CURVED STEEL

A REFERENCE FOR ARCHITECTS & ENGINEERS

AISC ASSOCIATE

There's always a solution in steel.

How did they do that?

As curved steel has been increasing in popularity, so have the questions about it:

- Who curves steel?
- Where can you use curved steel?
- How do you curve it?
- Is it easy?
- Where can I find additional information?

This brochure will answer these questions and many more. Multiple steel projects are highlighted to show how any project—from the largest monumental project to that building down your street—can benefit from the use of curved steel. In addition, this reference contains a pictorial description of how steel is bent as well as a technical article about curving steel.

The best way to answer all your curving questions is to contact AISC Associate Member Bender-Rollers listed at **www.aisc.org/benders**. In addition to contact information, the site is a great resource for curved steel, featuring technical articles, current industry developments, and the latest curved steel projects.

So keep reading—and learn how you can use curved steel in your next project.

PORTLAND INTERNATIONAL AIRPORT

PORTLAND, OREGON

Passengers departing from Portland International Airport are protected from rainy weather thanks to the 120,000 sq. ft steel and glass canopy covering the passenger drop-off area. The lacy network of curved triangular trusses supports two cable-suspended serpentine walkways connecting the main terminal to the airport's parking garages.

BELLSOUTH LINDBERGH CENTER

ATLANTA

With a curved steel and glass roof soaring four stories, this atrium provides circulation and retail space for several office towers. Curved exposed steel members add style and visual interest to an otherwise traditional space.

ENTRANCE CANOPIES

The first impression of any building, no matter how simple, is the entry. Using curved structural steel as part of an entrance canopy is a cost-effective way to combine style and function in even the tightest construction budgets.

AUTO DEALERSHIPS

Hummer Dealerships throughout the United States feature curved steel as a simple—but high impact—architectural element. In contrast to many suburban "big box" retail structures, Hummer Dealerships use curved steel as their primary roof structure. Curved steel members are usually left exposed inside, creating dramatic interior spaces.

How Steel is Bent

Have you ever seen a steel beam bent in real life? Probably not, but now you have the opportunity to find out how it's done. The pictures below show the most common bending process, which is called **roll bending** or **pyramid bending**. The rolling machine has three adjustable rolls in a pyramid configuration—a tighter roll spacing produces a tighter radius. The beam shown is a W30×135 being rolled along its weak axis, also called the "easy way."

1 The beam is placed in the rolling machine and the operator adjusts the three rolls to the proper spacing before starting the bending process.

2 The operator slowly begins rolling, and he frequently checks the beam for distortion of the web and flanges in these early passes.

3 Several additional passes are carried out, with the operator measuring the overall radius after each pass to check the beam's progress.

4 The operator confirms the beam's final radius (14'-4$\frac{3}{16}$" in this case), completing the bending process.

5 The curved beam is lifted out of the rolling machine and moved to another area of the shop where the member's geometry is checked one final time.

MILLENNIUM PARK
JAY PRITZKER PAVILION
CHICAGO

11,000 concertgoers can now enjoy auditorium-quality sound, light shows, and uninterrupted sight lines thanks to the trellis of curved pipe that supports speakers and lights at the Jay Pritzker Pavilion in Chicago's Millennium Park. Covering an area larger than 4 football fields, this complex structure is a functional work of art wholly integrated into a stage adorned with the billowing stainless steel sails so characteristic of the architect Frank O. Gehry's style. 570 tons of 12 to 20 inch diameter pipe were curved to multiple radii with no distortion or scratches.

DOLPHIN ADVENTURE, INDIANAPOLIS ZOO

INDIANAPOLIS

Visitors to the Indianapolis Zoo can figuratively swim with the dolphins at the zoo's underwater dolphin exhibit. The "Dolphin Adventure" exhibit includes a 30-ft diameter, domed viewing area that is 27 ft underwater. The structure is composed of a steel frame with a curved steel tension ring and an acrylic dome and perimeter walls. It is the first of its kind in the United States.

