CVEN 446
Structural Steel Design

Module 14

Welds and Welding

April 20, 2015

Welding - Definition

The process of joining metal pieces together by heating the metal to a fluid state.

The heat necessary to melt the metal can be supplied by the formation of an electrical arc in the gap between two metal pieces as a result of a high voltage differential. This type of welding is called arc welding.

The weld metal must be protected or "shielded" while molten and cooling. The introduction of oxygen and hydrogen into unshielded weld metal can reduce the strength.

Weld Processes

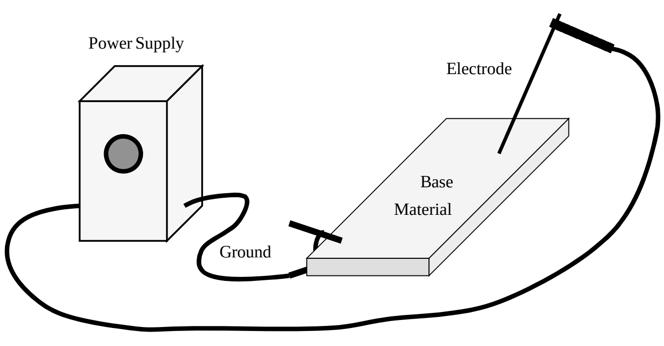
Four types of weld processes are typically used for fabrication of constructional steel:

- Shielded Metal Arc Welding (SMAW)
- Flux Core Are Welding (FCAW)
- Gas Metal Arc Welding (GMAW)
- Submerged Arc Welding (SAW)

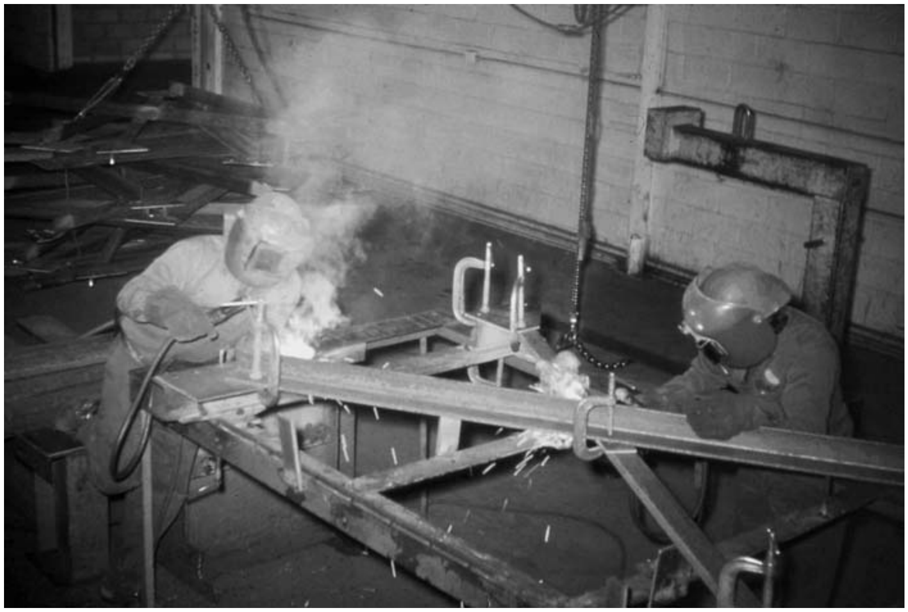
SMAW

A manual welding process that is easy to perform and suitable for field welding applications. The electrode serves to provide a source for the arc as well as introducing filler metal into the weld as the rod melts.

The rod is covered with a material that protects or "shields" the weld while cooling.



SMAW



FCAW

Can be either a manual or semi-automatic process in which the electrode has a center core of flux material. For the manual process, the electrode is similar to the stick electrodes used with SMAW but with the flux wrapped inside instead of coating the outside of the electrode. For the semi-automatic process, a thin diameter cored wire is used to facilitate it being continuously fed through a nozzle from a coiled spool.

