

ASPHALT SHINGLE BUCKLING AND ROOF SHEATHING

By Doug Logan

One of the most frequent complaints about asphalt shingles is the buckling that is often associated with the joints in the underlying roof sheathings. This article seeks to clarify the cause of buckling, illustrate some misconceptions, and suggest some possible remedies.

Shingle buckling is nothing new. In the past, when buildings and homes were sheathed with boards, shingle buckles were common. Wood is a hygroscopic material that responds to variations in relative humidity by changing moisture content. As moisture content increases, wood swells, increasing its dimensions. Conversely, as the moisture content decreases, dimensions decrease. Roofers often sought to overcome this instability in the sheathing material by nailing shingles above the headlap area so that only a single row of fasteners held each course in position. Before the days of factory-applied adhesives, this was a fairly effective remedy, allowing the shingles some freedom of movement. It did, of course, make the shingles more vulnerable to wind damage, which led to the practice of hand tabbing and the subsequent buckling problems resurfaced.

Today most roof surfaces are sheathed with plywood or oriented strand board, yet complaints of buckling continue to occur. These surfaces are much more stable than board construction but still respond dimensionally to changes in moisture content. On new construction, the underlying cause of asphalt shingle buckles can be divided into two overlapping events: initial conditioning and seasonal fluctuation. On reroofing projects when the sheathing is not being replaced, only seasonal fluctuation plays a role.

INITIAL CONDITIONING

Initial conditioning is the adjustment of the sheathing panels from their production EMC (Equilibrium Moisture Content) to their in-service EMC. Plywood leaves the production line at an EMC of approximately 6% to 8% and OSB at approximately 4% to 6%. Once the panels are stacked and banded for shipping, they have little opportunity to absorb moisture from the atmosphere. In these days of just-in-time delivery, the timespan between production and application to a structure has also been reduced. The in-service EMC of the panels is approximately



Photo 1: "Picture framing" buckles are obvious on this residence.



Photo 2: Severe sheathing distortion may be viewed on this unfinished home.

12% - 19%, depending on climate zone and season. It is for this reason that, during sheathing installation, it is recommended that a 1/8" gap be left between panels. This gap is to prevent buckling and distortion of the sheathing panels as they adjust dimension to match their in-service EMC. It is frequently interpreted that this gap is necessary to prevent shingle buckling. Exactly the opposite is true. It is because we leave this gap that shingle buckles occur. As the panels adjust their moisture content, they expand slightly in their linear dimensions. A shingle that bridges the gap between panels is put under compression as the nailing points move close together. To relieve this compression, the shingle buckles slightly. Very little motion of the nails is necessary to form a noticeable buckle.

This is contrary to the popular notion that the shingle buckle is a reflection of the swelling in thickness of the panel edge, although this does occasionally happen. When sheathing is being installed, H-clips are often used for edge support. This leaves a uniform space between the sheets on the long edges as recommended in APA and SBA technical bulletins. In spite of the recommendation that the ends of the plywood panels also be spaced, this is often ignored during field application. This would explain why shingle buckles are generally only observed on the long edges where there is some freedom of movement. With the plywood end edges in



Photo 3: "Stickering" helps to pre-condition the sheathing prior to application.

moderate contact with each other, there is no movement of the shingle nails, and the stress of the dimensional change in the plywood is spread along its entire 8-ft. length, sometimes resulting in buckling of the sheathing itself.

OSB is customarily handled in a slightly different manner, with the panels being spaced with the shank of a nail (see Photo 4). As before, a shingle that bridges this gap experiences compression when the sheet expands, thus allowing buckle to appear along the width of the OSB joints as well as along the length. This is often referred to as "picture framing" (see Photo 1).

How can buckling caused by initial conditioning be prevented? A survey of manufacturers' literature brings forth some bewildering and often contrary advice. Install the shingles as soon as possible, delay installing the shingles as long as possible, install felt underlayment as soon as possible but remove wrinkles before installing shingles, and so on. Delaying the installation of finished roofing is understandably not often done.

Many other trades need the assurance of a dry building before executing their tasks; simply covering the roof deck with felt cannot give this assurance. General contractors have little patience or enthusiasm for conditioning of roof decks prior to roofing application.

An alternative method is to pre-condition the sheathing prior to application to the structure. This can be accomplished by restacking the panels with lath stickers between each sheet a few weeks prior to use to allow seasoning (see Photo 4). These stacks should be stored outside, exposed to the air but under cover to prevent rainfall from damaging the sheets.

There is a precedent, just as lumberyards at one time stickered boards to decrease their moisture



Above: Photo 4: OSB panels are customarily spaced with the shank of a nail.

content, we are sticking panels to increase their moisture content. Clearly pre-sticking and conditioning the panels requires a commitment and expense; however, the alternative of sorting out who is responsible and resolving shingle buckles after the fact is a greater expense.

