TECHNICAL NOTE

Effect of Setting during Construction on Properties of Douglas-Fir Plywood and Oriented Strandboard Flooring

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Abstract

The effects of rainfall exposure on panel integrity were investigated for oriented strandboard and plywood. Both panel materials experienced substantial increases in moisture content and thickness with limited rainfall exposure and these were coupled with decreases in flexural properties. The results showed that even short-term rainfall exposure was detrimental to the properties of both materials and emphasized the importance of protecting these materials during construction.

Houses built in regions with moist winters as, for example, in the Pacific Northwest of North America, can be subjected to considerable wetting during construction. Nowhere is this more apparent than on subflooring installed before the roof is completed. In most residential construction, dimension lumber subflooring overlain with either plywood or oriented strandboard (OSB) is used to create a smooth surface suitable for the final flooring material. These horizontal surfaces create areas for collection and pooling of water that eventually soaks into the panels, creating the potential for swelling and deformation. While the potential for water absorption and swelling of flooring materials is well known (Wu and Piao 1999, Gu et al. 2005, Garay M. et al. 2009, Kojima et al. 2009), there is relatively little guidance for builders concerning how long this damage takes to occur in practice. The objective of study was to determine the effects of natural rainfall exposure on the properties of OSB and plywood panels.

Materials and Methods

Douglas-fir plywood and mixed hardwood OSB panels (19 mm thick) were obtained locally and cut into test samples measuring 19 by 77 by 508 mm. One hundred twenty (120) samples were prepared for each material. Each panel was edge sealed with an elastomeric paint that retarded moisture flow. The coating was applied to slow down the water uptake on the edges and simulate boundary conditions of a larger panel. The panel samples were conditioned to a constant weight at 65 percent relative humidity (RH) and 23°C before being weighed. Control samples were also conditioned before being weighed and tested. Calipers were used to measure panel thickness at three points; these locations were marked so that they could be measured over the exposure period. The panels were exposed so that the large face was horizontal on racks that were approximately 1 m above the ground. The panels were exposed from January (2012) during the wet winter months until June (2012) when rainfall had abated. Rainfall totals were collected from the campus weather station. Although this station collects an array of data, only daily rainfall data are reported.

Panel condition was assessed after 6, 25, 92, 148, and 193 days of exposure by weighing each panel and then measuring the thickness at the original sampling points. All but 15 samples of each material were returned to the exposure site. The 15 samples that were removed were reconditioned to a constant weight at 23°C and 65 percent RH before being subjected to a center-point loading to failure on an Instron Universal Testing Machine at a cross head speed of 5 mm/min. The specimen dimensions were selected to provide a span-to-depth ratio of 24 with a 25-mm overhang on either end as recommended in ASTM D1037 (ASTM International 2011). Load and deflection were continually recorded and resulting data were used to

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generate load deflection curves to calculate modulus of elasticity (MOE) and modulus of rupture (MOR) using Equations 1 and 2, respectively. The flexural data were subjected to a simple unpaired t test to compare time versus MOR or MOE for each material ($\alpha = 0.05$).

$$\mathrm{MOE} = PL^3/48\Delta I \tag{1}$$

$$\mathrm{MOR} = 3P_{\max}L/2bh^2 \tag{2}$$

where P is the load (N), $P_{\max}$ is the maximum load (N), L is the span length (mm), Δ is the deflection (mm), b is the width of the sample (mm), h represents the thickness of the sample (mm), and I is the moment of inertia of the specimen given by $bh^3/12$. P/Δ in Equation 1 is the slope of the initial linear region of the load deflection curve.

Results and Discussion

Samples were exposed to 441 mm of rainfall over the 193-day exposure period, representing 86 days with measurable precipitation (Table 1). Rainfall levels on any given day ranged from 1 to over 25 mm and levels had begun to decline near the end of the test, corresponding to the end of the rainy season (Fig. 1).

While only 31 mm of rain fell in the first 25 days of exposure, moisture contents in both plywood and OSB had increased to nearly 40 percent. Average moisture content increased further for OSB to a maximum of 46 percent after 92 days of exposure, but declined to 33 percent for plywood at the same time point (Fig. 2). In both cases, however, the materials were at or above the approximate fiber saturation point.

