Design With a Twist

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AISC's new design guide provides much-needed advice on designing projects with curved steel.

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THERE'S A COMMON misconception that architectural appeal and structural efficiency are mutually exclusive, with the idea that one comes at the expense of the other.

Curved members do an elegant job of busting that myth by highlighting the beauty of structural steel while also offering structural efficiency. They are often chosen for exposed structures when aesthetics are a priority, but industrial buildings and non-building structures make use of curved members as well. For these structures, functionality is more important than aesthetics, and curved members are typically used in situations where they are more efficient than straight members.

A New Resource for Curved Steel

Although curved structures represent beauty and simplicity, the structural behavior of curved members can be quite different from their straight counterparts. Despite the widespread use of curved structural steel members, detailed guidance relative to United States design practice has been scarce—until now. The recently

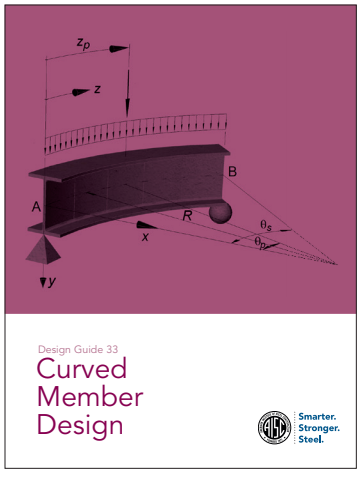
Curved steel can turn a pedestrian bridge into an art installation.

published AISC Design Guide 33: *Curved Member Design* (available at www.aisc.org/dg) provides design guidance and practical information on the fabrication, design and detailing of curved members. The contents of the new design guide are briefly summarized here:

Chapter 1 provides an introduction to curved members, with a discussion of typical applications in both commercial and industrial structures.

Chapter 2 describes various geometries available for curved members and the methods used to bend them. Due to the wide variety of bending equipment available, almost any structural shape can be curved, including wide-flanges, standard shapes, channels, angles, hollow structural sections (HSS) and welded built-up members. Bender-roller companies, who specialize in curving steel members, can provide further information on the fabrication of curved members. Because each bender-roller has different capabilities, discussing bending requirements as early in the project as possible will allow for a smooth design and construction process.

Chapter 3 discusses behavior during the bending operation. It provides information about curving mechanics and reducing the risk of fracture and excessive cross-sectional distortion during bending.



Chapter 4 focuses on detailing and fabrication requirements, including tolerances and dimensions required by the bender-roller for successfully bending members.

Chapter 5 discusses several considerations that, in some cases, may affect the design of curved members. These factors include potential changes in material properties caused by the bending process and their effects on the structural behavior of curved members. Other topics include residual stresses, nonlinear flexural stresses and cross-sectional distortion. The final section of Chapter 5 provides information that should be included in the contract documents to ensure the expected product is what is supplied.

Chapters 6 and 7 provide design methods and equations for vertically and horizontally curved members, respectively. These chapters discuss the strength, stability and serviceability of members, as well as connection design. All design equations comply with the 2016 AISC *Specification for Structural Steel Buildings* (ANSI/AISC 360, available at www.aisc.org/specifications).

Chapter 8 shows how to implement the equations in Chapters 6 and 7 via three extensive design examples.

The final parts of the publication include a glossary of common terms and a list of AISC associate member bender-roller member companies that can provide invaluable practical information in the conceptual and design stages of a project.

A curved HSS frame transforms a university building's atrium into a campus icon.

Curved Members

Here are a few of the more common types of curved steel:

Vertical. The ability of arches to span long distances provides an opportunity for large open spaces such as pedestrian bridges. A similar visual effect can be created with vertically curved roof beams. For industrial structures, vertically curved members may be used as circumferential shell stiffening rings for horizontal vessels, large industrial ducts and tubular conveyor galleries.

Horizontal. Although horizontally curved members are usually less efficient structurally than straight beams, they are often used to carry loads at curved floors and roofs. In some cases, such as for transportation and pedestrian bridges, horizontally curved structures are required due to geometrical constraints. For industrial structures, horizontally curved members can be used for monorail beams, chimney grillages, circumferential shell stiffeners and silo/tank roofs.

Specialty. Specialty bends are often required to form members to the proper geometry. Because parabolic curves are efficient for resisting gravity loads, many arches have a parabolic geometry, which requires a variable-radius specialty bend. Bender-rollers also have the capability to form complex curves with small, varying radii about multiple axes. For industrial structures, specialty bends are used primarily for spiral stairs providing access for circular vessels and for monorail beams with compound curves.

A curved roof steel in an airport project.

Curved HSS for a parking canopy.

S-shape curved canopy members.

Complex curves for a public sculpture.

Courtesy of AISC Bender-Roller Committee

Curved steel for a multistory spiral staircase.

Courtesy of AISC Bender-Roller Committee

Courtesy of AISC Bender-Roller Committee

Horizontally curved roof beams on a recreation center project.

An arch bridge, curved and painted for aesthetic purposes.

The design guide brings all of the latest information on curved members into a single document that is compatible with the 2016 AISC *Specification*. Although most of the guidance is focused on structural design, architects, fabricators and detailers will also find the document to be a great resource full of critical information on using curved members in steel structures. ■

Design Guide 33—and all other AISC design guides—is available at www.aisc.org/dg. For information related to curved members, visit ***www.aisc.org/curvedsteel****. Also see "There's More Than One Way to Bend a Beam" in the January 2016 issue, available at www.modernsteel.com.*

AISC Bender-Rollers

Here is a list of current AISC Bender-Roller Committee members:

A-1 Roll Company
Albina Company, Inc.
Bendco, Inc.
BendTec, Inc.
Chicago Metal Rolled Products
Greiner Industries, Inc.
Hodgson Custom Rolling, Inc.
Holloway Company, Inc.
Hornsby Steel
Kottler Metal Products
Kubes Steel, Inc.
Max Weiss Company
Metals USA
Midwest Metal Products
Paramount Roll and Forming
Shaped Steel, Inc.
SIMS Steel, Inc.
Trilogy Machinery, Inc.
Whitefab

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