TECHNICAL BULLETIN: 06/18/2021

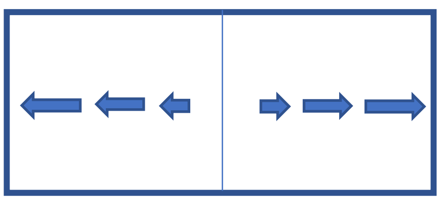
High-Density Fiber Cement Expansion and Contraction

Fixed and Gliding Points

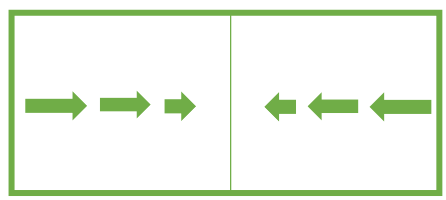
Overview

This technical bulletin addresses the expansion and contraction that occurs within high-density fiber cement panels and how AFCC's installation methods combat this issue. Fiber cement, like all materials will experience thermal expansion and contraction with temperature change. When there is a rise in temperature, the panel will expand, and when there is a drop in temperature, the panel will contract. While this is occurring, a majority of expansion and contraction is driven by moisture or humidity. As relative humidity increases, the panel expands, and as it decreases, the panel shrinks. This happens because fiber cement is porous, allowing moisture to enter through microscopic holes.

The figures below show how expansion and contraction can be visualized. Each figure shows movement in the horizontal direction only. The arrows represent how much movement can be calculated in each area. The farther from the center of the panel, the more movement can be calculated. At the center of the panel there is no movement at all when expansion or contraction occurs.



Expansion



Contraction

Attachment Method

The open joint rainscreen attachment system must be designed to account for these movements in order to create a sustainable system that will have a very long lifespan. To prevent the panel from bowing or cracking, the attachment system must allow for panel movement. In AFCC's rivet and screw fastening systems, this is done through the use of fixed and gliding points.

Fixed points are holes that match the diameter of the screw or rivet.
Gliding points are holes that are oversized.

Two fixed points are placed nearest the center of the panel to hold the panel in place. They are placed in the middle where little to no movement occurs. All other fastener holes are made gliding points to allow the panel to expand and contract without the fastener restricting the movement. The figure below displays the fixed and gliding point locations on a panel. Note that the fixed points are located on different vertical profiles to prevent stress.

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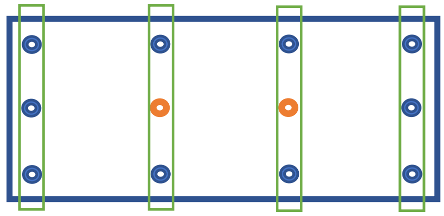


Fixed and ***Gliding*** *Point Locations*
(Vertical Profiles)

Here are the specifications of the hole sizes used for each system. The rivet system is used when fastening to metal profiles and the screw system is used when fastening to wood profiles. The gliding point diameter is made to be 3mm wider than the fastener diameter.

Diameter	**Rivet System**	**Screw System**
Fastener	8*mm* [5/16"]	5*mm* [13/64"]
Fixed Point	8.3*mm* [21/64"]	5*mm* [13/64"]
Gliding Point	11*mm* [7/16"]	8*mm* [5/16"]

Relative Humidity Expansion/Contraction Calculation

Below is an analysis of the Cembrit Patina panel maximum movement due to moisture and to see if the AFCC attachments methods allow for this movement.

Maximum Moisture Movement

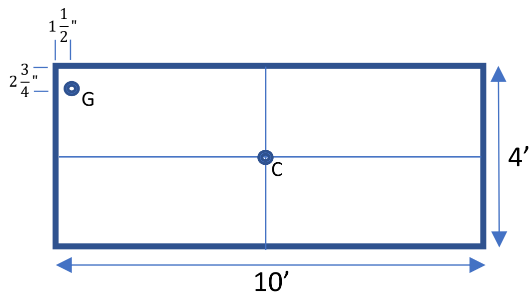
The EN 12467 Moisture Movement test brings fiber cement flat sheets from 30% to 90% relative humidity. In doing so, the samples will change in size. ASTM C1185/1186 has a similar moisture movement test that also calculates the movement when going from 30% to 90% relative humidity. A 60% change in relative humidity rarely occurs in any climate. Most US cities have an average relative humidity change from morning to afternoon of 20%-40%. So a 60% change can be considered the maximum change that may occur. The results of the EN 12467 Moisture Movement test for the Cembrit products are shown in the table below.

