STEEL COLUMNS

DEFINITION

Members which are subjected to compression are called compression member and load in all such members may be axial or non axial depending upon the position of the member. Columns are vertical compression member which are subjected to compressive force in a direction parallel to its longitudinal axis. When load is centric, columns are known as centric or axially loaded columns and when load is eccentric such columns are known as eccentric or non axially loaded columns.

CLASSIFICATION OF COLUMNS

Columns are of folowing types

1.Short columns

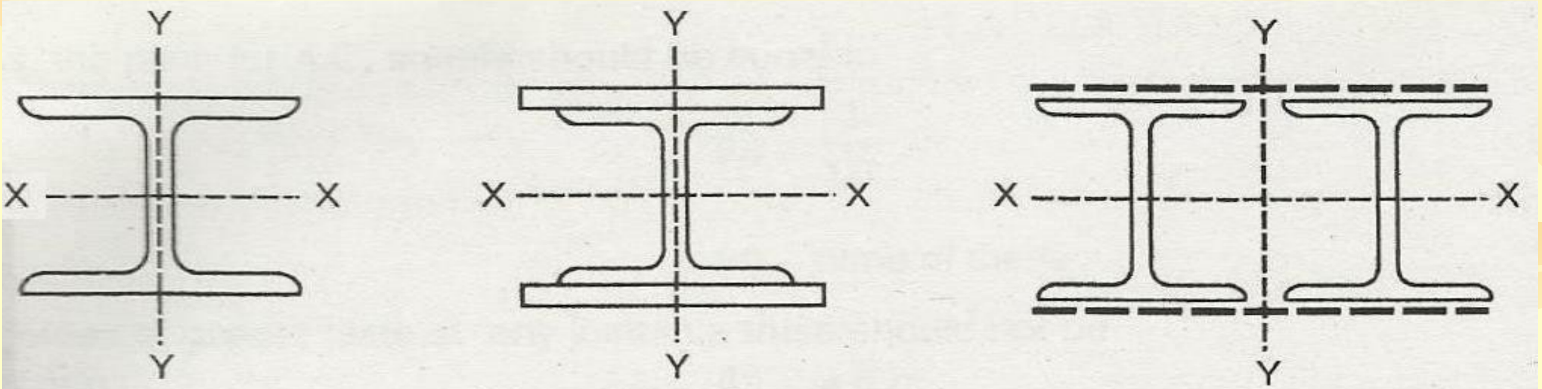
2. Long columns

1) *Short columns:-When the ratio of effective length of column to the least lateral dimension is less than equal to 12 is known as short column. The failure of such type of columns purely due to direct crushing. The load capacity of the column is equal to the safe compressive stress and x-sectional area of column.*

2) Long Columns:- When the ratio of effective length of column to the least lateral dimension is greater than 12 is known as long column. The failure of such type of columns is mainly due to buckling or bending. The column fails in bending before the compressive stress reaches the crushing value. Direct stress has little importance in its failure.

Common Sections For Columns

1. I-section. I-section can be used as columns. But ISHB section are more suitable as these provide minimum difference in two radii of gyrations. To get stronger section, additional plates can be attached on both flanges. For heavy column section, I-sections can be spaced to achieve the most economical sections.

