Design Of Raft Foundation

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Abstract- *The design of raft or mat foundation in present time i: e 2018 is discussed. The procedure of designing a raft foundation is explained along with its necessity and conditions where it is preferred. An example is demonstrated to get a better understanding of steps involved in designing a raft foundation.*

Keywords- foundation , raft foundation, mat foundation.

I. INTRODUCTION

A raft foundation, also called a mat foundation, is essentially a continuous slab resting on the soil that extends over the entire footprint of the building, thereby supporting the building and transferring its weight to the ground.

A raft foundation is often used when the soil is weak, as it distributes the weight of the building over the entire area of the building, and not over smaller zones (like individual footings) or at individual points (like pile foundations). This reduces the stress on the soil.

In paper [1] 'Structural Design of Raft Foundation Based on Geotechnical Analysis' et-al the authors have designed a raft foundation at Royal group of institute parking space, Guwahati. They have assumed load and column dimensions. Based on the Data gathered they designed a Raft Foundation using Is Code 2950-1-1981

In Paper [2] 'COMPARATIVE STUDY OF DESIGN OF RAFT FOUNDATION BY VARIOUS METHODS' by Jagaman Dutta and Jagat Jyoti Mandal. They have done a comparative study of design of raft foundation using three different methods namely STAAD Pro software. Rigid conventional method and flexible method (beams on elastic foundation and plates on elastic medium where the soil has been considered as the Winkler medium)

II. METHODOLOGY

Conventional method

A raft can be designed manually by referring Is code 2950-1-1981and Is code 456-2000.There are various methods of designing raft foundation but we have solved it using the rigid conventional method in which the raft is considered as a rigid slab. In this paper we have manually designed a raft foundation by referring to Indian standard codes of practise

Design and calculations:

The raft footing is to be designed for the following residential structure G+5 having column dimension 450 $mm \times 450mm$ and the raft have 1.5m offset from the centre of column.

Table no. 1:Design Parameters

Parameter	Annotation	Given data
Characteristic strength of steel	f_y	415 N/mm^2
Characteristic strength of concrete	f_{ck}	25 N/mm^2
Safe bearing capacity of soil	SBC	152.5 N/mm^2
Soil pressure	F	-
Nominal shear stress	τ_v	-
Shear strength of concrete	τ_c	-

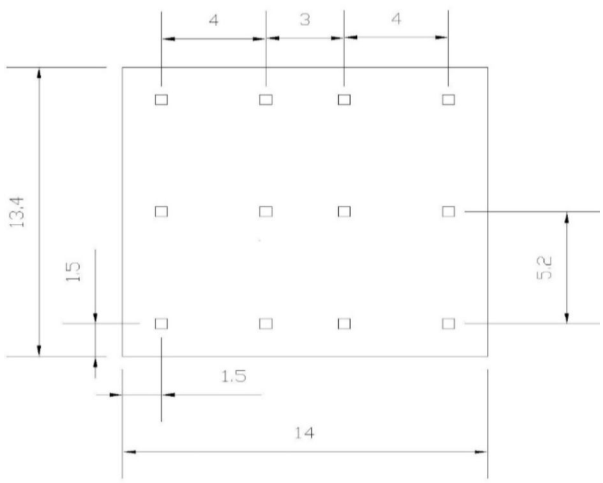


Figure 1: plan of Foundation

Table 2: Column Loads

Column no	Total load (KN)
1	1763
3	2101
5	2101
7	1763
9	2319
11	2729
13	2729
15	2319
17	1763
19	2101
21	2101
23	1763

Necessity of raft foundation

The max column load=2729 KN

Area of footing required = $\frac{load}{SBC} = \frac{2729}{152.5}$=17.89 m^2

As the area required would be more there would be overlapping of columns .Therefore a raft foundation is suitable in this case

Step1: Locating C.G. of column loads

Total load =1763+2101+2101+1763+2319+2729+2729+2319+1763+2101+2101+1763

=25552 KN

w.r.t column 1-9-17

$\bar{x} = \frac{(2101+2729+2101)\times 4+(2101+2729+2101)\times 7+(1763+2319+1763)\times 11}{25552}$

$\bar{x} = 5.5m$

$\bar{y} = \frac{(2319+2729+2729+2319)\times 5.2+(1763+2101+2101+1763)\times 10.4}{25552}$

$\bar{y} = 5.2m$

Therefore the location of C.G. from extreme edge is

X=$\bar{x} + 0.5 = 5.5 + 1.5 = 7m$

Y=$\bar{y} + 0.5 = 5.2 + 1.5 = 6.7m$

Which is at the center of the raft ,therefore there is no eccentricity

e_x=0 and e_y=0

Step 2:soil pressure:

