ANALYSIS OF SOIL FOR FOUNDATION DESIGNING

Project report submitted in partial fulfillment of the requirement for the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

under the Supervision of

Prof. S.K. Jain

By

Sudhanshu Gupta (111650)

Nyay Priya Singh (111296)

to

Jaypee University of Information and Technology,

Waknaghat, Solan, (H.P.)

CERTIFICATE

This is to certify that project report entitled **"Analysis of soil for foundation designing",** submitted by Nyay Priya Singh (111296) and Sudhanshu Gupta (111650) in partial fulfillment for the award of degree of Bachelor of Technology in Civil Engineering at Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

(Dr. S.K. JAIN)
Professor,
Department of Civil Engineering,
Jaypee University,
Anoopshahr.

EXTERNAL EXAMINER

Certified the above mentioned project work has been carried out by the said group of students. .

(Dr. ASHOK K. GUPTA)
Professor and Head,
Department of Civil Engineering,
Jaypee University of information Technology,
Waknaghat, Solan.

ACKNOWLEDGEMENT

This report would not have been possible without the essential and gracious support of **Dr. S.K. Jain**. His willingness to motivate us contributed tremendously to our report. We also would like to thank him for giving us his valuable time, showing us the path to achieve our objectives and goals and for being there whenever we needed his expert guidance.

Besides, we would like to thank our Head of Department **Dr. Ashok Kumar Gupta** for providing us good environment and facilities to complete this project. Also we would like to take this opportunity to thank Jaypee University of Information Technology for offering this project.

The successful compilation of final year project depends on the knowledge and attitude inculcated in the total length of course. So we want to express our sincere gratitude to all the faculties who taught us during the four years of B.Tech.

Date: -

Nyay Priya Singh (111296)

Sudhanshu Gupta (111650)

List of Contents

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This project presents an overview of the analysis of the soil and its characteristics such as bearing capacity of soil and calculation of bearing capacity of soil different field test such as SPT, DCPT and PLT. These are very useful to determine the bearing capacity of soil in cohesionless soil as well as cohesive soil. While excavating soil for performing of PLT it give brief idea about the soil such as type and nature of soil texture of soil, consistency of soil, Make a program using VBA coding to calculate the bearing capacity of the soil at the different water level and results are verified from solved examples. Various inputs that have been taken from user are: - length, breadth, depth of footing, etc. All the parameters like depth of water table eccentricity etc. are considered. By this program one can easily calculate the bearing capacity of soil at different level of water table.

Result of this will be net ultimate, net safe, allowable bearing capacity. Analysis and design of a storage unit and its foundation on the basis of IS 456:2000, the main objectives of design of storage unit that it will be cost effective and construction procedure is easy.

The safe bearing capacity for the design of foundation is minimum net allowable bearing pressure from field results. The soil is completely analyzed with the help of all the test performed and correspondingly bearing capacities have been calculated. With the help of this, a storage unit has been designed along with its foundation and in future a multistory building will be designed.

On the basis of different tests on soil, we have performed design and analysis of footing of shopping complex in Pratap Bihar Ghaziabad (U.P.). The Shopping complex have 8 shops. Each shop has floor area of 4m *8.5m and is to be 3m height. We assume a live load of 4KPa and dead load due to finish partition etc of 1.5 KPa. Fe 415 grade HYSD reinforcement and M25 concrete is to be used in construction.

To achieve this purpose, first we have calculated every column loads in KN, then we have calculated safe bearing capacity from strength considerations, and then we design the foundation accordingly, then we have calculated settlement and ensured that settlement and the resulting settlements are within permissible limits. We use structural analysis software STAAD Pro V8i for computing loads on foundation in KN. Then we have designed the footing according to IS 456: 2002.

CHAPTER 1: INTRODUCTION

1.1 General:

Basic Definitions

Bearing capacity: It is the load carrying capacity of the soil.

Ultimate bearing capacity or Gross bearing capacity (q_u): It is the least gross pressure which will cause shear failure of the supporting soil immediately below the footing.

