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DESIGN OF STEEL GRILLAGE FOUNDATION FOR AN AUDITORIUM

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Abstract - Grillage foundation may provide an economical alternative to offshore 'mud mat' foundations for seabed infrastructure, owing to their improved hydrodynamic characteristics, which are important during installation. The foundation of the grid structure is a solid steel frame. The lower base is located on a soil layer at the desired level. Offshore loadings on these foundations consist of vertical (dead weight) and horizontal 'in-service' loads. However, to date there is no accepted method of design, as foundation capacity may differ significantly from that of conventional solid shallow foundations. This is design of the grillage foundation that is to be constructed at Mannivakam. In our project we are analysing the analytical method of design to calculate the variation of vertical bearing capacity with grill penetration in the sand. The members like beams, columns, grid slab, footing and slab are manually designed using IS 456-2000 code book.

Keywords- grillage foundation, vertical bearing capacity, grid structure, Offshore loadings.

1. INTRODUCTION

1.1 GENERAL

A foundation is the element of an architectural structure which connects it to the ground, and transfers loads from the structure to the ground. Foundations are generally considered either shallow or deep. Foundation engineering is the application of soil mechanics and rock mechanics in the design of foundation elements of structures.

Shallow foundations, often called footings, are usually embedded about a meter or so into soil. One common type is the spread footing which consists of strips or pads of concrete which extend below the frost line and transfer the weight from walls and columns to the soil or bedrock. Another common type of shallow foundation is the slab-on-grade foundation where the weight of the structure is transferred to the soil through a concrete slab placed at the surface. Slab-on-grade foundations can be reinforced mat slabs, which range from 25 cm to several meters thick, depending on the size of the building, or post-tensioned slabs, which are typically at least 20 cm for houses, and thicker for heavier structures.

A deep foundation is used to transfer the load of a structure down through the upper weak layer of topsoil to the stronger layer of subsoil below. There are different types of deep footings including impact driven piles, drilled shafts, caissons, helical piles, geo-piers and earth stabilized columns. The naming conventions for different types of footings vary between different engineers. Historically, piles were wood, later steel, reinforced concrete, and pre-tensioned concrete.

1.2 GRILLAGE FOUNDATION

Grillage foundation is the most economical foundation in case of transferring heavy loads from columns to soil of low bearing capacity. A type of foundation often used at the base of a column. It consists of one, two or more tiers of steel beams superimposed on a layer of concrete, adjacent tiers being placed at right angles to each other, while all tiers are encased in concrete.