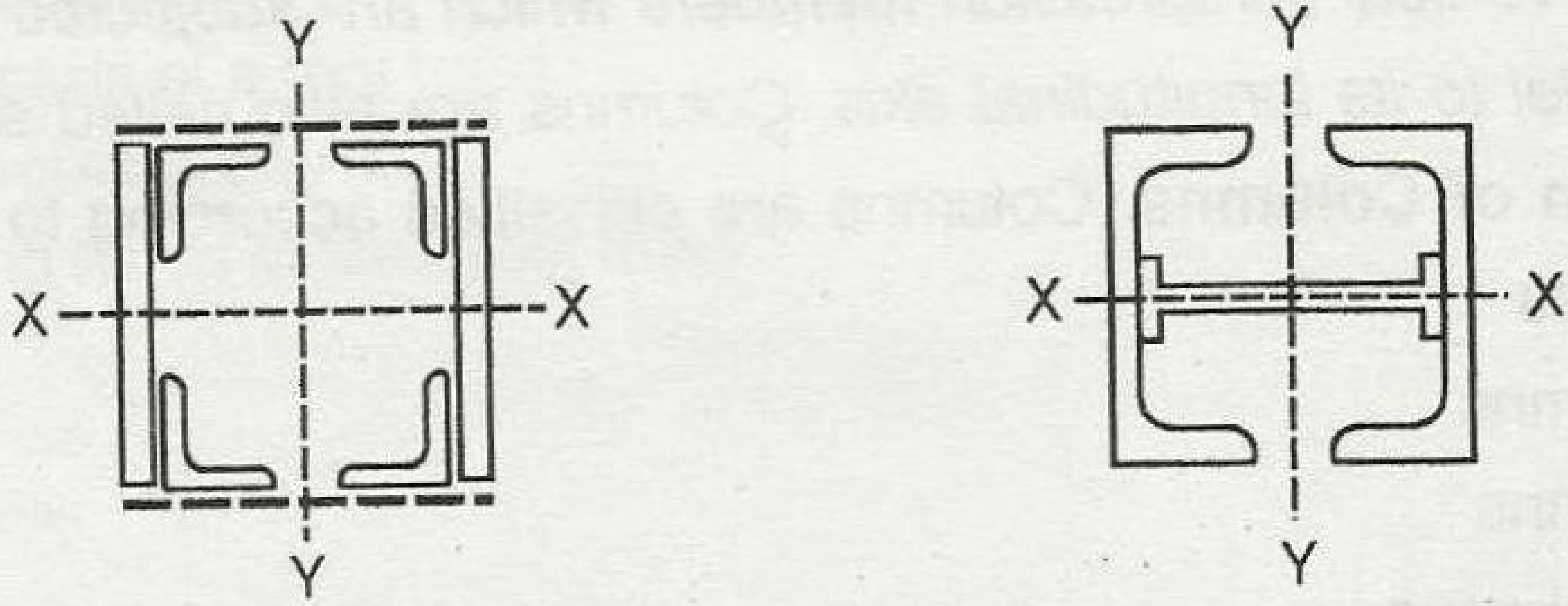


I-sections

2. Channel section. Single ISMC and ISLC are suitable as columns for light loads. Double ISJC, ISLC and ISMC can serve as good column sections when laced or battened and these can support moderate load. These can be spaced back to back for better strength and economy. Double channels with flanges butting and welded to toe to toe are also used as columns.

Channel Sections

3. Miscellaneous section. In addition to the above given sections, the combination of other sections can be used as column.



Miscellaneous Sections

Concept of Buckling of Columns

All compression members have a tendency to bend even if they are loaded axially. This bending of the column in the outward direction is called buckling. Buckling of the column is also know as deflection of column. Buckling takes place in a direction perpendicular to the axis, about which moment of inertia of the section is minimum.

The axial load at which buckling commences is called buckling load. The magnitude of buckling load is a function of effective length of member and its radius of gyration.

Effective Length (Equivalent Length)

The length of the column which bends as if it is hinged (pin jointed) at both ends is called effective length. It is denoted by l. Effective length of a column depends upon its end conditions.

The effective length is derived from the actual length L of the column. Effective length for different end conditions will be taken according to IS: 800-1984 as follows:-

S.No	End Conditions	Effective length Recommended
1.	Effectively held in position and restrained against rotation at both ends	0.65 L
2.	Effectively held in position at both ends and restrained against rotation at one end	0.80 L
3.	Effectively held in position at both ends, but not restrained against rotation.	1.00 L

S.No	End Conditions	Effective length Recommended
4.	Effectively held in position and restrained against rotation at one end, and at the other end restrained against rotation but not held in position.	1.20 L
5.	Effectively held in position and restrained against rotation at one end, and at the other end partially restrained against rotation but not held in position.	1.50 L

S.No	End Conditions	Effective length Recommended
6.	Effectively held in position at one end but not restrained against rotation, and at the other end restrained against rotation but not held in position.	2.00 L
7.	Effectively held in position and restrained against rotation at one end, but not held in position nor restrained against rotation at the other end.	2.00 L

Slenderness Ratio

It is defined as the ratio between the effective length of compression member and its least radius of gyration.

Slenderness ratio = l / r

l = effective length of compression member

r = least radius of gyration of section of a member.

Radius of gyration is the property of a section. It is always worked out with reference to a certain axis by the expression:

r = $\sqrt{I/A}$ where I = Moment of inertia of the section.

