A brief look at AISC's new Design Guide 31, which covers castellated and cellular beam design.

Holey STEEL!

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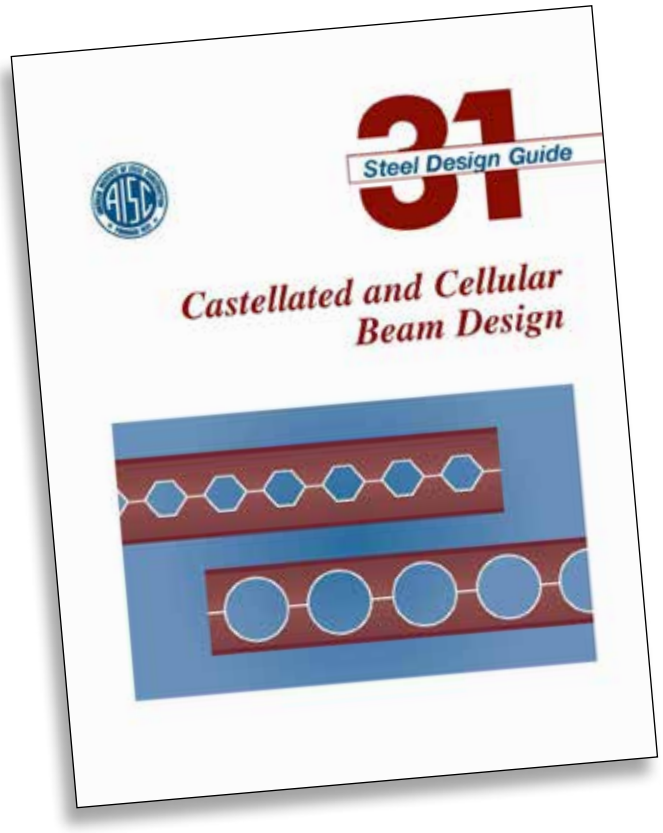

CASTELLATED AND CELLULAR BEAMS came about in a time and place when steel was scarce.

Introduced in Europe in the 1940s due to steel shortages, the beams provided a practical, strong solution using less steel than typical members.

While steel is now readily available in most parts of the world, the practice of using beams with repeating, regularly spaced "holes" continues to this day and is well established in structural design codes in the UK, also gaining global acceptance over the past 20 years. In fact, AISC has recently released Design Guide 31: *Castellated and Cellular Beam Design*, a new publication dedicated to designing projects using these beams (available at **www.aisc.org/dg**).

How Holey?

Castellated and cellular beams are steel beams with hexagonal and circular web openings, respectively. Castellated and cellular beams are fabricated by using a computer-controlled cutting torch to cut a pattern along the web of a wide-flange section. Once the section has been cut in the appropriate pattern(s), the two halves are offset, the waste at the ends of the beam is removed and the sections are welded back together to form a new section that is approximately 1.5 times deeper than the original section. As a result of the increased depth-to-weight ratio caused by expanding the web, beam strength and stiffness are increased. The increase in the moment of inertia, I_x, that results from increasing the depth of the root wide-flange section makes longer spans possible, providing potential cost savings when used in long-span applications. Generally speaking, castellated and cellular beams become an economical option for spans longer than 40 ft, and typical spacing for economical use is about 8 ft.

➤ Visible weld seams from the cellular beam fabrication process.

There are many advantages to incorporating castellated and cellular beams into a project. The ability to use fewer columns and footings to support the longer-spanning sections creates additional column-free space and floor space flexibility. The ability to use longer, lighter spans in comparison to the base wide-flange section results in fewer members needed for a given system, thus reducing erection cost. MEP designers can also run utilities directly through the web openings of the beams, saving several inches of height per floor. Additionally, the beams are aesthetically pleasing, providing an architectural feature in structures where they are exposed.

Official Guidance

Architects and engineers are increasingly incorporating these expanded-web sections in an effort to use steel more efficiently and address layout challenges. But compared to Europe, their acceptance in the U.S. has been relatively low due to the lack of design standards, as the web openings in these beams introduce new limit states and unique design considerations. But with the introduction of Design Guide 31, designers now have a comprehensive resource to the state of practice that

➤ Exposed celluar (and curved) steel at Chicago's O'Hare International Airport.