SEASONAL FLUCTUATION

Besides undergoing an adjustment from production to in-service, EMC roof sheathings must also adapt to seasonal variation in relative humidity. *Graph #1* shows a sample of seasonal variation in relative humidity in the coastal environment of western Canada. This graph will vary, depending on geographic region and climate zone.

Graph #2 shows the relationship between Equilibrium Moisture Content (EMC) and Relative Humidity. It is readily apparent that this relationship is not linear. EMC (and consequently sheathing dimensions) change much more dramatically as the relative humidity increases above 70%.

Using plywood as an example, the coefficient of hygroscopic expansion is approximately 0.2% from oven dry to complete saturation. On a 2,440 mm (8 ft.) panel, this is approximately a 0.17 mm change in length for each 1% change in panel EMC. A typical seasonal relative humidity range would be 40% to 80%, corresponding to an EMC change from 7% to 16%, resulting in a dimensional change of approximately 1.5 mm in panel length.

In geographic areas with natural high humidity or in cases of high humidity created by faulty ventilation, dimensional changes can be even greater. For example, an attic space that cycled from 60% to 100% relative humidity would result in an EMC variation of 11% to 28%, corresponding to a dimension change of approximately 2.9 mm. A humid attic space has almost double the effect on dimension and consequent shingle buckling.

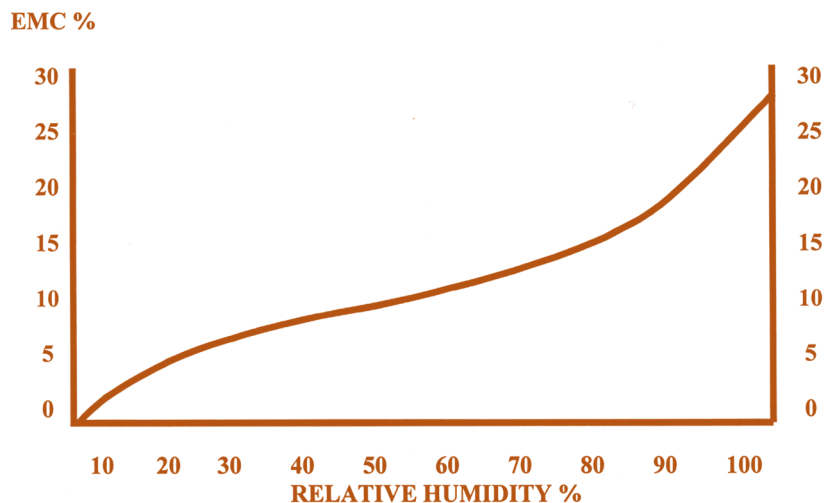
From this analysis, we can readily draw some conclusions:

- Regions with relatively low year-round humidity will experience minimal buckling problems unless attic spaces have high humidity from design or ventilation problems.
- Regions with high humidity fluctuation are vulnerable to seasonal buckling events even when everything is done properly. It is a direct consequence of climate and the nature of the sheathing materials.

After initial conditioning has taken place, timing can greatly affect the results. If a roof is installed during a season when the humidity and EMC are high, then the shingles that bridge the gap between panels will experience tension as the panels shrink slightly to adjust to the lower EMC of their annual cycle. No buckle would result in this situation. Conversely, shingles that are installed during the low end of the annual RH cycle will experience compression as the cycle progresses to higher moisture content. A shingle buckle is inevitable.



Graph 1: Seasonal relative humidity for coastal British Columbia, Canada.



Graph 2: Equilibrium moisture content of plywood and relative humidity.

Shingle buckles caused by seasonal fluctuation seem to diminish over time. Exactly why is unclear. Is it elongation of the shingle nail holes after several seasonal cycles? Do the sheathings not fully adjust to their original dimension after each expansive cycle? Can some compression of the shingles take place?

VENTILATION

Readers who have held on this far have no doubt been gasping out the phrase, "But what about ventilation?" for some time now. Well, you are right. As can be seen in the analysis of seasonal fluctuations, ventilation can play a critical role in reducing attic humidity. There are some caveats. How many consultants have examined a home or building from the outside, observed a lack of ventilation hardware, and thought, "This attic space is going to look terrible, with mold and mildew everywhere." Then, on occasion, a survey of the attic space proves them dead wrong. The underside of the sheathing is pristine. Clearly, ventilation behavior is complex and not always predictable. Among the variables affecting the ventilation outcome are:

- The magnitude of heat loss.
- The effect of wind pressure and wind frequency on air movement through the attic space.
- Orientation of the structure to solar radiation.

