
TESTING OF OSB AND PLYWOOD ROOF SHEATHING IN STEEP-SLOPE APPLICATIONS

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INTRODUCTION

Wiss, Janney, Elstner Associates, Inc. (WJE) and the Midwest Roofing Contractors Association (MRCA) Technical and Research (T&R) Committee have a history of collaborating to develop research and testing programs that focus on expanding knowledge of commonly used roofing materials. In 2024 and 2025, the focus of the research and testing was on oriented strand board (OSB) and plywood roof sheathing materials. The Phase 1, 2024 study evaluated whether multiple shingle applications and removals adversely affect the strength and performance of 1/2-inch-thick and 5/8-inch-thick OSB sheathing. The Phase 2, 2025 study evaluated the effects of periodic moisture exposure on the structural performance of 1/2-inch-thick plywood (3 ply) and 1/2-inch-thick OSB due to construction delays. WJE, in collaboration with the MRCA T&R Committee, developed testing programs to evaluate how roof sheathing is affected by repeated reroofing cycles and moisture exposure during construction as two separate endeavors.

PHASE 1: EFFECT OF MULTIPLE SHINGLE APPLICATIONS ON OSB SHEATHING

Test Program Description

Asphalt shingle roof systems are often replaced multiple times throughout a building's service life. Each replacement involves removal of existing nails and additional penetrations from new nails. The objective of this study was to evaluate the impact of multiple asphalt shingle roof replacements on the strength and performance of 1/2-inch-thick and 5/8-inch-thick OSB roof sheathing. A total of five (5) asphalt shingle roof installations were performed on the same sheathing, and the structural impact was evaluated through shingle nail withdrawal testing after each application and concentrated load strength testing after the third and fifth applications.

The basis of the testing is the National Institute of Standards and Technology's (NIST) *Voluntary Product Standard PS 2-18, Performance Standard for Wood Structural Panels*. PS 2 references several ASTM standards, two of which were used to perform the testing. Nail withdrawal tests were performed in general accordance with ASTM D1761 *Standard Test Methods for Mechanical Fasteners in Wood and Wood-Based Materials*, and concentrated load testing was performed in general accordance with ASTM E661 *Standard Test Method for Performance of Wood and Wood-Based Floor and Roof Sheathing Under Concentrated Static and Impact Loads*.

Four (4) test frames were fabricated in two sizes to perform the testing: two (2) 20-foot x 8-foot frames and two (2) 8-foot x 8-foot frames. 2x8 support framing at 24 inches on center with 2x6 blocking at third points was used to construct the frames. One frame of each size was used for the attachment of 2-foot x 4-foot x 1/2-inch-thick OSB panels, and the other two frames were used for the attachment of 2-foot x 4-

foot x 5/8-inch-thick OSB panels. Two H-clips were installed at all unsupported panel-to-panel joints. The frames were hinged along the bottom edge to allow for rotation (Figure 1). This enabled the shingles to be installed and removed on a slope (4:12) to represent field conditions, while also allowing for testing in the flat position. The frames could also be rotated more vertically to allow for documentation of the underside of the panels following each shingle application (Figure 2). The roofing materials consisted of synthetic underlayment attached with plastic cap nails and Vista AR asphalt roofing shingles manufactured by Malarkey attached with pneumatically installed 1-1/4" x .120 wire coil nails, four (4) per shingle. Typical installation and removal techniques were used and performed by an MRCA roofing contractor.



Figure 1. Test frames set up in WJE laboratory. Flat orientation used for testing. Sloped orientation used for installation and removal.



Figure 2. Vertical orientation of frame allows for documentation of nail holes on underside of sheathing.

Data Collection / Testing Procedure

All installations, removals, and tests were performed with the OSB sheathing in a dry condition within WJE's laboratory environment (~73 degrees F and 50% RH during the summer months).

Following each shingle installation, forty (40) locations were chosen to perform nail withdrawal tests. Locations were chosen without any consideration given to locations of previous nail holes and were chosen from the top side, two (2) per panel, sometimes at opposite ends of the panel, and sometimes close together to provide a distributed sample. The shingles were carefully cut from around the nails so as not to disturb them prior to the test. A ComTen pull test device was used to perform the withdrawal testing and the results were recorded following each test (Figure 3).

