TECHNICAL BULLETIN

Allowable Deflection for MCM Cladding – Why L/60?

Overview

One benefit, long enjoyed by metal composite materials (MCM), is the ability of the panel to deflect under load and return back to flat once the load is removed. Even with this ability, there is a limit to how far MCM panels are allowed to deflect. IBC Table 1604.3 defines the deflection limits of construction materials including metal roofing and siding. While MCM is not specifically listed, footnote "a" discusses "structural roofing and siding made of formed metal sheets" and allows the deflection of these materials to be L/60. MCM has long been included in this group and L/60 is recognized as a limiting factor.

Discussion

The allowable deflection limits have long been included in the code for both structural and visual reasons. Prior to the International Building Code (IBC), allowable deflection was long regulated by both the Model Codes and local building codes. The original intent was to provide a limited amount of movement that would prevent brittle interior finishes and materials from cracking under load. In some cases, such as wall cladding, this loading was generally limited to wind load, however in many cases ceiling panels were also covered and this loading would include both live loading from the floors above and the weight of the materials used in construction.

In today's building code, we can find deflection limits defined in Table 1604.3. These limits are generally identified as L/XXX with "L" being equal to the material span between support points and the denominator being a fixed number based on the construction member and the type of finish involved. For instance, exterior wall members with plaster or stucco ceilings are limited to L/360 for wind load (W) deflection. In this case, with a span between supports of 10' (120"), the allowable deflection of L/360 = 0.33".

Seems odd to be using the span between supports to determine allowable deflection, however past performance dictated that deflection in excess of this amount would create cracking in the plaster or stucco finish.

Metal materials are known for the ability to deflect and return to the original orientation once the loading is removed. Obviously, there is a point at which the panel yields and there is permanent deformation. However, prior to this yield point, the allowable deflection is identified in footnote "a" as L/60. This means that same 10' span would be allowed to deflect 120/60 = 2.0"

In a situation such as this, other criteria come into play including disengagement of materials due to movement or visual acceptance during loading. For this reason, we often see a limit put on allowable deflection and many times that limit is 0.75" for metal material. While the panel may resist load adequately after exposure to this load, the visual appearance is greater than what is deemed visually acceptable.

That would mean that the allowable deflection in a typical 5' x 12' metal panel would be 60"/60 = 1". Allowable deflection is always measured across the shortest distance between supports.) This would generally not be allowed on a structure as the panels would appear as sails on the building and possibly disengage from the perimeter support systems that hold the panel in place. This is why thin metal panels often incorporate a subframe behind the panel to limit deflection.

Panel Deflection and the Subframe

One component used in the equation to determine deflection is the inherent stiffness of the panel. This is reflected in the variable "I" (or "J" in some cases) and represents the Moment of Inertia of the panel. For a solid metal sheet, the entire thickness of the sheet contributes to that I-value and the sheet is stiffer than a thinner sheet would be. This is why a 0.25" thick aluminum panel is much stiffer than a 0.125" thick aluminum panel. While stiffer, this panel is also heavier and costlier than the thinner sheet or even MCM material.

An MCM sheet is two layers of metal separated by a thickness of core material. The stiffness value for that core material is most often temperature dependent, so most engineers consider the MCM panels as two layers of metal separated by a fixed thickness of air. While a bit conservative, this method provides a reasonable stiffness for MCM materials.

Back to our 5'x12' panel. In order to decrease the deflection on the panel, we must decrease the spacing between supports. This is where aluminum "stiffeners" are adhered to the backside of the panel using some type of structural adhesive. These "stiffeners" are generally aluminum extrusions with a depth of 1" to 1.5" and are adhered to the panel support structure at a 16" to 24" spacing, and in some cases as much as 36" spacing, depending on wind loading and strength of the stiffener being used. The stiffeners provide additional support to the panel when both positively and negatively loaded so that both the panel and stiffener must resist deflection. Therefore, the panel between stiffeners is allowed 16"/60 = 0.27" (between stiffeners at 16" spacing) and 36"/60 = 0.6" (between stiffeners at 36" spacing) and the stiffener, along with the tributary area of the panel is measured for deflection across the 60" (width) of the panel. There are some additional deflection limits associated to the use of a subframe located in IBC Chapter 16 however, the panel deflection typically controls the panel/panel framing design.

One last point to clarify is that we often see architectural specifications improperly calling for an allowable deflection of L/175 which is the level allowed for glass products. The difference in these allowable deflections is significant even for a 48" span:

L/60 = 0.80"   L/175 = 0.274"

The allowable deflection for glass is also limited by a maximum value of 0.75" based on extensive testing and the breakage point of glass that been supported by the American Architectural Manufacturers Association for a number of years provided the glass span is less than 13'6".

A case against holding MCM to allowable deflection less than L/60

Holding the allowable deflection of an MCM panel to a stricter deflection limit, such as L/175 or L/240, does not necessarily mean that a higher quality product will be supplied. Not only will the additional stiffeners required to meet this deflection add cost and weight to the panels, but the only time that the additional stiffness would be an advantage is during a high wind event. One of the significant benefits of MCM is that while the panel does deflect during wind loading, the deflection goes away with the removal of the load and there is no residual permanent deformation. Another alternative to limit deflection would be to decrease the panel size which seems to go against the architectural desire for larger panels.

The use of additional stiffeners could decrease panel deflection however, there can also be some unintended negatives in the form of creating more "hard points" to create permanent deformation due to thermal movement in the panel. MCM panels primarily move with the thermal expansion of the aluminum facers. The support frame (stiffeners) are also aluminum, however they do not generally see the kind of temperatures that the panel does since they are not directly exposed to solar radiation. On very rare occasions, where the panels are exposed to excessively high temperatures, the thermoplastic core will soften enough to allow very localized permanent set. This permanent set is often referred to in the field as "stiffener read-through". This effect may be caused by excessive temperatures or when a panel is restricted from thermal movement. (The advent of FR core panels has minimized the frequency of this effect, but there are still occasional cases that are reported.)

One must keep in mind that permanent set is an affect that will allow readthrough to be seen even after the panel load is removed. Panel deflection is only present while the load is being applied and goes away when the load is removed. On typical days it would be difficult to notice a difference between an MCM panel designed for a deflection limit of L/60 and one that is designed for a limit of L/175 or greater.

Finally, we must keep in mind that panel deflection and stiffener read-through are generally difficult to determine. The ability to see this issue is highly dependant on the finish color and gloss of the MCM panel as well as the light conditions and viewing angle. A panel with additional stiffeners may actually look *worse* than a panel with fewer or no stiffeners if the conditions are prone to stiffener read-through.

MCM Fabricators have had many years of experience addressing panel deflection and read-through and are generally well versed in minimizing the visual impact associated with the use of stiffeners. Their experience, based on multiple panel applications in a variety of conditions has helped to identify the best solutions to the "allowable" deflection when considering both building code and visual limitations.

Summary

While there are many structural calculation methods/programs available today to determine panel stress and deflection, historically the use of L/60 as an allowable deflection has been shown not only to be acceptable, but code compliant. At this level, the panels will not permanently deflect under loading and will generally be deemed "visually acceptable" in the eyes of the owner and building official.

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