APA Technical Topics
TT-028C MAY 2016

Moisture-Related Dimensional Stability

Wood structural panels are hygroscopic. Panel moisture content is a function of relative humidity (and temperature to a very slight degree) when not exposed to direct wetting. In construction applications, such as roofs, walls and floors, the panels in service are protected from wetting, so the panel moisture content (MC) is primarily a function of humidity.

Panels may be exposed to direct wetting during construction and during the service life for some applications. When exposed to direct wetting, the moisture content is influenced by wetting time and by panel variables that affect capillarity, such as veneer species of plywood and wax additives of OSB.

An APA study evaluated the equilibrium moisture content of structural panels. Results indicated that the moisture content of plywood and OSB at a given relative humidity is lower than the published values for solid wood. The APA data below are based on panels reaching a steady state moisture content at the tabulated relative humidity and a temperature of approximately 70°F.

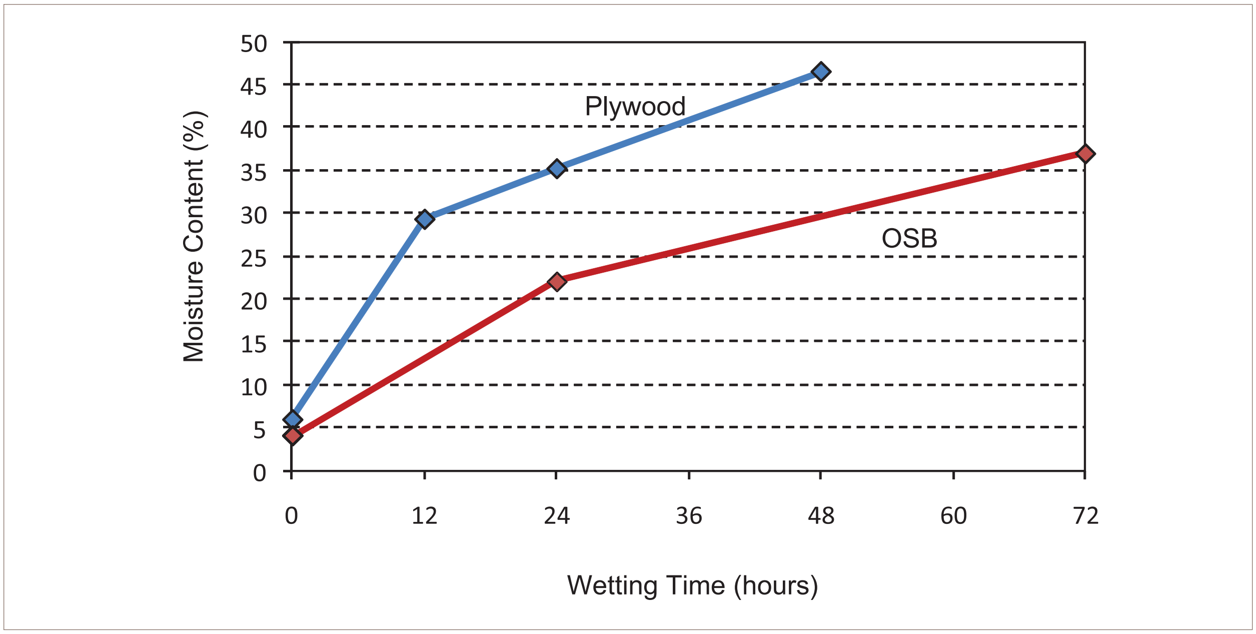
Table 1. Equilibrium moisture content of solid wood and structural panels at 70°F (21°C)

Relative Humidity	Moisture Content (%)		
	Solid Wood[a]	Plywood	OSB
10	2.5	1.2	0.8
20	4.5	2.8	1.0
30	6.2	4.6	2.0
40	7.7	5.8	3.6
50	9.2	7.0	5.2
60	11.0	8.4	6.3
70	13.1	11.1	8.9
80	16.0	15.3	13.1
90	20.5	19.4	17.2

a. From *Wood Handbook—Wood as an Engineering Material* by U.S. Forest Products Laboratory

A standardized wetting cycle was developed by APA and has subsequently been accepted in various performance and manufacturing standards. The method wets one exposed surface only with a water spray system, and the back side is exposed to the resultant high humidity. The procedure was designed to simulate exposure of a panel to weather, such as when wetted during construction. The wetting cycle is used to evaluate dimensional stability and is used prior to structural tests of sheathing panels. Figure 1 relates wetting time to panel moisture content for 7/16 Performance Category OSB and 1/2 Performance Category plywood.

