In Service Moisture Problems and Structural Performance of OSB Panels

Agron E. Gjinolli, P.E.
Staff Engineer, TECO, Certification and Testing Division, Sun Prairie, Wisconsin, USA and
Jim J. Vogt, P.E.
Senior Professional, Qualtim Technologies International, Madison, Wisconsin, USA.

ABSTRACT: Oriented strand board (OSB) wood structural panels along with plywood are the most common structural sheathing components used in light-frame wood structures built in North America. Since its introduction, OSB has been widely accepted and has virtually replaced other types of structural building panels in new residential construction in many areas in United States and Canada. Compared to other structural panels, OSB panels provide strength and versatility, are light-weight, easy to work with, and have been used successfully for almost three decades. Performance problems involving OSB are usually related to excessive moisture exposure and/or installation errors, although occasionally non-conforming product is also to blame. This paper reviews some of the performance problems observed with OSB as identified through numerous investigations of construction projects and existing buildings.

1 INTRODUCTION

The vast majority of all one and two family dwellings in North America are constructed with wood. Wood structural panels such as oriented strand board (OSB) are the primary structural sheathing component used in the roofs, walls and floors of these structures. Installers prefer these products because they are light-weight and easy to use. Building designers specify them because of their strength and stiffness, and relative low cost.

In the United States and Canada, OSB panels are manufactured to meet the U.S. Department of Commerce Voluntary Product Standard, PS 2, “Performance Standard for Wood-Based Structural-Use Panels” (2004) and CSA Standard O325 “Construction Sheathing.” PS 2 was a joint development of the U.S. and Canadian wood panel industry to harmonize the performance standards under the U.S./Canada Free Trade Agreement. The performance requirements of PS 2 and CSA O.325 are very similar, except that PS 2 has higher strength requirements for wall sheathing and requires wall racking tests for qualification of certain grades of span rated sheathing. Both standards establish minimum performance criteria based on the intended end-use application for the product. This criterion has worked well to ensure adequate performance of panels used in typical floor, roof and wall sheathing applications. As with any building product, however, performance problems can and do occur. This paper discusses some of the more common performance problems that can result from poor installation techniques and excessive exposure to moisture.
Performance problems with any building materials, including OSB, can occur during construction of the building or after the building has been completed and occupied. The most common problems associated with OSB are related to dimensional changes of the installed panels after they have been exposed to moisture. High moisture conditions can cause OSB panels to expand, which may lead to problems that are typically visible and manifested as panel buckling, ridging, warping, or twisting.

The moisture content of OSB panels at the time of manufacture is usually 2-3%. The equilibrium moisture content of protected wood building products in existing buildings is typically between 6-12%. Because OSB, like solid wood, will expand as its moisture content increases, it is recommended that the OSB panels be acclimated to their surrounding environment prior to installation, or installed with a gap between panels to allow for expansion. Proper installation is especially important if the panels will be exposed to wet weather conditions during the construction process, which is almost certain in most parts of North America.

PS 2 and CSA O325 provide a criterion that limits the amount of linear expansion permitted in the panel when tested under extreme exposure conditions. In addition, most OSB manufacturers recommend that panels be installed with a minimum 1/8 in (3 mm) gap between adjacent panels to allow for expansion if the panels get wet. However, even when properly spaced, OSB panels soaked by rain during construction or moistened by condensation or high relative humidity in improperly vented attics or crawl spaces can still buckle. Buckling occurs most readily with thinner panels, longer spans, and improper fastening (i.e. fasteners miss framing).

In addition to linear expansion within the plane of the panel, OSB edge swelling can also occur. Edge swelling results when the exposed edges of the panel absorb water much faster than the remainder of the panel. This results in the panel being thicker near the edges than away from the edges. Edges that swell after installation may telegraph through roof shingles or vinyl sheet flooring, resulting in a slight outline of the panel that is visible through the finish material.
Most OSB manufacturers seal the edges of panels with brightly colored, low-permeability coatings to minimize moisture gain through the panel edges during storage, shipment, and construction.