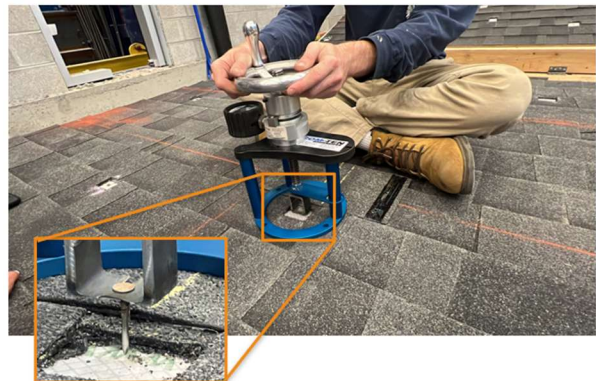


Figure 3. Nail withdrawal testing using the ComTen pull test device.

Three (3) different sets of concentrated load tests were performed: baseline tests were done on new OSB that had never had any shingles installed on it, tests were performed on the smaller test frames following the third application, and tests were performed on the large test frames following the fifth application. The

testing apparatus utilized a hydraulic ram that was attached to a reaction beam and applied force to a 3-inch-diameter steel puck that was placed on the OSB (Figure 4). That beam was weighed down to resist the reaction force. A ball was used on top of the puck to ensure that even bearing was achieved across the 3" diameter steel puck. A string pot attached to a screw in the puck was used to measure deflection (Figure 5). Based upon ASTM E661, deflection was measured under a 200-lb. concentrated load, and then the sample was taken to its ultimate load. Applied load and corresponding deflection were continuously monitored and recorded on a computer during each test.



Figure 4. Concentrated load test setup.



Figure 5. Close up view of puck, ball, and string to measure deflection.

Concentrated load test results were compared to PS 2 criteria given in Table 2 of the standard. According to the standard, for roof sheathing installed on rafters at 24" o.c. in a dry condition, the performance criteria is 400 lbs. minimum for ultimate load and a maximum deflection of 0.5" under a load of 200 lbs.

Test Results

Nail withdrawal test results were considered in two different ways: one as the distributed sampling of all tests performed after each shingle application and the other only looking at nails within 1/4-inch of another hole. The results are as follows (Table 1):

Table 1. Average Nail Withdrawal Loads for Distributed Sampling and Nails within 1/4" of Another Hole

Shingle Application	Average Withdrawal Load for Distributed Sampling of Nails (lbs.)		Average Withdrawal Load for Nails within 1/4" of Another Hole (lbs.)	
	1/2" OSB	5/8" OSB	1/2" OSB	5/8" OSB
1	43.4	62.3	N/A	N/A
2	41.0	61.0	N/A	N/A
3	42.2	63.7	32.6	47.6
4	42.1	63.3	28.9	61.0
5	40.7	64.0	27.3	32.2

Average concentrated load test results for both deflection at 200 lbs. and ultimate load are as follows (Table 2):

Table 2. Average Concentrated Load Test Values for Deflection at 200 lbs. and Ultimate Load

Shingle Application	Average Deflection at 200 lbs. (in.)		Average Ultimate Load (lbs.)	
	1/2" OSB	5/8" OSB	1/2" OSB	5/8" OSB
Baseline	0.29	0.21	541	689
3	0.24	0.16	521	713
5	0.33	0.22	460	667

Findings and Conclusions

Based upon the test results, the following conclusions were drawn:

- There was no significant change in average withdrawal loads observed following subsequent shingle applications when looking at the distributed sampling of nails. A larger decrease in withdrawal load was noted when considering only nails within 1/4 inch of another hole, especially for 1/2-inch OSB; however, for shingle applications 2-5, only 10% of the nails fell within the category, so significantly fewer nails were factored into these results. The results for withdrawal load for nails within 1/4 inch of another hole on 5/8-inch OSB varied. Withdrawal testing seemed to indicate that there is not a very significant effect on the pullout capacity of the nails after multiple shingle installations.
- Both average deflection and average ultimate load met the PS 2 requirements of 1/2 inch maximum and 400 lbs. minimum, respectively. When considering individual test values rather than averages, one test from the fifth application on 1/2-inch OSB exceeded the 1/2-inch deflection requirement and two tests from the fifth application did not meet the 400 lb. minimum for concentrated load testing. All tests on the 5/8-inch OSB met the PS 2 requirements. This indicated that 1/2-inch OSB may be at the end of its service life after five shingle applications, while 5/8-inch OSB appears to have additional service life beyond five shingle applications.

