STRUCTURAL DETAILS FOR STEEL CONSTRUCTION

MORTON NEWMAN

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STRUCTURAL DETAILS FOR STEEL CONSTRUCTION

Companion Volumes

Newman ▪ Structural Details for Concrete Construction
Newman ▪ Structural Details for Masonry Construction
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To my mother

About This Book

Since publication in 1968, over 30,000 copies of the hardcover edition of Morton Newman's STANDARD STRUCTURAL DETAILS FOR BUILDING CONSTRUCTION have been sold to architects, engineers, drafters, and others concerned with the design of building structure and communication of that design to those responsible for accomplishing it in construction..

Now the publishers have made it possible for persons interested in one particular type of structure—wood, concrete, masonry, or steel—to purchase just the section or sections of *Standard Structural Details* which they need. The hardcover book has been split up into four separate low-cost softcover editions:

Structural Details for Wood Construction
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Structural Details for Masonry Construction
Structural Details for Steel Construction

In this book, the designer will find a host of proven designs in time-tested details for base plates, base connections, beam and column connections, column splices, beam connections, composite steel beams and concrete slabs, fire protection, bar joists, light steel framing, steel stairs, and clevis connections.

Introductory material has been revised to reflect code changes since the original edition, and each page of details appears on the right, while facing pages incorporate a preprinted grid for drawings, notes, and ideas the reader may wish to preserve.

Preface

The purpose of this series of books is to provide a graphic means of communication between architects, engineers, contractors, and students who are engaged in the design and construction of buildings. The four basic structural materials that are employed in building construction are wood, concrete, masonry, and steel. In the application of these materials many standard details and methods of construction have been developed. For several years the author found it quite useful to collect and index standard structural details for the preparation of structural drawings of buildings. The use of structural graphic standards reduced the cost of production of structural drawings and also helped to facilitate the communication of information between all of the personnel who were involved in the design and construction of a building. No claim is made for the originality of the details in these books as they are standard methods of construction and they are extensively used throughout the construction industry.

These books consist of a series of drawings of standard structural details that are most frequently employed in building construction. The details are presented individually and in their most basic and general form. A brief description is given for each detail pertaining to the material used, the type of condition shown, and its method of construction. In no instance should a book be considered or used as a substitute for the engineer or as a shortcut method of engineering. It is the function of the engineer to verify the use of any detail and to determine the sizes, dimensions, and all other pertinent information that will be essential to its use in a particular building design. The details are separated and arranged into four books with respect to the type of construction materials used: wood, concrete, masonry, or steel. In some instances two types of construction materials are used in the same detail. The author endeavored to place each detail in the related book and in the sequence of its use in building construction so that it could be readily located. Also, the index for this book has been set up so that any particular detail that may be sought can be easily located.

The engineering information presented in these books is in accordance with the basic requirements of The American Institute of Steel Construction, The American Concrete Institute, The International Conference of Building Officials Uniform Building Code, "The West Coast Lumbermen's Douglas Fir Use Book," and The Concrete Masonry Association of California. Standard details and construction methods evolve from the structural design requirements. Many excellent books on structural design and analysis are available to the practicing engineer and student; there is also a great need for applied practical information related to structural drafting and the use of construction materials. Expanding technology in the fields of building engineering and construction has created a situation which demands that the structural drawings be more complete and therefore more complex.

The purpose of structural drawings is to communicate the engineer's design requirements to the various contractors and material fabricators.

To achieve total communication, the structural drawings should be clear and complete, the general presentation of information should be in a logical sequence, all sections and details should be shown and clearly referenced, and any field conditions should be considered on the drawings. A good set of structural drawings will ensure that the building is constructed in accordance with the engineering design requirements and that construction delays and unnecessary additional costs are avoided.

The engineer's work is the prime factor in the successful design and construction of a building; however, in the final event, his or her work is directly dependent upon the intelligence and integrity of the workers on the construction job, particularly at the supervisory level. Poor fieldwork in terms of accuracy and material quality control will negate a great deal of engineering effort. Building construction requires a high degree of teamwork between the engineers and the contractors. Each party should have a working knowledge of the other's functions and responsibilities. The author hopes that these books will serve as communication tools that will improve the quality of engineering and construction. Also, engineering and architectural students can use this book as a source of information to familiarize themselves with the methods and materials of construction. As students use the information presented in these books they will increase their ability to translate structural engineering calculations into practical applications.

