MCX

CMAA
Construction Management Association of America

Member Communication Experience

Any views and opinions expressed in this article may or may not refect the

cmaanet.org

Design and Construction of Structural Steel Work

Key Points

- Structural steel construction offers economical bay sizes that are much larger compared to using concrete.
- Structural steel construction offers high seismic performance.
- Structural steel construction offers flexibility to match current architectural trends for “building statements.”

The technical fundamentals described in this Executive Insight provide a foundation for an increased rate and depth of learning related to the design and construction of structural steel work.

Overview and Responsibilities for Structural Steel Construction

The scope of structural steel work typically consists of the steel elements of the building frame shown on the design drawings, which are essential to support the design loads. Contracts for steel erection typically require others to provide site access, prepare the overall schedule, and identify and manage interfaces with other construc(p)2n§3.995 018C035585pide s

The is responsible for the overall construction of the project. The GC's responsibility also includes coordination of steel erection with the civil, concrete, mechanical, electrical, and plumbing (MEP), and architectural work.

The provides construction input, reviews shop drawings, designs temporary steel, and develops detailed erection plans and drawings. They typically also prepare the schedule for arrival of the steel and the equipment needed. Another of their key activities is checking the site for stability of lifting equipment and safety.

The responsibility varies by region. In the U.S., fabrication is typically combined with a steel erector on the West Coast. The fabricator orders standard steel shapes from supplier, may design connections based on area practice, fabricates custom members for the project, and delivers fabricated members in a sequence that supports the erection plan.

The is responsible for the means, methods, and safety of erecting the structural steel frame. The erector prepares the erection plan, receives the steel, erects and connects (steel decking is typically by others in California), and provides temporary supports and safety protection.

1.0 Design of Steel Structures

1.2 Types of connections for structural steel

Connections for structural steel have an interesting history. In the 1920s, the designs used all riveted connection. In the 1930s, bolting started. Shop welding became common in the 1950s, followed by field welding in the 1970s. Controlled field welding and alternate systems developed in the 1990s.

Two major types of connections are currently used. Bolted connections include the bearing type and the slip critical type. The major types of welded joint types are complete penetration groove, partial penetration groove, and fillet.

2.2 Rolled steel shapes

AISC sets standards for member dimensions and properties. These are designated by shape symbol, depth, and weight per foot. Properties defined by AISC are weight in pounds per foot, cross sectional area in square inches, depth in inches, width and thickness of flanges in inches, web thickness in inches, moment of inertia, section modulus, and radius of gyration. Members of the same nominal size vary in cross section for different values of weight per foot.

3.0 Detailing and Fabricating Steel for Building Structures

3.1 Detailing structural steel

Detailing of structural steel is now performed primarily in 2D AutoCAD with increasing use of 3D. Integrated software packages allow partially automated fabrication. Several sources and activities provide key design criteria for detailing. These include standards; coordination with structural, architectural, and MEP drawings; and the desire to maximize shop connections as limited by maximum shipping size of pieces and capacity of the crane planned for erection. Other important considerations include access to the site and space required for material laydown and equipment locations. States and cities may limit the length and load and impose other restrictions.

3.2 Fabricating structural steel

Fabrication of structural steel begins with standard shapes and lengths from the supplier. Custom steel components are shipped to the site for assembly without further processing. Fabrication typically requires a large and well-equipped shop and a range of operations. The duration of fabrication for a typical job varies from three to eight weeks depending on the complexity, amount of welding, and use of an automated beam line.

The major operations for fabrication are: 1) cutting with a special saw (produces a machined finish) or a cutting torch; 2) bending with hydraulic benders for camber; 3) hole punching up to 1 ½ inches; 4) drilling holes larger than 1 ½ inches; 5) fit-up and assembly; 6) welding (automatic or manual); and7) sandblasting and surface coating.

4.0 Preparation for Steel Erection

The typical overall sequence for steel buildings involves the core and shell. This is followed by tenant work. Completing a steel structure requires steel erection, bolting or welding, decking with edge forms for opening, and other related activities.

4.1 Logistics for steel work

Building zones or segments are typically determined by about 10 truck loads; each member is marked

4.3 Steel erection plans and methods

Erection plans for structural steel include the following key elements: contract requirements (sequence, coordination), regulations (safety, environment, labor), structure (stability), and site (space and access restrictions). Erection drawings show the erection mark and location of each piece, the separation of

5.0 Erecting Structural Steel

Two main types of crews erect steel. The installs column base plates using shim packs and leveling nuts, verifies their position and grouts them in place.The crew then attaches slings and erects columns, followed by headers and beams.