Figure 1. Panel Moisture Content During Wetting



DIMENSIONAL STABILITY

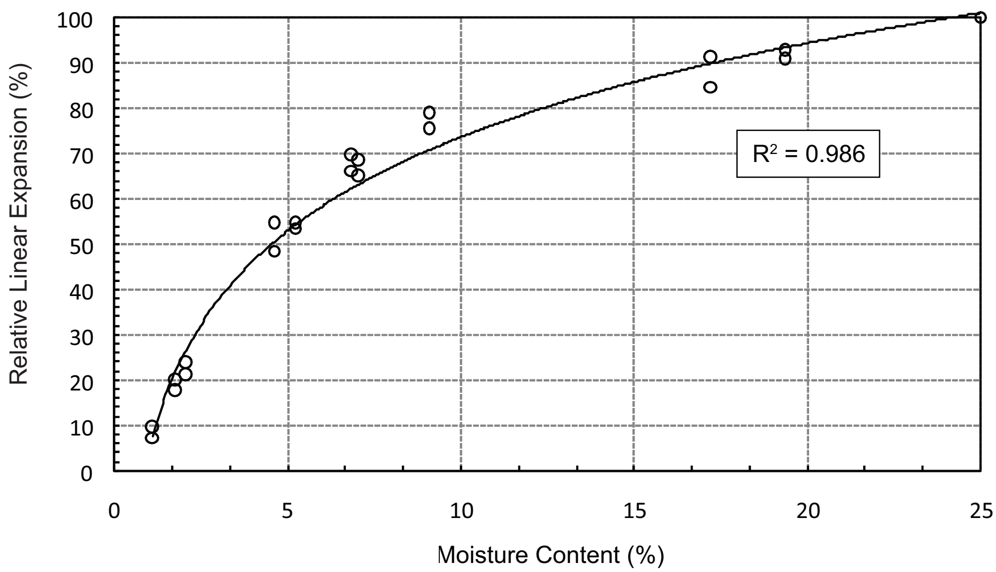
The moisture content of structural panels is generally 2 to 8 percent when manufactured. When exposed to elevated humidity or wetting after manufacture, the resultant increase in moisture content leads to dimensional increase in thickness, length and width. The increase in length or width is reported as linear expansion. The thickness increase is called thickness swell.

Linear Expansion

Linear expansion of structural panels is generally evaluated by measuring length increase due to a change in moisture condition. A steady-state moisture condition can be achieved by oven drying, humidity exposure, or vacuum soaking. Linear expansion can also be measured following exposure to moisture, such as a one-sided water spray, to simulate wetting typical during construction site exposure.

Linear expansion by humidity exposure is typically conducted by using standardized initial and ending humidities, such as 50 and 90 percent relative humidities. Since humidity exposure in actual applications can vary, APA undertook a study to evaluate the relative expansion of structural panels across interim moisture conditions from oven dry to complete saturation. The relative linear expansion (RLE) and thickness swell was determined at various equilibrium moisture contents by exposure to various levels of relative humidities. The RLE at each moisture content was determined as a percentage of total expansion from oven dry to complete saturation by a vacuum-soak cycle. The relation is shown in Figure 2.

Figure 2. Relative Linear Expansion (RLE) as a Function of Moisture Content (MC)



The RLE is a function of moisture content as expressed below:

$RLE = 5.125 + 69.109\ LOG_{10}\ (MC)$

Where:

RLE = relative linear expansion at reference moisture content as a percent of total from oven dry to saturated (%)

MC = reference moisture content (%)

The above relation can be used to estimate actual expansion when the linear expansion from oven drying to saturation is known. Approximate moisture content of panels after manufacturing is 2 to 4 percent for OSB and 5 to 8 percent for plywood. Some acclimation to ambient humidity conditions may occur during transit. Table 2 provides information on linear expansion from oven dry to saturation (i.e., vacuum soak). The oven dry/vacuum soak cycle represents the extreme amount of potential expansion which may occur. It is not representative of expansion which normally occurs in service.