Net ultimate bearing capacity (q_{nu}): It is the net pressure that can be applied to the footing by external loads that will just initiate failure in the underlying soil. It is equal to ultimate bearing capacity minus the stress due to the weight of the footing and any soil or surcharge directly above it. Assuming the density of the footing (concrete) and soil (γ) are close enough to be considered equal, then

$$q_{nu} = q_u - \gamma D_f.$$

Where, D_f = depth of the footing

Safe bearing capacity: It is the bearing capacity after applying the factor of safety (FOS). These are of two types:

- **Safe net bearing capacity (q_{ns})** : It is the net soil pressure which can be safety applied to the soil considering only shear failure. It is given by,

$$q_{ns} = \frac{qnu}{FOS}$$

- **Safe gross bearing capacity (q_s)**: It is the maximum gross pressure which the soil can carry safely without shear failure. It is given by,

$$q_s = q_{ns} + \gamma D_f.$$

Allowable Bearing Pressure: It is the maximum soil pressure without any shear failure or settlement failure.

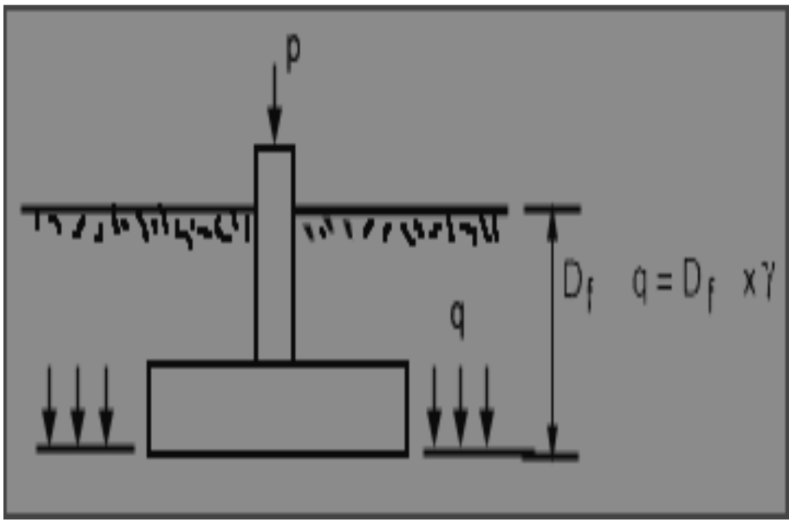


Fig.1 Bearing capacity of footing

Presumptive bearing capacity:

Building codes of various organizations in different countries gives the allowable bearing capacity that can be used for proportioning footings. These are "Presumptive bearing capacity values based on experience with other structures already built. As presumptive values are based only on visual classification of surface soils, they are not reliable. These values don't consider important factors affecting the bearing capacity such as the shape, width, depth of footing, location of water table, strength and compressibility of the soil. Generally these values are conservative and can be used for preliminary design or even for final design of small unimportant structure. IS1904-1978 recommends that the safe bearing capacity should be calculated on the basis of the soil test data. But, in absence of such data, the values of safe bearing capacity can be taken equal to the presumptive bearing capacity values given in Table 1 for different types of soils and rocks. It is further recommended that for non-cohesive soils, the values should be reduced by 50% if the water table is above or near base of footing.

Table 1: Presumptive bearing capacity values as per IS1904-1978.

Type of soil/rock	**Safe/allowable bearing capacity (KN/m2)**
Rock	3240
Soft rock	440
Coarse sand	440
Medium Sand	245
Fine sand	440
Stiff clay	100
Soft clay	100

1.2 Methods of analyzing the soil

The various methods of computing the bearing capacity can be listed as follows:

1. Analytical Methods
2. Plate Bearing Test
3. Penetration Test

Analytical Methods:-

This method includes:

Terzaghi's Bearing Capacity Theory

Skempton's Analysis for Cohesive soils

Meyerhof's Bearing Capacity Theory

Hansen's Bearing Capacity Theory

Vesic's Bearing Capacity Theory

IS code method

1.3 Terzaghi's Bearing Capacity Theory

There are certain assumptions in Terzaghi's Bearing Capacity Theory,

- Depth of foundation is less than or equal to its width.
- Base of the footing is rough.
- Soil above bottom of foundation has no shear strength; is only a surcharge load against the overturning load
- Surcharge upto the base of footing is considered.