PHASE 2: EFFECT OF MOISTURE ON PLYWOOD AND OSB SHEATHING

Test Program Description

Moisture exposure during weather and/or construction delays is a familiar challenge for roofing contractors, especially in regions like the Midwest where spring weather is unpredictable. Roof decks on new construction projects are often left exposed for days—or even weeks—due to unforeseen scheduling changes, material delays, or extended weather events. During this time, roof sheathing may experience multiple cycles of wetting and drying before a roof covering is installed. Phase 2 of the sheathing study was completed in spring 2025 and the objective of this testing was to identify and compare changes in the structural characteristics of 1/2-inch-thick, 3-ply plywood and 1/2-inch-thick OSB sheathing following natural exposure to moisture from the environment during Midwest climate conditions caused by construction delays. Comparisons were made through visual observations and measuring moisture content, edge thickness, nail withdrawal capacity, and concentrated load strengths.

The four (4) test frames constructed in Phase 1 were reused to support 2-foot x 4-foot plywood and OSB sheathing panels. Of the two (2) 8-foot x 8-foot test frames, one was sheathed with 1/2-inch plywood and the other with 1/2-inch OSB. Similarly, of the two (2) 20-foot x 8-foot test frames, one was sheathed with plywood and the other with OSB. The sheathing was installed with test frames in a flat position (Figure 6) and were lifted to a 4:12 pitch for exposure and oriented south to allow for optimal drying conditions (Figure 7).



Figure 6. Sheathing installation with frames in a flat position.



Figure 7. Test frame lifted to 4:12 pitch for exposure,

Moisture content readings were taken using a Delmhorst BD-2100 meter with 3/8-inch-long pins. The pins were inserted at both partial and full depth and aligned parallel to the wood grain direction. Readings were collected on both the top side and underside of the panels. Thickness measurements were taken using digital calipers at designated edge locations, with each location clearly marked for reference and repeated measurement. Measurements were taken along the edges of the test frames to capture dimensional variability, with a total of 24 measurement locations on the 8-foot x 8-foot frames and 36 locations on the 20-foot x 8-foot frames.

The basis of testing was PS 2-18, consistent with Phase 1 of the study. As in Phase 1, nail withdrawal testing was performed in general accordance with ASTM D1761, and concentrated load testing was performed in general accordance with ASTM E661.

Data Collection / Testing Procedure

Throughout the exposure period, daily weather conditions were documented using data from Weather Underground, including temperature, humidity, wind speed and direction, and precipitation events with associated rainfall amounts. In addition, a rain gauge was mounted to the side of each 20-foot x 8-foot test frame to provide a visual indication of precipitation amounts.

A testing schedule was developed and followed over the course of the panel exposure. Baseline measurements of sheathing thickness and moisture content were collected the day the panels were attached to the test frames. Following installation, thickness and moisture content measurements were

recorded at weekly intervals. Additional measurements were also taken on the day immediately following any documented precipitation event.

Nail withdrawal tests were performed weekly using the same procedures established in Phase 1. Fifteen (15) 1-1/4" x .120 wire coil nails were pneumatically installed in the morning and withdrawn later the same afternoon. All withdrawal tests were performed within the same sheathing panel, with the nails at least 2-inches away from existing holes. Phase 1 testing demonstrated that holes spaced 2-inches or more apart did not influence withdrawal performance. Baseline withdrawal values for OSB were taken from Phase 1, while baseline measurements for plywood were performed as part of Phase 2 testing.