Area of raft foundation=14$\times$13.4=187.6m^2

$I_{xx} = \frac{bd^3}{12} = \frac{14\times 13.4^3}{12} = 2807.12m^4$

$I_{yy} = \frac{db^3}{12} = \frac{13.4\times 14^3}{12}$ =3064.13 m^4

e_x=0 and e_y=0

$M_x = P_u.e_y$=25552$\times$0 = 0

$M_y = P_u.e_x$=25552$\times$0 = 0

Soil pressure=$F = \frac{P}{A} \pm \frac{M_x}{I_{xx}} \times \bar{y} \pm \frac{M_y}{I_y} \times \bar{x}$

$\bar{x}$ and $\bar{y}$ are the distance towards the extreme points from C.G. of Raft foundation

Soil pressure at column 1:

$F_1 = \frac{25552}{187.6} + \frac{0}{2807.12} \times 5.5 + \frac{0}{3064.13} \times 5.2$=136.20 KN/$m^2$ < 152.5 KN/m^2

Hence Safe

Likewise ,calculate soil pressure for all the columns

As our C.G. of load and C.G. of Raft coincides the soil pressure at all points is same

Step 3: Bending moment calculation

Bending moment in X-X direction

Consider a beam at column 17-19-21-23 as A

$B.M._A = \frac{wl^2}{8} = \frac{136.02\times 4^2}{8}$ =181.36 KN.m

$(w = \frac{F_{17}+F_{23}}{2})$

As the value of w remains constant the value of $B.M._B$ and $B.M._C$ would be same as above.

Bending moment in Y-Y direction

Consider a beam at column 1-9-17 as P , column 3-11-19 as Q , column 5-13-21 as R and column 7-15-23 as S

Same as above the bending moment will remain constant

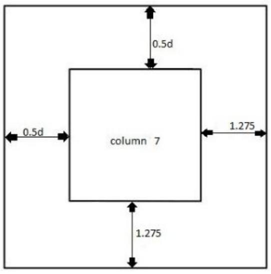
$B.M._P = B.M._Q = B.M._R = B.M._S = \frac{wl^2}{8} = \frac{136.02\times 5.2^2}{8} = 459.74\ KN.m$

Step 4: Depth of foundation

Depth for Punching shear

Check for edge column and column with maximum load

Consider column 7



Load on column=1763 KN

Column dimension=0.45×0.45

L=0.45+0.5d+1.275=1.725+0.5d

B=0.45+0.5d+1.275=1.725+0.5d

Nominal shear stress=$\tau_v=\frac{V_u}{b_o+d}$

b_o=perimeter of section=(L+B)×2=6.9+2d

Shear strength of concrete=$\tau_c=k_s\times\bar{\tau_c}$

$\bar{\tau_c}$=0.25×$\sqrt{f_{ck}}$ = 0.25 × $\sqrt{25}$= 1.25 N/mm^2 = 1250 KN/m^2

$k_s=\frac{\text{short side of column}}{\text{longer side of column}}$+1 <1

=1.94≈ 1

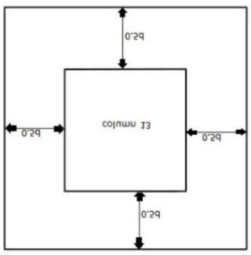
$\tau_c=k_s\times\bar{\tau_c}$ = 1× $1250 = 1250\ KN/m^2$

Equating τ_c to τ_v

$1250=\frac{1763\times1.5}{(6.9+2d)\times d}$

d_1=0.283 m

Consider column 13



Column load= 2729 KN

Column dimension =0.45m × 0.45m

L=0.45+0.5d+0.5d=0.45+d

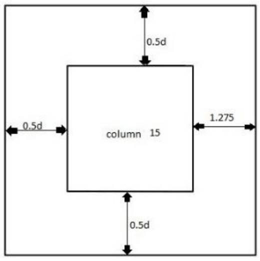
B=0.45+0.5d+0.5d=0.45+d

Equating τ_c to τ_v

1250$=\frac{2729\times1.5}{(1.8+4d)\times d}$

$d_2=0.707m$

Considering column 15



Column load=2319 KN

Column dimension=0.45×0.45mm^2

L=0.45+0.5d+1.275=1.725+0.5d

B=0.45+0.5d+0.5d=0.45+d

Equating τ_c to τ_v

1250=$\frac{2319\times1.5}{(4.35+3d)\times d}$

d_3=0.48m

Depth for Bending moment

Equating max B.M. with $M_{u_{lim}}$

For Fe415 $M_{u_{lim}}$ = 0.138 $f_{ck}bd^2$

459.74×10^6=0.138× 25× $1000\times d^2$

d_4=365.04mm=0.365m

Therefore taking the maximum value of d

d=0.707m

assuming 18 mmØ bar and 75 mm clear cover

D=707+$\frac{18}{2}$+75=791mm≈800mm=0.8m

d=800-$\frac{18}{2}$-75=716mm

Step 5 : Reinforcement calculation:

