Notes by-

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[COLUMN BASES]

* The column transfer their loads to the soil through colm base resting over concrete or masonary blocks. A colm base distributes pressure evenly on large area so that pre. on block does not exceed the permissible bearing stress.

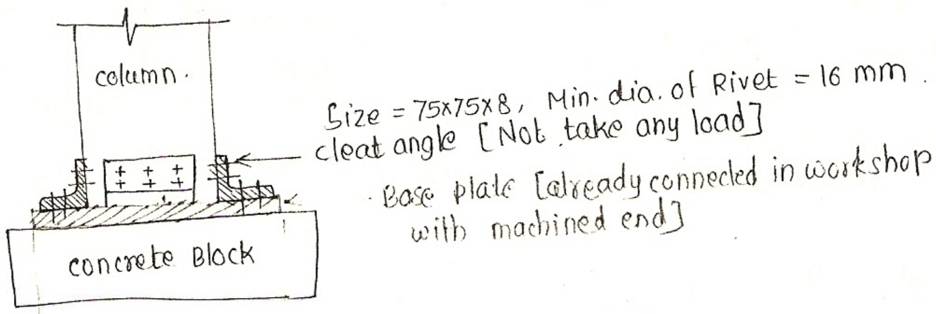
* Types of colm Base :-
  1. Slab base — Hinged / Pinned end.
  2. Gusseted base - Rigid / Fixed end.
  3. Grillage foundation.

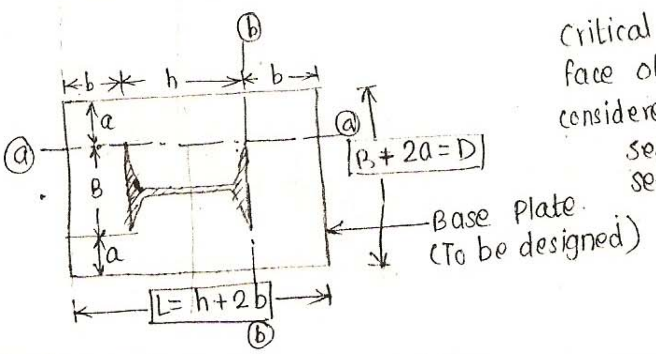
(1) Slab Base

* Provided for small loads, no moment.
* Full bearing (Machined end) - The ends of colm are pts polished so that whole area of colm rest on base plate & pressure distribution is uniform.
* Base plate
  - at workshop : shop welded.
  - at site : To handle additional stresses due to loading, unloading, transport, erection etc.
    * cleat angles are used.

* Design steps :-

1. Assume Per. bearing stress in concrete δac, as per IS 456 / Pg 122 / Table 15 depending upon grade of concrete.
2. Area of plate reqd = $\dfrac{\text{col}^m\text{ load} + 10\%\ \text{col}^m\text{ load due to SW}}{\text{Per. stress in concrete}} = \dfrac{1.1P}{\delta ac}$ (m^2)
3. Provide
   - square plate $\Rightarrow L = D = \sqrt{A_{reqd}}$ (a, b unequal) - fig.
   - Rectangular plate $\Rightarrow (a = b)$, $L \times B = A_{reqd}$
     $\Rightarrow (h + 2b) \times (B + 2a) = A_{reqd}$.
     Find a, = b = ...
     ∴ Hence decide size of base plate.



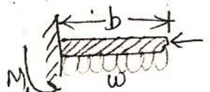


Critical sections will be at face of colm & they are considered as cantilevers.
sectn (a)-(a)
sectn (b)-(b)

④ Upward Pressure offered by concrete block = $w = \frac{P_{axial}}{A_{pro}}$ < 6ac (4 or 5 Depending on ...)

⑤ Thickness of plate :- Assume 1mm width of plate.

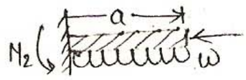
a] section ⓑ-ⓑ



$\therefore M_1 = \frac{w \times 1 \times b^2}{2}$.

