Unit – V

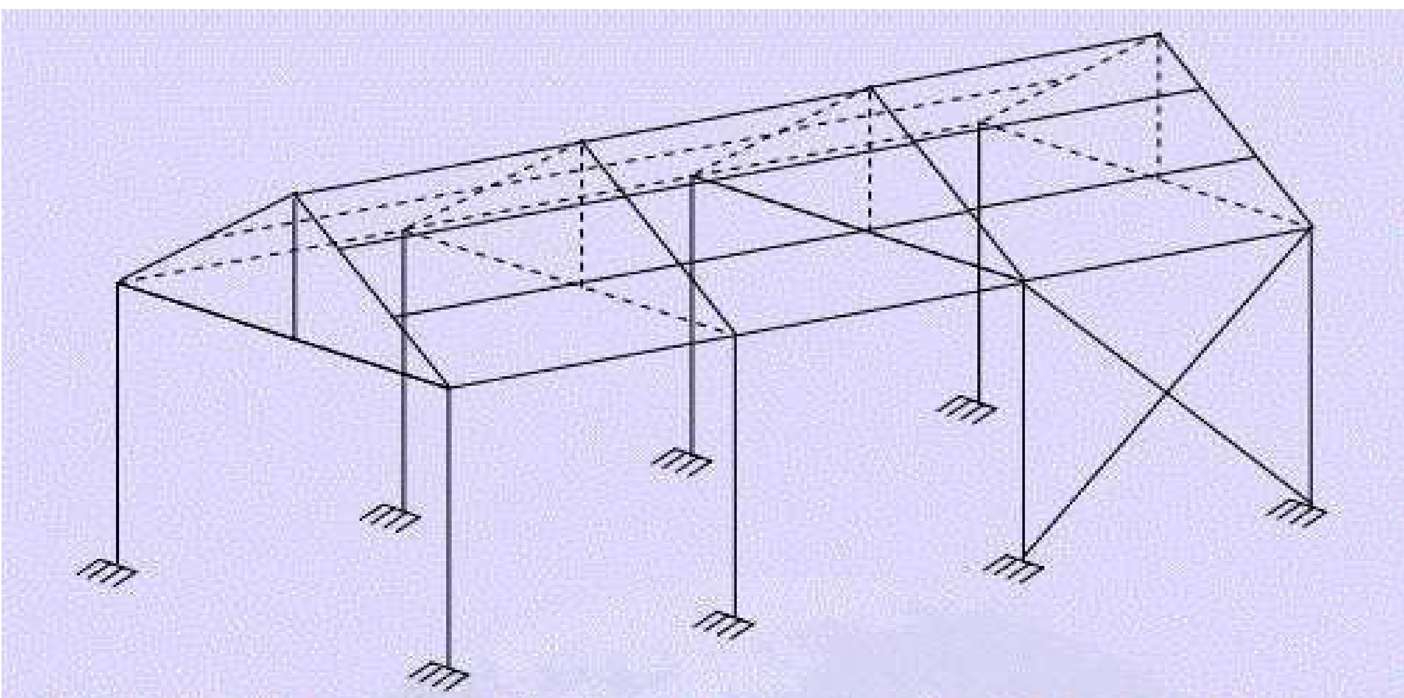
Design of Industrial building frames, multistory frames, Bracings for high rise structures, Design of transmission towers.

Industrial building frames

Any building structure used by the industry to store raw materials or for manufacturing products of the industry is known as an industrial building. Industrial buildings may be categorized as Normal type industrial buildings and Special type industrial buildings. Normal types of industrial building are shed type buildings with simple roof structures on open frames. These buildings are used for workshop, warehouses etc. These building require large and clear areas unobstructed by the columns. The large floor area provides sufficient flexibility and facility for later change in the production layout without major building alterations. The industrial buildings are constructed with adequate headroom for the use of an overhead traveling crane. Special types of industrial buildings are steel mill buildings used for manufacture of heavy machines, production of power etc. The function of the industrial building dictates the degree of sophistication.