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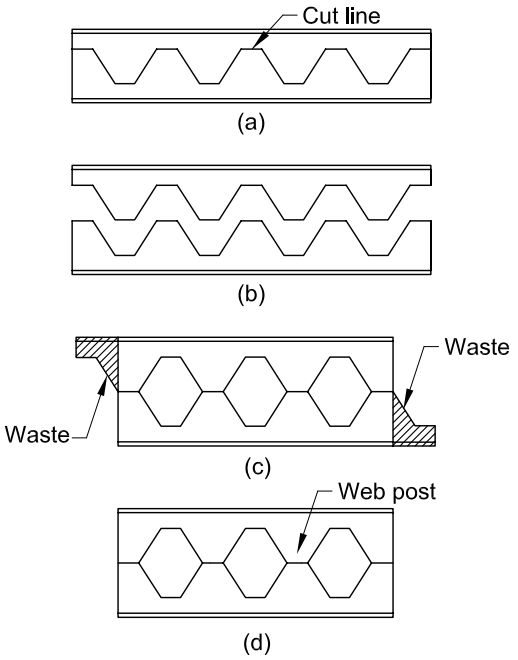

Fig. 1-1. Manufacturing of a castellated beam.

▲▼ The manufacturing processes for castellated and cellular beams. Both are detailed in the Design Guide.

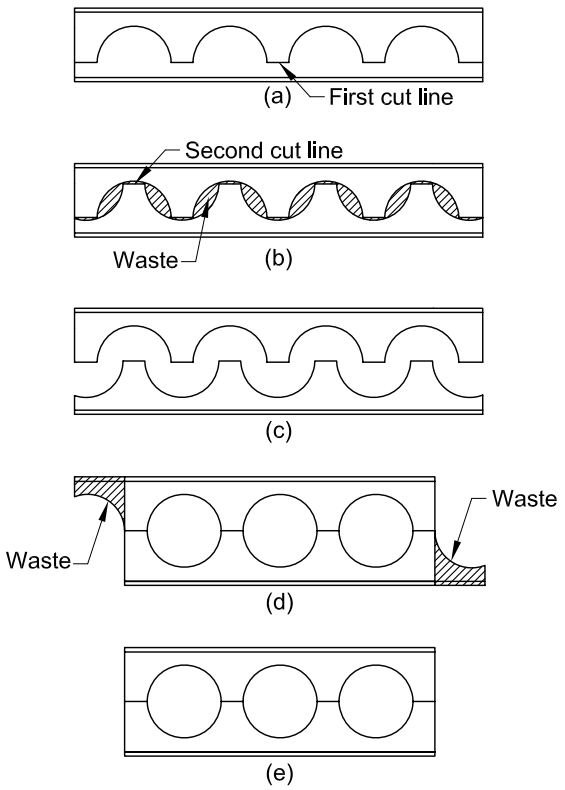

Fig. 1-3. Manufacturing of a cellular beam.

➤ Cellular beams in Boise's Banner Bank (read about it in "Banking on Sustainability" in the July 2007 issue, available at **www.modernsteel.com**.

▲ Exposed beams in a parking garage project.

adheres to the 2016 AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360-16) available at **www.aisc.org/specifications**. Here is a brief summary of what's to be found in the new design guide:

- **Chapter 1** provides a brief introduction that includes the difference in manufacturing processes between castellated and cellular beams and beam nomenclature.
- **Chapter 2** highlights the applications for the beams, web opening size and spacing considerations, and presents special considerations such as concentrated loads, depth-sensitive projects, erection stability, fireproofing and coating systems.
- **Chapter 3** provides design procedures for castellated and cellular beams for noncomposite and composite construction. Subsections include Vierendeel bending, web-post buckling, horizontal and vertical shear, lateral-torsional buckling and deflection.
- **Chapter 4**, which encompasses the bulk of the guide, presents four detailed design examples: noncomposite castellated, noncomposite cellular, composite castellated and composite cellular.

The publication concludes with a listing of familiar and new symbols included within, citations of the references used and a bibliography of other relevant published information for further reading.

By bringing the state-of-the-practice designs and research outcomes of castellated and cellular beams together in one document, engineers will gain a better understanding of this beam type and hopefully accelerate their acceptance and application in the U.S. ■

For up-to-date information on manufacturers that produce castellated and cellular beams and software providers that address their design, contact the AISC Solutions Center at ***solutions@aisc.org****.*