Product	**Moisture Movement (%)**
Cover	0.10
Patina	0.08
Solid	0.10
Transparent	0.10

Cover, Solid, and Transparent have the highest moisture movement values at 0.10%, but this is when the edges are not sealed to block moisture from penetrating the panel. In a real life application, these three product lines will have their edges sealed using Cembrit Edge Sealer. Doing so effectively reduces the maximum moisture movement to a fraction of 0.10% when the panel is not sealed. Patina is not sealed in real life applications. For this reason, Patina's moisture movement will be analyzed. It is also worth noting that these moisture movement values were calculated soon after the making of the products. Cement is constantly curing throughout its life, so as time goes by, the moisture movement values will decrease.

The maximum moisture movement coefficient (MMC) of Patina is 0.08% which converts to $0.8\frac{mm}{m}$. This can be considered the maximum amount of potential movement due to a change in relative humidity.

The worst case scenario would be on the maximum panel size which is 4’x10’. The farthest hole from the center of the panel would be at a corner. The hole would be 2-3/4” off the top or bottom edge and 1-1/2” off the side edge.



G = Gliding Point | C = Center Point

The distance between the center point of the panel (C) and gliding point (G) must be calculated.

<u>Horizontal Length:</u>

$$a = \frac{L}{2} - 1\frac{1}{2}in \quad > \quad L = 10ft \times \frac{12in}{1ft} = 120in \quad > \quad a = \frac{120in}{2} - 1\frac{1}{2}in = 58.5in$$

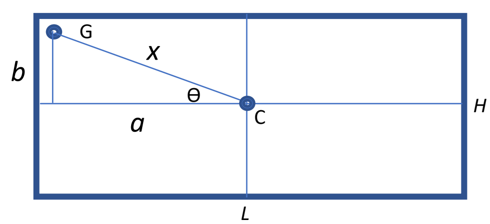
<u>Vertical Length:</u>

$$b = \frac{H}{2} - 2\frac{3}{4}in \quad > \quad H = 4ft \times \frac{12in}{1ft} = 120in \quad > \quad b = \frac{48in}{2} - 2\frac{3}{4}in = 21.25in$$

<u>C to G Length:</u>

$$\sin(\Theta) = \frac{b}{x} \quad > \quad x = \frac{b}{\sin(\Theta)} \quad > \quad \Theta = tan^{-1}(\frac{b}{a}) \quad > \quad \Theta = tan^{-1}\left(\frac{21.25in}{58.5in}\right) = 19.96°$$

$$\boldsymbol{x} = \frac{21.25in}{\sin(19.96°)} = \mathbf{62.24}\boldsymbol{in} \quad > \quad 62.24in \times \frac{0.0254m}{1in} = \mathbf{1.5809}\boldsymbol{m}$$



Now, the panel movement over this distance can be calculated.

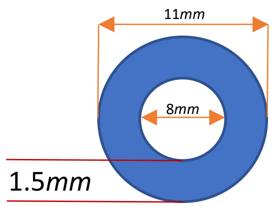
<u>Maximum Moisture Movement</u>

$$M = Maximum\ Movement$$

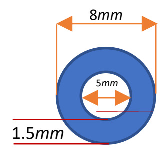
$$M = MMC \times x \quad > \quad M = 0.8\frac{mm}{m} \times 1.5809m = 1.26mm$$

$$\boldsymbol{M = 1.26\ mm}$$

Now we can compare the maximum movement to the amount of movement a gliding point allows with both the rivet and screw fastening methods. The blue area represents the amount of open space allowing for expansion and contraction.



Rivet Gliding Point



Screw Gliding Point

From these two diagrams, gliding points allow for 1.5*mm* of free movement in any direction. This allows up to 1.5*mm* of expansion and contraction. The maximum moisture movement of 1.265*mm* is less than 1.5*mm*. Therefore, in any moisture situation, the AFCC attachments systems will never restrict panel movement.

Thermal Expansion/Contraction Calculation

In addition to moisture movement, there is still some movement due to temperature change that needs to be accounted for. We will assume a temperature change of 60˚Fahrenheit to calculate a typical maximum expansion/contraction temperature scenario.

<u>Maximum Thermal Movement</u>

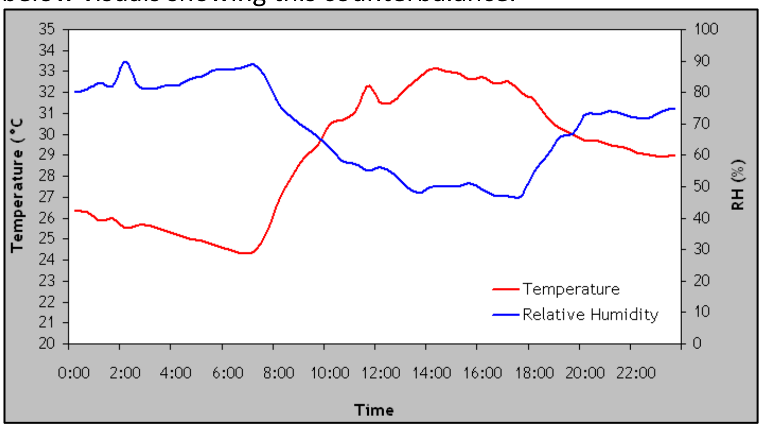
$$\Delta L = \alpha L \Delta T$$
$$L = 62.24in = 1.5809m$$
$$\Delta T = 60°F = 33.33°C$$
$$\alpha = Thermal\ Expansion\ Coefficient = 0.01\frac{mm}{m°C}$$
$$\Delta L = 0.01\frac{mm}{m°C} \times 1.5809m \times 33.33°C = 0.527mm$$

The total movement due to temperature change is 0.527mm. This is also lower than the 1.5mm of free movement the panel is allowed.