Field investigations involving buckled, warped and/or twisted OSB panels typically reveal that the recommended spacing was not provided (Fig. 1). These investigations also often indicate that the size and spacing of the fasteners used to attach the panels to the framing was insufficient.

![Image](image_url)

Figure 2. Continuous ridge vent has been blocked by ridge board and covered by roofing underlayment and shingles, severely reducing its effectiveness.

Condensation occurs when warm moisture laden air comes in contact with a cold surface and changes the moisture in the air from vapor to liquid form. Condensation can occur on exterior and interior surfaces of buildings, including the interior of wall cavities and can lead to paint failures, mold and mildew, corrosion of fasteners and/or structural problems. In order to control the amount of moisture generated within the living space of the building, all the exhaust fans and appliances should be vented directly outdoors rather than into the attic or crawlspace. Condensation in the attic, wall, and crawl space can be prevented with proper installation of vapor retarders with a minimum permeability of 1 perm (60mg/Pa· S·m²). In cold climates a vapor retarder is generally installed on the warm side of the wall or attic space. The crawl space moisture can be reduced or minimized by placing a vapour retarder over the ground beneath the structure. In warm and humid climates, the International Energy Conservation Code recommends that crawlspace be sealed with conditioned air to prevent the introduction of moisture from the warm and humid outside air.

Expansion of the OSB panels can also occur after the building is occupied. In cold weather climates excessive expansion of roof panels is typically the result of poor attic ventilation, as a result of improper design or poor construction practices. U.S. and Canadian building codes provide prescriptive ventilation requirements for residential construction. All too often these minimum requirements are improperly implemented, or are inadequate for more complicated roof geometries.
Expansion of the OSB panels can also occur after the building is occupied. In cold weather climates excessive expansion of roof panels is typically the result of poor attic ventilation, as a result of improper design or poor construction practices. U.S. and Canadian building codes provide prescriptive ventilation requirements for residential construction. All too often these minimum requirements are improperly implemented, or are inadequate for more complicated roof geometries.

Unfortunately, poor construction practices that result in OSB panel performance problems are not uncommon. Typical construction errors include obstruction of soffit and/or roof vents, and discharging interior ventilation ducts directly into the attic space and poor ventilation and/or water penetration in crawl space (Figs 2-7). The result is an increased moisture load in the attic space, which creates a moisture gradient within the panels and uneven panel expansion. If the panels are not spaced and/or fastened properly buckling or warping is usually the result (Figs 8-9).
Figure 5. Mold growth in the OSB floor panels due to water penetration beneath the plate and inadequate ventilation of the crawl space.

Figure 6. Thickness swells due to excessive moisture and lack of spacing between the OSB floor panels.

Figure 7. Typical reduction in edge thickness of existing panel after sanding, and close-up of the OSB panel with cleavage-type of failure due to “tight” installation and excessive moisture.

Panels that buckle, warp or twist after installation are not considered to be defective and typically do not need replacing. These panels can generally be brought back into plane by securely attaching the deformed portion of the panel to dimension lumber blocking and attaching the blocking to adjacent structural framing members (Fig. 10).
Figure 8. Buckling and ridging of the OSB roof sheathing panels due to ventilation problems.

Figure 9. Ridging and/or buckling of the OSB roof sheathing at 8 ft (2440 mm) intervals. Unbalanced and limited ventilation caused by installation of three different types of the ridge ventilators greatly impeded the airflow inside the attic. Installing intake (gable louver) and exhaust (ridge louver) ventilation too close created a “short circuit” that significantly decreased attic ventilation.
Figure 10. Simple and effective repair for buckled, warped or twisted roof sheathing panels is to securely attach the deformed portion of the sheathing to dimension lumber blocking and attach the blocking to adjacent support framing.

Figure 11. A circular saw can be used to effectively “create” a gap at tight joints of adjacent panels.

If the panels have been installed tight, without a gap, an expansion gap can be created by cutting along the unspaced edges with circular saw (Fig. 11). Care must be taken not to cut too deep and cause damage to the support framing. Of course, before the panels are repaired, the cause of the problem must be determined and fixed. Additional ventilation or proper ventilation may be needed.