After three weeks of exposure (21 days), concentrated load testing was performed on the 8-foot x 8-foot test frames with the sheathing tested in its current condition at exactly three weeks. No additional data was recorded following the testing of the panels. After six weeks of exposure (43-44 days), concentrated load testing was performed on the 20-foot x 8-foot test frames. Prior to testing, panels were allowed to dry to a moisture content below 12 percent. OSB sheathing was tested after 43 days of exposure, while plywood sheathing was tested after 44 days. Baseline concentrated load values for OSB were taken from Phase 1, while baseline measurements for plywood were performed as part of Phase 2 testing. The same testing apparatus and data collection procedures used in Phase 1 were also used for these tests, including recording the deflection under a 200-lb concentrated load and the ultimate load value.

Phase 2 concentrated load testing also included documenting the first significant break. Per ASTM E661, "a first significant break of the sheathing is defined as a fracture that propagates into or through the sheathing or other deformation that affects its basic stiffness or strength." Not all concentrated load tests resulted in a visible crack. For the purposes of this study, the first significant break was defined as a 15 percent or greater reduction in load. Not every test had a first significant break and then continued to take additional load; sometimes the first significant break occurred at the ultimate load. Results were compared to PS 2 criteria provided in Table 2 of the standard.

Test Results

Immediately following the first rain event, visual deformation and swelling were observed in both sheathing materials. Swelling in the plywood panels was most pronounced along the edges and at joints (Figure 8). Although OSB panels also exhibited swelling, the associated deformations were less pronounced and not as visually apparent when compared to the plywood (Figure 9).



Figure 8. Swelling of plywood along the edges of the panels following the first rain event.



Figure 9. Swelling of OSB panel edge following the first rain event.

During the three-week exposure period, ten (10) precipitation events were recorded, resulting in a total precipitation accumulation of 1.55 inches. For the same time frame, the 25-year average precipitation is 2.67 inches, which is greater than the rainfall experienced by the test panels. Over the six-week exposure period, seventeen (17) precipitation events were recorded, resulting in a total precipitation accumulation of 2.81 inches. The 25-year average precipitation for this period is 5.81 inches, approximately three (3) inches greater than the amount experienced by the panels. The calendar (Figure 10) highlights individual precipitation events along with the corresponding daily precipitation totals.

	SUN	MON	TUE	WED	THU	FRI	SAT
April 2025	30	31	1 Panel installation	2 0.79"	3	4 0.03"	5 0.04"
	6	7	8	9 0.15"	10 0.01"	11	12
	13	14	15 0.02"	16	17 0.07"	18 0.12"	19
	20 0.28"	21 0.04"	22 OSB and plywood 3-week concentrated load testing	23 0.10"	24	25 0.26"	26
	27	28	29	30 0.01"	1	2	3
	27	28	29	30	1 0.57"	2 0.04"	3
	4 0.24"	5	6	7	8	9	10
May 2025	11	12 0.04"	13	14 OSB 6-week concentrated load testing	15 Plywood 6-week concentrated load testing	16	17
	18	19	20	21	22	23	24
	25	26	27	28	29	30	31

Figure 10. Calendar highlighting precipitation events and totals over the course of test frame exposure.

Average moisture content values of plywood and OSB are compared in the following graph (Figure 11):