For rectangular plate [a=b]

b] section ⓐ-ⓐ,



$\therefore M_2 = \frac{w \times 1 \times a^2}{2}$

c] ∴ Bending stress at sectⁿ ⓑ-ⓑ $= f_{b1} = \frac{M_1}{Z_1}$ $\qquad Z_1 = \frac{I}{y} = \frac{1 \times t^2}{6}$

$\therefore f_{b1} = \frac{wb^2}{2} \times \frac{6}{t^2} = \frac{3wb^2}{t^2}$

d] Bending stress at section ⓐ-ⓐ $= f_{b1} = \frac{M_2}{Z_2} = \frac{3wa^2}{t^2}$

Assume $N = \frac{1}{4}$, as per IS, f_{bz} at sectⁿ ⓐ-ⓐ will be bending stress of $f_{b2} = -\frac{3wa^2}{4t^2}$

$\therefore f_{net} = f_b = \sigma_{bs} = f_{b1} - f_{b2} = \frac{3wb^2}{t^2} - \frac{3wa^2}{4t^2}$

$\therefore \sigma_{bs} \geq \frac{3w}{t^2}\left(b^2 - \frac{a^2}{4}\right)$ $\qquad [b>a]$

$$\boxed{t_{min} = \sqrt{\frac{3w}{\sigma_{bc}}\left(b^2 - \frac{a^2}{4}\right)}}$$ → (1.5.4.3/Pg 40)

σ_{bc} → 0.75fy = 187.5 MPa.

w = upward pressure offered by slab.
σ_{bc} = per. bending stress in conc. = 0.75fy = 187 MPa
b & a - see fig.

Provide base plate of size [L×D×t] mm

* Design of foundation bolt :-

Provide 4 bolts of 20mm ∅ at corners, because due to unexpected moment or eccentricity base plate may be displaced. So 4 bolts of 20 mm dia. are provided at corner satisfying min. edge dist. criteria (2d)

(GATE) In case of square slab base plate (under a 'Solid Round colᵐ) IS 800-1984 gives -

$$\boxed{t_{min} = 10\sqrt{\frac{90W}{16\,\sigma_{bs}} \times \frac{B}{(B-d_o)}}}$$

Where, t = Min. thk. of base plate (mm)
W = Total axial load (kN)
σ_{bs} = per. bending stress in slab bases = 185 MPa.
B = length of side of cap or base (mm)
d_o = Dia. of reduced end (if any) of the colᵐ (mm)

min. Dia. or length of base plate = [1.5(d+75) mm]

Q. Design a slab base for a column section consisting of one SC 250 with two cover plates 300x25 mm carring an axial load of 2500 kN. The SBC of soil is 250 kN/m² & permissible bearing pressure on concrete = 4000 kN/m².

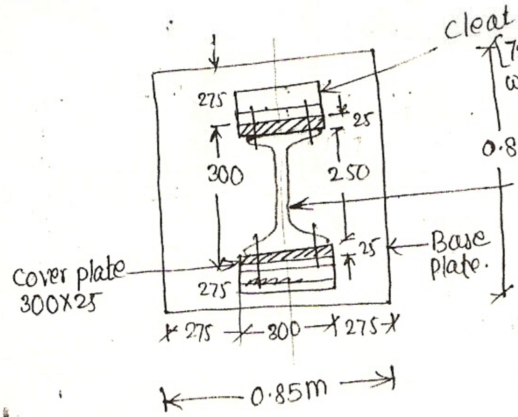
Soln:-

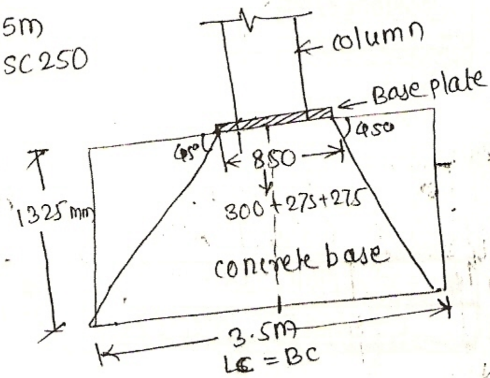
① Area of Base plate reqd = $\frac{1.1P}{4000} = \frac{1.1 \times 2500}{4000} = 0.69\ m^2$

② Providing square base plate, $L = B = \sqrt{0.69} = 0.83\ m$

Say 85 m.

③ Upward pre. offered by concrete = $w = \frac{P}{A_{pro}} = \frac{2500}{0.85^2} = 3460\ kN/m^2 = 3.46\ MPa$.





∴ a = 275, b = 275 mm.