Building configuration

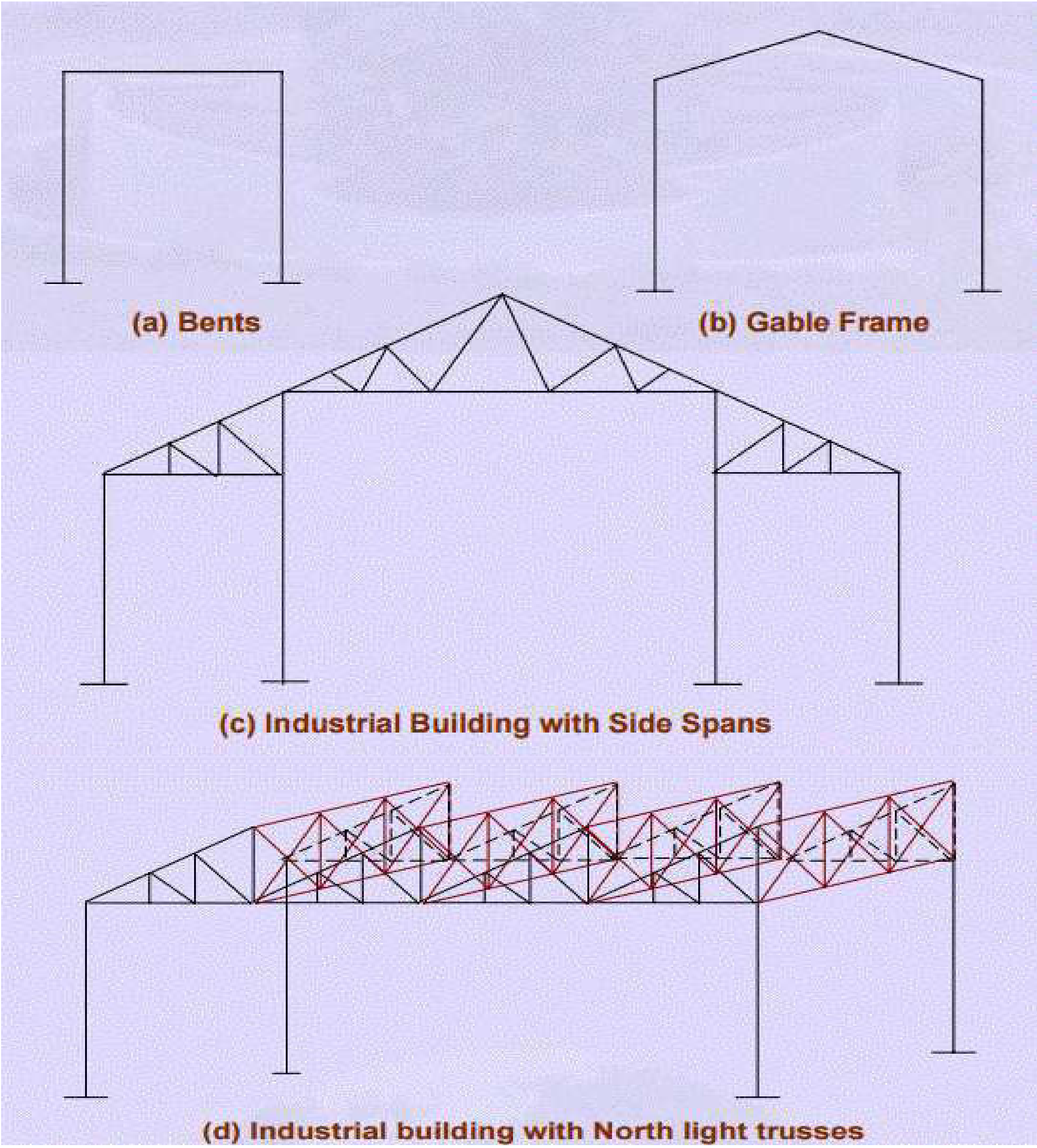
Typically the bays in industrial buildings have frames spanning the width direction. Several such frames are arranged at suitable spacing to get the required length (Fig.). Depending upon the requirement, several bays may be constructed adjoining each other. The choice of structural configuration depends upon the span between the rows of columns, the head room or clearance required the nature of roofing material and type of lighting. If span is less, portal frames such as steel bents (Fig.) or gable frames (Fig.) can be used but if span is large then buildings with trusses (Fig.) are used.



