DESIGN AND DRAWING (RCC AND STEEL) FOOTINGS

INTRODUCTION:

Footings are structural elements that transmit column or wall loads to the underlying soil below the structure. Footings are designed to transmit these loads to the soil without exceeding its safe bearing capacity, to prevent excessive settlement of the structure to a tolerable limit, to minimize differential settlement, and to prevent sliding and overturning. The settlement depends upon the intensity of the load, type of soil, and foundation level. Where possibility of differential settlement occurs, the different footings should be designed in such away to settle independently of each other.

Foundation design involves a soil study to establish the most appropriate type of foundation and a structural design to determine footing dimensions and required amount of reinforcement. Because compressive strength of the soil is generally much weaker than that of the concrete, the contact area between the soil and the footing is much larger than that of the columns and walls.

The important purpose of foundation are as follows;

1. To transfer forces from superstructure to firm soil below.
2. To distribute stresses evenly on foundation soil such that foundation soil neither fails nor experiences excessive settlement.
3. To develop an anchor for stability against overturning.
4. To provide an even surface for smooth construction of superstructure.

TYPES OF FOUNDATIONS

Based on the position with respect to ground level, Footings are classified into two types;

1. Shallow Foundations
2. Deep Foundations

Shallow Foundations are provided when adequate SBC is available at relatively short depth below ground level. Here, the ratio of D_f / B < 1, where D_f is the depth of footing and B is the width of footing. Deep Foundations are provided when adequate SBC is available at large depth below ground level. Here the ratio of D_f / B >= 1.

Shallow Foundations

The different types of shallow foundations are as follows:

- Isolated Footing
- Combined footing
- Strap Footing
- Strip Footing

- Mat/Raft Foundation
- Wall footing

Deep Foundations

Deep foundations are provided wh en adequate SBC is available at large depth below GL. There are different types of deep foundations. Some of the common types of deep foundations are listed below.

- Pile Foundation
- Pier Foundation
- Well Foundation

BEARING CAPACITY OF SOIL

The safe bearing capacity of soil is the safe extra load soil can withstand without experiencing shear failure. The Safe Bearing Capacity (SBC) is considered unique at a particular site. But it also depends on the following factors:

1. Size of footing
2. Shape of footing
3. Inclination of footing
4. Inclination of ground
5. Type of load
6. Depth of footing etc.

The steps followed in the design of footings are generally iterative. The important steps in the design of footings are;

1. Find the area of footing (due to service loads)
2. Assume a suitable thickness of footing
3. Identify critical sections for flexure and shear
4. Find the bending moment and shear forces at these critical sections (due to factored loads)
5. Check the adequacy of the assumed thickness
6. Find the reinforcement details
7. Check for development length
8. Check for bearing stresses

COVER: The minimum thickness of cover to main reinforcement shall not be less than 50 mm for surfaces in contact with earth face and not less than 40 mm for external exposed face. However, where the concrete is in direct contact with the soil the cover should be 75 mm. In case of raft foundation the cover for reinforcement shall not be less than 75 mm.

Minimum reinforcement and bar diameter: The minimum reinforcement according to slab and beam elements as appropriate should be followed, unless otherwise specified. The diameter of main reinforcing bars shall not be less 10 mm. The grade of steel used is either Fe 415 or Fe 500.

Design an isolated footing of uniform thickness of a RC column bearing a vertical load of 600 KN and having a base of size 500x500 mm. Tthe safe bearing capacity of soil may be taken as 120 KN/m^2. Use M20 concrete and Fe 415 steel.
Solution

<u>Size of footing</u>

W=600 KN;

Self weight of footing @ 10% =60 KN

Total load =660 KN

Size of footing = 660/120 = 5.5 m^2

Since square footing , B= $\sqrt{5.5}$ =2.345 m^2

Provide a square footing = 2.4mx 2.4m

Net upward pressure , p_0= 600/(2.4x2.4) = 104.17 KN/m^2

<u>Design of section</u>

The maximum BM acts at the face of column

M=p_0 B/8 $(B-b)^2$ =112.8kNm

Mu = 1.5M =169.2 KN-m

Therefore d = 160 mm; D = 160+60 = 220mm

Depth on the basis of one-way shear

For a one way shear, critical section is located at a distance 'd' from the face of the column where shear force V is given by

V = p_0 B {0.5(B-b)-d}= □ □104.17 x2.4{0.5 (2.4 -0.5) 0.001d}

Vu = 1.5V

Tc = Vu/bd = 375012(0.95-0.001d)/2400d

From table B.5.2.1.1 of IS 456:2000 k=1.16 for D = 220mm.