GMAW

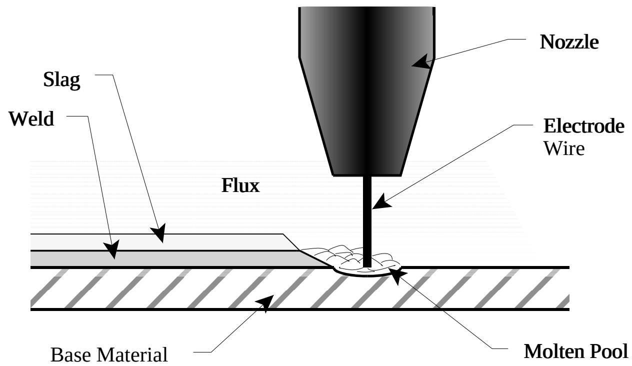
A semi-automated process, however, a shielding gas is substituted for the solid granular flux. The gas is delivered through the electrode nozzle where a continuous electrode wire is fed. The GMAW process provides more flexibility with different electrode shielding gas combinations than FCAW.

GMAW

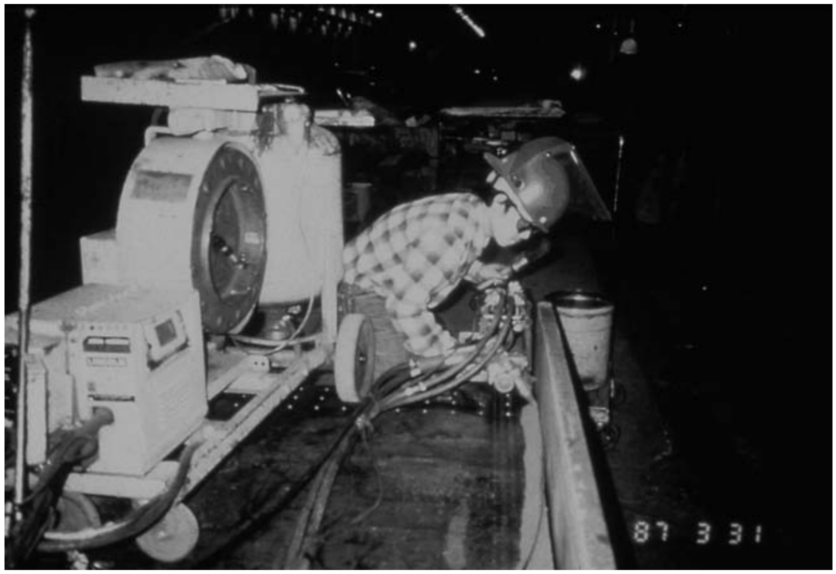
SAW

A semi-automatic or automatic process that will produce a higher quality weld than the shielded metal arc welding process. However, it requires more complicated equipment and is usually limited to the fabricating shop.

The electrode or filler metal is a thin wire that is continuously fed through a nozzle as it travels along the length of the weld. The arc occurs underneath the flux and no eye protection is required.



SAW



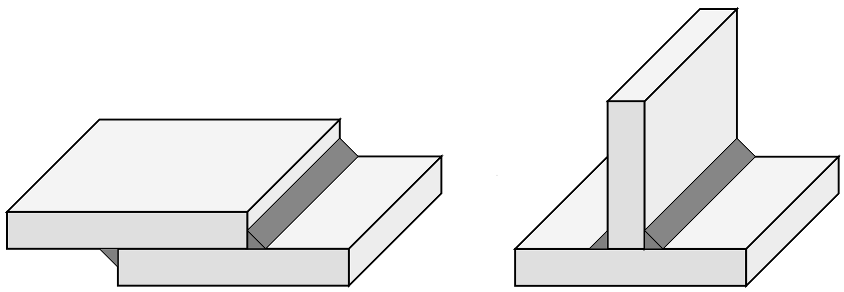
Types of Welds

Different weld types can be used to make the necessary attachments between plates of a structural connection. AISC-LRFD contains design provisions for four different weld types commonly using in structural connections:

- Fillet Weld
- Full or Complete Joint Penetration Groove Weld
- Partial Joint Penetration Groove Weld
- Slot or Plug Weld