Typical structural layout of an industrial

The horizontal and vertical bracings, employed in single and multi-storey buildings, are also trusses

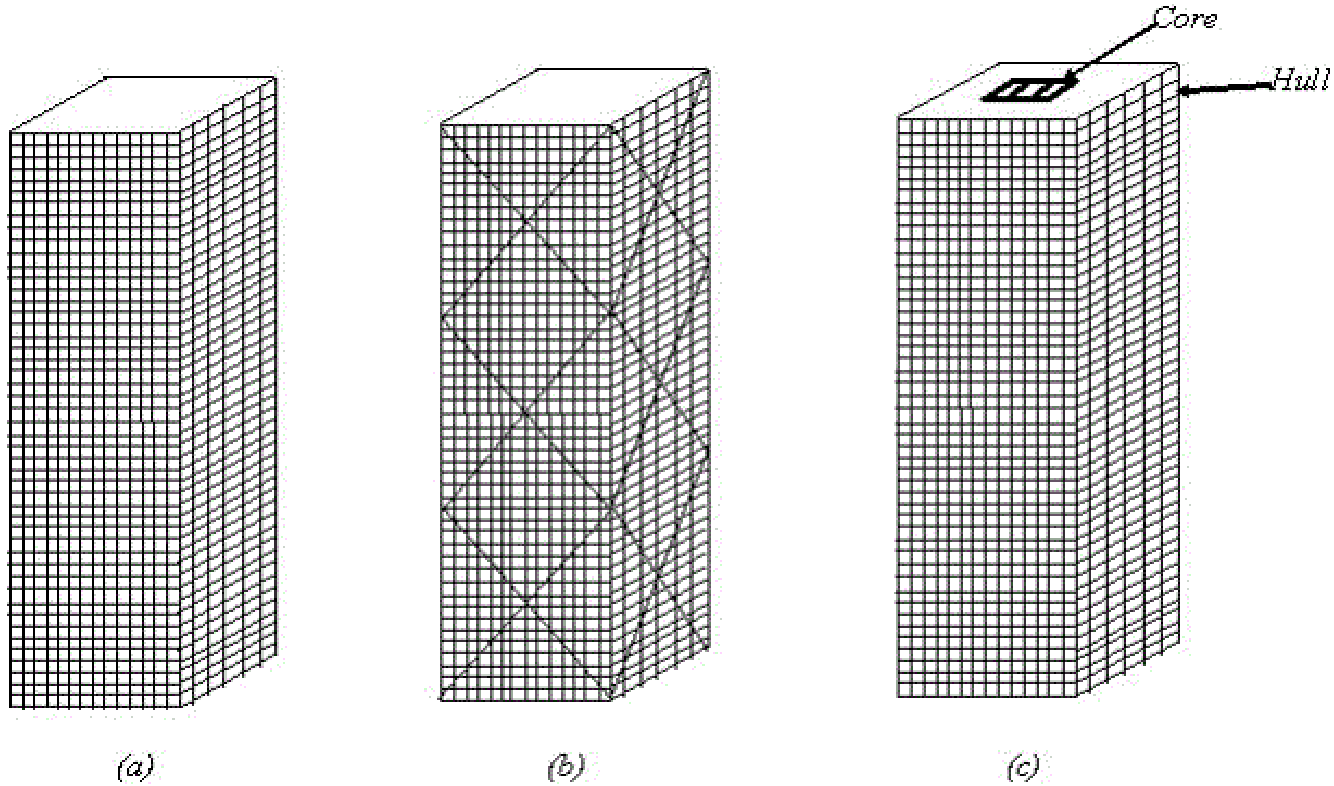
used primarily to resist wind and other lateral loads. These bracings minimize the differential deflection between the different frames due to crane surge in industrial buildings. They also provide lateral support to columns in small and tall buildings, thus increasing the buckling strength.



(a) Bents
(b) Gable Frame
(c) Industrial Building with Side Spans
(d) Industrial building with North light trusses

Bracings for high rise structures

The bracing systems discussed so far are not efficient for buildings taller than 60 stories. This section introduces more advanced types of structural forms that are adopted in steel-framed multi-storeyed buildings taller than 60 storeys.



