UNIT I INTRODUCTION AND ALLOWABLE STRESS DESIGN

Allowable Stress (Strength)

The **allowable stress** or allowable strength is the maximum **stress** (tensile, compressive or bending) that is allowed to be applied on a structural material. The allowable stresses are generally defined by building codes, and for steel, and aluminum is a fraction of their **yield stress** (strength)

$$F_{\alpha} = \frac{F_y}{F.S.}$$

In the above equation, F_{α} is the allowable stress, F_y is the yield stress, and $F.S.$ is the factor of safety or safety factor. This factor is generally defined by the building codes based on particular condition under consideration. Since tension members do not generally buckle, they can resist larger loads (larger) F_{α} due to small $F.S.$ value.

Limit State Design Methods for Steel structures

Limit states are **the acceptable limits for the safety and serviceability requirements of the structure before failure occurs**. The design of structures by this method will thus ensure that they will not reach limit states and will not become unfit for the use for which they are intended.

For steel structures, two major limit states need to be considered for general design: **the ultimate limit state and the serviceability limit state**. There are other limit states that may need special treatment and are usually classified under "accidental loadings" in design codes.

There are three different methods for design of steel structure, i.e.

- **simple design**
- **continuous design**
- **semi-continuous steel design**.

Joints in structures have been assumed to behave as either pinned or rigid to render design calculations manageable. In simple design the joints are idealized as perfect pins.

A degree of loading or other actions imposed on a structure can result in a ‘limit state’, where the structure’s condition no longer fulfils its design criteria, such as; fitness for use, structural integrity, durability, and so on. Limit states are conditions of potential failure.

All actions likely to occur during a structure’s design life are considered during the LSD method, to ensure that the structure remains fit for use with appropriate levels of reliability.

LSD involves estimating the subjected loads on a structure, choosing the sizes of members to check, and selecting the appropriate design criteria. LSD requires two principal criteria to be satisfied: the ultimate limit state (ULS) and the serviceability limit state (SLS).

Limits state Method: Limit sates are the states beyond which the structure no longer satisfies the specified performance requirements. The limit states are normally grouped under two headings:

- Limit state of strength or safely also known as ultimate limit state
- (b) Limits state of serviceability

Limits state of strength are those associated with failures (or imminent failure),Under the action of probable and most unfavorable combination of loads on the structure using the appropriate partial safety factors which may endanger the safety of life and property. The limit state of strength includes

- Loss of stability /equilibrium of the structure (including the effect of sway where appropriate and overturning) or any of its parts including supports and foundations
- (b) Strength limits (general yielding, formation of mechanism, rupture of the structure or any of its parts or components)
- (c) Fatigue (leading to fracture)
- (d) Brittle fracture

Limit state of serviceability are limit states beyond which specified service criteria are no longer met. These include

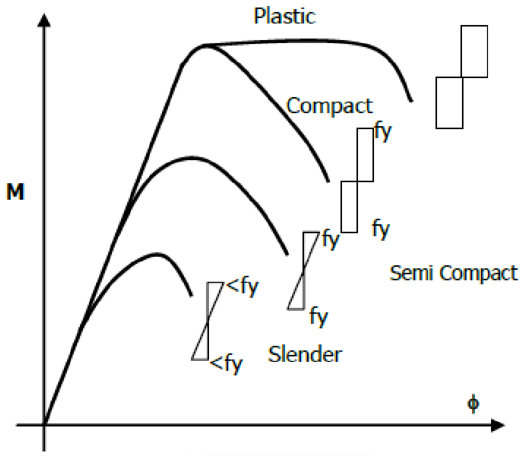
- Deformation and deflections, which may adversely affect the appearance or effective use of the structure, or may cause improper functioning of equipment or services, or may cause damages to finishes and non-structural members.
- Vibrations in the structure or any its components causing discomfort to people, damages to the structure, its contents or which may limits its functional effectiveness.

Ultimate limit state is related to the maximum design load capacity under extreme condition. The partial load factors are chosen to reflect the probability of extreme conditions, when loads act alone or in combination. Serviceability limit state is related to the criteria governing normal use. Unfactored loads are used to check the adequacy of the structure. Fatigue limit state is important where distress to the structure by repeated loading is a possibility

Classification of cross – section:

- Plate elements of a cross – section may buckle locally due to compressive stresses. The local buckling can be avoided before the limit state is achieved by limiting the width to thickness ratio of each element of a cross – section subjected to compression due to axial force, moment or shear.
- When plastic analysis is used, the members shall be capable of forming plastic hinges with sufficient rotation capacity (ductility) without local buckling to enable the redistribution of bending moment required before formation of the failure mechanism.
- When elastic analysis is used, the members shall be capable of developing the yield stress under compression without local buckling.
- On basis of the above, four classes of sections are defined as follows:

Class 1 (Plastic): Cross sections, which can develop plastic hinges and have the rotation capacity required for failure of the structure by formation of plastic mechanism. The width to thickness ratio of plate elements shall be less than that specified under Class - 1(Plastic)



Class 2 (Compact): Cross – section, which can develop moment of resistance, but have inadequate plastic hinge rotation capacity for formation of plastic mechanism, due to lical buckling. The width to thickness rati of palte elements shall be less than that specified under class – 2 (compact), but greater than specified under class – 1 (Plastic)

Class 3 (Semi - compact): Cross – section, in which extreme fiber in compression can reach yield stress, but cannot develop the plastic moment of resistance, due to local buckling. The width of thickness ratio of plate elelemnts shall be less than specified under Class – 3 (Semi – compact), but greater than that specified under class 2 (compact),

Class 4 (Slender): – Cross sections in the elements buckle locally even before reaching yield stress. The width to thickness ratio of plate elements shall be greater than that specified under class – 3(semi-compact), in Table 2. In such cases, the effective sections designed shall be calculated either by following the provisions of IS 801 to account for the post – local – buckling strength or by deducting width of compression plate element in excess of the semi – compact section limit.