A = Area of the section

The slenderness ratio is very important factor deciding upon the x-sectional dimensions of compression members. When slenderness is too high, the x-section of member is small. It will show visible deflection under load. Thus to avoid slim (thin and long) looking members, the slenderness ratio should be with in specified limits depending upon nature of load. Also if the slenderness ratio is too low, the x-section of member will be stocky.

Minimum Slenderness Ratio

The ratio of effective length, l to the appropriate radius of gyration, r of a compression member shall not exceed the corresponding values specified for it as per IS: 800-1984.

S.No	Type of member	l / r
1.	A strut connected by single rivet at each end.	180
2.	Carrying compressive loads are superimposed loads resulting from dead loads and superimposed loads.	180

S.No	Type of member	l / r
3.	Carrying loads resulting from wind or seismic forces only, provided the deformation of such members does not adversely effect the stress in any part of structure.	250
4.	Compression flange of a beam.	300
5.	Normally acting as a tie in a roof truss or a bracing system but subject to possible reversal of stress resulting from the action of wind or seismic forces.	350

Strength of an Axial Loaded Columns

The maximum permissible axial compressive load on a columns is given by

$$P = \sigma_{ac} \times A$$

where P = Axial compressive load or buckling load or crippling load (N)

σ_{ac} = permissible stress in axial compression (N/mm^2)

A = Effective cross-sectional area of the member (mm^2)

= Gross cross-sectional area minus deduction for any hole not filled complete by rivets or bolts.

Design of Axial loaded Columns

The following steps are followed for designing an axially loaded columns:

Step 1. Approximate gross sectional area required = Axial compressive load / Assumed permissible compressive stress

(a) For single I-section columns assume permissible compressive stress = 80 N/mm^2

(b) For built-up columns assume permissible compressive stress = 100 or 110 N/mm^2

(because Such members have lesser slenderness ratio)

Step 2 Choose a trial section having area

= Approximate gross sectional area required

Step 3 Calculate slenderness ratio (λ) of trial section.

Step 4 Determine the actual permissible compressive stress corresponding to the calculate slenderness ratio.

Step 5 Calculate the safe load to be carried by trial section. It is calculated by multiplying, the actual permissible stress by the area of the trial section. If the safe load is equal to or slightly more than the applied axial load, then the trial section is suitable for selection, otherwise try another section.

Step 6. Check for the maximum slenderness ratio. The maximum slenderness ratio of the selected section should not exceed the values.

- ***Calculate the load carrying capacity of ISMB 350 @ 514 N/m to be used as a column. The effective length of the column is 4 m.***

Solution:-

From Steel tables, properties of ISMB 350 @ 514 N/m are:

$$a = 66.71\ cm^2 = 6671\ mm^2$$

$r_{xx} = 14.29$ cm = 142.9 mm and

$r_{yy} = 2.84$ cm = 28.4 mm

Minimum radius of gyration, r = 28.4 mm

(Least of r_{xx} and r_{yy})

