White Paper

High Strength Base (HSB)

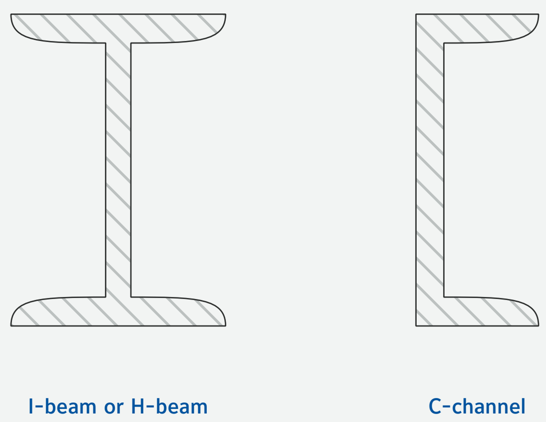
Advancements in structural base design for custom air handlers

The structural steel base has been the mainstay of custom air handler construction since the first half of the twentieth century. The plethora of commonly available steel shapes manufactured via hot and cold rolling provides convenient components for manufacturing almost any steel structure, including custom commercial and industrial air handlers. Every custom air handler manufacturer has pulled from this same list of parts for structural members, such as side and cross-rails - until now. The needs of this century – sustainability, energy efficiency, and reduced carbon footprints – demand a better solution.

As previously noted, hot and cold-rolled structural steel components available from any major metal distributor provide convenience in supply chain, engineering, and fabrication. The most commonly used shapes are the I-beam (similar to H-beam) and C-channel.

But this convenience comes with certain inefficiencies that affect the air handler and everything around it. The two features of hot-rolled, structural shapes that lead to inefficiency are:

- Weight
- Dimensional accuracy



Weight

High weight is the result of using shapes of with a very simple cross section that are convenient to the manufacture of long structural members with a hot-rolling mill. The extra weight comes from:

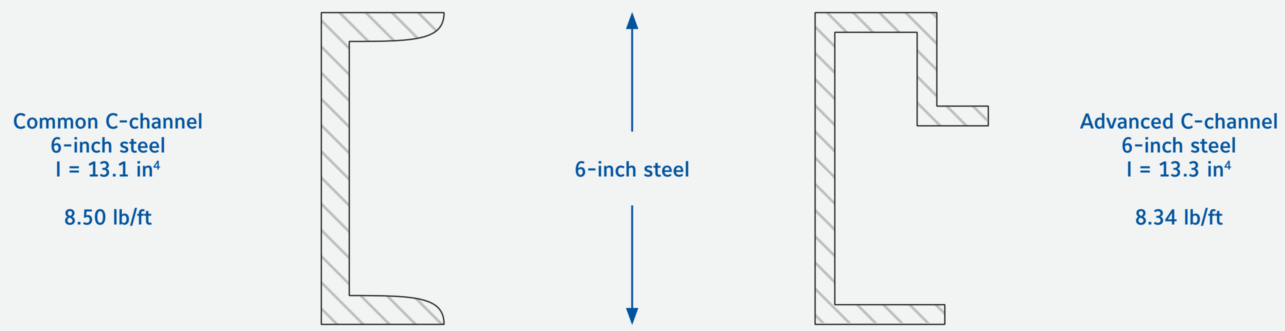
1. The structural steel manufacturing process and tolerances
2. The Moment of Inertia

The structural steel manufacturing process is done with relatively large equipment. This results in large manufacturing tolerances. Additionally, the material rolled in the hot condition must be sized such that the correct dimensions are attained when the material has cooled. In order to ensure the minimum required material thickness is attained while providing guaranteed average weight, the member may be run at a weight higher than the average requirement.

The strength of a structural member's cross-section depends on the particular material and its temper, along with its Moment of Inertia (MOI). The MOI is a measure of the capacity of a member to resist bending and is based on the geometry of the cross-section. Shapes with lower MOI require either stronger materials or thicker cross sections in order to provide the overall member strength needed for the application.