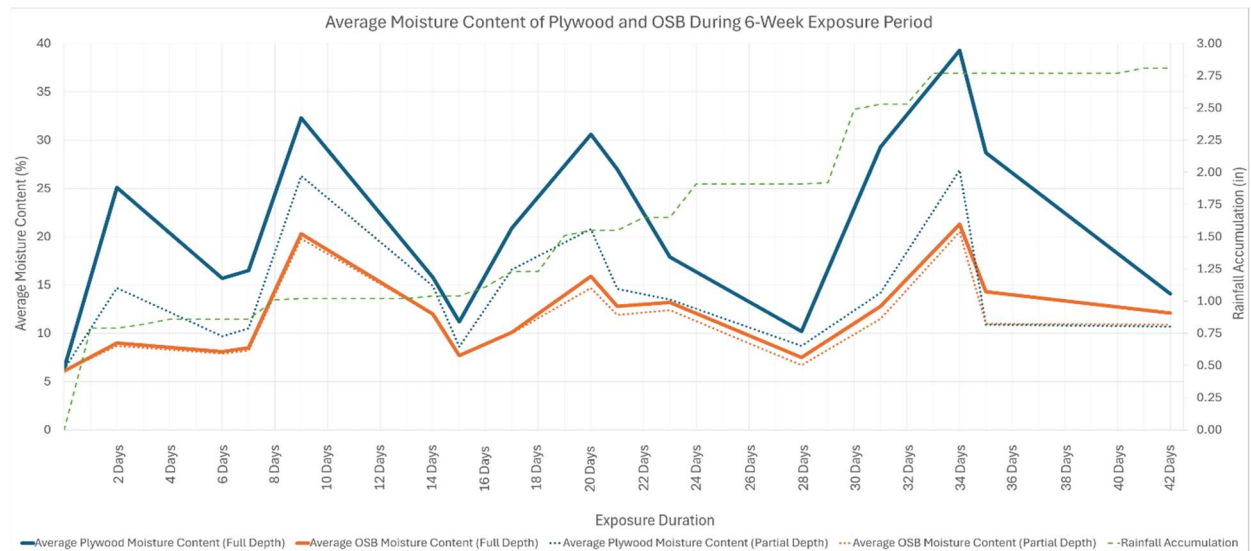


Figure 11. Graph comparing average moisture content of plywood and OSB.

Average edge thickness values of plywood and OSB are compared in the following graph (Figure 12):

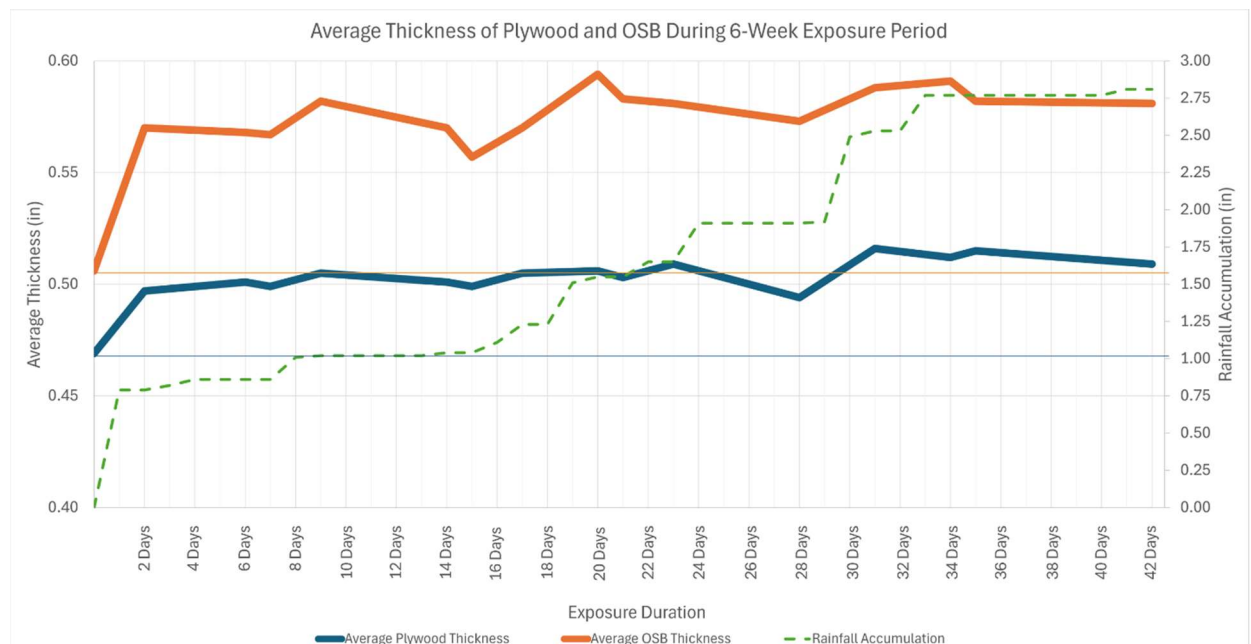


Figure 12. Graph comparing average edge thickness of plywood and OSB.