Effective length of column, l = 4 m = 4000 mm

Slenderness ratio, $\lambda = l/r$

$$\lambda = 4000 / 28.4 = 140.85$$

For λ = 140.85 and f_y 250 N/mm^2

$\sigma_{ac} = 51 - (51 - 45) \times (140.85 - 140) / (150 - 140)$

$= 50.49$ N/mm^2

Load carried by column = $\sigma_{ac} \times A$

$$= 50.49 \times 6671 = 336818.8 \text{ N}$$

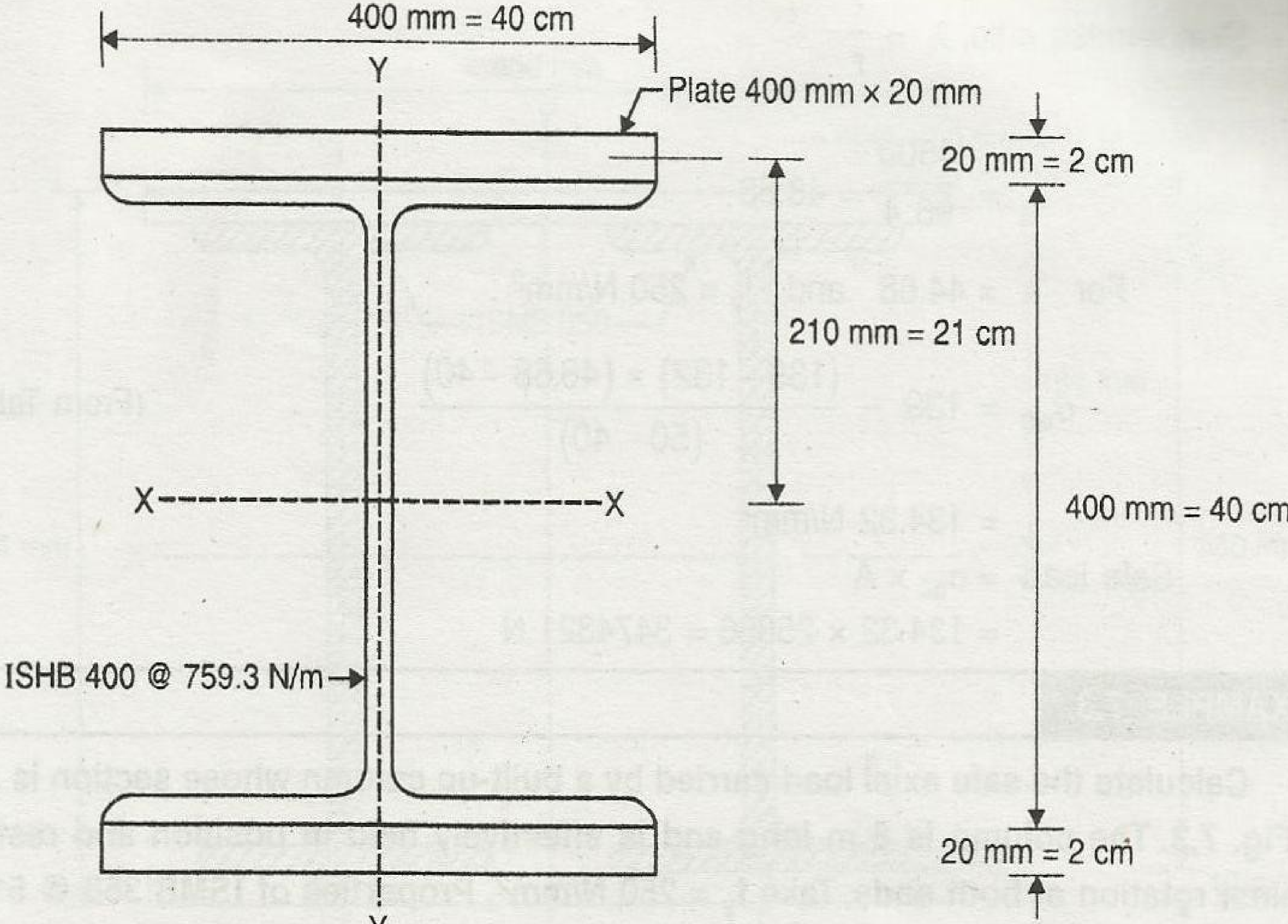
- ***Calculate the safe axial load carried by built-up column consisting of ISHB 400 @ 759.3 N/m with a plate 400 mm × 20 mm is welded to each flange. The column is 4.5 m long and is effectively held in position at both ends but not restrained against rotation. Take*** f_y ***= 250 N/mm²***

Solution:-

From Steel tables, properties of ISHB 400 @ 759.3 N/m are:

$$I_{xx} = 28083.5 \text{ cm}^4$$
$$I_{yy} = 2728.3 \text{ cm}^4$$
$$a = 98.66 \text{ cm}^2$$

Effective length, l = 4.5 m = 4500 mm



400 mm = 40 cm
Y
Plate 400 mm × 20 mm
20 mm = 2 cm
210 mm = 21 cm
X
X
400 mm = 40 cm
ISHB 400 @ 759.3 N/m
20 mm = 2 cm
Y