- Load applied is vertical and non-eccentric.
- The soil is homogenous and isotropic.
- L/B ratio is infinite.

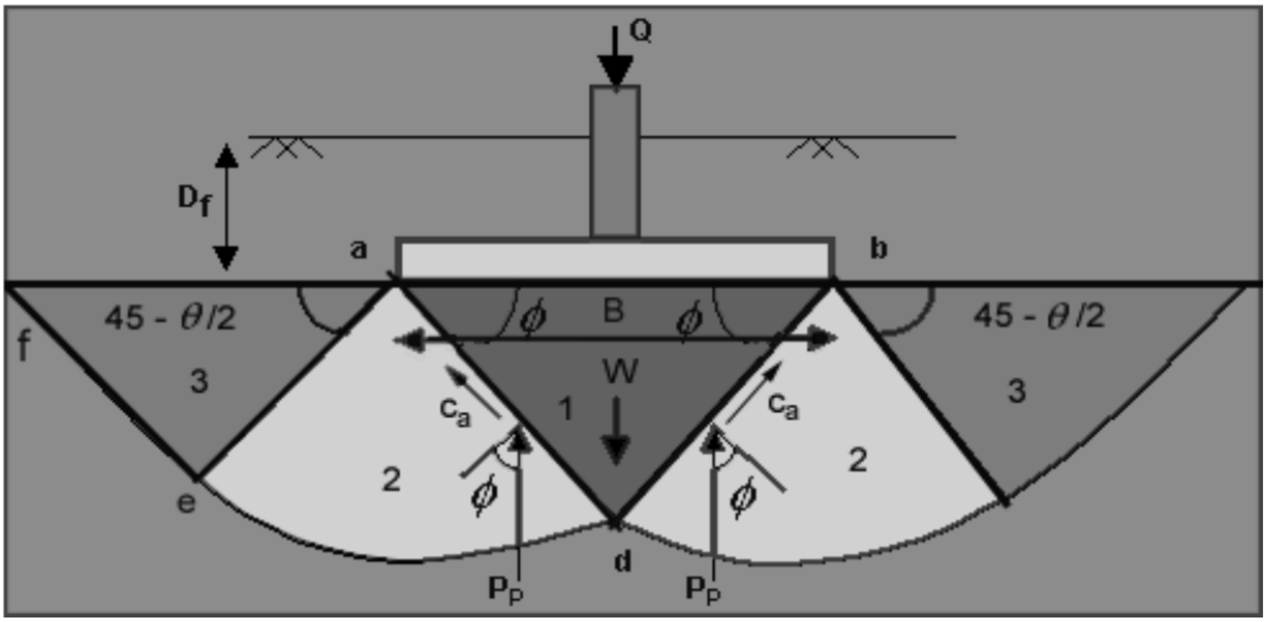


Fig.2 Terzaghi's Bearing Capacity Theory

Extensions of Terzaghi's Original Theory

(a) Local Shear Failure

Terzaghi's theory can still be used but with the reduced values of c and ∅. Reduce c and ∅ such that,

$$(c)_{new} = \frac{2}{3}c$$

$$tan(\emptyset)_{new} = \left(\frac{2}{3}\right) tan\emptyset$$

Then, Terzaghi's equation of bearing capacity becomes,

$$q_u = \left(\frac{2}{3}\right) c\,N_c + qN_q + 0.5\,\gamma B N_\gamma$$

where $N_c, N_q, and\ N_\gamma$ are read from the tables of general shear failure using,

$$(\emptyset)_{new} = tan^{-1}(0.667\ tan\emptyset)$$

Here, c and ∅ are the shear strength parameters for the soil experiencing local shear failure.

(b) Square and Circular Footings

(i) for square footing

$$q_u = 1.2\, cN_c + qN_q + 0.4\, \gamma B N_\gamma$$

(ii) for circular footing

$$q_u = 1.2\, cN_c + qN_q + 0.3\, \gamma B N_\gamma$$

For circular footings, B is taken as the diameter of the footing.