I would like to acknowledge the very able assistance of Bruce L. Ward, who drew the details shown on the following pages and assisted in assembling the information into book form. Also, I would like to thank Jack Clark for his advice and encouragement, and acknowledge the assistance of Bogdan Todorovic in the early stages of these books.

Morton Newman
Civil Engineer

Abbreviations

Adjustable	Adjust.
Alternate	Alt.
American Concrete Institute	A.C.I.
American Institute of Steel Construction	A.I.S.C.
American Society of Testing and Materials	A.S.T.M.
Architect	Arch.
Area	A.
Beam	Bm.
Block	Blk.
Blocking	Blkg.
Bottom	Bott.
Building	Bldg.
Calculations	Calcs.
Ceiling	Ceil.
Cement	Cem.
Center Line	C.L.
Channel Stud	C.S.
Civil Engineer	C.E.
Clear	Clr.
Column	Col.
Concrete	Conc.
Connection	Conn.
Construction	Constr.
Continuous	Cont.
Cubic	Cu.
Deflection	Defl.
Depression	Depr.
Detail	Det.
Diagonal	Diag.
Diameter	Dia.
Dimension	Dim.
Discontinuous	Disc.
Double	Dbl.
Drawing	Drwg.
Each	Ea.
Elevation	El. or Elev.
Engineer	Engr.
Equal	Eq.
Equipment	Equip.
Existing	Exist.
Expand	Exp.
Expose	Expo.
Exterior	Ext.
Fillet	Fill.
Finish	Fin.
Floor	Flr.
Foot	Ft.
Footing	Ftg.
Foundation	Fdn.
Framing	Frmg.
Gauge	Ga.
Glued Laminated	Gl. Lam.
Grade	Gr.
Grout	Grt.
Gypsum	Gyp.
Hanger	Hngr.
Height	Ht.
Hook	Hk.
Horizontal	Horiz.
Inch	In.
Inclusive	Incl.
Inside Diameter	I.D.
Interior	Int.
Joint	Jnt.
Joist	Jst.
Lag Screw	L.S.
Laminated	Lam.
Lateral	Lat.
Light Weight	Lt. Wt.
Machine	Mach.
Masonry	Mas.
Maximum	Max.
Membrane	Memb.
Metal	Met. or Mtl.
Minimum	Min.
Moment of Inertia	I

Nails	d (penny)
Natural	Nat.
Number	No. or #
On Center	O.C.
Opening	Opng.
Opposite	Opp.
Outside Diameter	O.D.
Panels	Pnls.
Partition	Part.
Penetration	Pen.
Plaster	Plas.
Plate	Pl.
Plywood	Plywd.
Pounds per Cubic Foot	P.C.F.
Pounds per Square Foot	P.S.F.
Pounds per Square Inch	P.S.I.
Pressure	Press.
Radius	R.
Rafter	Rftr.
Rectangular	Rect.
Reinforcing	Reinf.
Required	Reqd.
Riser	R.
Roof	Rf.
Room	Rm.
Round	ϕ
Schedule	Sched.
Section	Sect.
Section Modulus	S.
Seismic	Seis.
Sheathing	Shtg.
Sheet	Sht.
Spacing	Spcg.
Specification	Spec.
Spiral	Sp.
Stagger	Stgr.
Standard	Std.
Steel	Stl.
Steel Joist	S.J.
Stiffener	Stiff.
Stirrup	Stirr.
Structural	Struct.
Structural Steel Tube	S.S.T.
Square	Sq.
Symmetrical	Sym.
Thick	Thk.
Through	Thru.
Tread	Tr.
Ultimate	Ult.
Ultimate Stress Design	U.S.D.
Uniform Building Code	U.B.C.
Utility	Util.
Vertical	Vert.
Volume	Vol.
Waterproof	W.P.
Weight	Wt.
Welded Wire Fabric	W.W.F.
Wide Flange	W.F.
With	W/
Working Stress Design	W.S.D.

Contents

INTRODUCTION

This volume presents the drawings of the various alternate methods of connecting the component members of a building's structural steel frame. Each type of connection and its combinations of different size steel members is detailed and presented individually. The details, arranged in the sequence of their use in building construction, are classed in the following general categories: column base plates, column base connections, simple beam and column connections, rigid-frame beam and column connections, steel canopy details, column splices, composite steel beams and concrete slabs, steel member fire protection, light-steel stud and joist construction, steel stair details, and miscellaneous clevis connections.