Table 2. Linear Expansion from Oven Dry to Vacuum Soak

Performance Category and Panel Type	No. Tested	Along Direction[a]		Across Direction[b]	
		Avg (%)	COV (%)	Avg (%)	COV (%)
3/8–1/2 Plywood	203	NT[c]	NT	0.34	44.4
19/32–3/4 Plywood	187	NT	NT	0.31	35.1
7/16 OSB	734	0.23	25.7	0.38	20.0
23/32 OSB	499	0.22	25.6	0.38	21.1

a. Along direction refers to the strength direction

b. Across direction refers to the perpendicular-to-strength direction

c. NT = not tested

The effect of linear expansion of structural panels may lead to buckling of panels after they are nailed to supports. The buckling potential has been studied by APA and reported in *Research Report 144, Predicting Buckling Performance of Plywood Composite Panels for Roofs and Floors,* Form D460, and *Research Report 149, Dimensional Performance of Wood-Based Siding,* Form L310.

APA's use recommendations recognize potential for expansion of structural panels. Gapping of panel edges provides room for panel expansion prior to developing axial compression which can lead to buckling. Techniques to minimize buckling are addressed in APA use recommendations and Technical Notes.

Thickness Swell

Thickness swell of structural panels is evaluated by techniques similar to those for testing linear expansion. Thickness swell can be evaluated using steady-state humidity cycles or direct wetting. Unlike linear expansion, thickness swell is sensitive along panel edges since the end grain of the fiber increases capillarity. For that reason, thickness swell measurements are typically focused on the swell near the panel edge. In addition to the above moisture cycles, thickness swell is frequently measured using the 24-hour soak specified in ASTM Standard D1037.

The thickness swell of plywood is primarily related to the radial expansion of the wood species with some increase expected from release of compression set that occurs during pressing. The thickness swell of OSB is generally greater than solid wood due to release of compaction stress created during pressing.

APA undertook a study to evaluate the relative thickness swell (RTS) of structural panels across interim moisture conditions from the oven-dried condition to complete saturation. The RTS was determined at various equilibrium moisture contents by exposure to various humidities. Unlike linear expansion, thickness swell increases uniformly as a function of moisture content. The RTS can be expressed as below:

$$RTS = 4.0 \times MC$$

Where:

RTS = relative thickness swell at reference moisture content as a percent of total from oven dried to saturated (%)

MC = reference moisture content (%)

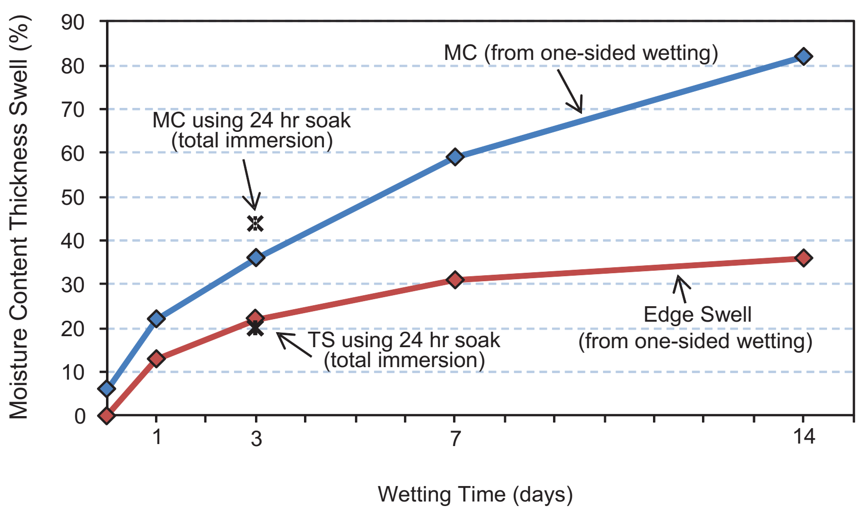
The above relation can be used to estimate actual thickness swell when the thickness swell from oven drying to saturation is known. Table 3 provides information on thickness swell for structural panels when measured using the oven-dry-to-saturation cycle.

Table 3. Thickness Swell from Oven Dry to Vacuum Soak

		Thickness Swell OD-VS	
Performance Category and Panel Type	No. Tested	Average (%)	COV (%)
3/8–1/2 Plywood	203	9.4	19.3
19/32–3/4 Plywood	187	8.8	18.0
7/16 OSB	154	32.9	17.1
23/32 OSB	61	28.9	15.1

Since thickness swell is especially sensitive to one-sided wetting, such as during construction, other methods, such as the 24-hour soak or water spray methods, are also used to test thickness swell as applicable to construction applications. Figure 3 presents the relation between wetting time and thickness swell of OSB sheathing panels. Note that the thickness swell after 24 hours of total water immersion is about the same as three days of one-sided wetting.

Figure 3. OSB Sheathing Response to One-Sided Wetting



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