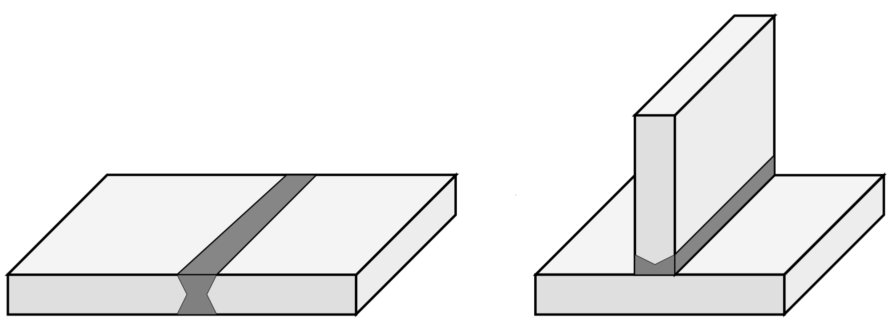
Fillet Welds

Fillet welds generally are the simplest and least expensive welds to fabricate. Therefore, preference should be given to this weld type. The weld is produced by depositing weld metal at the corner formed by intersecting or lapping plates.



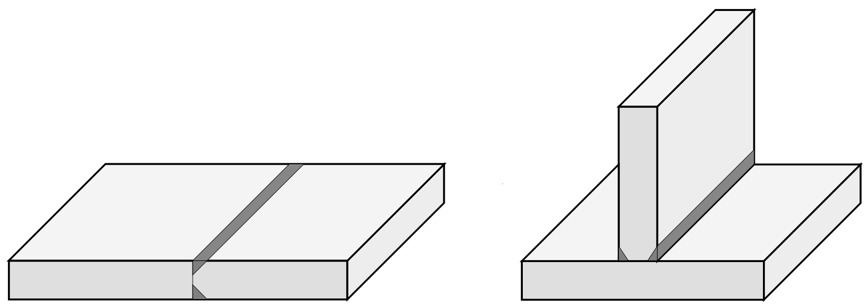
Complete Joint Penetration Groove Welds (CJP)

Full or complete joint penetration groove welds can be used in application were maximum strength of the connection is required. The weld is produced by cutting or grinding a chamfer or bevel on the edge of the plate(s).



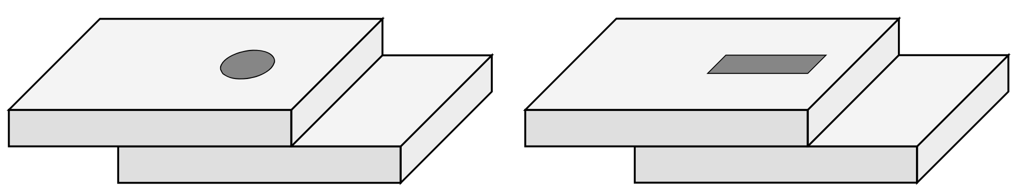
Partial Joint Penetration Groove Welds (PJP)

Partial joint penetration groove welds are similar to complete penetration welds in that the plate edges are beveled prior to welding. However, the finished weld does not fully penetrate the plate thickness due to reduced strength requirements.



Plug and Slot Welds

These types of welds are used to connect lapped plates. Either a circular (plug) or rectangular (slot) hole is cut into one of the plates. The plates are then lapped and the hole filled with weld metal.



Both types of welds should be avoided due to the inherent low weld quality that results. It is often difficult to obtain adequate penetration of the weld due to limited access area at the bottom corners of the holes. In addition, it is difficult to avoid trapping slag and other inclusions as the weld pool rises in the hole.

Weld Economy

- The cost of welding is directly related to the volume of weld metal that needs to be deposit. Therefore, do not oversize welds.
- The amount of plate preparation necessary to produce the weld affects the cost. Give preference to fillet welds over groove welds.
- The number of passes necessary to produce a finished fillet affects the cost. Use fillet weld sizes that can be produced in one pass (5/16" SMAW, 3/8" SAW).
- Minimize non-deposition time while welding.

Types of Welded Joints

Various welded joints are possible with the four weld types previously discussed. The use of a particular joint is dictated by the connection geometry, strength requirements, and economic considerations. (Not all weld types can be used with all joints types.)

- Lap Joint
- Butt Joint
- Tee Joint
- Corner Joint

Lap Joint

The simplest type of welded connection to fabricate. No special plate preparation is necessary and fit-up errors are easily accommodated. The joint can be used to splice tension members, connect various members to gusset plates or other members, and any situation where the force to be transferred through the connection need not change direction.