The type and strength of structural steel used in the details shown are not designated. Manufacturers and fabricators of structural steel rolled sections are required to conform to the American Institute of Steel Construction specifications, which outline the standards for design, fabrication, and erection of steel structures. The type of steel used in construction is designated by an A.S.T.M. standards number. The "Manual of Steel Contruction," compiled and published by the A.I.S.C., gives the A.S.T.M. designation number for each type of structural steel and the respective allowable working stresses (tension, compression, or shear) for the method of use. Types of steel designated as A.S.T.M. Spec. No. A36 and A.S.T.M. Spec. No. A529 have specific yield point stresses of 36,000 and 42,000 psi respectively and allowable working stresses in tension or compression from bending of 24,000 and 28,000 psi. Steel designated as A.S.T.M. Spec. No. A36 is currently the most widely used steel. The allowable working stresses from bending also depend on the shape of the structural section (a compact or noncompact section, determined by the width-to-thickness ratio of the compression flange) and the laterally unbraced length of the compression flange of a beam. The A.I.S.C. specified allowable working stresses for tension or compression from bending is equal to $0.66 f_y$ (f_y being the yield point stress of the steel as specified by the A.S.T.M.). High strength low-alloy steels are also used for structural steel members. This type of steel is designated as A.S.T.M. Spec. No. A441, and A.S.T.M. Spec. No. A572 with minimum yield point stresses of 40,000 psi and 42,000 psi, respectively. A242 steel is highly corrosive resistant; A441 steel is relatively corrosive resistant and is used in the construction of bolted or riveted structures and for welded structures that may be subjected to high impact loads. The minimum yield point stress of high strength steel is also governed by the thickness of the material. That is, a thickness not greater than $\frac{3}{4}''$ has a yield point stress of 50,000 psi; thickness from $\frac{3}{4}''$ to $1\frac{1}{2}''$ has a yield point stress of 46,000 psi; thickness from $1\frac{1}{2}''$ to 4" has a yield point stress of 42,000 psi. The above is a general statement concerning the types and strengths of the structural steels that are presently available for use in construction. Complete and specific data on this subject can be found in the "Manual of Steel Construction." Mill test reports may be supplied to the fabricator to verify the material quality control. These reports must be requested prior to the time the steel members are fabricated at the rolling mill.

Structural steel members are manufactured by extruding steel billets between a set of rolling dies in a series of forward and reverse passes until a uniform and standard size shape is produced. The nomenclature for steel shapes describes their cross section configuration, for example, wide flange beams, I beams, Tee sections, angles, and channels. The structural steel sections are fabricated to standard sizes and weights; however, each manufacturer's product may vary from another's by a small degree. The two major producers of structural steel in the United States are Bethlehem Steel Company and the United States Steel Corp. Both companies manufacture the Regular Series Shapes, which are those shapes most frequently used, and the Special Series Shapes, which are not generally used and therefore are not continuously produced. There are certain structural steel sections that are manufactured exclusively by only a few steel producing companies, such as Jones & Laughlin Steel Corporation, Inland Steel Company, and Northwestern Steel and Wire. The primary considerations in specifying structural steel members for construction are strength, deflection, cost, and availability. The capacity of a steel member to resist stress and deflection is a function of its size and its shape and the yield point stress of the steel. Since steel is generally purchased by weight, it is economically important to use sections of the least weight that will be capable of sustaining the imposed loads and forces within the limits of the allowable working stresses and deflections. Table 1 gives the names of the companies that manufacture the various structural steel shapes.

Details 1 to 6(d) inclusive show the various methods of connecting columns, base plates, and foundations. The function of a base plate is to transfer the column loads to the foundation. This can be achieved by designing the base plate with sufficient surface area and cross-sectional thickness. The contract surface between the top of the plate and the column should be flat to obtain a complete bearing area. Plates over 4" thick should be milled to ensure a smooth surface: however, plates that are between 2" and 4" thick may be straightened by pressing. The bearing pressure on the bottom of the base plate is assumed to be equally distributed over the entire area of the plate. This pressure will cause the surface that is not directly beneath the column cross section to bend upward as a cantilever. The thickness of the plate is calculated to resist this bending. The column can be attached to the base plate by shop welding or by field welding; in either case the weld must be strong enough to resist the column lateral loads as well as bending and compression. The anchor bolts react against the base plate in bearing and in shear. The capacity of the anchor bolt to act as a resisting element depends on the size of the bolt, the thickness of the base plate, and the depth of embedment of the bolt in the concrete. The anchor bolts shown in Detail 6(a) to (d) are also used to transfer the column bending moments into the foundation by acting as resisting elements of a force couple. If the anchor bolts in this type of connection are to be completely effective as resisting elements, they must be capable of withstanding axial tension and compression loads. Further, anchor bolts must develop enough bond strength between the concrete of the foundation to prevent their slipping out or being pulled out. Base plates and anchor bolts are usually the first step in construction to coordinate the foundation with the steel superstructure; therefore, it is necessary that they be accurately placed. A small dimensional variation in elevation or horizontal location of the base