(c) Effect of the Ground Water: Rules are,

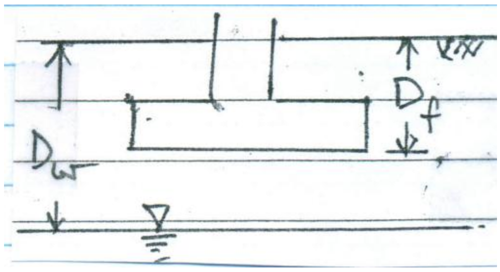
1) If the water table is below the rupture zone (depth B below base level), the water table has no effect on bearing capacity.

2) If the water table is in the rupture zone, then modify γ in Terzaghi's equation.

3) If the water table is above the base level of the footing, then modify γ and q both in Terzaghi's equation.

We modify γ in Terzaghi's equation as per 3 cases:

Case 1: $D_w \geq D_f + B \rightarrow \gamma_{new} = \gamma(no\ change)$



Case 2: $D_f < D_w < D_f + B$

Interpolate between γ'at D_f and, γ at $(D_f + B)$.

The Interpolation formula is,

$$\gamma_{new} = \gamma - \gamma_w \left(1 - \frac{D_w - D_f}{B}\right)$$

Case 3: $D_w \leq D_f \rightarrow \gamma_{new} = \gamma' = \gamma - \gamma_w$

Fig.3 Effect of ground water

Note, γ' is the submerged or effective unit weight.

Different books, and I.S. codes, introduce the water table correction differently. But the end result is nearly the same. The following thumb rules are helpful in checking your computations.

- In granular soils, when the water table rises from below the rupture zone to the base of the footing, the bearing capacity goes down by 25%.
- In granular soils, when the water table rises from below the rupture zone to the ground surface, the bearing capacity goes down by 50%.

First thumb rule is often used in engineering practice. A designer computes the bearing capacity assuming that the water table is touching the base of the footing even though the observed position of water table is below the rupture zone.

(d) Eccentrically loaded foundations

In 1953, Meyerhof introduced the concept of "useful width" or "effective width". The concept immensely simplified this complex problem.

The concept says, if the load has an eccentricity e_x in the direction of the width, then use in Terzaghi's equation a modified width B' instead of B.

$$B' = B - 2e_x$$

Thus, Meyerhof envisioned designing a footing assuming that the width is $(B - 2e_x)$. If the load has eccentricity e_y in the direction of length L, then effective length would be $L' = L - 2e_y$.

If the load has eccentricity, e_x and e_y, in both directions, then both B' and L' must be computed. Thus, the net effect of eccentricity is to reduce the effective area of a footing.

1.4 IS CODE METHOD: (IS 6403:1981 – Reaffirmed 2002)

This method gives **Net ultimate bearing capacity** by,

$$q_{nu} = cN_c s_c d_c i_c + q(N_q - 1)s_q d_q i_q + 0.5B\gamma s_\gamma d_\gamma i_\gamma W' N_\gamma$$

The factor W' takes into account, the effect of the water table. If the water table is at or below a depth of D_f + B, measured from the ground surface, =1. If the water table rises to the base of the footing or above, W' =0.5. If the water table lies in between then the value is obtained by linear interpolation. The shape factors given by Hansen and inclination factors as given by Vesic are used. Various factors used in the formula are explained below.

Shape factor (Are introduced due to the shape of the footing)

SL No.	Shape of Base	Shape Factor s_c	s_q	s_γ
i)	Continuous strip	1.00	1.00	1.00
ii)	Rectangle	$1 + 0.2\ B/L$	$1 + 0.2\ B/L$	$1 - 0.4\ B/L$
iii)	Square	1.3	1.2	0.8
iv)	Circle	1.3	1.2	0.6

Use B as the diameter in the bearing capacity formula.

