TECHNICAL BULLETIN

Insulated Metal Panels – Structural Loading

What types of structural loading do insulated metal panels support?

Insulated Metal Panels (IMPs) perform very well at resisting transversely applied loading. This type of loading is applied normal to the face of the panel and includes wind loading, as well as live/dead/snow loading – for roof panels. Being separated by an insulating core, IMPs also resist thermal loading that can be induced when the face and liner sheet are at different temperatures.

IMPs are not classified as “load-bearing” panels in the sense of axial loading. They can be used on a load-bearing wall, but only if the axial load is carried by other construction – not by the panels. Many insulated panels have a progressive tongue-and-groove interlock joint, being hard fastened to the structure only along their leading edge. These side joint fastened panels can exhibit low resistance to racking type loads.

Structural Analysis of IMPs

IMPs are analyzed as nonhomogeneous structural beams that have five basic modes of failure:

- Flexural buckling of the metal facings
- Shear failure of the core
- Excessive deflection
- Clip/fastener failure
- Connection failure

The complete structural analysis of an IMP system must address each one of these issues. It is important to note that when placed under a shear load, the foam core cells will deform elastically to a certain degree. The extent to which this deformation occurs defines a physical property of the core called “shear modulus”. This action causes additional deflection that redistributes reactions among the supports and alters conventional beam analysis equations.

Accurate structural analysis is best performed by the panel manufacturer’s design team or by an independent design professional familiar with composite foam panel design. It is unwise to limit such calculations only to those “licensed to practice in the state in which the project is located” unless these professionals are familiar with composite foam panel behavior. The panel manufacturer will typically provide panel calculations and/or test reports to the project’s Engineer of Record.

How do IMPs Carry Structural Loads

Understanding the manner in which IMPs carry structural loads requires a basic knowledge of the potential failure modes. Design considerations can overcome these characteristics.

Flexural Buckling

The metal facings of IMPs carry flexural tension and compression like flanges on an I-beam. Flexural buckling of one or both facings will occur if the panel’s ultimate moment capacity is exceeded. The thin, metal facings of IMPs often buckle at values considerably lower than those calculated from the yield strength of the metal. The panel’s ultimate moment capacity needs to be determined by full-scale structural testing such as ASTM E72, ASTM E330, or ASTM E1592.

Shear Stress

With flat-faced IMPs, the panel core carries virtually all of the shear stress. If the metal facings are deeply profiled (such as with ribbed-roof panels) both the core and the metal facings share the shear stress. A panel’s ultimate shear capacity can be determined by testing short spans under extremely high transverse loading; such that a horizontal shear failure is induced on the core before flexural buckling occurs. A shear failure is evidenced by a tearing fracture in the core or at the bond line. A tearing fracture at the bond line occurs within the foam core and should not be confused with a composite bond failure between the foam core and the metal.

Excessive Deflection

Although not classified as a true structural failure, excessive deflection can cause seals to break down, resulting in leaks. Most project specifications limit panel deflection to a percentage of the span length. A maximum panel deflection of L/180 is common for wall applications, although the 2015 International Building Code (IBC) Table 1604.3 allows a maximum deflection of L/120 for walls with a flexible finish. Roof applications generally limit panel deflection to lesser values like L/240 or L/360 when supporting a ceiling and as flexible as L/180 when not supporting a ceiling. IMP deflection is calculated as the sum of the metal facing's elastic beam deflection plus the core's shear deflection. The shear deflection component is a function of the core's shear modulus, a value that can be determined from deflection readings taken during ASTM E72, ASTM E330, or ASTM E1592 testing. Sustained loading, such as a long term snow load, can cause additional shear deflection due to "creep" of the foam core cells. IMPs are quite resilient and will return to their flat position soon after the transverse load is removed.

Clip/Fastener Loading

When subjected to a wind uplift or "suction" load, the panel anchorage mechanism receives a concentrated point load. This point load can be quite high because IMP systems normally contain far fewer attachment points than field assembled panel systems. Anchorage clips and panel side joints need to be designed with enough capacity to withstand this concentrated loading. The anchorage clips are not usually the mode of failure; the panel will fail in the area where the anchorage clips are located.

The screw holding power into the structural support must be examined to ensure that a sufficient safety factor exists to prevent "pullout". This can be a problem in lighter gauge supports when spaced far apart. Many IMP anchor clips have two or even three holes, so that more than one screw may be used if necessary. Mid-span anchorage points typically receive higher loading than end attachments.

Connection Failure

Stresses induced under negative wind load often create the most critical conditions that govern the spanning capabilities of IMPs. These are the same forces as those described for clip/fastener loading. Wind loads act to draw the panels off the building as opposed to positive loading that pushes the panels into the supports. When side joint concealed fastening is used, the panel not only deflects along its span length, but also across its width. The resulting combination of tensile and shear stresses concentrated at the attachment points may fracture the composite bond and distort the anchorage mechanism to the point of joint disengagement.

Back fastening can also be used in many cases to hold wider panels against the supports and achieve specified "high-load" conditions. The failure mode of a back fastener is typically bond failure of the core/liner interface, rather than fastener pullover. The panels' negative load carrying capacity, including the actual fastening method, or methods employed on a project, must be tested in accordance with ASTM E72, ASTM E330, or ASTM E1592.

Another factor involved in all five basic failure modes of IMPs is thermal stress. Because IMP materials have very high insulating values, the face and liner sheet are usually at different temperatures. Temperature differential causes the face and liner sheet to expand or contract dissimilarly. The metal faced foam panel will have a tendency to bow toward the warmer side (i.e. thermal bow). Thermal bow may cause the panel to fail because of excessive deflection, especially on tall, interior partition walls in cold-storage applications.

Multiple span conditions restrain the panel from thermal bow and induce stresses in the facings and core similar to structural loading. Long-length panels with dark-color exterior faces can have thermally induced facing stresses that exceed those caused by the design structural loading. Factors that increase thermal stress include long panels, dark colors, aluminum facings, and thin cores.

Conclusion

IMPs provide exceptionally strong building enclosures. It is not uncommon for these panels to successfully achieve spans of 10 ft or more between supports. For structural support, the width and thickness of the panels or the support spacing can be adjusted. The gauge of the metal facings can affect spanning capability, resistance to thermal stress and flexural buckling. The composite bond of IMPs produces a building unit that is much stronger than the individual components, even with very light gauge facings.

Founded in 1983, the Metal Construction Association brings together the diverse metal construction industry for the purpose of expanding the use of all metals used in construction. MCA promotes the benefits of metal in construction through:

- Technical guidance
- Product certification
- Educational and awareness programs
- Advocating for the interests of our industry
- Recognition of industry-achievement awards
- Monitoring of industry issues, such as codes and standards
- Research to develop improved metal construction products
- Promotional and marketing support for the metal construction industry
- Publications to promote use of metal wall and roof products in construction

For more information, please visit the MCA Web site at www.metalconstruction.org

V1 – Dated 3/07

METAL CONSTRUCTION ASSOCIATION
8735 W. Higgins Road, Suite 300, Chicago, IL 60631
847.375.4718 I mca@metalconstruction.org I www.metalconstruction.org

BUILD LEGACIES METAL