Table 1. Principal Steel Producers

A. Armco Inc.	I. Inland Steel Co.	U. United States Stell Corp.
B. Bethlehem Steel Corp.	J. Jones & Laughlin Steel Corp.	
C. CF&I Steel Corp	N. Northwestern Steel & Wire Corp.	

Section & weight per ft.	Producer code	Section & weight per ft.	Producer code	Section & weight per ft.	Producer code
W 36—all	B, U	W 8×31–67	A, B, C, I, N[5], U	MC 18—all	B, U
W 33—all	B, U	W 8×24–28	A, B, C, I, N, U	MC 13—all	B, U
W 30—all	B, U	W 8×18–21	A, B, C, I, N, U	MC 12×35–50	B, U
W 27—all	B, U	W 8×10–15	A, B, C, I, N, U[6]	MC 12×30.9–37	B, U
W 24—all	A, B, I, U	W 6×15–25	A, B, C, I, N, U,	MC 12×10.6	J
W 21—all	A, B, I, U	W 6×9–16	A, B, I, J[7], N, U[8]	MC 10×28.5—41.1	B, U
W 18×76–119	A, B, I, U	W 5×16–19	A, B, I	MC 10×21.9–28.3	B, U
W 18×50–71	A, B, I, N, U,	W 4×13	A, B, N	MC 10×8.4	J
W 18×35–46	A, B, I, N, U			MC 10×6.5	J
W 16×67–100	A, B, I, U			MC 9—all	B
W 16×36–57	A, B, C[1], I, N, U			MC 8×21.4–22.8	B, U
W 16×26–31	A, B, C, I, N, U	M 14×18	N	MC 8×18.7–20	B, U
W 14×145–730	B, U	M 12×11.8	J	MC 8×8.5	J
W 14×90–132	B, U	M 10×9	J	MC 7×19.1–22.7	B, U
W 14×61–82	A, B, I, U	M 8×6.5	J	MC 7×17.6	U
W 14×43–53	A, B, C, I, U	M 6×20	U	MC 6×18	B
W 14×30–38	A, B, C, I, N, U	M 6×4.4	J	MC 6×15.3	B, U
W 14×22–26	A, B, C, I, N, U	M 5×18.9	B	MC 6×15.1–16.3	B, U
W 12×65–336	A, B[2], I, U[2]	M 4×13	I, U	MC 6×12	B, U
W 12×53–58	A, B, I, U				
W 12×40–50	A, B, C, I, U				
W 12×26–35	A, B, C, I, N, U				
W 12×14–22	A, B, C, I, N, U	HP—all	B, U		
W 10×49–112	A, B, I, N[3], U	HP 13—all	A, I		
W 10×33–45	A, B, C, I, N, U	HP 12—all	A, B[9], I, U[9]		
W 10×22–30	A, B, C, I, N, U	HP 10—all	A, B, I, N, U		
W 10×12–19	A, B, C, I, N, U[4]	HP 8×36	A, B, I, N, U		

[1]W 16×57 excluded.
[2]W 12×210–336 excluded.
[3]W 10×77–112 excluded.
[4]W 10×12 excluded.

[5]W 8×48–67 excluded.
[6]W 8×10 excluded.
[7]W 6×12 and W 6×16 excluded.
[8]W 6×9 excluded.
[9]HP 12×63 and HP 12×84 excluded.

Listings of American Standard beams and channels, as well as angles, are omitted from the above table since these shapes are generally available from all mills, including many not shown in the table heading.

Maximum lengths of shapes obtainable vary widely with producers, but a conservative range for all mills is from 60 to 75 feet. Some mills will accept orders for lengths up to 120 feet, but only for certain shapes and subject to special arrangements. Consult the producers for unusual length requirements.

