# The fundamentals of weld joint design

The performance of weld joints is determined by not only the load resisting cross sectional area of joint but also properties of region close to the weld metal i.e. heat affected zone (HAZ). The design engineer must keep in mind that HAZ can be significantly wider or stronger than weld and so accordingly various parameters of weld joint design should be established. This module based on design of weld joints has been covered in next nine lectures (Lecture 22 to 30). This chapter describes the fundamentals of weld joint design including the parameters that are obtained after designing a weld joint.

**Keywords:** Modes of failure, rigidity and stiffness, loading condition, welding symbol, type of weld and weld joint,

## 22.1 Introduction

Weld joints may be subjected to variety of loads ranging from a simple tensile load to the complex combination of torsion, bending and shearing loads depending upon the service conditions. The capability of weld joints to take up a given load comes from metallic continuity across the members being joined. Mechanical properties of the weld metal and load resisting cross section area of the weld (besides heat affected zone characteristics) are two most important parameters which need to be established for designing a weld joint.

## 22.2 Modes of failure of the weld joints

A poorly designed weld joint can lead to the failure of an engineering component in three ways namely a) elastic deformation (like bending or torsion of shaft and other sophisticated engineering systems like precision measuring instruments and machine tools) of weld joint beyond acceptable limits, b) plastic deformation (change in dimensions beyond acceptable limits as-decided by application) of engineering component across the weld joint and c) fracture of weld joint into two or more pieces under external tensile, shear, compression, impact creep and fatigue loads.

Therefore, depending upon the application, failure of weld joints may occur in different ways and hence a different approaches are needed for designing the weld joints as per application and service requirements.

## 22.3 Design of weld joints and mechanical properties

Stiffness and rigidity are important parameters for designing weld joints where elastic deformation is to be controlled. Under such conditions, weld metal of high modulus of elasticity (E) and rigidity (G) is deposited for producing weld joints besides selecting suitable load resisting cross sectional area. When the failure criterion for a weld joint is the plastic deformation, then weld joints are designed on the basis of yield strength of the weld metal. When the failure criterion for weld joint is to avoid fracture under static loading, then ultimate strength of the weld metal is used as a basis for design. While under fatigue and creep conditions design of weld joints is based on specialized approaches which will be discussed in later stages of this chapter. Under simplified conditions, design for fatigue loads is based on endurance limit. Weld joints invariably possess different types of weld discontinuities of varying sizes which can be very crucial in case of critical applications e.g. weld joints used in nuclear reactors, aerospace and space craft components. Therefore, weld joints for critical applications are designed using fracture mechanics approach which takes into account the size of discontinuity (in form of crack, porosity or inclusions), applied stresses and weld material properties (yield strength and fracture toughness) in design of weld joints.

## 22.4 Factors affecting the performance of the weld joints

It is important to note that the mechanical performance of the weld joints is governed by not only mechanical properties of the weld metal and its load resisting cross sectional area (as mentioned above) but also on the welding procedure used for developing a weld joint which includes the edge preparation, weld joint design, and type of weld, number of passes, preheat and post weld heat treatment, if any, welding process and welding parameters (welding current, arc length, welding speed) and method used for protecting the weld contamination from atmospheric gases. As most of the above mentioned steps of welding procedure influence metallurgical properties and residual stresses in weld joint which in turn affect the mechanical (tensile and fatigue) performance of the weld joint.

**22.5 Design of weld joints and loading conditions**

Design of weld joints for static and dynamic loads needs different approaches because in case of static loads the direction and magnitude become either constant or changes very slowly while in case of dynamic loads such as impact and fatigue conditions, the rate of loading is usually high. In case of fatigue loading both magnitude and direction of load may fluctuate. Under the static load condition, low rate of loading increases the time available for localized yielding to occur in area of high stress concentration which in turn causes stress relaxation by redistribution of stresses through-out the cross section while under dynamic loading conditions, due to lack of availability of time, yielding across the section of weld doesn’t take place and only localized excessive deformation occurs near the site of a high concentration stress which eventually provide an easy site for nucleation and growth of cracks as in case of fatigue loading.

**22.6 Need of welding symbols**

It is important to communicate information about welding procedure without any ambiguity to all those who are involved in various steps of fabrication of successful weld joints ranging from edge preparation to final inspection and testing of welds. To assist in this regard, standard symbols and methodology for representing the welding procedure and other conditions have been developed. Symbols used for showing the type of weld to be made are called weld symbols. Some common weld symbols are shown below in Fig. 22.1.

