A look at the basics of curving steel—a process that is anything but basic.

There's More than One Way to BEND A BEAM

BY GEOFF WEISENBERGER

Photos are from Paramount Roll and Forming, Inc.'s facility in Santa Fe Springs, Calif.

▲ Various examples of curved steel, ready for fabrication.

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WHY FRAME A BUILDING with straight structural steel when you can use curved steel instead?

Obviously, I say that in jest. But for those applications where a certain amount of curved steel is desired, there are a few things to know. First of all, not all curved steel is created equal—or at least not curved in the same exact way. While different bender-rollers might use similar equipment, it's a matter of how they use that equipment that sets them apart.

"Much of rolling and bending is an art and not a science—one company's ability to use a certain machine in a certain method," says Barry Feldman, president of bender-roller Kottler Metal Products. "No matter how good the machine is, you need a skilled operator in order to achieve a quality bend. You can't just put the steel in and push a button and expect it to come out perfectly. On many of these jobs, especially for architectural applications, you may have 100 pieces, but they may have different radii and different degrees."

➤ Bending rectangular HSS using the heat induction method.

▲ Curved steel plate, with the welds visible.

▼ Curving steel angle via the roll/pyramid bending method.

Means and Methods

Secondly, there a multiple methods used to bend steel. Two of the most common types of bending are rotary-draw/compression bending and roll bending or pyramid bending. The latter gets its name from the fact that the rolling machine has three adjustable rolls in a triangle or pyramid configuration. Tighter roll spacing results in a tighter radius. Here's how it works: The beam is placed in the rolling machine and the operator adjusts the three rolls to the proper spacing before starting the bending process. The operator slowly begins rolling, and he or she frequently checks the beam for distortion of the web and flanges in these early passes. Several additional passes are carried out, with the operator measuring the overall radius after each pass to check the beam's progress.

Rotary-draw/compression bending is a different animal and is mainly used for complicated bends in the machine and parts industry. In this process, 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, producing a very tight radii.

While both of these methods curve steel in the cold condition, another method—heat induction—calls for the steel to be heated while it is being curved.

"Heat induction bending relaxes the steel during the bending process, which helps achieve tight radii as well as minimizes distortions," explains Ken Moscrip, president of Paramount Roll and Forming. In this process, an electric heating coil is placed around the bend point. Once the steel reaches a certain temperature range, pressure is applied to the front end of the member in order to bend it to the proper radius. When bending is completed, the steel is quenched via water spray.

➤ HSS passing through an induction coil.

▼ Specialized equipment further down the member from the coil slowly applies pressure to the steel to bend it into shape.

AISC Associate Member Bender-Rollers
Albina Company, Inc.
Bendco, Inc.
Bowers Fabrication
BendTec, Inc.
Chicago Metal Rolled Products Company (two locations)
Greiner Industries, Inc.
Hodgson Custom Rolling, Inc.
Hornsby Steel
Kottler Metal Products
Kubes Steel, Inc.
Max Weiss Company
Metals USA (four locations)
Paramount Roll and Forming
Shaped Steel, Inc.
SIMS Steel, Inc.
Whitefab

Visit **www.aisc.org/benders** for contact information for each of these companies.

▲ ▼ Steel for two sets of curved stairs. A layout for the steps is shown above while a more completed set is shown below. Both use special jigs in the shop to mimic the actual assemblies in the field.

Two other methods—incremental/camber bending and rotoform bending—can also be used to curve steel. The first involves bracing steel at two ends and applying pressure at a third point via a hydraulic ram or press and is particularly useful for curving steel to high radii. The second uses a specialized process to extrude steel from the straight condition into a bend and is the most flexible when it comes to radius parameters.

Bending Inquiries

Given the various methods of bending and the infinite possibilities that are achievable, designers are always looking for insight. Below is a handful of questions that AISC's Steel Solutions Center has received recently regarding bending steel. While AISC can provide some general guidance, it's usually best to contact a bender-roller to tap their expertise.

I am looking for a data table giving the minimum rolled radius for wide-flange steel. Does AISC have any information on wide-flange steel radius minimums for rolling?

Rigid guidelines for the minimum bending radius are not available because it is dependent on several variables, such as:

- Axis of curvature
- Cross-sectional shape of the member
- Bending method used by the bender-roller
- The equipment limitations of the bender-roller
- Level of acceptable cross-sectional distortion
- Level of acceptable cold-working of the material

These limitations should be discussed with the bender-roller who will provide the service; however, some general guidelines are on page 2-37 of the AISC 14th Edition *Steel Construction Manual*. The AISC website also has a publications page for information related to curved members at **www.aisc.org/curvedsteel**.

According to the general guidelines for cold bending on page 2-37 of the 14th Edition *Steel Construction Manual*, sweep (curving about the weak axis) can be provided to "practically any radius desired." The minimum radius for camber (curving about the strong axis) by cold bending of members up to a nominal depth of 30 in. is between 10 and 14 times the member depth.

Are there any tolerances on curved beams imposed by AISC? The ASTM A6 tolerances are primarily for straight beams and really do not cover the web deformation. Are there any guidelines for ensuring that deformation does not happen?

There are limited tolerances for curved members in the 2010 AISC *Code of Standard Practice* (a free download at **www.aisc.org/code**). According to Section 6.4.2, "For curved structural members, the variation from the theoretical curvature shall be equal to or less than the variation in sweep that is specified for an equivalent straight member of the same length in ASTM A6/A6M." Other acceptable tolerances, such as any cross-sectional distortion, are not generally available because they are dependent on whether the member is architecturally exposed structural steel (AESS) and any effect they may have on the member strength. AESS tolerances are discussed in Section 10 of the *Code of Standard Practice*. The actual geometric imperfections for rolled members are dependent on several factors, including:

- Cross-sectional shape of the beam
- Bending radius
- Bending axis
- Bending method used by the bender-roller
- Equipment limitations of the bender-roller

It is best to discuss the required tolerances with the bender-roller who will provide the service—and be sure to add the required tolerances to the contract documents to ensure that you get what you are asking for.

What is the maximum geometric camber that I can specify for a W27 rolled beam?

The capabilities of bender-rollers and fabricators vary, as does the equipment used and the cost. A tighter radius can often be obtained using a more sophisticated and costly process. It is best to speak with a bender-roller and a fabricator to get their opinions.

Is it possible to put a 90° bend in a pipe?

Yes. The key factor is the radius and the bending method used. You will need to contact a bender-roller or a fabricator to discuss the limits, options and costs.

Best Bend

What's the best way to bend steel? Several factors determine the best technique, including the overall member size, web and flange thickness or HSS wall thickness, radius requirement and end application of the material. Also, keep in mind that varying amounts of extra material are required at one or both ends of the member, depending on the process used; you don't want to have to splice additional material to one or both ends. Talk to a bender-roller about the best options for your particular application as well as their capabilities.

As with steel fabricators, getting benders involved early in the process will help you achieve the best results for your next curved steel masterpiece.

"Including benders early in a project can help assist with what is and isn't feasible concerning a design, and can help save time and money as a project moves forward," says Brian Smith, president of Albina Company, Inc. "And many benders have the necessary equipment and abilities to bend whatever is required in very fast time frames. We are used to working and performing under considerable pressure." ■