(a) Framed tube (b) Braced framed tube (c)Tube-in-Tube frame

The framed tube is one of the most significant modern developments in high-rise structural form. The frames consist of closely spaced columns, 2 - 4 m between centers, joined by deep girders. The idea is to create a tube that will act like a continuous perforated chimney or stack. The lateral resistance of framed tube structures is provided by very stiff moment resisting frames that form a tube around the perimeter of the building. The gravity loading is shared between the tube and interior columns. This structural form offers an efficient, easily constructed structure appropriate for buildings having 40 to100 storeys.

When lateral loads act, the perimeter frames aligned in the direction of loads act as the webs of the massive tube cantilever and those normal to the direction of the loading act as the flanges. Even though framed tube is a structurally efficient form, flange frames tend to suffer from shear lag. This results in the mid face flange columns being less stressed than the corner columns and therefore not contributing to their full potential lateral strength. Aesthetically, the tube looks like the grid-like façade as small windowed and is repetitious and hence use of prefabrication in steel makes the construction faster. A typical framed tube is shown.

Braced tube structures

Further improvements of the tubular system can be made by cross bracing the frame with X-bracing over many stories, as illustrated in Fig. 3.14(b). This arrangement was first used in Chicago's John Hancock Building in 1969.

As the diagonals of a braced tube are connected to the columns at each intersection, they virtually eliminate the effects of shear lag in both the flange and web frames. As a result the structure behaves under lateral loads more like a braced frame reducing bending in the members of the frames. Hence, the spacing of the columns can be increased and the depth of the girders will be less, thereby allowing large size windows than in the conventional framed tube structures.

In the braced tube structure, the braces transfer axial load from the more highly stressed columns to the less highly stressed columns and eliminates differences between load stresses in the columns.

Design of Transmission Towers

Once the external loads acting on the tower are determined, one proceeds with an analysis of the forces in various members with a view to fixing up their sizes. Since axial force is the only force for a truss element, the member has to be designed for either compression or tension. When there are multiple load conditions, certain members may be subjected to both compressive and tensile forces under different loading conditions. Reversal of loads may also induce alternate nature of forces; hence these members are to be designed for both compression and tension. The total force acting on any individual member under the normal condition and also under the broken- wire condition is multiplied by the corresponding factor of safety, and it is ensured that the values are within the permissible ultimate strength of the particular steel used

Bracing systems

Once the width of the tower at the top and also the level at which the batter should start are determined, the next step is to select the system of bracings. The following bracing systems are usually adopted for transmission line towers.

Single web system

It comprises either diagonals and struts or all diagonals. This system is particularly used for narrow-based towers, in cross-arm girders and for portal type of towers. Except for 66 kV single circuit towers, this system has little application for wide-based towers at higher voltages.

Double web or Warren system

This system is made up of diagonal cross bracings. Shear is equally distributed between the two diagonals, one in compression and the other in tension. Both the diagonals are designed for compression and tension in order to permit reversal of externally applied shear. The diagonal braces are connected at their cross points. Since the shear preface is carried by two members and critical length is approximately half that of a corresponding single web system. This system is used for both large and small towers and can be economically adopted throughout the shaft except in the lower one or two panels, where diamond or portal system of bracings is more suitable.

Pratt system

This system also contains diagonal cross bracings and, in addition, it has horizontal struts. These struts are subjected to compression and the shear is taken entirely by one diagonal in tension, the other diagonal acting like a redundant member.

It is often economical to use the Pratt bracings for the bottom two or three panels and Warren bracings for the rest of the tower.

Portal system

The diagonals are necessarily designed for both tension and compression and, therefore, this arrangement provides more stiffness than the Pratt system. The advantage of this system is that the horizontal struts are supported at mid length by the diagonals.