The effects of moisture uptake on panel integrity can be seen by the increased swelling observed in both materials. Plywood panel thickness increased by approximately 5 percent after 25 days of exposure, while the thickness of OSB samples had increased by approximately 15 percent in the same period (Fig. 3). The rate of swelling observed in the OSB is consistent with previous results (Taylor et al. 2008). Interestingly, only 31 mm of rain representing 13 days with precipitation were sufficient to increase moisture content above the fiber saturation point and produce this degree of swelling. These results suggest that even limited rainfall exposure produces sharp increases in both moisture uptake and associated panel deformation. Swelling continued to increase for OSB and then declined between 92 and 148 days of exposure. On the other hand, plywood swelling remained steady initially but lesser in magnitude than OSB, and then declined. While efficient construction practices can minimize exposure to wetting, the results illustrate that even

Table 1.—Days with precipitation and precipitation level near the panel exposure site.[a]

Exposure period (days)	Rainfall (mm/interval)	Days with precipitation (no./interval)	Total rainfall (mm)
6	8.1	3	8.1
25	23.6	10	31.8
92	289.3	44	321.1
148	91.4	21	412.5
193	29.2	8	441.7
Total	441.7	86	441.7

[a] Values may not add up to the total because of rounding.

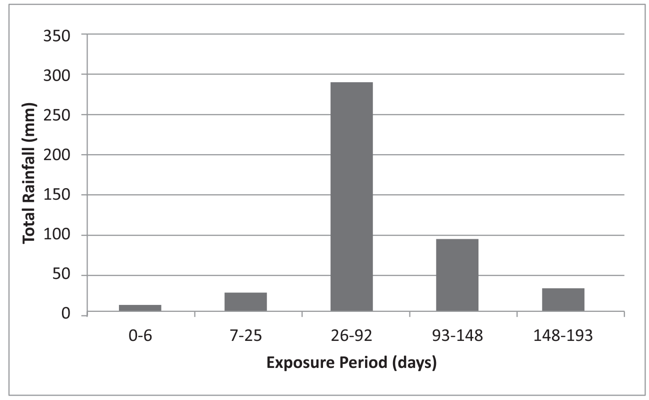

Figure 1.—Amount of precipitation near the test site over the 193-day exposure period.

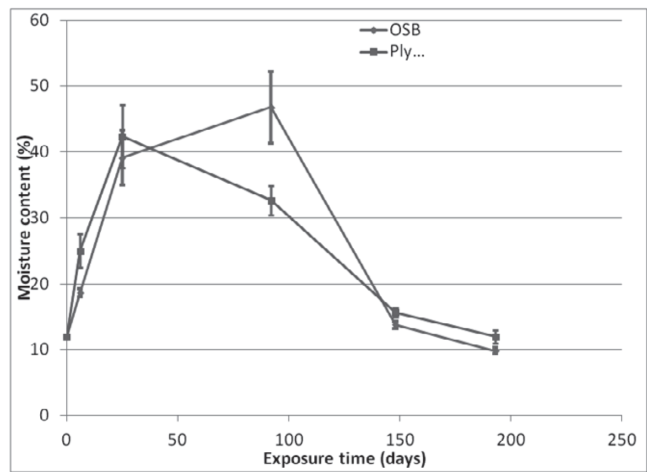

Figure 2.—Moisture contents of oriented strandboard (OSB) and plywood (Ply) panels exposed to rainfall over a 193-day period in Corvallis, Oregon.

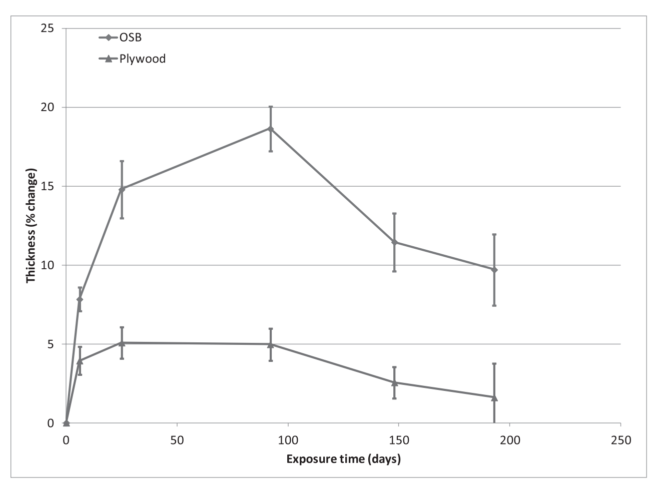

Figure 3.—Changes in thickness of oriented strandboard (OSB) and plywood panels over a 193-day outdoor aboveground exposure near Corvallis, Oregon.