Area of built-up section, $A = 98.66 + 2 \times 40 \times 2$

$= 258.66\ cm^2 = 25866\ mm^2$

I_{xx} of the built-up section =

$= 28083.5 + 2 \times (40 \times 2^3 / 12 + 40 \times 2 \times 21^2)$

$= 28083.5 + 2 \times (26.67 + 35280)$

$= 98696.84\ cm^4$

I_{yy} of the built-up section =

$= 2728.3 + 2 \times (2 \times 40^3 / 12)$

$= 2728.3 + 21333.33$

$= 24061.63\ cm^4$

Since $I_{yy} < I_{xx}$

$\therefore$ Least radius of gyration, $r = \sqrt{I_{yy} / A}$

$= \sqrt{24061.63 / 258.66}$

$= 9.64$ cm $= 96.4$ mm

Slenderness ratio, $\lambda = l / r$

$= 4500 / 96.4 = 46.68$

For $\lambda = 44.68$ and $f_y = 250$ N/mm^2

$\sigma_{ac} = 139 - (139 - 132) \times (46.68 - 40) / (50 - 40)$

$= 134.32$ N/mm^2

Safe load $= \sigma_{ac} \times A$

$= 134.32 \times 25866$

$= 3474321$ N

Column Bases

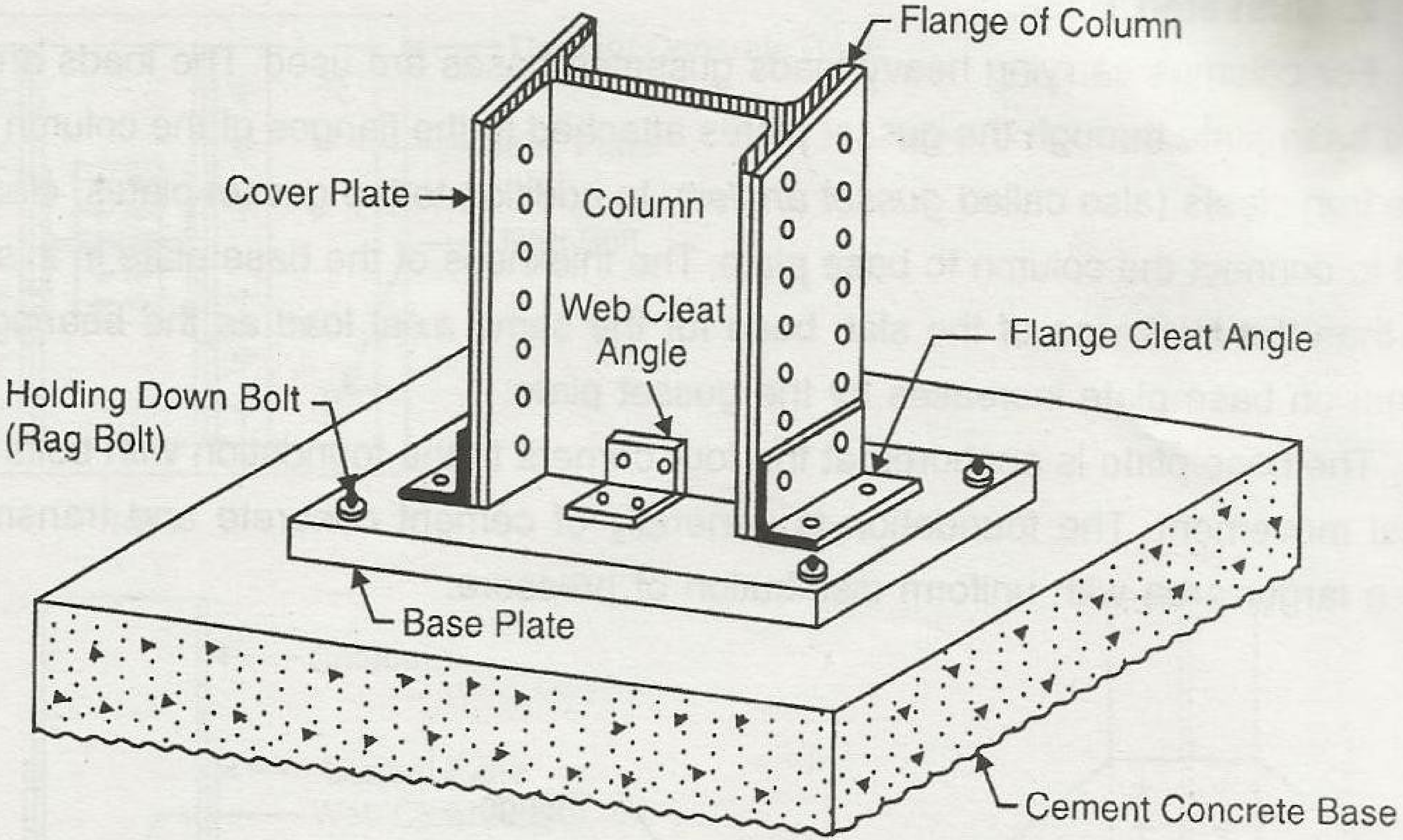
The columns are supported on the column bases. The column base is provided for transferring the load from the column to the base and distribute it evenly on the concrete bed. The load is also distributed over a larger area, so that the stress induced in the concrete is within its permissible limits and is capable of resisting overturning.