Source: Adapted from Table 3, "Manual of Steel Construction," 8th edition, 1980, Second Revised Printing, 1986, American Institute of Steel Construction, Inc., with permission.

plate will result in discrepancies in the superstructure connections. The columns can be plumbed to their final positions by setting the base plates on a relatively thin layer of nonshrinkable grout. The structural steel erector should verify the locations and elevations of the base plates in the field to ensure that the members will fit together as shown on the working drawings.

Details 9(a) to 12(d), 24(a) to (d), and 39(a) to 42 are drawings of simple beam to column connections. This type of connection is classified generally as a non-rigid, or simple, connection since it is assumed that it cannot restrain the end of the connected beam from rotating. The flexibility of simple connections depends on the stiffness of the connecting parts. A standard simple connection con-

Table 2. Availability of Shapes, Plates, and Bars According to ASTM Structural Steel Specifications

Steel type	ASTM designation	F_y Minimum yield stress (ksi)	F_u Tensile stress[a] (ksi)	Shapes: Group per ASTM A6 1[b]	2	3	4	5	Plates and bars: To 1/2" incl.	Over 1/2" to 3/4" incl.	Over 3/4" to 1-1/4" incl.	Over 1-1/4" to 1-1/2" incl.	Over 1-1/2" to 2" incl.	Over 2" to 2-1/2" incl.	Over 2-1/2" to 4" incl.	Over 4" to 5" incl.	Over 5" to 6" incl.	Over 6" to 8" incl.	Over 8"
Carbon	A36	32	58-80																■
		36	58-80[c]	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
	A529	42	60-85	■					■										
High-strength low-alloy	A441	40	60													■	■	■	
		42	63				■	■					■	■	■				
		46	67			■					■	■							
		50	70	■	■				■	■									
	A572 – Grade 42	42	60	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
	A572 – Grade 55	50	65	■	■	■	■	■	■	■	■	■	■						
	A572 – Grade 60	60	75	■	■				■	■	■								
	A572 – Grade 65	65	80	■					■	■	■								
Corrosion-resistant high-strength low-alloy	A242	42	63				■	■					■	■	■				
		46	67			■					■	■							
		50	70	■	■				■	■									
	A588	42	63														■	■	
		46	67													■			
		50	70	■	■	■	■	■	■	■	■	■	■	■	■				
Quenched and tempered alloy	A514[d]	90	100-130												■	■	■		
		100	110-130						■	■	■	■	■	■					

a Minimum unless a range is shown.

b Includes bar-size shapes.

c For shapes over 426 lbs./ft., minimum of 58 ksi only applies.

d Plates only.

■ Available.

☐ Not available.

SOURCE: Table 1, "Manual of Steel Construction," 8th edition, 1980, Second Revised Printing, 1986, American Institute of Steel Construction, Inc. Reproduced with permission.

sists of two angles with each leg of each angle bolted through the beam web or with one leg of each angle bolted through the beam web and one leg bolted through the column flange or web. Non-flexible connections are classified as rigid frame connection. This type of connection is capable of resisting bending and shear, thus restraining the connected member from rotating independently. Rigid connection joints are defined by the fact that the angle between the connected parts or members will remain essentially the same after the members are deflected from flexure or shear. Details 13 to 20, inclusive, show rigid frame steel connections. It can be seen in these details that this type of connection is fabricated to resist both shear and bending. In rigid connections and simple connections, the vertical shear reaction of the beam is supported with angles or plates that are joined with bolts, rivets, or welds; however, in rigid type connections the bending in the joint can be resisted only by welds or by a bolt fastener that will not permit slippage between the connection parts. Details 26(a) and (b) and also Details 48(a) to (d) show simple beam to column connections with a seat angle. The seat angle is generally used as a temporary support for the beam during the erection of the steel frame. Details 48(c) and (d) use a structural Tee for a beam seat. This type of beam seat employs the web of the Tee as a stiffener plate. It is not necessary to make elaborate seat angle connections since they are rarely used as permanent connections, but rather to support the temporary construction dead and live loads. Engineers and draftsmen should pay particular attention to structural steel connections. Inadequate connections can be the source of serious structural failures or at least limit the amount of load a member may safely support.

The connections described in the previous paragraph can be fabricated by using bolts, rivets, or welds. The simple type connections are joined with unfinished, or machine, bolts of low-carbon steel, designated as A.S.T.M. Spec. No. A307. Machine bolts can be easily identified by their square head and nut. In standard simple connections, the bolt shank reacts in bearing against the cross section of the web hole and transfers the load to the connecting angles by the shear resistance of the bolt shank cross section. The nuts are tightened in place with a spud wrench with sufficient force not to overstress the washer in bearing but to prevent the bolt from becoming loose from the connection. This type of connection can also be made by using hot-driven rivets or with bolts that are manufactured with ribbed or serrated shanks. The "Manual of Steel Construction" lists and diagrams the standard connections for the various size structural beams and the connection capacity for the different types of mechanical fasteners. It is important to use the minimum specified size angles in this type of connection. Thicker angles will reduce the flexibility of the joint and restrain the end of the beam as it bends.