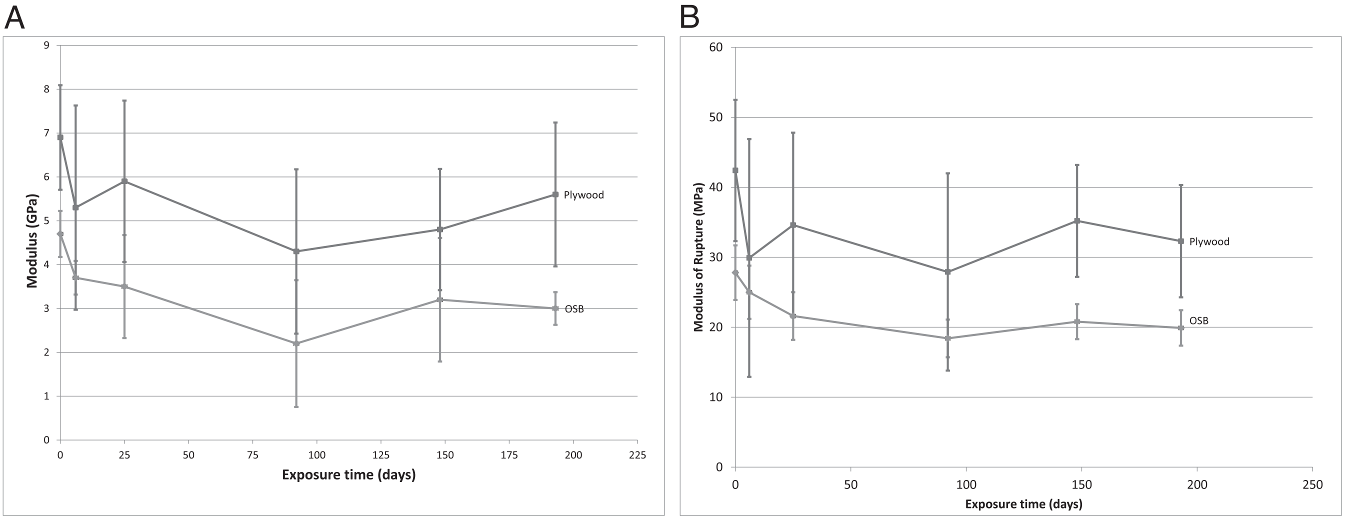

Figure 4.—Maximum load (modulus of elasticity [MOE]) and modulus of rupture (MOR) sustained by oriented strandboard (OSB) and plywood panels subjected to 193 days of outdoor exposure near Corvallis, Oregon, and tested to failure in center-point loading: MOE (A) and MOR (B) versus exposure time.

short delays in construction can substantially affect panel integrity.

Disruption of wood/resin interfaces produced by swelling has the potential to reduce flexural properties of both materials. The maximum load for plywood experienced a nearly 17 percent drop after 6 days of exposure, representing only 6 mm of precipitation, while OSB panels experienced only a 4 percent drop during the same time interval (Fig. 4). Differences in maximum load for plywood were not significant from the nonexposed control except at the 92-day exposure ($P = 0.013$) and this effect was absent after 148 days ($P = 0.13$). These results suggest that moisture had a limited, variable effect on plywood. Decreases in MOR for OSB were not significant after 6 days ($P = 0.345$), but were significant after 25 and 148 days ($P = 0.0343$ and 0.0091, respectively). The effect on OSB properties between 6 and 25 days was interesting, because there was only a 4 percent increase in thickness swell over that same time period. Maximum load is an indication of MOR of the panel. Decreases in maximum load coupled with increased panel thickness due to swelling had a large impact on the MOR of the panel. MOR is inversely related to the square of sample thickness. Therefore, a small increase in thickness has a large impact on MOR. MOE also decreased for both panels (25% for plywood and 21% for OSB) after only 6 days of exposure. These effects were statistically significant for both materials at the 6-day point and illustrate the detrimental effects of even short-term wetting on panel properties ($P = 4.4 \times 10^{-6}$ and 0.02 for OSB and plywood, respectively, at $\alpha = 0.05$).

Conclusions

Exposure to rainfall produced nearly immediate gains in moisture content as well as associated increases in panel thickness coupled with reductions in flexural properties. Within 13 days of exposure to precipitation, the OSB reached the fiber saturation point and significant decreases in properties were observed. The maximum load carrying capacity of plywood and OSB decreased by 17 and 4 percent, respectively, after 6 days of exposure. MOR significantly decreased after 25 days of exposure for OSB and dropped initially for plywood and then remained steady. These results illustrate the need to protect subfloors from wetting as soon as possible to avoid moisture-related changes in properties.

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REVIEWED ARTICLES

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ERRATUM

There is a typographical error in the title of the article that appeared in *Forest Products Journal* 63(5/6):199–201 by Luis Meza, Arijit Sinha, and Jeffrey J. Morrell. The title should read

Effect of Wetting during Construction on Properties of Douglas-Fir Plywood and Oriented Strandboard Flooring