Occasionally, performance problems involving OSB are the result of mis-manufactured product. Although OSB manufacturers typically do a very good job of detecting and disposing of non-conforming product, some “off-grade” material may occasionally find its way into the field. If this occurs, this material must be replaced, repaired and/or “overlaid” with on-grade material.

PS 2 and CSA O325 have minimum bond durability requirements intended to ensure that the panels can resist the effects of elevated moisture on structural performance during construction delays, or other conditions of similar severity. OSB panels meeting these requirements are classified as “Exposure 1”, which represents the vast majority of wood structural panels used as sheathing in the U.S. and Canada.
Figure 12. Overdriven staples due to thickness swell after panels have been wetted and overdriven fastener performance under lateral loads for OSB wall panels in accordance with PS 2-04, Performance Standard for Wood-Based Structural-Use Panels

Figure 13. Verification of reduction in shear capacity of the OSB shear wall due to overdriven nails using full size racking test in accordance with ASTM E72

Diaphragms and shear walls, constructed with OSB and plywood, provide the primary lateral load resisting system in many types of construction. The ability of these systems to resist and transfer shear load is greatly dependent on the strength and behavior of the sheathing-to-framing connection (i.e., fastener connection). The allowable shear loads provided in the model building codes for wood-framed diaphragms and shear walls are based on the assumption that the fasteners used to attach the sheathing to the framing members are driven so that their heads or crowns are flush with the surface of the sheathing. During construction of these assemblies, however, it is common to have at least a portion of the fasteners with their heads overdriven below the surface of the panels. This can be especially true when power-driving equipment is used to install the fasteners (fig.12-13). Improper installation of the fasteners may potentially reduce the shear capacity of the shear walls and diaphragms. Recent studies indicate that overdriven nails reduce...
shear wall strength from 5% to 22% depending on the depth of the overdriven nail-head. The bar chart in the figure 14 provides an estimate of the percent reduction in shear capacity for various percentages of fasteners overdriven to three different depths. This chart is based on an extensive field investigations and static testing of the 8 by 8’ shear walls utilizing 7/16” thick OSB and 8d common nails testing by TECO staff, and analytical model developed from research by Judd and Fonseca (1, 2), and Jones and Fonseca (3) involving in part the pseudo-dynamic testing of the 8 by 8’ shear walls utilizing 7/16” thick OSB and 8d cooler nails.

The reduction in shear capacity depends on the magnitude of the overdriven depth of the fasteners and the percentage of total fasteners overdriven. This chart can be used to estimate the reduction in shear capacity if fasteners are overdriven by varying percentages and depths. The allowable shear capacity of diaphragms and shear walls depends on several other factors including fastener type, size, spacing, and amount of penetration into the framing members. In addition, wood species, width of framing members, panel grade, thickness, layout, and presence or absence of panel edge framing support influence the allowable shear capacity. Each of these factors must be considered when evaluating the effects of overdriven fasteners. Another factor to consider is whether or not the panels have been wetted, thus causing the fastener heads to have become embedded in the panel due to thickness swell as opposed to being overdriven.

![Reduction in Shear Capacity Due to Overdriven Fasteners](chart.png)

Figure 14. Verification of reduction in shear capacity of the OSB shear wall due to overdriven nails using full size racking test in accordance with ASTM E72

4 CONCLUSIONS

Oriented strand board (OSB) structural panels along with plywood are the primary structural sheathing components used in many types of light-frame wood structures built in North America. In comparison with other sheathing products, OSB structural panels offer many advantages and have a well established record of reliability. Most performance problems associated with OSB panels are related to moisture exposure, OSB like all other wood products reacts to changes in moisture and humid conditions. OSB panels used as structural sheathing applications in Canada and the U.S. are required to maintain their strength and stiffness performance when exposed to weather during normal construction delays. OSB is not designed to be permanently exposed to the elements. In addition, poor design and installation practices are persistently ob-
served. When problems occur they can usually be corrected relatively easy. We hope that that the information provided in this paper can be effectively implemented by practicing professionals, forensic engineers, and during the design and construction phases of the building project.

5 REFERENCES

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