Butt Joint

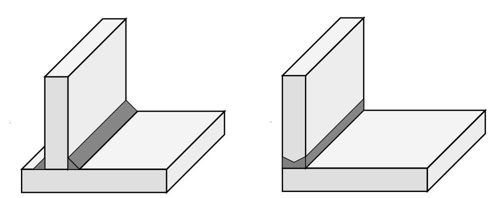
The butt joint is typically used when joining plates end to end. This may be required to provide a plate that is longer than commonly available from a rolling mill, or to splice a plate of different thickness or width to meet strength requirements. Both the complete and partial penetration groove welds are used for this joint type.

Tee Joint

The tee joint is used to join plates at right angles and is commonly used to join the flange plates to the web of built-up beam sections. Typically the fillet weld, balanced on both sides of the web plate, is used due to it economy and ease of application. In heavy, thick plate cross sections, it might be necessary to use either the partial or complete penetration groove weld.

Corner Joint

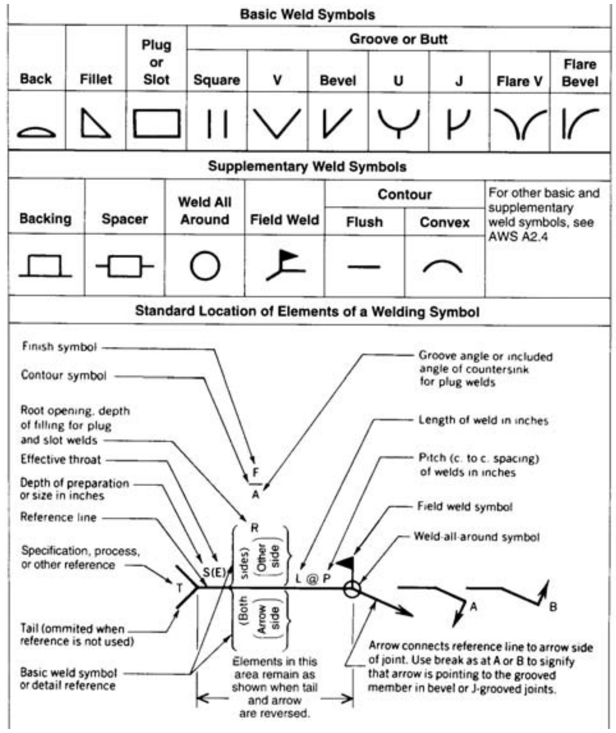
The corner joint is similar to the tee joint but used to weld box section instead of I-shape cross section. Note that if fillet welds are used, it is necessary to extend one plate out beyond the corner in order to provide a shelf for the weld.



Weld Symbols

AISC-13 Table 8-2 (p. 8-34) provides a list of basic weld symbols.

Note that the perpendicular leg of the fillet weld symbol is always to the left.



Weld Metal Designations

The ASTM designation used to identify and classify electrodes for SMAW is comprised of a letter followed by four digits, for example E7011. The letter E designates that the electrode is for use with an electric welding process (as opposed to gas flame). The first two digits designate the tensile strength of the electrode (F_u = 70 ksi for this example). The third digit designates the welding position (1 = all positions) and the fourth digit the type of current (1 = AC).

The designation used for other welding processes, such as FCAW, GMAW, and SAW is comprised of 1 or 2 letters followed by only 2 digits, for example E71T (FCWA) and ER70S (GMAW).

Weld Metal Designations - SMAW

Welding Positions

1 - all positions
2 - horizontal or flat
3 - flat only
4 - all positions but vertical down

Welding Current

0 - DC, RP
1 - AC, DCRP
2 - AC, DCSP

RP - Reverse Polarity (electorde is positive, more heat at electrode, more weld profile buildup)

SP - Straight Polarity (electrode is negative, more heat at weld pool, deeper penetration)

Weld Profiles

Shown are three different weld profiles. The welds were formed by place a bead (single pass) of weld along the surface of a plate. The plate was cut and the cross section polished and etched to reveal the micro- structure of weld and base metal. Note the different degrees of weld penetration which is a function of heat input and current setting.