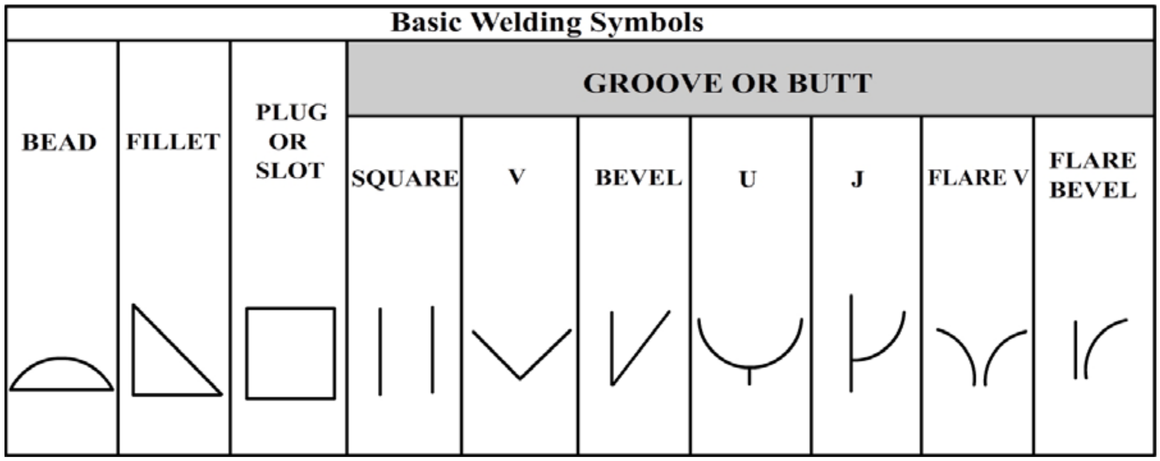



Fig. 22.1 Basic weld symbols

Symbols which are used to show not only the type of weld but all relevant aspects related with welding like size & location of weld, welding process, edge preparation, bead geometry and weld inspection process and location of the weld to be fabricated and method of weld testing etc. are called welding symbols. Following sections present standard terminologies and joints used in field of welding engineering.

### 22.7 Types of weld Joints

The classification of weld joints is based on the orientation of plates/members to be welded. Common types of weld joints and their schematics are shown in Fig. 22.2 (a-e).

- ☑ Butt joint: plates are in same horizontal plane and aligned with maximum-deviation of $5^0$.
- ☑ Lap joint: plates overlapping each other and the overlap can just one side or both the sides of plates being welded
- ☑ Corner joint: joint is made by melting corners of two plates being welded and therefore plates are approximately perpendicular ($75^0$ - $90^0$) to each other at one side of the plates being welded
- ☑ Edge joint: joint is made by melting the edges of two plates to be welded and therefore the plates are almost parallel ($0^0$ - $5^0$)
- ☑ T joint: one plate is approximately perpendicular to another plate ($85^0$ - $90^0$)

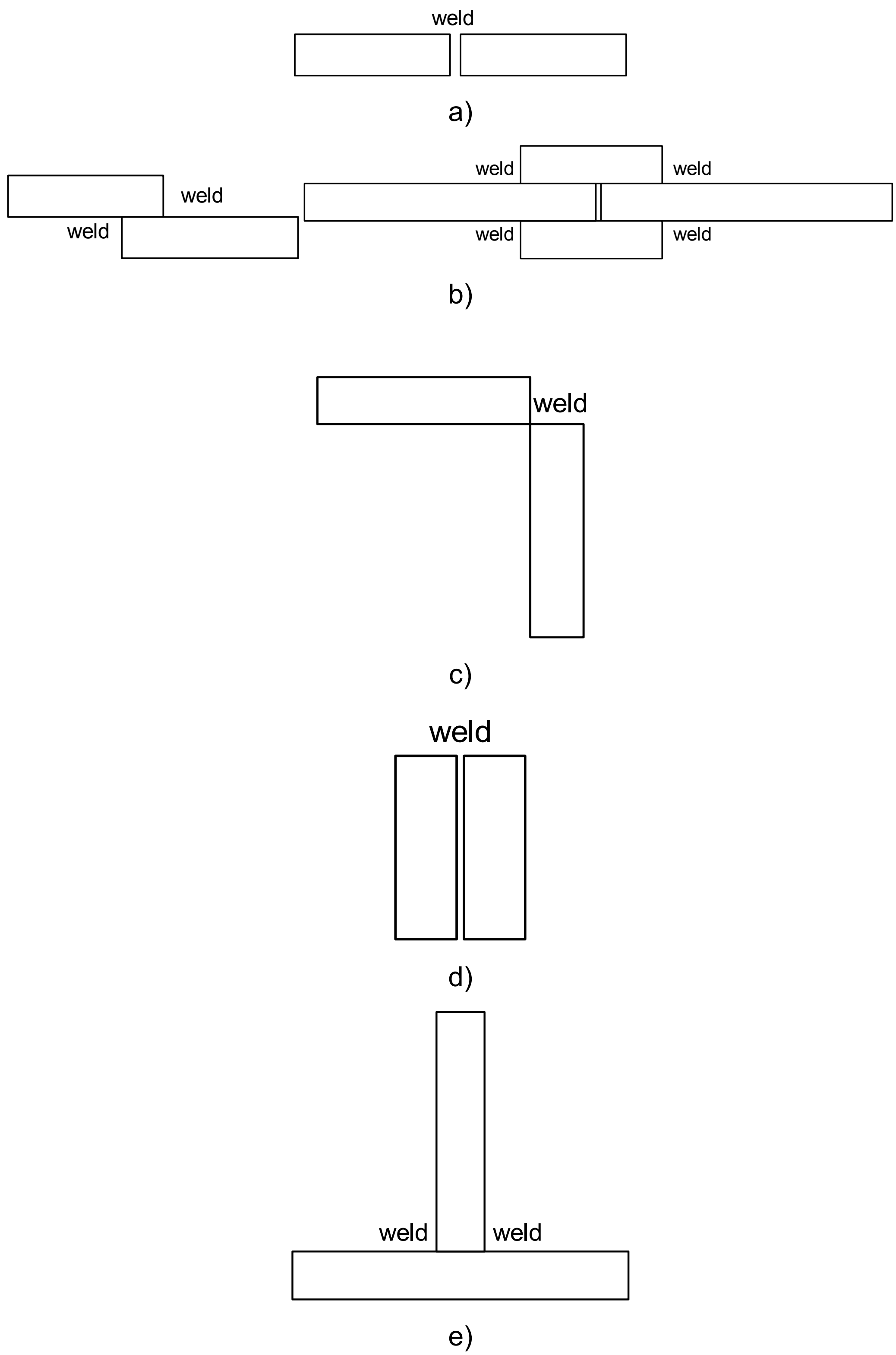
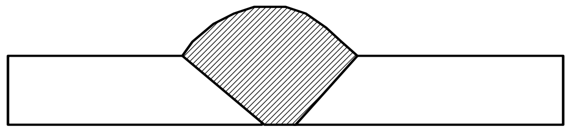


