steelwise

LIFTING DEVICES

BY CHAD FOX, SE, PE

An expert provides tips on designing lifting devices for steel erection.

Chad Fox (**cfox@rubyandassociates.com**) is a project manager with Ruby + Associates, Inc., Structural Engineers and leads Ruby's Heavy Lift Service. He is a member of the ASME BTH-1 Standard Committee.

TECHNOLOGICAL ADVANCES IN MODELING have helped simplify the design and fabrication of more complex steel structures in recent years. Steel erection has also seen advancements, with cranes and other heavy-lift equipment continuing to increase in lifting capacity.

To keep pace with these developments, steel erectors are increasingly challenged to develop safe and efficient means and methods for lifting. This is where heavy-lift engineering, including the design of unique lifting devices, comes in.

Below the Hook

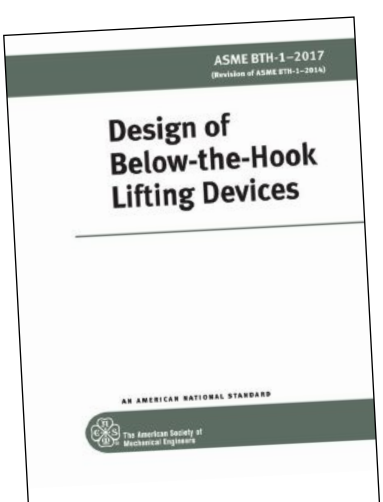
An essential tool set to assist with these challenges is below-the-hook lifting devices. Some of the most common types of below-the-hook lifting devices in steel erection include:

Spreader beams. As their name indicates, spreader beams are used to "spread" out the attachment points to a lifted load, typically using slings. This capability is particularly useful in lifting trusses or joists, where added compression due to rigging forces has the potential to cause buckling in the chord members.

Clamps. When lift points (typically lift lugs) are not possible and sling baskets or choker hitches are not safe, clamping fixtures, which rely on friction, can provide options for erection of unique fabrications. Section 4-9 of ASME BTH-1 (see Design and Construction Standards below) addresses clamping devices, requiring a minimum factor of safety of 2.0 on friction resistance.

Bolt-on attachment points. Repetitive objects can lend themselves to the use of reusable attachment fixtures, such as bolted lifting lugs. Since these are lifting attachments that can be removed and reused, ASME B30.20 (see Design and Construction Standards below) and BTH-1 consider these to be below-the-hook lifting devices. Lifting attachments that remain permanently attached to the lifted load are not subject to the requirements of B30.20 or BTH-1. Clarity in the delineation between lifting attachments and below-the-hook lifting devices will be included in the 2020 revision.

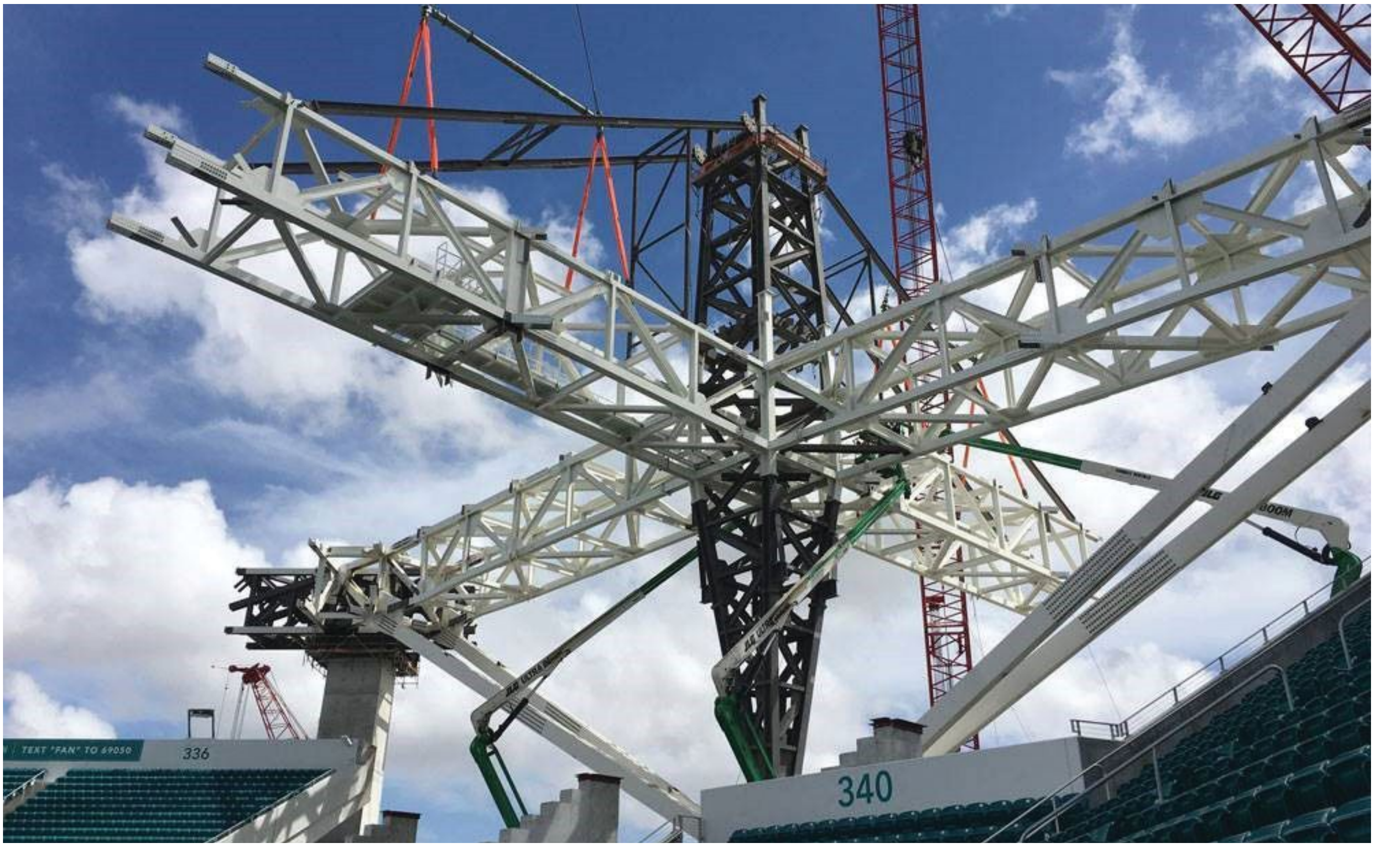
Triangular plates or frames. Triangles can provide a variety of functions in the lifting of objects. When crane capacity limitations require the use of more than one hook, triangles provide a convenient means to equalize loading between cranes. Triangles can also be used for the attachment of a third line, typically adjustable, which allows for geometry manipulation of the lifted object.