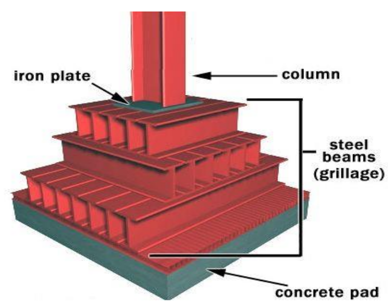

Fig. 1: Typical Layout of Grillage Foundation

2.Plan

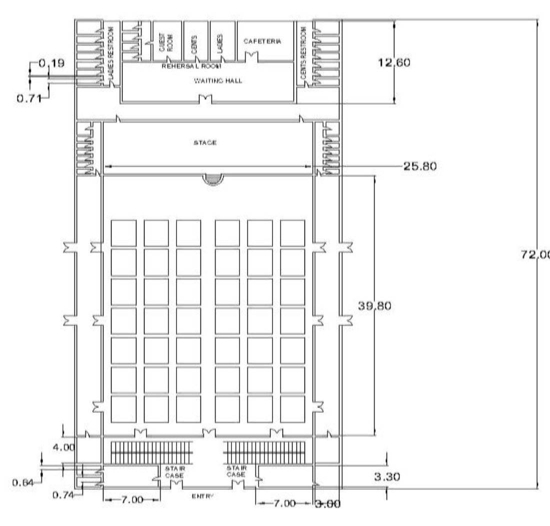

Fig 2: Plan for Auditorium

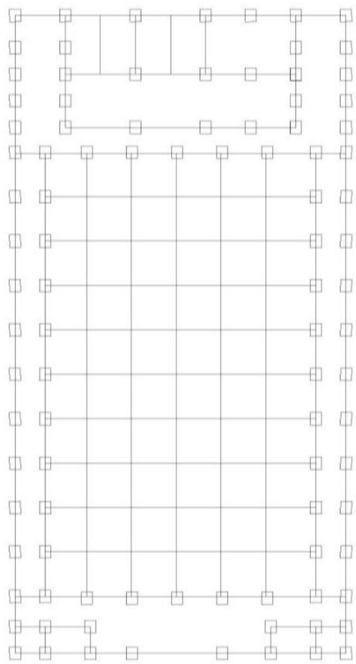

Fig. 3: Grid Slab Layout

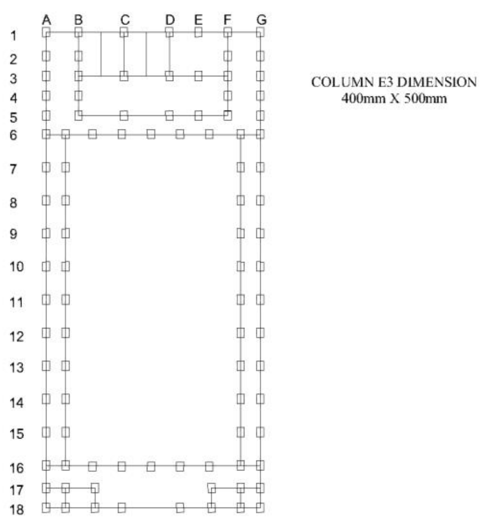

Fig. 4: Column Layout

3. DESIGN OF SLAB

Data:

L_x = 3 m Shorter span
L_y = 5 m Longer span
F_{ck} = 30 N/mm²
F_y = 415 N/mm²
Live load = 4kN/ m²
Floor finish = 1 kN/ m²
L_x / L_y = 1.67 < 2
So, the slab must be designed by two way slab.

Step 1: Thickness of slab

Effective depth d= 107.142
= 110 mm (approx.)
Overall depth D = 110 + 5 + 20 (cover)
= 135 mm

Step 2: Effective span

L = 3 + 0.110 = 3.11 m

Step 3: Load calculation

Consider 1m length of the slab.
Self weight of the slab
= 3.375 kN/m
Live load = 4 kN/m
Floor finish = 1 kN/m
Total load = 8.375 kN/m
Factored load = 12.5625 kN/m

Step 4: Design moment and SF

M_x = $\alpha_x W_u L^2$
L_X / L_Y = 1.67,
α_x = 0.046
α_y = 0.028
M = 5.58 kN.m
M_y = 3.402kN.m
V_u = 0.5 W_u
= 19.53 kN

Step 5: Check for effective depth

$$d = \sqrt{\frac{Mx}{0.138\ Fck\ b}} = \sqrt{\frac{5.58*10^6}{0.138*30*1000}}$$

= 36.712
= 40 mm (approx.)
$d_{required} < d_{provided}$
Hence, safe

Step 6: Main reinforcement for shear span

$$M_{ux} = 0.87\ F_y A_{st}\ d \left[1 - \frac{Fy\ Ast}{Fck\ bd}\right]$$

A_{st} = 143.073 mm²
Using 10 mm ϕ of bars,
No. of bars = 1.82 = 2 bars
A_{st} provided = 157.07 mm²
Spacing of bars = 500 mm
Not possible, adopt 300 mm
So, provide 2 no's of 10 mm ϕ bars @ 300 mm c/c
1. Width of middle strip
= ¾ L_y
= 3.8325 m
2. Width of edge strip
= 1/8 L_y
= 0.638 m

Step 7: Main reinforcement for longer span

M_{uy} = $0.87\, F_y A_{st}\, d \left[1 - \frac{F_y\, A_{st}}{F_{ck}\, bd}\right]$

A_{st} = 86.602 mm^2

No. of bars = 3 bars

A_{st} provided = 78.53 mm^2

Spacing of bars = 345.12 mm

Not possible, adopt 300 mm

So, provide 3 no of 10 mm ϕ bars @ 300 mm c/c

1. Width of middle strip = ¾ L_x
   = 2.332 m
2. Width of edge strip = 1/8 L_y
   = 0.388 m

Step 8: Distribution, reinforcement

A_{st} = 0.12 x b x D

= 162 mm^2

Using 8 mm ϕ of bars

No. of bars = 3.22 = 4 bars

Spacing of bars = 300 mm (approx.)