If column base is not provided, the column is likely to punch through the concrete block. Mild steel plates of sufficient area are attached to the bottom of the column in order to increase the bearing area. Such plates are column bases. These plates are secured to the concrete block through holding down bolts.

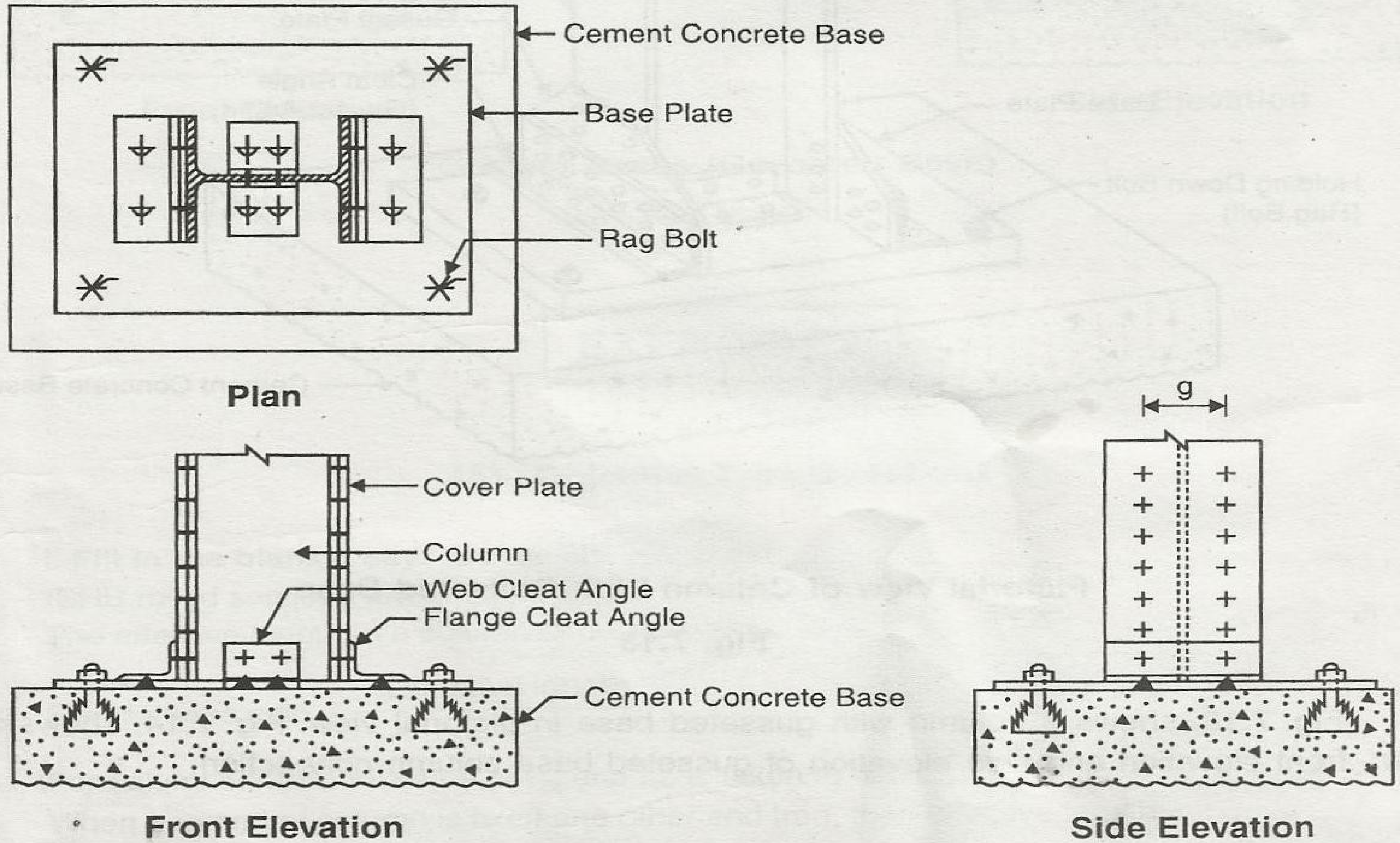
Types of Column Bases

1. Slab Base
2. Gusseted Base

1. Slab Base:- For columns carrying small loads, slab bases are used. It consists of a base plate (placed underneath a machined column end) and cleat angles. The machined column end transfers the load to the slab base by direct bearing. The column end is connected to base plate by welding or by means of riveted angle iron cleats. In order to have a flush base for the slab base it is necessary to use counter-sunk rivets in the horizontal legs of the angle iron cleats. No gusset plates are required for connecting the slab base.