④ ∴ Thickness of base plate:-

From IS-800 / Pg. 44. / Cl. 5.4.3,

$\sigma_{bs} = 185$ MPa

$$t = \sqrt{\frac{3w}{\sigma_{bs}}\left(a^2 - \frac{b^2}{4}\right)}$$

$$= \sqrt{\frac{3 \times 3.46}{185}\left(275^2 - \frac{275^2}{4}\right)}$$

$= 56.41\ mm \simeq 58\ mm$

Provide 85 X 85 X 5.8 cm base plate at finshed end of column

⑤ Cleat angles:-

Although no fastening are reqd. to transmit load from colm to slab base, nominal cleat angles 2 ISA 75x75x8 mm are provided with 4-16 mm dia. pds rivets as shown in fig. to keep the colm in place.

⑥ Foundation bolts: Provide 4 No - 20 mm pds rivets at 4 corner keeping min. edge dist. of 2x21.5 ≃ 45 mm.

⑦ Design of concrete base:-

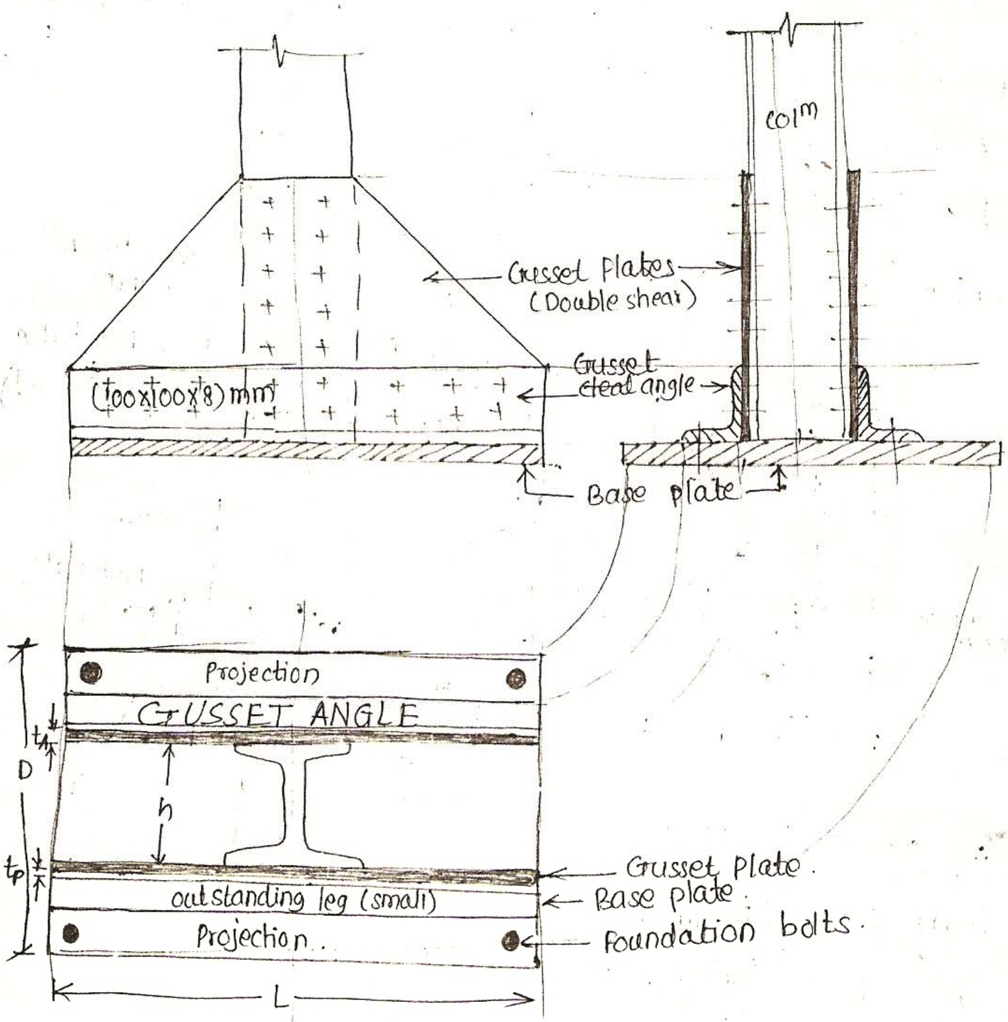
a] Area of Concrete base reqd = $\frac{1.1 \times P}{SBC\ of\ soil}$ = $\frac{1.1 \times 2500}{250} = 11\ m^2$ (10% due to sw.)

b] Assuming 45° angle of dispersion, $L_c = B_c = 3.31 \simeq 3.5\ m$.