So, provide 4 no's of 10 mm ϕ bars @ 300 mm c/c

Step 9: Torsional reinforcement

Size of the torsional length = $L_x/5$

= 0.62 m

Area of torsional reinforcement = ¾ A_{st}

= 117.8 mm^2

Using 10 mm ϕ of bars,

No. of bars = 2.49 = 3 bars

A_{st} provided = 157.07 mm^2

Spacing of bars = 355 mm

Not possible, adopt 300 mm

So, provide 3 no's of 10 mm ϕ bars @ 300 mm c/c

Step 10: Check for shear

τ_v = 0.177 N/mm^2

P_t = 0.142

τ_c = 0.36 N/mm^2

$\tau_v < \tau_c$, The slab is safe in shear

Step 11: Check for deflection

$(L/d)_{provided} < (L/d)_{max}$

$(L/d)_{provided}$ = 28.27

$(L/d)_{max}$ = $(L/d)_{basic} \times K_t \times K_f \times K_c$

P_t = 0.142

K_t = 1.55

Hence safe

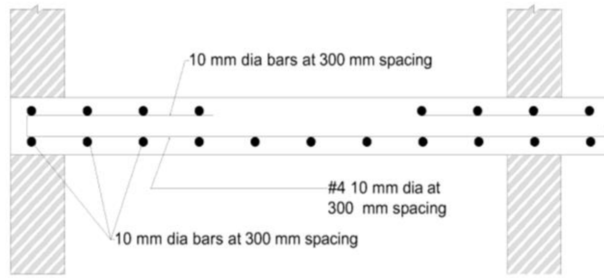

Fig 5: Reinforcement Details of Slab Section

3.2 GRID SLAB DESIGN

Grid size = 51m x 27m

Spacing of ribs = 3m c/c

Concrete = M30 grade

Steel = Fe415

DIMENSIONS OF SLABS AND BEAMS

Thickness of slab= 300mm

Depth of ribs based on span/depth

= 27 x 10^3 / 20

= 1250mm ≈ 1300mm

Assume width of rib = 500mm

Adopt overall depth of ribs = 1000mm

LOADS

Wt. of slab = 0.1 x 25

= 2.5 kN/m^2

Total load of slab= 2.5 x 27 x 51

= 3304.8 kN

Wt. of ribs = 12.5kN/m

Total wt. of beams

(x-direction) = 17 x 12.5 x 27

= 5737.5kN

Total wt. of beams

(y-direction) = 9 x 12.5 x 51

= 5737.5 kN

Total wt. of FF = 0.6 x 27 x 51

= 826.2kN

Total live load = 3 x 27 x 51

= 4131 kN

Total live load and dead load on grid floor

= 19737 kN

Load per m^2 = 19737 / (27 x 51)

= 14.33 kN/m^2

Ultimate load per m^2

= 14.33 x 1.5

= 21.49 kN/m^2

APPROXIMATE METHOD (MOMENTS)

If q_1 and q_2 are the loads shared in the x & y direction

$q_1 = q\,(b_y^4 / (a_x^4 + b_y^4))$
$= 21.48(51^4/(27^4+51^4))$
$= 19.92$ kN/m

$q_2 = q\,(a_y^4 / (a_x^4 + b_y^4))$
$= 21.48(27^4/(27^4+51^4))$
$= 1.564$ kN/m

Moments in x & y direction at center of grid or 2m width

$M_x = (q_1 \times b_1 \times a^2 / 8)$
$= (19.92 \times 3 \times 27^2 / 8)$
$= 5445.63$ kN.m