Average nail withdrawal test results for plywood and OSB are as follows (Table 3):

Table 3. Average Nail Withdrawal Loads for Plywood and OSB

Exposure Duration	Number of Tests per Sheathing Type	Average Plywood Moisture Content (%)	Average Plywood Withdrawal Load (lbs.)	Average OSB Moisture Content (%)	Average OSB Withdrawal Load (lbs.)
Baseline	40	6.9	79.4	7.2	43.4
1 Week	15	14.0	75.0	8.1	56.4
2 Weeks	15	15.3	52.9	10.1	65.5
3 Weeks	15	26.8	79.9	11.8	65.4
4 Weeks	15	8.0	73.0	7.2	64.9
5 Weeks	15	23.2	58.5	9.6	50.7
6 Weeks	15	17.9	48.5	11.6	44.9

Average concentrated load test values for deflection at 200 lbs., load at first significant break, ultimate load are as follows (Table 4):

Table 4. Average Concentrated Load Test Values for Deflection at 200 lbs., Load at First Significant Break, and Ultimate Load

Exposure Duration	Number of Tests	Average Moisture Content (%)	Average Deflection at 200 lbs. (in.)	Average Load at First Significant Break (lbs.)	Average Ultimate Load (lbs.)
Plywood Baseline	30	7.9	0.31	554	709
Plywood – 3 Week	12	23.8	0.51	446	609
Plywood – 6 Week	29	10.6	0.27	510	666
OSB Baseline	26	8.1	0.29	474	541
OSB – 3 Week	12	11.4	0.35	415	480
OSB – 6 Week	29	8.6	0.31	431	518

Findings and Conclusions

Based upon the test results, the following conclusions were drawn:

- Immediate pronounced deformation following the first rain was observed on both sheathing types but was more pronounced on plywood sheathing. This has an impact on aesthetics as underlayment and shingles (or other roofing materials) cannot lay flat as swelling at the panel edges will be reflected through the finished roof surface.
- Plywood can hold more moisture but releases it quicker than OSB. The release rate of moisture is dependent on environmental conditions.
- Moisture content has an impact on deflection and load resistance. Higher moisture content leads to higher deflections, more significantly in plywood. A higher moisture content leads to lower concentrated load capacity.

- Some degree of sheathing swell tends to be permanent. While thickness measurements varied slightly throughout the duration of the testing period, the original thickness measurements taken before exposure to any moisture were smaller than any subsequent measurements.
- Nail withdrawal loads were highly variable. Plywood had higher average withdrawal values than OSB. Moisture content of the sheathing did not have a consistent impact on withdrawal values.
- Plywood withstands higher concentrated loads than OSB.
- Concentrated load values were lower when moisture content values were higher; however, strength partially returns if panels are allowed to dry.
- Data from this testing is based on the sheathing having the ability to wet and dry repeatedly. No roof coverings were present preventing the release of moisture/drying. Based on experience, deterioration will occur when OSB and plywood panels are exposed to a continuously wet environment.

CONCLUSION

Both phases of testing focused on wood sheathing in steep-slope roof applications. While Phase 1 looked at differences in thickness of one material (OSB), Phase 2 used a single thickness (1/2 inch) but allowed comparison between two materials (plywood and OSB). While it seems to be common perception within the roofing industry that OSB is an inferior choice for roof sheathing, both studies produced results indicating that OSB performed relatively well under the tested conditions. However, it is important to note that sustained moisture was not part of either phase of the testing. Sustained moisture will have a significant impact on performance of OSB and plywood panel sheathing, and this is well documented in the construction industry and aligns with WJE and MRCA experience. If wood sheathing has the opportunity to dry, it regains some of its strength. Exposure to moisture was not part of Phase 1, as all testing was conducted in the laboratory. Moisture was a large part of the Phase 2 testing; however, the sheathing had the opportunity to dry between rain events. Several wetting and drying cycles were experienced. Based on experience, excessive, sustained moisture during construction or in service can weaken both OSB and plywood sheathing panels.

WJE recommends that roofing contractors critically review conditions of OSB and plywood roof decks, especially pertaining to moisture and related deformations, prior to accepting them as substrates for roofing assemblies.

For further information on either study, please refer to the PowerPoint presentations that were presented at the 2024 and 2025 MRCA Conferences which are available on the MRCA website.