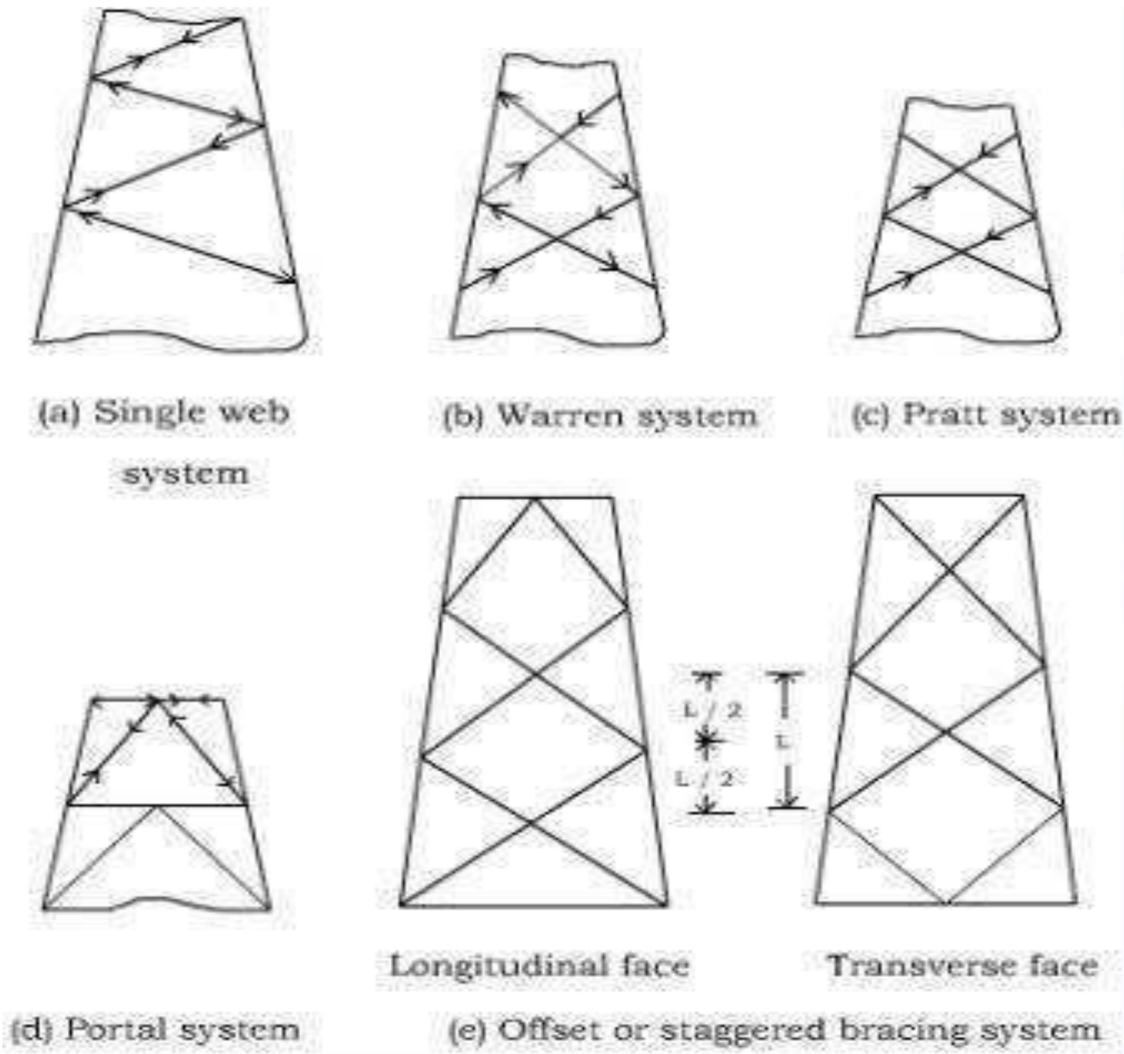
Like the Pratt system, this arrangement is also used for the bottom two or three panels in conjunction with the Warren system for the other panels. It is especially useful for heavy river-crossing towers.

Where p = longitudinal spacing (stagger), that is, the distance between two successive holes in the line of holes under consideration,

g = transverse spacing (gauge), that is, the distance between the same two consecutive holes as for p, and

d = diameter of holes.

For holes in opposite legs of angles, the value of 'g' should be the sum of the gauges from the back of the angle less the thickness of the angle.



(a) Single web system (b) Warren system (c) Pratt system

(d) Portal system (e) Offset or staggered bracing system