$M_y = (q_2 \times a_1 b^2 / 8)$
$= (1.564 \times 3 \times 51^2 / 8)$
$= 1525.48$ kN.m

SHEAR FORCE CALCULATIONS

Shear force in beams running in x direction

$Q_x = q_1 a b_1 / 2$
$= 18.82 \times 3 \times 27 / 2$
$= 806.76$ kN

Shear force in beams running in y direction

$Q_y = q_2 b a_1 / 2$
$= 1.564 \times 3 \times 51$
$= 119.64$ kN

RIGOROUS METHOD (Plate theory)

Section properties:

$D_f/D = 300/1300$
$= 0.23$

$b_w/b_f = 500/3000$
$= 0.167$

Second moment of inertia of beam in x direction and in y direction (I_2)

$I = C.bw.D^3$

Where,

$C =$ constant ($C=0.19$)
$= 0.19 \times 500 \times 1300^3$
$= 2.10 \times 10^{11}$ mm^4

If I_1 & I_2 are the second moment of area of tee-section about their centroidal axis in the x and y direction respectively.

So $I_1=I_2=I$

And $a_1=b_1=3$m
$= 3 \times 10^{12}$ mm^4

Flexural rigidity per unit length of plate along x direction

$D_x = EI_1/b_1$
$= E \times 2.08 \times 10^{11} / 3 \times 10^{12}$

D_x & D_y $= 0.06933E$

The torsional rigidity in the x and y directions are

$c_1 = c_2 = k_1 G (2a)^3\, 2b$

$G = E/2(1+\mu)$ ($\mu=0.15$)
$= 0.43478E$

k_1 = constant of torsional rigidity by Timoshenko

$k_1 = k_2 = 0.263$

$C_1 = C_2 = 1.42 \times 10^{10}$ Emm^4
$= 0.0142E$

$E = 5700 \times (30)^{1/2}$

$E = 31.22 \times 10^6$ kN/m^2

DEFLECTION AT CENTRE SPAN

$(D_x/a_x^4) = 0.06933E/27^4$
$= 0.06933 \times 31.22 \times 10^6 / 27^4$

$(D_x/a_x^4) = 2.073$

$(D_y/b_y^4) = 0.06933 \times 31.22 \times 10^6 / 51^4$
$= 0.3199$

$(2H/a_x^2 b_y^2)$

Where, $2H = c_1/b_1 + c_2/a_1$
$= 0.43478E/3 + 0.43478E/3$
$= 0.0948E$

$(2H/a_x^2 b_y^2) = 0.0948 \times 31.22 \times 10^6 / (27^2 \times 51^2)$
$= 0.156$

The deflection at centres of plate is given by the equation

$A = 0.0724$

The modified modulus of elasticity

$E_{ce} = E_c/(1+\Theta)$

Creep co-efficient

$\Theta = 0.4$
$= E_c/1.4$

Long term deflection
$= 1.4 \times 0.0724$
$= 0.10136$

According to IS 456:2000 the long term deflection should not exceed

Span/250 $= 27/250$
$= 0.108$m

So $0.108 > 0.10136$

The maximum deflection including long term effects lies within the permissible limits.

DESIGN OF MOMENTS

The bending moments, torsional moments and stress at various points are computed the equation.

$M_x = D_x\,(\sigma^2 a/\sigma_x^2)$

$Mx = 2121.61((\sin(x\pi/a) \times (\sin(y\pi/b))$

$M_y = D_y\,(\sigma^2 a/\sigma_y^2)$
$=594.63$kN.m$((\sin(x\pi/a) \times (\sin(y\pi/b))$

$M_{xy} = -(c_1/b_1)\,(\sigma^2 a/\sigma_x\sigma_y)$
$=-76.62((\cos(x\pi/a) \times (\cos(y\pi/b))$

$M_{xy} = -(c_2/a_1)\,(\sigma^2 a/\sigma_x\sigma_y)$
$=-76.62((\cos(x\pi/a) \times (\cos(y\pi/b))$