Dimensional accuracy

Dimensional accuracy of the structural members has more of an impact on the overall performance of the air handler than the weight. Cross-sectional dimensions can vary by up to a quarter of an inch on standard I-beams. Straightness, camber, and sweep tolerances add up to potentially large gaps at the interface of the beam's top flange and the Air Handler Unit (AHU) wall and floor panels. This provides challenges in providing adequate structural attachment while also impeding installation of a consistent thermal break. It results in over-use of sealants to reduce leaks, condensation, and address fitment issues at the job site.



A better solution is here. Improving the sustainability, boosting energy efficiency, and reducing the carbon footprint requires structural members that are lighter, use less material, and have highly accurate dimensions. The improved structural base design utilizes members that accomplish this goal.

Weight reduction

The weight reduction was achieved by first designing an ideal cross-sectional profile that would minimize the material content while providing strength and stiffness similar to that of current structural steel members. This involved developing a profile that has an increased MOI.

When comparing C-channels of the same height, the advanced C-channel provides a weight reduction of approximately two perecent in comparison to the common C-channel while offering an increase in the MOI of 1.5 percent. These are modest, yet real, improvements.

Significant weight reductions are recognized when comparing the advanced C-channel design to larger C-channels. The following tables illustrates a comparison for 8-12-inch members.

Std. Channel Size	High Strength Channel Depth	Std. Weight/Ft	Adv. Weight/Ft	Std. MOI	Adv. MOI
8″	8″	11.5	9.63	32.6	26.72
10″	10″	15.3	10.90	67.4	45.94
12″	12″	20.7	12.18	129	71.87

The straps are typically attached to the lifting lugs using shackles.

The data shows weight reductions from 16.3 percent to 41.2 percent, depending on the channel depth. However, unlike the six-inch channel, there also is a similar reduction in MOI.

The reduction in MOI with the larger channels requires further refinement to the design to utilize the significant weight savings.

This requires two primary approaches:

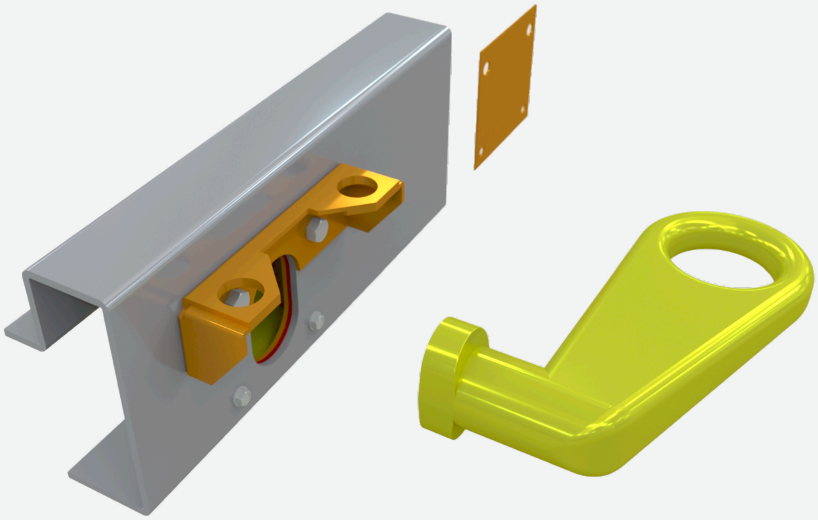
1. Analysis of the overall air handler weight with the optimized members

2. Development of a new lifting system that allows for an increased number of lifting points without adding significant cost

A weight reduction for the base results in lower total air handler weight and thus decreased bending moments on the structural members during rigging. With a conventional structural steel base comprising 15-24 percent of the total air handler weight with components (based on standard wall, floor, and roof panel construction for custom air handlers), the bending load reduction can be in the range of 0.3 percent (for six inch) to 10 percent (for 12 inch). This translates to a decrease of similar magnitude in the required MOI.

The second approach involved the development of an innovative lifting system that cost-effectively allows the installation of more lifting points. Instinctively, having more lifting points results in shorter bending moments and thus further reduces the MOI requirements. However, this approach is much more complex than a weight-stress analysis.