Also for under-reinforced section with pt = 0.3% for M20 concrete, τc==0.384 N/mm^2

Hence design shear stress = $k\tau c$ =0.445 N/mm^2

From which we get d= 246.7 =250 mm

Depth for two way shear

Take d greater one of the two i.e. 250mm. for two-way shear, the section lies at d/2 from the column face all round. The width b_o of the section = b+d = 750mm

Shear force around the section $F = p_o[B^2 - b_o^2] = 541.42KN$

Fu=1.5F

$Tv = Fu/4b_od = 812.13x\ 10^6/(4x\ 750x\ 250) = 1.083N/mm^2$

Permissible shear stress = ks τc

where ks =(0.5+βc) = (0.5+1) with a maximum value 1. ks=1

$\tau c = 0.25\sqrt{fck} = 1.118\ N/mm^2$

Permissible shear stress= 1.118 N/mm^2

Hence safe.

Hence d=250 mm, using 60 mm as effective cover and keeping D=330 mm, effective depth = 330-60= 270 mm in one direction and other direction d=270- 12 =258 mm.

Calculation of reinforcement

Ast= 1944 mm^2

Using 12 mm bars, spacing required = 138.27 mm

So provide 12 mm @ 125mm c/c in each direction.

Development length

L_d=564 mm

Provide 60 mm side cover, length of bars available =0.5[B-b]-60=890 mm >Ld

So safe.