- Shingle color.
- Viewing the structure as a system; what is the overall humidity profile?
- Integrity of air barriers.
- Climate region.

With so many difficult variables to measure over time, the tracing of buckling incidents to ventilation problems is no easy task, especially if the basic ventilation guidelines have been followed. To repeat: some buckling can occur even when everything is done properly.

The guideline ventilation ratios of 1/150 and 1/300 cannot always provide protection. Increasing ventilation volume is not always a solution. In a theoretically perfectly vented attic space, the attic air would be the same as the outdoor air. When the outdoor humidity is high, there is not much ventilation benefit (drying of the attic space) being gained. In that surprise pristine attic space described earlier, it is often observed that insulation levels are low. Heat loss contributes to drying of the attic space. In cool climates with a history of moist attics, perhaps we should rethink our fixation on energy conservation and allow some heat loss to combat another enemy: moisture.

CONCLUSIONS

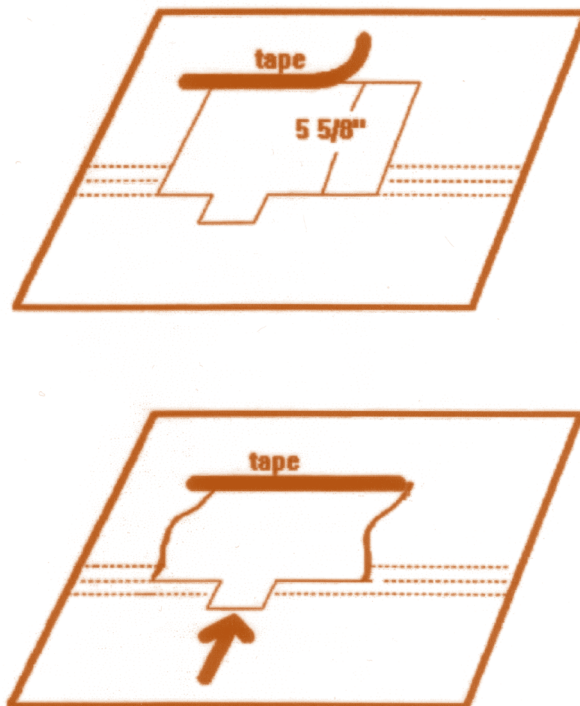
Shingle buckling associated with substrate movement can be traced back to two events: 1) the initial conditioning of roof sheathing; and 2) seasonal fluctuations in humidity. We can exert some control over the first event by pre-conditioning of sheathing prior to shingle application. Gapping of sheathing materials protects from distortion of the sheathing but does not provide protection from shingle buckling. The second event is less controllable, and some buckling is inevitable. Ventilation is absolutely essential in mitigating sheathing moisture content and dimension changes but cannot always provide complete protection. ■

REFERENCES

- APA bulletin, "Proper Installation of APA Rated Sheathing For Roof Applications."
- ARMA bulletin, "Plain Facts About Buckled Shingles."
- CANPLY, "Plywood Design Fundamentals," pg. 7, 17 and 18.
- SBA bulletin, "Installation Instructions For OSB Products."

VISUAL DEMONSTRATION

To provide a visual demonstration of the buckling resulting from shingle compression as sheathing panels change dimension, take a strip of paper the width of the shingle exposure (typically 5-5/8 inches), and tape it to a stiff piece of cardboard. Several lines 1/16" apart are marked on the cardboard at the edge of the demonstration piece. The demonstration piece is then pushed to each line to exhibit the potential buckle. It is easier to do this if a small tab is left on the demonstration piece (see drawing). Demonstrating tension would require pulling the strip loose from the tape or ripping (splitting) it.



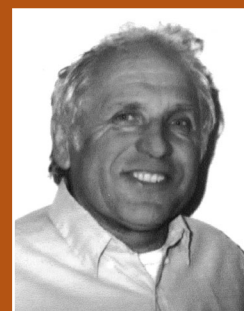
Numerous other books have contributed to my knowledge of wood, humidity and ventilation, most notably:

- Baker, Maxwell C., *Roofs, Design, Application, and Maintenance*.
- Hoadley, R. Bruce, *Understanding Wood*.
- Kubler, Hans, *Wood as Hobby and Building Material*.
- Lstiburek, Joseph, *Building Science*.

Climate data for the seasonal graph was prepared using data from the Vancouver Island Regional Library.

ABOUT THE AUTHOR

Doug Logan has worked in the roofing industry for 31 years in a variety of tasks, from a kettleman to the owner and manager of Shelter Roofing Ltd. The importance of specification has always held Logan's interest; consequently, he is a constant observer and student of the relationship between roof system behavior and specification intent. Mr. Logan joined RCI in 1999 to improve his specification skills and educational level and became a Registered Roof Observer in 2001.



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