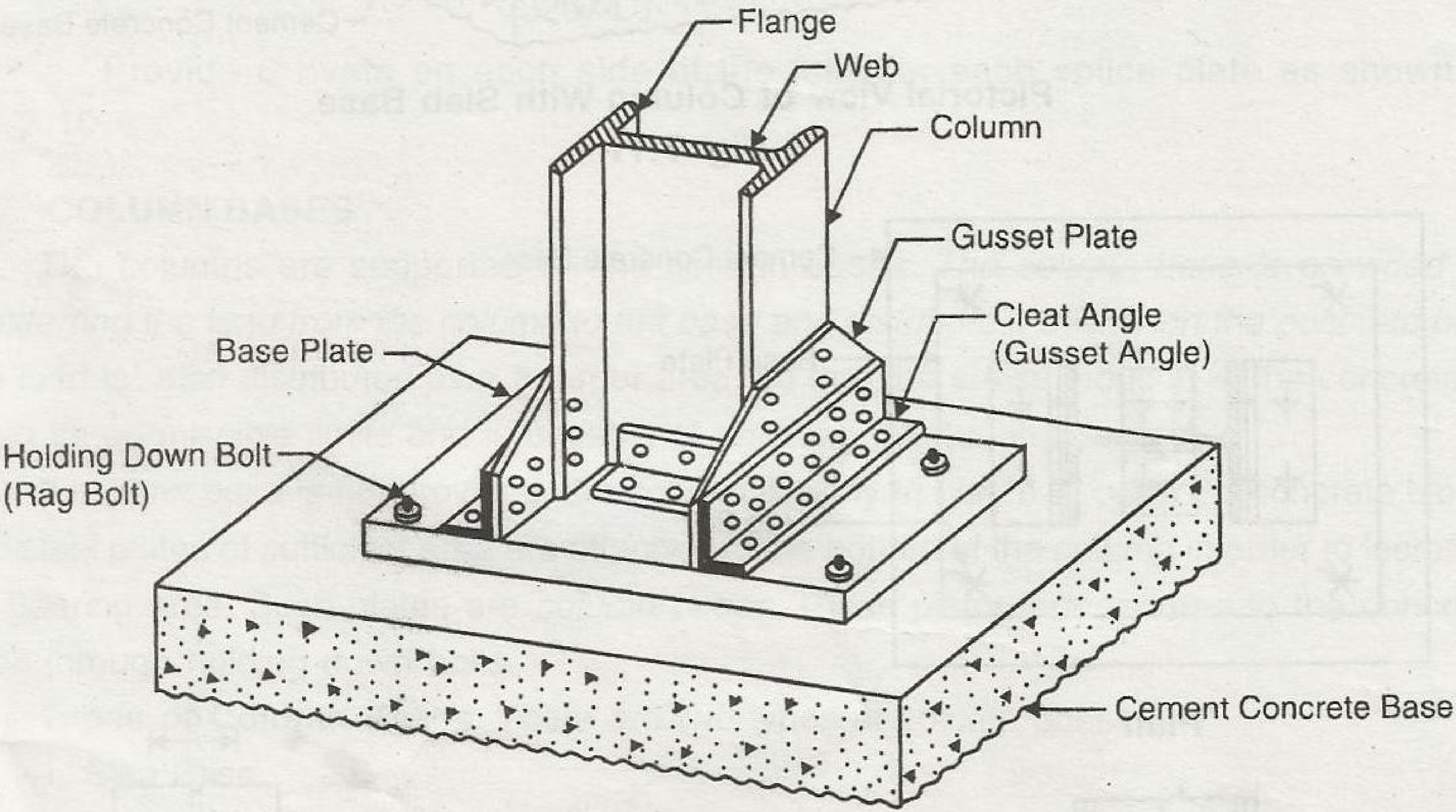
Pictorial View of Column With Slab Base



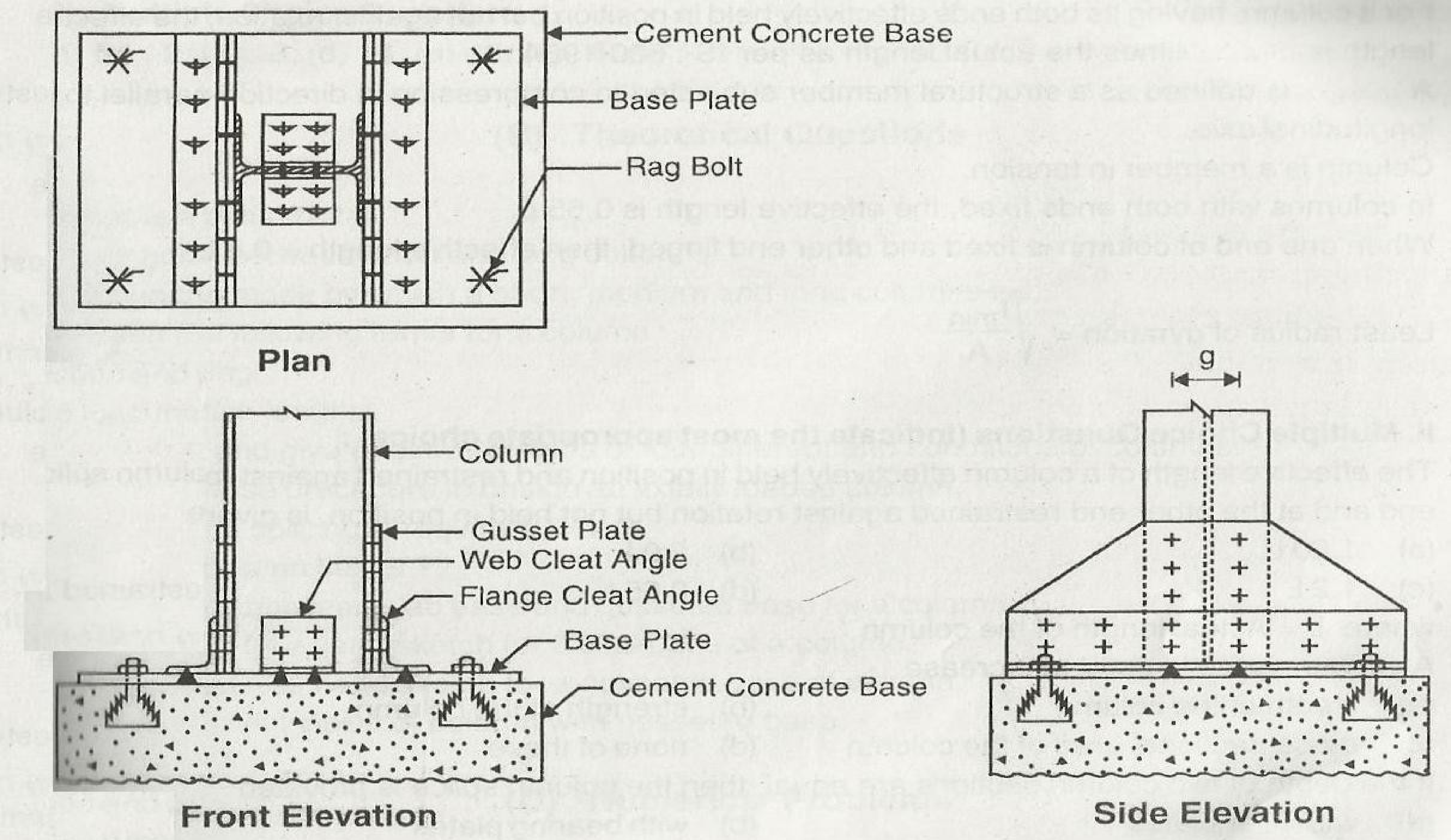
Column Bases (Slab Base)

2. Gusseted Base:- For columns carrying heavy loads, gusseted bases are used. The loads are transmitted to the base plate through the gusset plates attached to the flanges of the column by means of angle iron cleats (also called gusset angles). In addition to the gusset plates, cleat angles are used to connect the column to base plate. The thickness of base plate in this case will be less than the thickness of the slab base for the same axial load as the bearing area of the column on base plate increases by the gusset plate.

The base plate is anchored at the four corners to the foundation with bolts to check the lateral movement. The foundation is generally of cement concrete and transmits the load over a larger area with uniform distribution of pressure.



Pictorial View of Column With Gusseted Base



Column Bases (Gusseted Base)