Depth of slab = $\frac{1}{2}(3500 - 850)$

= 1325 mm

Gusseted Base



Necessity:- ① When load on col^m are too high.
② Loads are eccentric.
③ Full bearing at end (machined) is not possible.

Due to gusset plate & gusset angle shears load transfer up to some extent (50% of total load), therefore the thk. of base plate reqd. is less.

* components : ① Base Plate LXBXt → Design element
② Gusset Plate - LXHXL → Design [t = 16mm]
③ Gusset angle - std - 150 x 115 x 16. same
④ Web angle
⑤ Rivet / weld
⑥ Found^n bolts.

Design steps:-

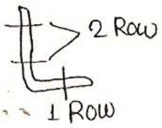
① Area of base plate reqd = $A_{reqd} = \frac{1.1P}{\sigma_{ac}}$

② Draw plan, elevation & side view.

③ Assume :-

ⓐ Thk. of GP ≮ 16 mm.

ⓑ GA = 150×115×16 mm [i.e. two rows of rivet in vertical & 1 row in horizontal leg is possible.



ⓒ Thk. of GP = Thk. of GA

ⓓ Length of GP = Length of GA = length of base plate ‖el to flange & colm.

⑤ D_{reqd} = depth of sectn (h) [steel table] + 2[(thk. of GP) + (small leg) + GA + overhang)] [see fig].

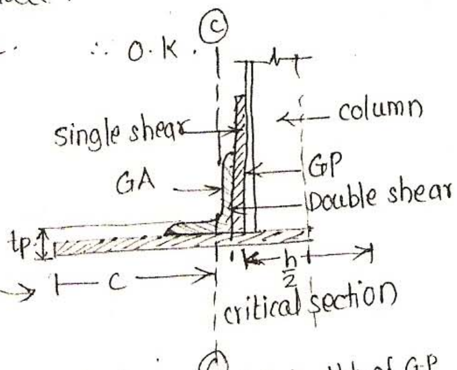
⑥ ∴ $L_{reqd} = \frac{A_{reqd}}{D_{reqd}}$

∴ Calculate L×B & Apro of base plate.

④ ∴ Upward pressure = $\omega = \frac{P}{A_{pro}} < \sigma_{bc}$. ∴ O.K.

⑤ Thk. of base plate :-

$$t_p = \sqrt{\frac{3 \cdot \omega \cdot c^2}{\sigma_{bs}}}$$ $\sigma_{bs} \rightarrow 187.5$ MPa



Note t_p = Thk. of plate + Thk. of angle

Find thk. of base plate = $t_p - t_a$.

Adopt = 20 mm

$c = \frac{B}{2} - \frac{h}{2}$ - thk. of GA - thk. of GP

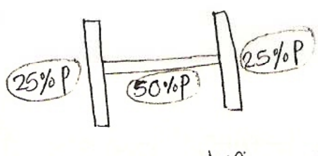
⑥ Connection :-

Possibilities :- Load transfer is through end bearing as well through connection betn GP & GA.

a) Assume 50 % Bearing & 50 % GP
or 100 % load is transfered through GP.

Generally assume 50 % load to be transfered through bearing & 50 % thr rivet & GP.

∴ Rivet takes force = $\frac{50\% \text{ of } P}{\text{No. of Rivets}}$.



Find Rivet value →
- Single shear = $\tau_{vf} \times \frac{\pi}{4} d^2$
- Double shear = $2 \tau_{vf} \times \frac{\pi}{4} d^2$
- Bearing = $\sigma_{pt} \times d \times (t)$ → min. of colm, GP, GA.

∴ on safer side assume single shear.

⇒ n = ∴ No. of Rivet on each side = $\frac{25\% P}{\text{Rivet value}}$ ≈ Even No.

∴ Symmetrical pattern. **Ht. of GP = n × pitch + 2 edge dist**

Prob: Design a gusset base for ISHB 400, carrying a load 2000kN. Grade of concrete = M20

Design:- ① Area of Base plate reqd = $\frac{1.1 \times P}{\sigma_{bc}} = \frac{1.1 \times 2000}{5}$ (for M20) $= 440 \times 10^3\ mm^2$

② Assume GA = 150×115×15 mm.