What Engineers and Architects Should Know About Bending Steel

BY TODD A. ALWOOD

With these tips under your belt, you'll be ahead of the curve on your next bending or rolling project.

How much do you know about bending structural steel? Do you know what you need to show on construction drawings to transfer the idea of what the result should actually look like? Do you know how tight of a radius you can roll a W12×19, and what to expect it to look like? If you have bending questions, who do you ask? AISC's bender-roller committee is taking steps to address these questions, which are coming up more and more within the structural steel industry.

Bender = Fabricator?

Not so! The bender is typically a specialty subcontractor of the fabricator. Benders receive the steel from the fabricator (or sometimes furnish it themselves), and then ship the curved steel back to the fabricator. Benders usually have limited fabrication capabilities, such as hole drilling and plate welding, but they are generally used for smaller jobs that usually are not structural in nature. Typical fabrication is still carried out through the main project fabricator who organizes the steel package from procurement through delivery to the site for erection.

There's only one type of bending, right?

Nope! There are five typical methods of bending in the industry: rolling, incremental bending, hot bending, rotary-draw bending, and induction bending. Each method has its advantages. Some methods are more commonly used in the steel construction industry, while others are more common in the automobile or manufacturing industries:

- **Rolling** or cold bending is the typical method of curving steel for construction and is usually the most economical for rolling members with tighter radii. A steel member is placed in a machine and curved between three rolls. Cold bending may also be called "pyramid rolling" because of the three rolls' pyramid arrangement. Bending occurs when the distance between these rolls is manipulated before each successive pass.
- **Point bending** or gag pressing is usually used for cambering and curving to very large radii. Bending is achieved by applying a minimal number of point loads with a hydraulic ram or press at selected points.
- **Hot bending** is where a structural member is heated directly and then bent. The heat source could be a direct flame or furnace. This application is used extensively in repair.
- **Rotary-draw bending** is where the structural member is bent by rotating it around a die. The member is clamped into a form and then is drawn through the machine until the bend is formed. This method produces tight radii and is mainly used for complicated bends in the machine and parts industry.
- **Induction bending** uses an electric coil to heat a short section of a structural member, and then that member is drawn through a process similar to rotary-draw and cooled with water directly after. In some cases, this process can produce a smaller, tighter radius.
- **Synchronized incremental cold bending** is performed by applying pressure in a highly synchronized fashion at several locations on the section. This can result in tight radii with minimal distortion.
- **Other methods** have been developed by AISC members to enhance rolling and bending results.

What about construction drawings?

Have you worked on a building project that included bent steel and then had to answer RFIs because you were not exactly sure what the detailer or bender needed to produce that curved member? Here are several very important but very simple items that should be included on construction drawings when dealing with curved steel.

- **What are you trying to bend—what is the member shape and size?** This is simple and straightforward, but the benders often see requests for an estimate without a member size, and there is a big difference between bending a W8×10 and a W40×215. Plus, don't forget to list the grade of steel for the member, and if it must be domestically produced.
- **How about the orientation of the member?** The table at right shows several different member shapes with common terminologies:
  - "Easy way" is bending a member around its weak axis, and "hard way" is bending around the strong axis;
  - "Flanges in" or "flanges out" refers to the direction of the flanges on channels, angles, and tees;
  - When an angle is curved on its diagonal, is the heel (the

intersection of each leg) oriented in, out, or up?

- Note whether the section is going to be used in an AESS (architecturally exposed structural steel) application—tolerances will be tighter and more attention will be paid to possible imperfections or distortions. Of course, this could increase the cost of bending, so be sure it's specified sparingly—such as when the steel is within 20'-0" of the viewer's eye level.
- Be sure to label the correct radius. If you have a W8×10 bent the hard way and you need the inside radius to be 10', then label that on the drawings.
- A final item to note is the trimming requirement. If you have a 25' length of beam, only 22' to 23' of that beam may be bent due to the placement requirements within the bending machine. Note the total length of beam needed on the drawings for the estimator, material purchaser, and detailer. The last thing you want to hear from the field is that the beam is short.