High strength carbon-steel bolts are used in structural joints that require that the shear between the connecting parts be resisted by friction. This bolt is known as a friction type connector and is designated as A.S.T.M. Spec. No. A325. Friction resistance in the connection is accomplished by mechanically tightening the nuts to develop a specified tension in the bolt shank that will clamp the contact surfaces of the connecting parts together. The friction resistance of the A325 fastener depends on the tension in the bolt and the condition of the contact surfaces, which must be free of paint or any coating that may permit slippage. Another type of bolt that is used in the same manner as the A325 bolt is designated as A.S.T.M. Spec. No. A490. This bolt is a high strength alloy-steel fastener used for connections of high strength steel members. Both types of bolts require that the nut be tightened to develop a specified tension in the shank. A325 and A490 bolts can be identified by their hexagonal shaped heads and nuts and by their respective A.S.T.M. number and manufacturer's symbol. The thread length of friction type connector bolts or of high strength bolts should be excluded from the shear planes, except when they are used with thin adjacent connection parts. The A.I.S.C. specification for installing A325 bolts and A490 bolts require that they be tightened by using a calibrated torque wrench or by the "turn of nut method." The calibrated torque wrench may be power operated and set to cut off at a torque resistance that will correspond to the required tension in the bolt shank. The turn of nut method is performed manually with a wrench by successively tightening the bolts by rotating the nuts a certain amount after they are brought to a snug, tight condition. High strength bolt assemblies are required to have two hardened steel washers; however, A325 bolts do not require a hardened steel washer when they are installed by the turn of nut method. Where the connecting part's surfaces slope more than 1 to 20, the washers should be beveled to accommodate a snug fit of the bolts. The A.I.S.C. recommends that bolts or rivets be installed through holes that are $\frac{1}{16}''$ larger in diameter than the bolt. Bolt or rivet holes may be reamed, punched, or drilled. The dimension between centers of bolts or rivets should be not less than $2\frac{2}{3}$ times the nominal diameter of the bolt. The minimum recommended distance between bolt or rivet holes is 3″ o.c. The minimum distance between the edge of a structural steel part and the center of a bolt hole depends on the bolt diameter and on whether the edge is sheared or it is the edge of a rolled section or plate. Table 1.16.5.1 of the A.I.S.C. specifications gives the edge distance requirements for bolt diameters for sheared or rolled edges of plates and structural sections. The A.I.S.C. "Manual of Steel Construction" diagrams and tabulates the significant dimensions of all structural shapes. The clear dimension of the length of the web of a section is designated as "T." It is recommended that the length of a structural connection be not less than $\frac{1}{2}$ the T dimension. Also, the gauge dimensions for spacing of bolt holes in flanges and webs of wide flange shapes and I beams and in the legs of angles are tabulated in the "Manual of Steel Construction."

Many of the details in this chapter require that the members or the parts of joints be connected by welding, particularly those members shown in Details 11 to 20, inclusive. Welding technology is a vast and complex subject and will not be completely covered in this text. The specific information that is ordinarily required in the structural design and drawing of steel buildings can be found in Sec. 1.17 of the A.I.S.C. specifications and in the "Structural Welding Code— Steel" by the American Welding Society. Basically, structural welding is the process of uniting two metal surfaces by fusion from the heat of an electric arc. The electric-arc welding process consists of applying heat to the steel pieces to be joined by a low voltage, high amperage electric arc. The arc is maintained across the steel by an electrode which deposits a small amount of weld metal to the fused surfaces. Welding electrodes consist of a coated steel rod composed of a metal of the same chemical and mechanical properties as the steel to be joined. The strength of the weld also depends on the chemical composition of the rod coating.

When the shielded arc welding process is used, the arc deposits the weld metal on the surface, and the rod coating burns to create a gaseous shield within the immediate atmosphere around the weld and at the same time introduces a flux material into the molten metal. The effect of the gaseous shield is to prevent the hot weld material from combining with the oxygen and nitrogen in the air. Oxidation will make the weld porous and therefore