DESIGN OF SHEAR

Θ_x $=\sigma/\sigma_x(D_x(\sigma_u^2/\sigma_x^2)+(c_2/a_1)(\sigma^2a/\sigma_y^2)$
Θ_x $= -251.25((\cos(x\pi/a) \times (\cos(y\pi/b))$
Θ_y $= \sigma/\sigma_y(D_y(\sigma_u^2/\sigma_y^2)+(c_1/b_1)(\sigma^2a/\sigma_x^2)$
$=-45.55((\sin(x\pi/a) \times (\cos(y\pi/b))$

TABLE 1: Maximum Shear Force In Grid Slab

METHOD	Q_x	Q_y
Approximate method (ranking grash off theory)	806.76 kN	119.64 kN
Rigorous analysis (plate theory)	251.58 kN	45.55 kN

TABLE 2: Maximum Moments In Grid Slab

METHOD	M_x	M_y
Approximate method (ranking grash off theory)	5445.63 kN.m	1525.48 kN.m
Rigorous analysis (plate theory)	2121.61kN.m	594.63kN.m

DESIGN OF REINFORCEMENTS

Maximum ultimate working moment
M_u = 5445.63KN.m
Moment capacity of flange section
M_{uf} = $0.36f_{ck}b_fD_f(d-0.42D_f)$
D = D-d'
= 09×10^{10}N.mm
= 10925.98kN.m
Since $M_u<M_{uf}$
Neutral axis falls within the flange
M_u $= 0.87f_yA_{st}d(1-(A_{st}f_y/f_{ck}bd)$
A_{st} = 12659.58mm^2
Provide 26 bars of 25mm dia bars
A_{stpr} = 12762.62mm^2
Spacing = 35mm c/c
Maximum ultimate shear force
V_u = 806.76
τ_v = v_u/bd
= 0.125N/mm^2
Assuming 13 bars to be bent up near the supports
A_{st} at supports = 6381.31 mm^2
(100 A_{st}/bd) = 100x6381.31/3000x1250
= 0.17
From IS 456:2000 (pg. no: 73)
τ_c = 0.306N/mm^2
Since $\tau_c < \tau_v$
Hence safe
So minimum shear reinforcements shall be provided (IS 456:2000 (pg. no: 72)
S_v = $0.87 A_{sv}F_y/0.4b$
= 121.98mm
Provide 16mm dia bars of two legged stirrups at 130mm c/c at supports and the spacing gradually increased to 200mm towards the center of span.
Maximum ultimate moment in central rib in y-direction
M_u = 1525.48kN.m
M_u $= 0.87f_yA_{st}d(1-(A_{st}f_y/f_{ck}bd)$
A_{st} = 3423.56mm^2
Provide 18 bars of 16mm dia
A_{stpr} = 3619.08mm^2
Spacing = 55.56mm c/c = 50 mm

4.3 DESIGN OF BEAM

M-30 grade of concrete
Fe-415 grade of steel
Width of support= 230mm
Span = 6000mm

DIMENSION OF BEAM

Provide 230mm width
D = L/10
D = 6000/10
= 600mm
Effective cover = 25mm
D = 600-25
d = 575mm

EFFECTIVE SPAN

Clear span + width of the support
6+0.23m = 6.23m
Clear span + effective depth
4+0.575 = 4.575m

LOAD CALCULATION

Self-weight of beam
= 25x0.23x0.6
= 3.45KN/m
Load from slab = 12.525KN/m
Load from brick wall
= 0.23x3x20.5
= 14.145KN/m
Total UDL (W) = (3.45+14.145)x1.5
= 26.39KN/m
Design load = UDL + slab load
= 26.39+12.525
= 38.92KN/m

MOMENT AND SHEAR FORCE

M_u = $wl^2/8$
= $38.92 \times 6^2/8$
= 175.12kN/m
Vu = WL/2
= 38.92 x 6/2
= 116.67kN
$M_{u\,lim}$ = $0.138\, f_{ck}\, bd^2$
= $0.138 \times 30 \times 230 \times 575^2$
= 314.82kNm
$M_u < M_{u\,lim}$ section is under reinforced
A_{st} = 934.96mm²
Provide 16mm bar
No of bars = 5 bars