A conventional air handler lifting lug is shown in the photo above.



The container-style lifting lug interfaces with a specially designed mating slot on the air handler perimeter structural member such that the weight of the load itself secures the container-style lug in the slot.

The conventional lifting lug installation method involves cutting the appropriate section from metal sheet or plate stock and making a hole through it via punching, machining, plasma, or water jet. The section is then attached perpendicular to the outer surface plane of a base perimeter member via welding, bolting, or other mechanical attachment method along with adding reinforcement gussets as necessary. The lifting lugs then protrude from the sides of the base like wings and allow two functions:

1. Lifting of the air handler onto trucks/trailers and rigging into place while preventing the lifting straps from damaging the outer skin of the air handler
2. Securing the air handler to the truck/trailer bed for transport

This system has been in use for many decades and is proven to be reliable and safe. However there are shortcomings to this method:

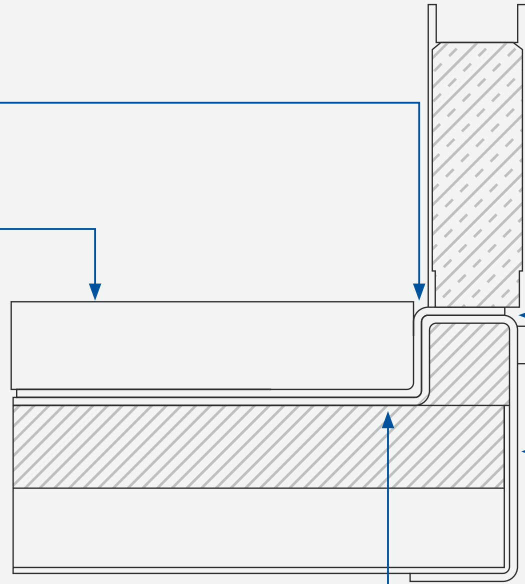
- The lifting lugs add significant extra width to the air handler
- The lifting lugs add notable extra cost
- Proper selection, inspection, and installation of the shackles is paramount to safe lifting

The new Johnson Controls Structural Base system includes a patent-pending lifting system design that is simple, elegant and, most importantly, that overcomes the weaknesses of the conventional system. Our engineers adapted a concept used on shipboard containers and applied it to commercial air handlers. It starts with a container-style lifting lug as shown above.

In comparing the newer, less complicated lifting system to the shortfalls noted in the conventional system, we can see that:

- The adapter plate reduces the added air handler width by several inches
- The new system uses significantly less material and requires less labor to install
- Lifting safety is enhanced by the elimination of the standard shackles – no more improperly secured shackle pins

The development of the unique lifting system then allowed our designers to optimize the number of lifting points for a given air handler. This reduces the bending load on the Advanced Structural Base to minimize the MOI required for safe, effective rigging.



Improved thermal break

A primary concern with air handlers is having condensation present on the outer surfaces during cooling operation. This indicates poor thermal performance. Thermal breaks are used to increase the thermal resistance between the inner and outer surfaces of the air handler and thereby increase the thermal efficiency. However, as previously mentioned, the dimensional tolerance issues associated with using off-the-shelf structural shapes make the proper installation of a thermal break inconsistent and unreliable.

The unique shape of the patent-pending structural members, along with their superior dimensional accuracy, provide a platform for providing a significantly improved thermal break between the walls, floor panels, and the base members.

Once the new structural system design was complete, experiments on a full-size air handler were conducted to determine the thermal performance of the new base system in comparison to a conventional base system. The results showed a reduction of the temperature difference between the ambient air and the perimeter member outer surface ranging from 0.5°F to 3.5°F, thus indicating a significantly improved thermal break.

We offer an industry-leading air platform for increased safety and sustainability.

Summary

The all-new base, through its optimized structural design, innovative lifting system, and significantly improved thermal break provides an industry-leading custom air handler platform. The implementation of modern structural members that are lighter, use less material, and have highly accurate dimensions improves sustainability, increases energy efficiency, and provides a carbon footprint reduction that results in a more cost-effective solution – with the bonus of added safety during lift operations.

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