∴ Thk. of GP = Thk. of GA = 16 mm.

∴ $D_{reqd} = h + 2(t_p + \text{Shorter leg of GA} + \text{projection})$

$= 400 + 2(16 + 115 + 10)$

$= 682\ mm$

$\simeq 700\ mm$.

∴ $L_{reqd} = \frac{A_{reqd}}{D_{pro}} = \frac{440 \times 10^3}{700} = 628\ mm \simeq 650\ mm$.

∴ L×D of base plate = 650×700 mm.

∴ $A_{pro} = 455 \times 10^3\ mm^2$

③ **Thk. of Base plate:-**

$t_p' = \sqrt{\frac{3wc^2}{\sigma_{bs}}}$

$w = \frac{P}{A_{pro}} = \frac{2000 \times 10^3}{455 \times 10^3} = 4.4\ N/mm^2$

$c = \frac{D}{2} - \frac{b}{2}$ − thk. of ~~base~~ Gusset plate − thk. of GA

$= \frac{700}{2} - \frac{400}{2} - 15 - 16$

$= 119\ mm$.

$\sigma_{bs} = 185\ MPa$.

∴ $t_p' = \sqrt{\frac{3 \times 4.4 \times 119^2}{185}}$

$= 31.78 \simeq 32\ mm$.

∴ thk. of plate = 32 − thk. of GA

= 32 − 16

= 16 mm.

∴ Provide t = 20 mm.

∴ Use Base plate : 650×700×20 mm

Gusset angle : 150×115×16 mm.

④ **Connection:-**

Assume 50% load is transfered by bearing
50% load is transfered through GP & rivet.

∴ Total load on rivet = 50% of 2000

= 1000 kN.

∴ Strength of Rivet (20 mm) dia. pds rivets,

(a) In shearing (for safer side) assume single shear

$= \tau_{vf} \times \frac{\pi}{4} d^2$

$= \frac{100}{1000} \times \frac{\pi}{4} (21.5)^2$ → Gross dia.

$= 36.3\ kN$

④ In bearing = $\delta t f \times d \times L$ → Thk. of thicker thinner plate
[t_{GP} = 20 mm
t_{GA} = 16 mm
t_{col^m} = 12.7 mm – ISHB-400

$= \frac{300}{1000} \times 21.5 \times 12.7$
$= 81.92$ kN.

∴ Rivet value = 36.3 kN.

∴ No. of Rivets reqd = $\frac{1000}{36.3}$ = 27 ≃ 28 No's.

∴ No. of Rivets on each face = 14 No's.

Pitch = 2.5d = 2.5×21.5 = 53.75 ≃ 55 mm
Edge dist = 2d = 2×21.5 = 43 ≃ 45 mm.

∴ Ht. of GP reqd = 14×55+2×45
= 860 mm.

Which is so large
∴ Provide 4 Rivets in one row.
∴ No. of Rivet in one col^n = $\frac{28}{4}$ = 7.

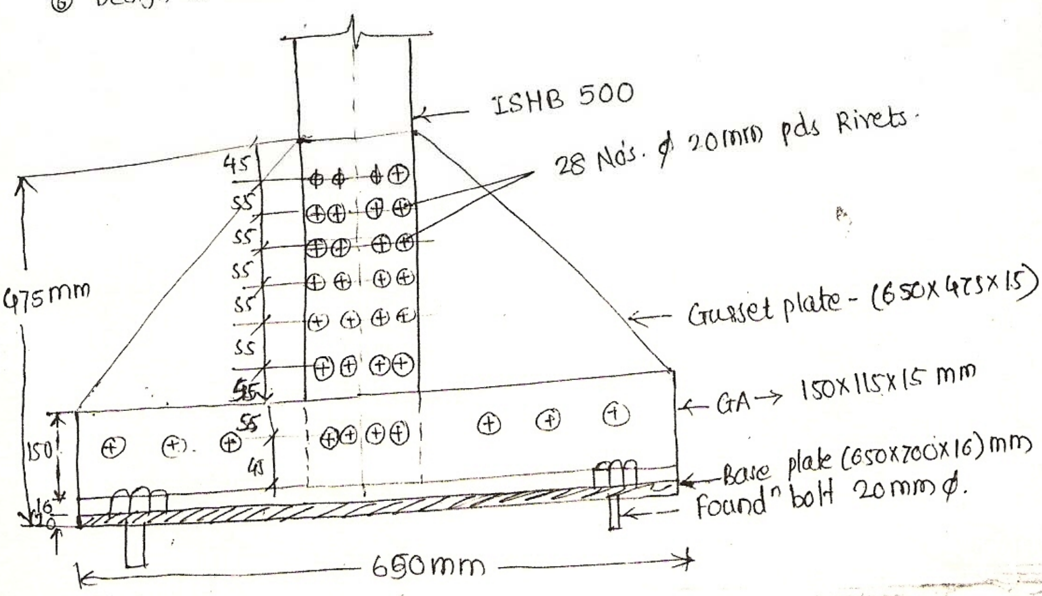
∴ H_{GP} = 7×55+2×45 = 475 mm.