SHEAR REINFORCEMENT

$a_{st\,min}$ = 0.12% bd
= 0.12x (bd)/100
= (0.12x230x575)/100
= 158.7 mm² ≈ 160 mm²
Use 8mm Φ bars
Spacing = $((\pi/4 \times 8^2 \times 1000)/160)$
= 284.65mm = 280mm c/c

CHECK FOR SHEAR

V_u = 116.76kN
T_u = $116.76 \times 10^3/(230 \times 575)$
= 0.88N/mm²
p_t = $100A_{st}/bd$
= (100x934)/(230x575)
= 0.706N/mm²
Z_c = 0.545N/mm²
Balanced shear, $V_u - (T_u bd)$
= 116.76-(0.545x230x575)
= 44.68kN
$S_v > 0.75d$ = 0.75x575
= 431.25mm

CHECK FOR DEFLECTION

P_t = 0.706
$(L/d)_{max}$ = $(L/d)_{basic} \times k_t \times k_c \times k_f$
= 20 x 1.15 x 1 x 1
= 23
$(L/d)_{actual}$ = (6000/575)
= 10.43 < 23
HENCE SAFE

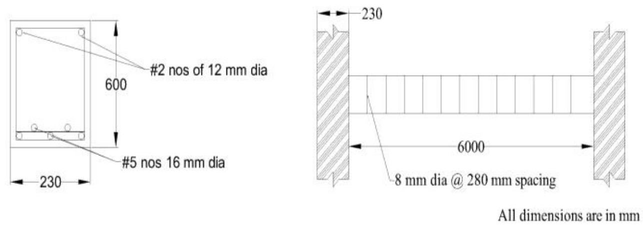

Fig 6: Reinforcement Details of Beam Section

4.4 DESIGN OF COLUMN:

Design of rectangular column:

Column size = 0. 4x0.5m
Self-weight of column
= 0.4x0.5x25
= 35kN
Factored load = 1270+35
= 1305
Axial load = 1305kN
P = $(0.4\, f_{ck} \times A_c) + (0.67 \times f_y \times A_{sc})$
= 89014.69mm²
Column size = 400x500
= 200000mm²
A_{sc} = $0.01\, A_g$
= 0.01x89014.69
= 890.14mm²
Assume 16mm φ bars
No of bars = $890.14(\pi/4) \times 16^2$
= 4.42
= 5 bars

Slenderness ratio

Le/d = 7000/500
= 14>12
Hence it is column.

Eccentricity

E_{max} = 1/500 + D/30
= 7000/5000 + 500/30
= 30.67
E_{min} = 7000/500 + 400/30
= 27.34

Reinforcement lateral bars

Diameter of lateral ≤ 1/4xφ of main bar
≤ 1/4x16
= 4
Assume diameter of the lateral bars = 6mm

Pitch of lateral bars = 16xd
= 16x6
= 96mm
Pitch of lateral bars = 100mm
Hence safe.

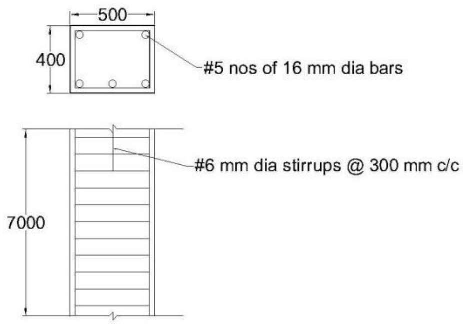

Fig. 6:Reinforcement Details Of Rectangular Column

4.5 DESIGN OF FOUNDATION

DATA

Axial load on column= 1305 kN
Permissible compressive stress on concrete
= 4 N/mm^2(M$_{15}$)

COLUMN BASE:

Area of base plate= 1305/4000
= 0.33mm^2
Use a square base
Therefore side of base plate
= √0.33 = 0.574 = 600mm
Adopt base plate of size 600mm x 600mm
The projection of the base plate from the edge is obtained as
a = greater projection
= 0.5(600-400) = 100mm
b = smaller projection
= 0.5(600-500) = 50mm
Intensity of the pressure on the plate,
= 2050x10^3/600x600
= 3.62 N/mm^2
Permissible bearing stress in the base plate,
= 185 N/mm^2
Thickness of base plate,
T = $\sqrt{3w/\sigma_{bs}}(a^2 - b^2/4)$
= $\sqrt{3x3.62/185}(100^2 - 50^2/4)$
= 23.46 = 30mm
Adopt base plate size
= 600mm x 600mm x 30mm

For connecting the column to the base plate,adopt ISA 100x100x10mm angle with 4#, 22mm φ rivets on flange and ISA 75x75x8mm with 3# 22mm φ rivets in the web.

DESIGN OF GUSSETED PLATE

1. Size of the Base Plate

Area of base plate
= 1305/4000 = 0.33m^2
Adopt ISA 150x150x12 mm angles on flange side with smaller leg horizontal, gusset plate 12mm thick 10mm batten and cover plates = 30mm projection on either sides in direction parallel to web.
Minimum length required
= (400+20+24+200+60)
= 104mm
Length of base plate parallel to the flanges
= 750mm
Adopt base plate= 750mm x 750mm

2. Thickness of Base Plate:

Intensity of pressure below the plate
= 1305x10^3/750x750
= 2.32 N/mm^2
Cantilever projection of plate from face of the gusset angle
= 141mm
μ = wl^2/2
= 2.32x141^2/2
= 23062 Nmm.
Thickness of plate required ,
μ = σ_{bs} bt^2/6
t = $\sqrt{6M/\sigma_{bs}}$ b
= $\sqrt{6 \times 23062/185}$ x 1
= 27.35mm
In WSD, σ = 0.75 f_y
Therefore base plate thickness
= 27.35 – 12
= 15.35 mm
Adopt 750 x 750 x 16mm base plate

Connections

Outstand on each side
= (750 – 400/2)
= 175mm
Load on each connection
= (175 x 750 x 2.32/100)
= 304.5 kN
Using 22mm φrivets,
Single shear = (π x 23.5 x 100/4 x 1000)
= 43.4 kN
Bearing = 23.5 x 12 x 300/1000
= 84.6 kN
Least value = 43.4 kN

Number of rivets= 304.5/43.4 = 7.2 = 8

Design of Grillage Foundation

SBC of the soil = 250 kN/m^2
Load = 1305 kN
Area of grillage:
Using gusseted base for the column,
Total load = (1305 + 10% for self weight)
= 1435.5 kN
Two-tier girder will be used,
Bottom tier area = 1435.5/250
= 5.74m^2
Use square grillage
a = √5.74
= 2.39m = 2.4m
Allow 125mm concrete cover on all sides,
Overall size of block= 2.65x2.65m

Design of Top Tier Girders

B.M = w/8 (l-l_1)
W = 1305 kN, L = 2.65m, l_1 = 0.75m
BM = 1305/8(2.65 – 0.75)
= 309.94 kN
Allowable stress can be increased by 33.33% since beams are encased in concrete.
σ_{bt} = (165x1.33)
= 220 N/mm^2
Z = μ/σ_{bt} = 309.94 x 10^6/220
= 1.409 x 10^6 mm^3
Using three beams in top tier,
Z for each beam = 1.409x10^6/3
= 469667 mm^3
Use ISHB 225,with sectional properties
Z_{xx} = 487000 mm^3, t_f = 9.1 mm
T_w = 8.6mm
Maximum shear force
= w/2l(l – l_1)
= 1305/2(2.65) (2.65 – 0.75)
= 467.8 kN
Shear force per beam
= 467.8/3
= 156 kN
Average shear stress τ_v
= 156x10^3/8.6x225
= 80.6 N/mm^2< 100 N/mm^2
Minimum gap between two beams
= 75mm