Transfer of load at column base

A_2= 500x500 = 250000 mm^2

A_1=[500+2(2x330)]= 3312400 mm^2

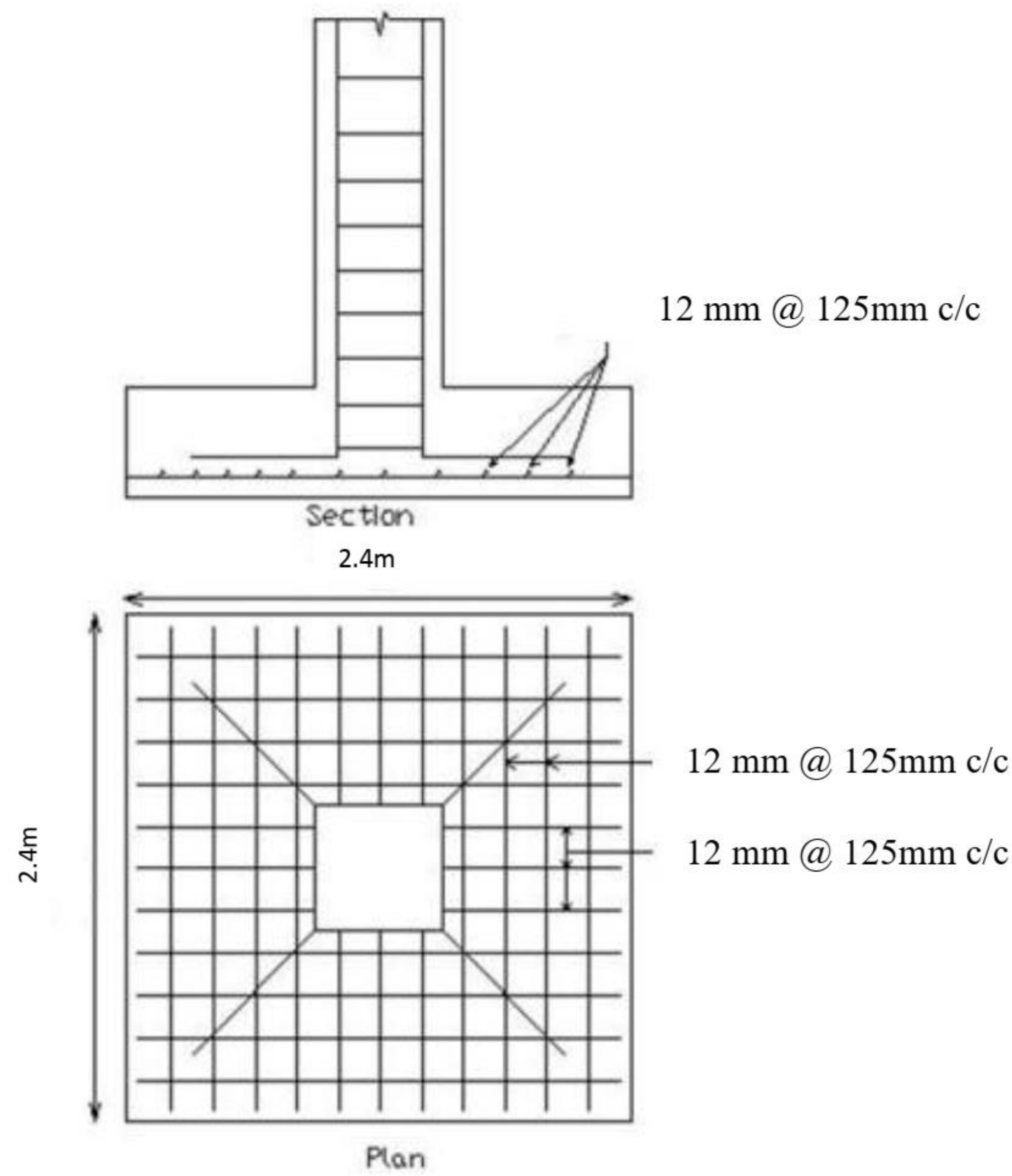
$\sqrt{(A_1/A_2)} = 3.64$

Taking $\sqrt{(A_1/A_2)} = 2$

Hence permissible bearing stress = 18 KN/m^2

Actual bearing stress = 3.6 N/mm^2

Hence safe.



Reinforced Cement Concrete (R.C.C)

Reinforced cement concrete a composite material has been accepted worldwide as a construction material for different civil engineering structures. these structures include dam, bridges, retaining walls, docks and harbour, airfield pavements, flyovers, multi-storey building, complexes and simple houses etc.,

Composite Structure

A structural member made by two or more different components constructing together is called as Composite structure. example: reinforced concrete structure.

Concept of Elastic Method /Working Stress Method
In this method, behavior of the structure is assumed to act as linearly elastic body under the action of service loads.

Assumption of working Stress Method
1. At any cross section, plane sections before bending remains plane after bending.
2. All tensile stresses are taken up by reinforcement and none by concrete, except otherwise specially permitted.
3. stress-strain relationship of steel and concrete under working load is a straight line.
4. The modular ratio m has the value 280/3 stress is permissible compressive stress due to bending in concrete.

Factor of Safety
It is the Ratio Between ultimate load and working load
Factor of safety = ultimate load/working load

Note:
a) Factor of safety for concrete in bending(compression) = 3
b) Factor of safety for concrete in bending(tension) = 1.8

Partial Safety Factor
It is the ratio between design load and characteristic load.
Partial safety factor = design load/characteristic load

Grade of Concrete and Apporximate Proportions Of Ingredients:

GRADE OF CONCRETE	APPORXIMATE PROPORTIONS OF INGREDIENTS
M5	1:5:10
M7.5	1:4:8
M10	1:3:6
M15	1:2:4
M20	1:1.5:3

Factor Considered in Limit State of Collapse
1. Flexure

2. Compression
3. Shear
4. Torsion

Factor Considered in Limit State of Serviceability

1. Deflection
2. Cracking
3. Durability
4. Vibration
5. Fatigue
6. Fire Resistance

Factor Governing Concrete Mix Design:

A) Grade of Concrete
B) Type of Cement
C) Cement Content
D) Size, Shape, Grading of Aggregate

WORKING STRESS METHOD

a) the stresses in an element is obtained from the working loads and compared with permissible stresses.
b) the method follows linear stress-strain behaviour of both the materials.
c) modular ratio can be used to determine allowable stresses,
d) ultimate load carrying capacity cannot be predicted accurately.
e) the main drawback of this method is uneconomical.

Lecture 10

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