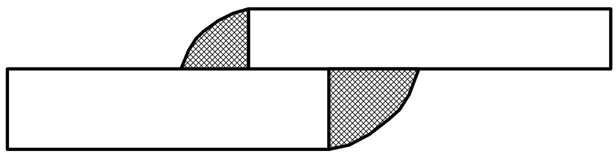

Fig. 22.2 Schematic of different types of weld joints a) butt, b) lap, c) corner, d) edge and e) T joint

### 3.0 Types of weld

This classification in based on the combined factors like “how weld is made” and “orientation of plates” to be welded. Common types of weld joints and their schematics are shown in Fig. 22.3 (a-e).



a)



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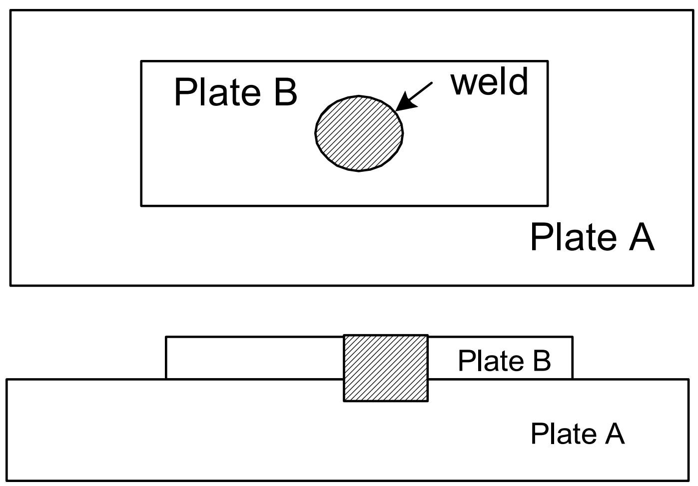
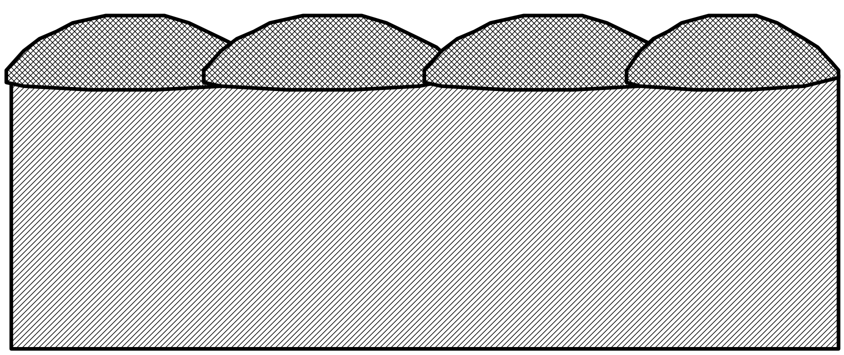



c)



d)

Fig. 22.3 Schematic of different types of weld a) groove, b) fillet, c) plug and d) bead on plate

**References and books for further reading**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