Fig. 4 Shape Factor

Depth factor-(Are introduced due to variation with depth of the footing)

$d_c = 1 + \frac{.2\,D_f}{L}\tan(45^\circ + \frac{\phi}{2})$

$d_q = d_\gamma = 1 + \frac{.1\,D_f}{L}\tan(45^\circ + \frac{\phi}{2})$ $\phi \geq 10^\circ$

$d_q = d_\gamma = 1$ $\phi \leq 10^\circ$

Inclination factor-(Are introduced due to inclination of the loading with vertical)

$i_c = i_q = (1 - \frac{\alpha}{90^\circ})^2$

$i_\gamma = (1 - \frac{\alpha}{\phi^\circ})^2$

The rest of the terms have regular meaning and putting all the values in the formula one can get the **Net ultimate bearing capacity.**

CHAPTER 2: THE PROGRAM

2.1 Introduction

The program is used to determine bearing capacity using various input data from user as per IS code method using IS 6403-1981. It has been made on excel using VBA coding. Various inputs that has been taken from user are:- length, breadth, depth of footing, etc. All the parameters like depth of water table eccentricity etc. are considered. The program will result in giving us net ultimate, net safe, allowable bearing capacity plus allowable loading.

2.2 The Code

The following code when written in macros in excel, will give the desired result.

```
Sub bearingcapacity()
Dim L As Single
Dim B As Single
Dim L1 As Single
Dim B1 As Single

Dim D As Single
Dim Y As Single
Dim C As Single
Dim O As Single
Dim w As Single
Dim tanO As Single
Dim Nc As Single
Dim Nq As Single
Dim Ny As Single
Dim Sc As Single
Dim Sq As Single
Dim Sy As Single
Dim Dc As Single
Dim Dq As Single
Dim Dy As Single
```

```
Dim Ic As Single
Dim Iq As Single
Dim Iy As Single
Dim cotO As Double
Dim AL As Single
Dim WT As Single
Dim Ey As Single
Dim Ex As Single
Dim Qnu As Single
Dim Qns As Single
Dim Qa As Single
Dim q As Single
Dim fos As Single
Dim Ysat As Single
L = Range("B6").Value
B = Range("B7").Value
D = Range("B8").Value
Y = Range("B9").Value
C = Range("B10").Value
O = Range("B11").Value
AL = Range("B12").Value
Ex = Range("B13").Value
Ey = Range("B14").Value
WT = Range("B15").Value
fos = Range("B16").Value
Ysat = Range("B17").Value
If (B < D) Then
  MsgBox ("deep foundation")
  Else
  MsgBox ("shallow foundation")
End If
tanO = Tan(O * 3.14 / 180)
If (O <> 0) Then
cotO = 1 / tanO
```

```
End If
Nq = Tan((45 + O / 2) * 3.14 / 180) ^ 2 * Exp(3.14 * tanO)
If (O <> 0) Then
Nc = (Nq - 1) * cotO
Else
Nc = 5.14
End If
Ny = 2 * (Nq + 1) * tanO
'depth factor
Dc = 1 + 0.2 * (D / B) * Tan((45 + O / 2) * 3.14 / 180)
If (O < 10) Then
Dq = Dy = 1
Else
Dq = 1 + 0.1 * (D / B) * Tan((45 + O / 2) * 3.14 / 180)
Dy = Dq
End If
'inclination factor
Ic = (1 - AL / 90) ^ 2
Iq = Ic
Iy = (1 - AL / O) ^ 2
'shape factor
B1 = B - 2 * Ex
L1 = L - 2 * Ey
If (B1 = L1) Then
   MsgBox ("square footing")
    Sc = Sq = 1.2
    Sy = 0.6
  ElseIf (B1 <> L1) Then
  MsgBox ("rectangular footing")
      Sc = 1 + 0.2 * (B1 / L1)
      Sq = Sc
      Sy = 1 - 0.4 * (B1 / L1)
  Else
    MsgBox ("strip footing")
```

```
    Sc = Sq = Sy = 1
End If
If (WT >= (D + B)) Then
  w = 1
  q = Y * D
 Qnu = (C * Nc * Sc * Dc * Ic) + (q * (Nq - 1) * Sq * Dq * Iq) + (0.5 * Ny * Sy * Dy
* Iy * B * Y * w)
 ElseIf (WT <= D) Then
  w = 0.5
  q = (WT * Y + (D - WT) * Ysat) - (9.81 * (D - WT))
 Qnu = (C * Nc * Sc * Dc * Ic) + (q * (Nq - 1) * Sq * Dq * Iq) + (0.5 * Ny * Sy * Dy
* Iy * B * Y * w)
 Else
 w = 0.5 * (1 + (WT - D) / B)
 q = Y * D
 Qnu = (C * Nc * Sc * Dc * Ic) + (q * (Nq - 1) * Sq * Dq * Iq) + (0.5 * Ny * Sy * Dy
* Iy * B * Y * w)
End If
Qns = Qnu / fos
Qa = (Qns + Y * D) * B * L
Range("G6").Value = Qnu
Range("G7").Value = Qns
Range("G8").Value = Qns + Y * D
Range("G9").Value = Qa
End Sub
```

End sub will indcate the end of the code and now the program is ready to run and execute and will give the desired result.