ASME BTH-1 provides guidance on designing heavy lift systems.

Design and Construction Standards

There are several resources that can provide guidance when designing heavy-lift systems. The American Society of Mechanical Engineers (ASME) has developed domestic industry standards for both the design (ASME BTH-1) and construction (ASME B30.20) of these devices. ASME BTH-1 was first published in 2005, and an updated version is set to be published later this year. Chapter 3 of the standard, "Structural Design," may look familiar to structural engineers, as it largely follows the 1989 version of AISC's *Specification for Structural Steel Buildings*. (Be aware that since 1989,



A spreader beam (above) and a multi-crane lift using triangular frames (right) were employed to erect the Hard Rock Stadium Shade Canopy in Miami Gardens, Fla. (The project was a 2018 AISC IDEAS[2] Award winner. See the May 2018 issue at **www.modernsteel.com**.)

the AISC *Specification* has been updated many times to correct issues.) However, designers should be mindful of some important differences between the two publications. Since ASME governs lifting devices and not building design, the ASME standard should govern. Here are the main differences:

1. **Safety Factor.** Lifting devices, for reasons such as lack of redundancy, dynamic loading, and a high risk to human safety in the event of failure, require safety factors higher than those found in the AISC *Specification* for the building design. Chapter 2 of ASME BTH-1 prescribes different safety factors based on Design Category (type of use) and Service Class (frequency of use).
2. **Pin Plates.** Pin plates, commonly known as lift lugs or pad eyes, are regularly used in lift devices for attaching rigging components such as shackles. BTH-1 includes an entire section (3-3.3) dedicated to their design. Many of the checks included differ from or are not included in the AISC *Specification*.
3. **CLTB.** Lift devices, typically known as lift beams, are subject to bending and require a reduction in buckling strength due to a lack of resistance to twist or lateral displacement at the ends of their unbraced lengths. The lateral-torsional buckling strength coefficient (CLTB) attempts to account for this reduction.
4. **Combined Normal and Shear Stresses.** Section 3-2.5 requires a combined normal and shear stress check based upon the Energy of Distortion Theory.

above: Lift beams were used for gantry crane erection at the Consumers Energy Pumped Storage Hydroelectric Plant project in Ludington, Mich.

below: A below-the-hook lifting device with identifying information per ASME B30.20 section 20-1.2.1

Clamping fixtures on the Interstate 94 Gateway Bridge arch section lift, a tied-arch bridge in Taylor, Mich.

5. **Fillet Weld Load Direction Factor.** ASME BTH-1, as of 2020, does not include the fillet weld directional strength increase included in AISC *Specification* Equation J2-5.

Another standard that covers lifting devices is ASME B30.20: *Below-The-Hook Lifting Devices*, first published in 1985. ASME B30.20 includes provisions for the marking, construction, installation, inspection, testing, maintenance, and operation of below-the-hook lifting devices, but refers to BTH-1 for their design. It should be noted that per B30.20, all welding should be in accordance with ANSI/AWS D14.1.

Load testing of below-the-hook lifting devices is of critical importance to ensure the device will lift its rated load, and ASME B30.20 Section 20-1.3.8.2 describes load testing requirements. And although B30.20 states that a load test "should" be performed, it is important to note that OSHA 1926.251(a)(4) states that special custom design grabs, hooks, lamps, or other lifting accessories "shall" be proof-tested prior to use. Both B30.20 and the OSHA standard specify that the load test shall be performed at 125% of the rated load, the lifting device shall be visually inspected following the test, and a test report should be developed and made available.

In addition, ASME B30.20 Section 20-1.2.1 states that below-the-hook lifting devices should be marked with the following identifying information:

- Rated load
- Manufacturer's name and address
- Serial number
- Lifting device self-weight
- ASME BTH-1 Design Category
- ASME BTH-1 Service Class

Inspection requirements are described in Section 20-1.3.1, and Table 20-1.3.3-1 ("Minimum Inspection for Below-the-Hook Lifting Devices") is particularly useful to spelling them out for designers.

Steel erectors face many challenges when building steel structures. But when designed by a qualified structural engineer with the guidance of ASME BTH-1, and constructed per ASME B30.20, lifting devices can provide safe and efficient tools to assist in development of practical erection solutions. ■