Ask the Experts

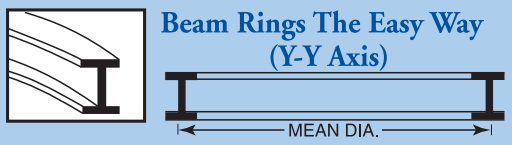
What if you have a spiral channel stringer for a staircase that needs to be bent in both directions? How do you go about detailing that properly? What about that thin-walled HSS tube? Can it be bent to a 16' radius without buckling the walls?

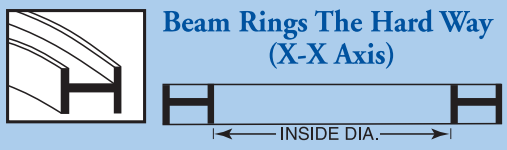
Contact an AISC member bender-roller with specific questions like these. AISC member bender-rollers can lend their expertise and work through a solution with you. Realize that your client is coming to you because you are an expert in engineering or architecture—so go to an expert in bending.

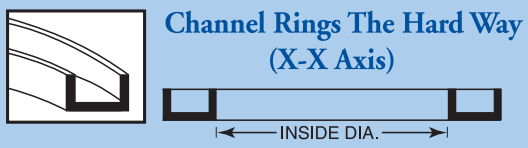
For a list of AISC member bender-rollers and other bending information, visit **www.aisc.org/benders**. And, as always, AISC's Steel Solutions Center is available to answer any and all questions concerning structural steel within one business day. Contact the Steel Solutions Center at 866.ASK.AISC or at solutions@aisc.org.

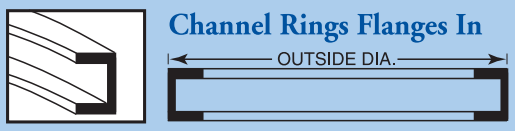
Todd Alwood is the senior advisor for AISC's Steel Solutions Center and is Secretary of AISC's Bender-Roller Committee. This article is reprinted from the May 2006 issue of Modern Steel Construction.

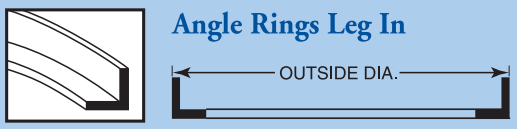
Common Terminology and Essential Dimensions for Curving Common Hot-Rolled Shapes

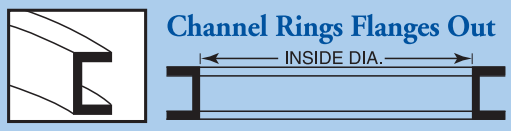


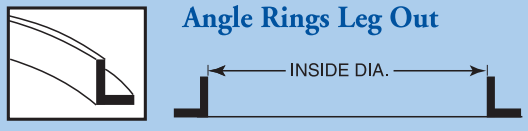


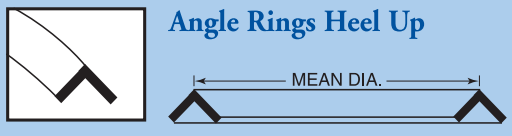












To contact an AISC Associate Member Bender-Roller, please visit **www.aisc.org/benders**.

Contact the AISC Steel Solutions Center at 866.ASK.AISC or solutions@aisc.org to discuss how structural steel can benefit your next project.

A special thanks to Kottler Metal Products for providing and bending the beam shown on pp. 6–7.

AISC ASSOCIATE

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American Institute of Steel Construction
One East Wacker Drive, Suite 700
Chicago, IL 60601-1802

866.ASK.AISC www.aisc.org

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