2.3 An Example

An example has been discussed here to check whether the coding will result in correct answer or not. The following example has been taken from Basic and Applied Soil Mechanics, Ranjan and Rao with answer given and later on program is used to calculate for the same and comparison is done between the two result so obtained.

The example is as follows,

3. A rectangular footing, 2 m × 3.5 m, is placed at a depth of 1.5 m below ground surface. Determine both by Meyerhof's recommendations as well as IS: 6403 (1981) recommendations, the net safe load that can be supported by the footing with a factor of safety of 2.5 with respect to shear failure. The soil properties are: $c' = 20$ kN/m^2, $\phi' = 22°$. (a) 2424 kN, (b) 2251 kN.

Fig.5 An Example

In excel input the required values, which will be something like the figure below,

DATA VALUES

PARTICULARS	VALUES	UNIT
LENGTH OF FOOTING(L)	2	m
BREADTH OF FOOTING(B)	3.5	m
DEPTH OF FOOTING(Df)	1.5	m
UNIT WEIGHT OF SOIL(γ)	15	KN/m3
COHESION(C)	20	KN/m2
ANGLE OF INTERNAL FRICTION(ϕ)	22	degrees
ANGLE OF INCLINATION OF LOAD TO VERTICAL(α)	0	degrees
ECCENTRICITY ALONG X AXIS(ex)	0	m
ECCENTRICITY ALONG Y AXIS(ey)	0	m
DEPTH OF WATER TABLE FROM GROUND(Dw)	8	m
FACTOR OF SAFETY(FOS)	2.5	

Fig.6 Data input in excel

After inputting the values then run the macros, to get to the result which will be shown something like the figure on the next page,

RESULT		
PARTICULARS	RESULT	UNIT
NET ULTIMATE BEARING CAPACITY(Qnu)	790.8744507	KN/m2
NET SAFE BEARING CAPACITY(Qns)	316.3497925	KN/m2
SAFE BEARING CAPACITY(Qs)	338.8497925	KN/m2
ALLOWABLE LOADING(Qa)	2371.948486	KN

