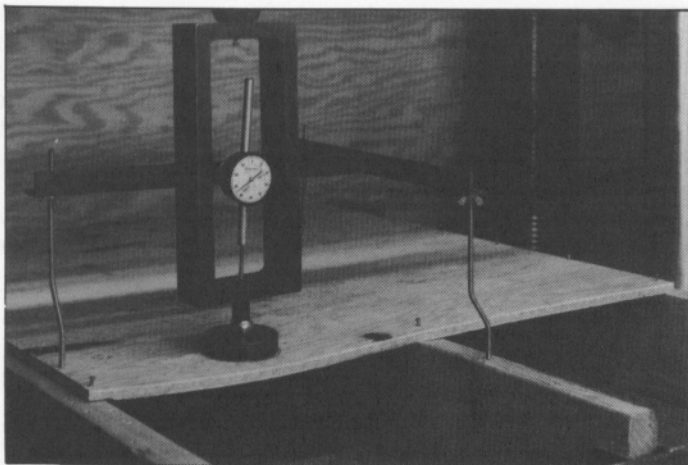
**STRUCTURAL PARTICLEBOARD**

Panels comprised of small particles usually arranged in layers by particle size, but not usually oriented.

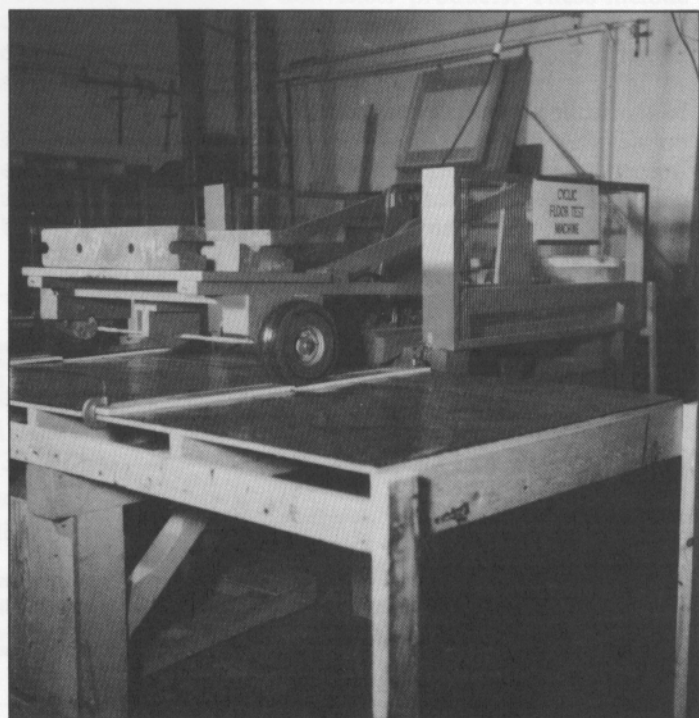
Figure 2 Types of Performance-Rated products



*Figure 3 Roofing felt layer in operation*



*Figure 4 Typical concentrated load test showing 3-inch loading disc and deflection gauge*



*Figure 5 Repetitive load test on roofing applied over Performance-Rated roof deck*