Reinforcement along longitudinal top

Max B.M. in x-direction=272.04× 1.5=408.06KN.m

$A_{st_{min}}=\frac{0.12BD}{100}=\frac{0.12\times1000\times716}{100}=$ 859.2mm^2

$A_{st}=\frac{0.5f_{ck}bd}{f_y}\left[1-\sqrt{1-\frac{4.6\times M_u}{f_{ck}bd^2}}\right]$

$$A_{st_x}=\frac{0.5\times25\times1000\times716}{415}\left[1-\sqrt{1-\frac{4.6\times408.06\times10^6}{25\times1000\times716^2}}\right]$$

A_{st_x} = 1641.77mm^2 > $A_{st_{min}}$ ∴ SAFE

Spacing = $\frac{1000\times\text{area of 1 bar}}{\text{total } A_{st}}$ = $\frac{1000\times254.47}{1641.77}$ =154.99 ≈ 150mm

$A_{st_{provided}}$=$\frac{1000\times\text{area of 1 bar}}{\text{spacing}}$ = $\frac{1000\times254.47}{150}$ = 1696.47 mm^2 >

$A_{st_{required}}$ ∴ SAFE

Provide 18mm Ø@ 150 $mm\ ^c/_c$ as reinforcement along longitudinal top

Reinforcement along longitudinal bottom

$A_{st}=\frac{0.12BD}{100}=\frac{0.12\times1000\times716}{100}=859.2mm^2$

Providing 12 mmØ

Spacing = $\frac{1000\times area\ of\ 1\ bar}{total\ A_{st}}=\frac{1000\times113.1}{859.2}$ =131.63 ≈ 130mm

Provide 12mm Ø@ 130 $mm\ ^c/_c$ as reinforcement along longitudinal bottom

Reinforcement along transverse top

Max B.M. in y-direction=459.75×1.5=689.625 KN.m

d=800-75-18-$\frac{24}{2}$=695

$A_{st}=\frac{0.5f_{ck}bd}{f_y}\left[1-\sqrt{1-\frac{4.6\times M_u}{f_{ck}bd^2}}\right]$

$A_{st_y}=\frac{0.5\times25\times1000\times695}{415}\left[1-\sqrt{1-\frac{4.6\times689.625\times10^6}{25\times1000\times695^2}}\right]$

$A_{st_y}=$2958.75$mm^2 > A_{st_{min}}$ ∴ SAFE

Spacing = $\frac{1000\times area\ of\ 1\ bar}{total\ A_{st}}=\frac{1000\times452.39}{2958.75}$ =152.89 ≈ 150mm

$A_{st_{provided}}=\frac{1000\times area\ of\ 1\ bar}{spacing}=\frac{1000\times452.39}{150}$ = 3015.93 $mm^2 >$ $A_{st_{required}}$ ∴ SAFE

Provide 24mm Ø@ 150 $mm\ ^c/_c$ as reinforcement at transverse top

Reinforcement along transverse bottom

$A_{st}=\frac{0.12BD}{100}=\frac{0.12\times1000\times716}{100}=859.2mm^2$

Providing 12 mmØ

Spacing = $\frac{1000\times area\ of\ 1\ bar}{total\ A_{st}}=\frac{1000\times113.1}{859.2}$ =131.63 ≈ 130mm

Provide 12mm Ø@ 130 $mm\ ^c/_c$ Øas reinforcement along transverse bottom

Design Summary:

- Raft dimension= 14 ×11.4 m^2
- Depth of raft= 0.8m overall
- Reinforcement details:
- Provide 18mm Ø@ 150 $mm\ ^c/_c$ as reinforcement along longitudinal top
- Provide 12mm Ø@ 130 $mm\ ^c/_c$ as reinforcement along longitudinal bottom
- Provide 24mm Ø@ 150 $mm\ ^c/_c$ as reinforcement at transverse top
- Provide 12mm Ø@ 130 $mm\ ^c/_c$ Øas reinforcement along transverse bottom

III. CONCLUSION

The design of raft foundation is done manually successfully. the details are given about the depth of raft and reinforcement to be adopted. A raft foundation is a common type of foundation adopted in soil having low bearing capacity and therefore its thorough knowledge is desirable in a civil engineer

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