The fits beams into a column or other beams by using a spud wrench in the bolt holes. This crew installs a minimum of two erection bolts through columns and plates or one bolt through braces. Potential problems with fit-up of structural steel include inability to align bolt holes and obstructions from either the configuration of the individual member, adjacent members, or work by other trades. Standard practice allows reaming bolt holes a specified amount to allow fit-up.

Safety regulations typically require the sequence of column erection, beam erection, and then bolting

Bearing type connections require snug-tight bolts, tightened by a few bursts from an impact wrench or the full effort of ironworkers with spud wrenchs. Slip-critical type connections require tensioning the bolt to a minimum value based on bolt diameter and type.

Three main methods are used in tension bolted connections to verify correct values. The requires bringing the nut to a snug-tight condition and then further tightening an additionally 1/3 to one full turn, depending on the length and diameter of the bolts. The amount of turn is defined by AISC tables. Contractors consider turn-of-the nut as the most reliable and preferred method. The uses wrenches set to provide bolt tension at least five percent greater than

7.3 Heat flow in welding

Quality welding requires maintaining the specified thermal conditions in and near weld metal within specific limits to control metallurgical structure, mechanical properties, residual stresses, and distortions that result from a welding operation.

The rate of heat input to the workpiece during welding is governed by magnitude and rate of energy input at the weld, the distribution of heat input, and the weld travel speed. Heat transfer in a weldment forms a time-dependent temperature distribution. The weld undergoes a thermal cycle that varies from location to location depending on the heat input, weldment geometry, and material properties.

7.4 Types of arc shielding

Metals at high temperature react chemically with oxygen and nitrogen in air to form harmful oxides and nitrides. Arc welding processes must provide a means to cover the arc and the molten metal with gas, vapor, or slag to prevent contact of molten metal with air.

The covering for “stick” electrodes in certain arc welding processes, under the heat of the arc, generates a gaseous shield. The arc covering also supplies ingredients that react with deleterious substances on the metals, such as oxides and salts, and tie up these substances chemically in a slag that rises to the top of the pool and crusts over newly solidified metal. Other welding processes use a shielding gas supplied to the point of welding.

8.0 Metallurgy of Welding

Weldability of base metal is the capacity of the material to be welded under the imposed fabrication conditions into a specific, suitably designed structure for satisfactory performance of its intended purpose. It is primarily determined by chemical composition. Most common engineering alloys are weldable, but some are more difficult.

Weld metal differs in microstructure based on different thermal and mechanical histories. It depends heavily on the sequence of events when the weld metal solidifies, including reactions with gases and lo clidocatioud strucsfactli7tst cbutio

9.3 Gas metal arc or metal inert gas welding

Gas metal arc (GMAW) or metal inert gas (MIG) welding processes use a continuous filler metal electrode supplied by solid wire on a reel. These are considered semi-automatic and are relatively easy to learn. Shielding is provided by externally supplied gas. Advantages are high versatility, unlimited electrode length, welding in all positions, slag-free weld bead, and high deposition rates.

Potential problems during MIG welding include: burnback, metal hardening, reduction in fatigue

About the Authors

Bob Tatum was elected to the National Academy of Construction in 2002. His field experience began with serving in the U.S. Army Corps of Engineers on infrastructure projects in Vietnam. He worked as a field engineer and area superintendent on two large power plant projects. He joined the Stanford University construction faculty in 1983. His teaching and research focus on construction engineering, integration, and innovation.

Cliff Schexnayder was elected to the National Academy of Construction in 2012. He is a construction engineer with over 45 years of practical experience, beginning with a U.S. Army Corps of Engineers assignment to build a road to the airbase at Nakhon Phanom on the Mekong River in northern Thailand. Other parts of his career include working with major heavy/highway construction contractors as a field engineer, estimator, and corporate chief engineer.

[redacted] National Academy of Construction in 2013. He served as general president of the Association of Bridge, Structural, Ornamental and Reinfircing Iron Wokers from 2001 until his retirement in 2011. He has been involved in the ironworker industry his entire career, which spans more than 50 years. He is an active advisor to labor groups in Washington, D.C., and was instrumental in launching the IMPACT programatod