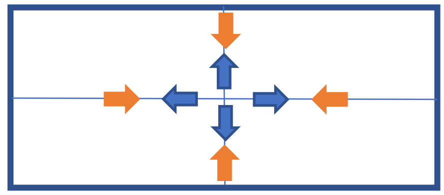
Summing up all Movements

Accounting for both thermal and moisture movement is not as simple as adding the two together. It is much more complicated because moisture and thermal movement work in very different ways. Moisture movement causes the panel to get larger when humidity goes up and smaller when humidity goes down. Thermal movement causes the panel to get larger when temperature goes up and when humidity goes down. High temperatures occur when humidity is lower while high humidity occurs when the temperature is lower. For this reason, the two movements counter balance one another.

To explain this using a real life scenario, mornings start off cold with higher relative humidity. As the day progresses into the afternoon, the temperature rises and the relative humidity falls. As the morning progresses into the afternoon, thermal expansion is occurring from temperature rise, and moisture contraction is occurring from humidity falling. Because of this counterbalance, the gliding points do not need to account for adding up both the maximum thermal expansion and thermal contraction. See the below visuals showing this counterbalance.



Relationship between relative humidity and temperature over a typical day.



Panel during Transition from morning to afternoon

Thermal expansion *is occurring from temperature rising while* ***moisture contraction*** *is occurring from relative humidity lowering.*

In addition, the profiles behind the panels will also move with temperature change. The profile is directly connected to the rivet, meaning the rivet is not locked in place. For the $60°F$ scenario above, galvanized steel would expand vertically 0.221*mm* at the gliding point location. This means the rivet would move up 0.221*mm*. The panel's vertical movement is nearly identical at 0.180*mm* meaning that they will move at very similar rates which aids in allowing the panel to expand and contract freely. See the appendix for vertical panel and steel profile movement calculations.

The calculations can help show how the gliding point system was designed but the proof of its functionality is in the 50 years of high-density fiber cement panel applications. The experience and sheer number of data points across a variety of different climates have proven that the gliding point sizes allow sufficient panel expansion and contraction in all types of climates.

Proper Installation

In order for the fixed and gliding point system to properly work, AFCC's Standard Installation Guidelines must be followed. The panels must be installed with a vertically oriented air cavity directly behind the panels to allow for water drainage and airflow. The screws and rivets must also be installed in the center of the gliding point. For rivets, this can be done with the AFCC provided centralizing tool. For the screw system, the installer must place them in the center of the hole and screw them in perfectly perpendicular to the hole and make sure to not overtighten. Following these guidelines ensures the functionality of the system allowing for the panels to last the lifespan of the building.

Appendix

Steel Profile Thermal Expansion/Contraction (Vertical Direction)

Maximum Thermal Movement

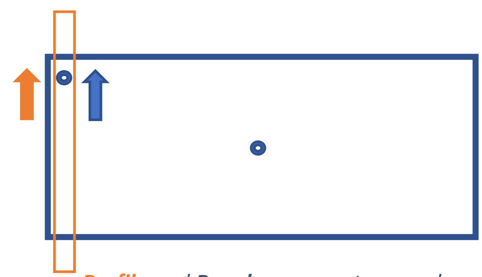
$\Delta L = \alpha L \Delta T$

$L = 21.25in = 0.54m$

$\Delta T = 60°F = 33.33°C$

$\alpha = Thermal\ Expansion\ Coefficient = 0.0123 \dfrac{mm}{m°C}$

$\Delta L = 0.0123 \frac{mm}{m°C} \times 0.54m \times 33.33°C = \mathbf{0.221mm}$



Panel Thermal Expansion/Contraction (Vertical Direction only)

Maximum Thermal Movement

$\Delta L = \alpha L \Delta T$

$L = 21.25in = 0.54m$

$\Delta T = 60°F = 33.33°C$

$\alpha = Thermal\ Expansion\ Coefficient = 0.01 \dfrac{mm}{m°C}$

$\Delta L = 0.0123 \frac{mm}{m°C} \times 0.54m \times 33.33°C = \mathbf{0.180mm}$

Total thermal vertical displacement from the center of the hole $= 0.180mm - 0.221mm = \mathbf{-0.041mm}$