⑤ Foundation bolts:-
Provide 4 No. ϕ 20 mm ϕ foundation bolt one at each corner.

⑥ Draw Fig.

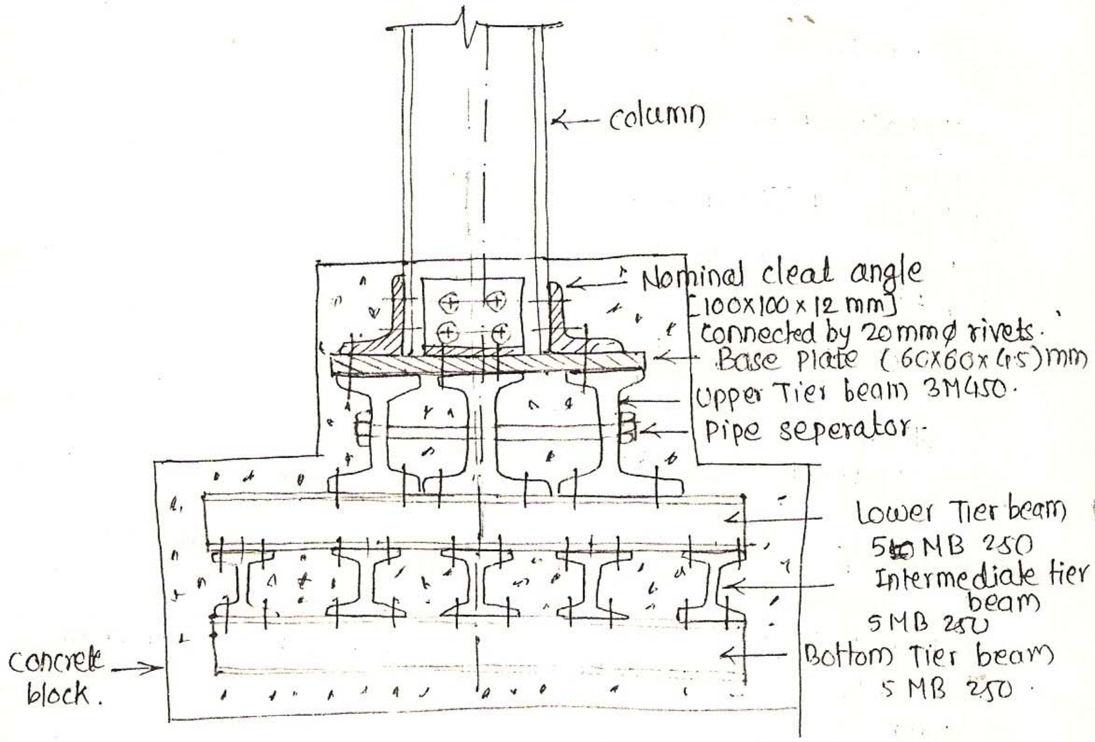
⑦ Summary :-

① Base plate : 650×700×20 mm
② Gusset plate : 650×475×16 mm
③ Gusset angle : 150×115× 15 mm.
④ No. of 20 mm ϕ pds rivets = 28 No's.
No. of rows = 7.
⑤ Found^n bolts · Provide 4 No, 20 mm ϕ foundation bolt.
⑥ Design of concrete block :- Assume 45° angle of dispersion.



* Grillage foundation :-

Grillage foundations are provided at shallow depths for column carring heavy loads on weak soil. It consist of two or more layers of steel beams completely encased in concrete.



Grillage foundation

As per IS: 800-1984 - See clauses.