

### OUT OF PLANE SUBSTRATE IMPACTS

There are three fundamental areas affected by an out-of-plane metal roof or wall substrate; aesthetics, thermal movement, and performance.

#### Aesthetics

The first issue with an out-of-plane substrate deals with aesthetics. Any unevenness or undulations in the roof or wall substrate will telegraph through the metal panels and may cause an unpleasant exterior appearance. This can accentuate oil canning and give a wavy appearance along the length of the metal panels.

#### Thermal Movement

The next concern is that an uneven substrate could interfere with the panel's ability to expand and contract under thermal loads. This is particularly an issue with concealed fastener metal roof and wall panels that utilize concealed clips for attachment. These clips are designed for installation on a relatively flat plane. An out-of-plane substrate could cause binding points at clip locations. This can create an unwanted point of fixity and could prohibit the panel from expanding and contracting normally. Expansion and contraction should not be impeded; due to high thermal forces, panel expansion and contraction will still occur, even if the clips are bound or restricted at uneven areas of the roof or wall substrate. The thermal movement forces could result in clip failure or complete panel disengagement from the substrate if the shear resistance of the clip and/or clip fasteners is compromised.

#### Performance

The last concern deals with wind uplift performance. If metal roof or wall panels are installed on an out-of-plane substrate, there is the potential for improper panel-to-clip engagement at the panel side laps. If the panel interlock is not engaged properly the wind uplift performance of the panels could be impacted. This has the potential to create significant problems with a metal roof or wall panel's ability to resist wind uplift pressure. Improper panel side lap engagement can also affect air and water infiltration resistance which can compromise the environmental performance of the roof or wall system as well.

### GUIDELINES

Common industry guidelines have established that roof substrates should not exceed the following limits for out-of-plane conditions:

- ¼ inch in 20 feet
- ½ inch across building elevation
- ¾ inch in 5 feet

ASTM E 1514, "Standard Specification for Structural Standing Seam Steel Roof Panel Systems", also addresses substrate requirements. Section 5.1.2 within states, "Deflection and serviceability shall be accounted for. The deflection shall be limited so as to allow the roof to perform as designed. The substrate deflection shall not cause strains to the panels that affect serviceability of the system."

The "transfer of ownership" clauses in project contracts are becoming a significant factor in recent times with regards to out-of-plane or deflected substrates. Addressing out-of-plane substrates is

of vital importance.

### SOLUTIONS

When a metal roof and/or wall subcontractor takes over the substrate and commences their scope of work, typically there is meant to be an inspection by a qualified representative. The subcontractor should be authorized to accept the substrate or reject questionable areas that may need reworking by the appropriate previously responsible trade.

If subcontractors fail to do this and start installing metal roof or wall panels, they are essentially accepting whatever conditions they are given with no recourse. Additional labor costs may be incurred to correct other trades' substrate installation issues. Inconsistent substrate joints, seams and framing will almost always transfer through to the metal roof or wall panels and create a kaleidoscope of issues which the installer becomes responsible for at their expense.

A possible corrective action to resolve out-of-plane conditions with minimal impact to the substrate or metal panels is to use shims under the panel clips. ¼" thick shims of plywood can be cut into 4" X 6" squares – sized similar to a panel clip bearing plate, and layered under the clips to even out the clip line with the rest of the substrate areas. Multiple shims may be required depending on the extent of the unevenness of the substrate.

The fasteners will need to be long enough to go through the shims and penetrate the substrate as originally designed. If installed properly, and the uneven area is made level with the rest of the roof or wall, there should be no impact to installed panel aesthetics, thermal movement, or system performance. Manufacturer warranties should also remain intact.

The corrective action above only applies to panels that have the ability to span open framing as the shims lift the panel off the substrate thereby creating a spaced framing condition. The plywood shim method is acceptable for use on all AEP Span roof and wall panels with the exception of Select Seam. Select Seam requires a continuously solid substrate for installation and cannot span open framing.

The corrective action above or any alternate solutions shall be reviewed and approved by the design professional overseeing the project to determine if they are acceptable. Other materials and/or techniques may be required for resolving out-of-plane conditions if the above plywood shim option is not acceptable.