Design of Bottom Tier Girders

BM = w/8(l-l_2)
= 1305/8(2.65 – 0.75)
= 309.93 kNm.
Z = μ/σ_{bt}
= 309.93x10^6/165x1.33
= 1.41x10^6 mm^4
Use 8 beams in bottom tier
Z for each beam = 1.41x10^6/8
= 176.250 mm^3
Beam spacing = 1/7(2.65-0.75)
= 350mm
Use 8 beams of ISHB 150@ 350mm c/c
Maximum shear force v
= w/2l(l-l_1)
= 467.83 kN
Shear force per beam
= 467.83/8 = 58.5 kN
Shear stress τ_v
= 72.2 N /mm^2< 100 N/mm^2

Adopt separators of angles ISA 50x50x6mm and 2.75m long bolted with 12mm φ both to the flanges of the lower tier girders at two ends to prevent girder displacement.

4.6 DESIGN OF STAIRCASE

DOG LEGGED STAIRCASE

Rise = 100mm
Thread = 400mm
Number of steps = 15
Width of landing beam
= 300mm
Grade of concrete= M_{30}
Grade of steel = Fe_{415}

To Calculate Effective Span

Effective span
= nt + width of the landing beam
= 15x400+300
L = 6300mm
L = 6.3m
Thickness of waist slab
= span/20
= 6300/20
= 315mm
= 0.315m
Effective depth = 0.315-0.025
= 0.29m

Loads

Dead load slab on step (w_s)
= 1x0.315x25
= 7.875m^2
Dead load of step of horizontal span
= (w_sx$\sqrt{R^2 + T^2}$)/ T)
W = (7.875x$\sqrt{0.1^2 + 0.4^2}$/0.4)

= 8.11m

Dead load on step (D_o)

= 0.5xRxTx25

= 0.5x0.1x0.4x25

(D_o) = 0.5 kN/m

Load step per m length

= D_ox1000/T

= 0.5x1/0.4

= 1.25kN/m^2

Total service load

= D.L+L.L+F.L

Live load for residential building

= 2 to 3 kN/m^2

Live load for public building

= 5 kN/m^2

Weight of floor load

= 0.6 kN/m^2

Dead load = 8.11+ 1.25

= 9.36 kN/m^2

W = 9.36 + 5 + 0.6

= 14.96 kN/m^2

Factored load(w_u)= 1.5xw

= 1.5x14.96

= 22.44 kN/m^2

BENDING MOMENT

Bending moment at the center of span (m_u)

= $wul^2/8$

= $22.44x4.3^2$

= 51.86kNm

CHECK FOR DEPTH OF WAIST SLAB

D = $\sqrt{}$ (m_u/0.138 f_{ck}b)

= $\sqrt{}$ (51.86x10^6/0.138x30x1000)

D = 111.92

D = 112 < 315mm.

MAIN REINFORCEMENT

M_u = 0.87 $f_y a_{st} d(1-a_{st} f_y / f_{ck} bd)$

A_{st} = 513.62mm^2

Use 12mmφ bars

Spacing = $a_{st\,(provided)} / a_{st\,(required)}$

=((π/4 x 122)/ 513.62)x1000

= 220 mm c/c

Provide 12mm φ bars @ 220mm c/c as main reinforcement

Hence safe.

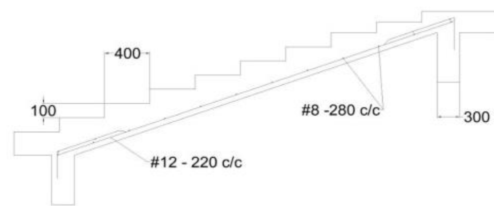

Fig. 7: Reinforcement Details of Staircase

5. CONCLUSION

Thus we designed the well facilitated auditorium with a suitable steel grillage foundation. These designs are carried out with the guidance of IS 456:2000. A proper fittings and grouting has to be provided to the grillage. The steel grillage is provided with respective corrosive resistant coatings to ensure the risk of disturbing contaminants.

The planning of auditorium was done as per guidelines. The designs of various structural elements were done by limit state method. The project portrays all the fundamental design and load consideration in the erection of the building. All design in accordance with those specified in Bureau of Indian Standard and IS 456:2000. Finally the auditorium was designed with a steel grillage foundation to meet the necessary requirements.

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