Fig.7 Result of the example from excel

2.4 Comparison

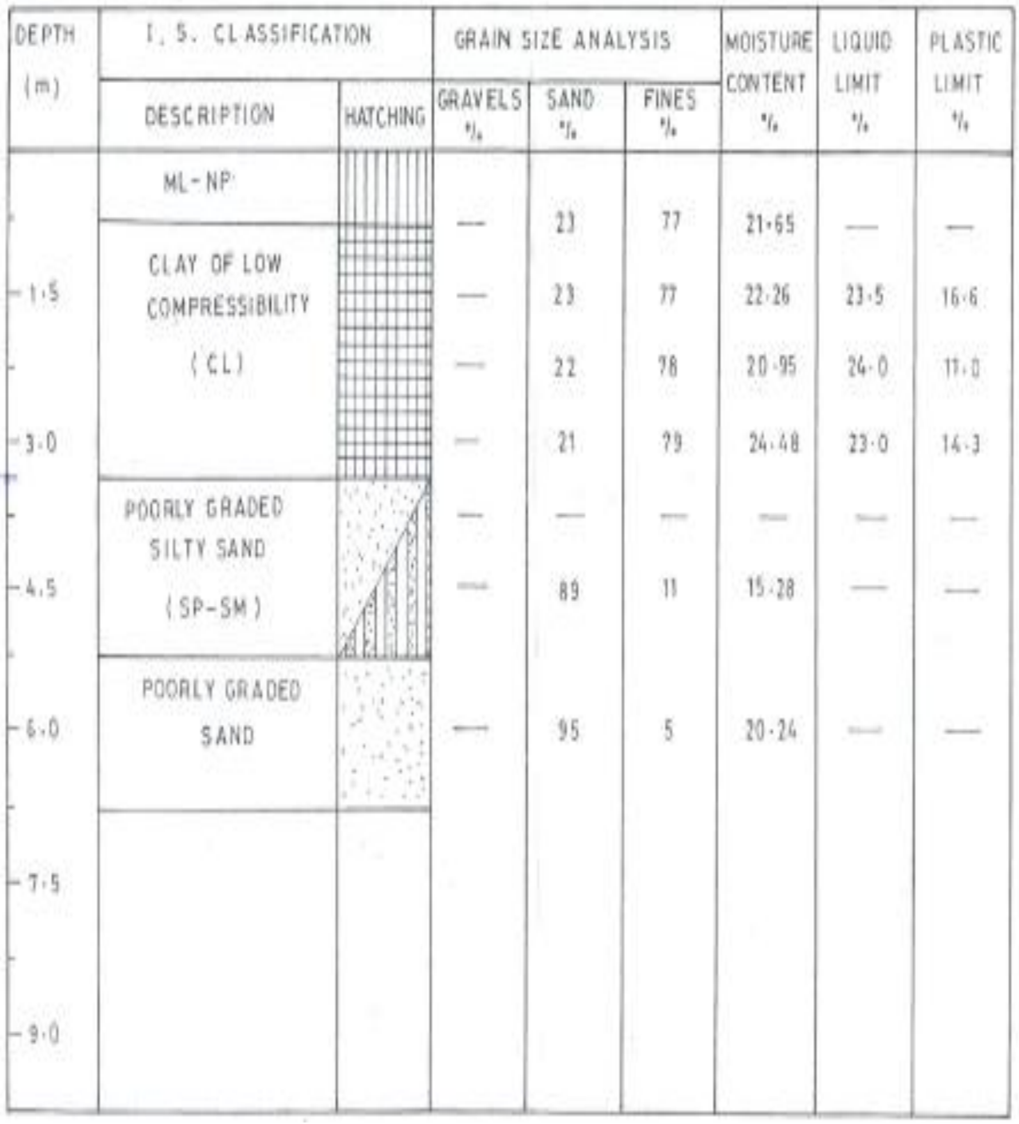
On comparing the results obtained from program and that mentioned alongside the question, it can be seen that there is a slight difference in both the answers that may be because of many reasons one may be, method by which Nc, Nq, Ny has been calculated, in here we have used formula to derive these parameters but the book might have taken the values by using charts given in IS-6403(1981). There is error of about 5.3% in our answer than mentioned, which is not too large, hence this error can be neglected and the program can said to deliver a satisfactory answer.

CHAPTER 3: ANALYSIS OF SOIL

Here analysis of soil is done on the basis of various test data and bearing capacity, to calculate width of footing for required load of the building, considering both settlement and shear criteria. Also various parameters such as unconfined shear and compressive strength, cohesion, angle of internal resistance etc. can be also known by conducting test and properly analyzing them.

3.1 Location And Soil Profile:

The test data analyzed here is taken from Pratap Vihar Colony in Noida. Soil profile of the site is shown below,



DEPTH (m)	I. S. CLASSIFICATION DESCRIPTION	GRAIN SIZE ANALYSIS GRAVELS %	SAND %	FINES %	MOISTURE CONTENT %	LIQUID LIMIT %	PLASTIC LIMIT %
	ML-NP	—	23	77	21·65	—	—
1·5	CLAY OF LOW COMPRESSIBILITY (CL)	—	23	77	22·26	23·5	16·6
		—	22	78	20·95	24·0	11·0
3·0		—	21	79	24·48	23·0	14·3
	POORLY GRADED SILTY SAND (SP-SM)	—	—	—	—	—	—
4·5		—	89	11	15·28	—	—
6·0	POORLY GRADED SAND	—	95	5	20·24	—	—
7·5							
9·0							

Fig. 8 Soil profile

3.2 Standard Penetration Test Data:

The following is the test data obtained when performed SPT test on the soil,

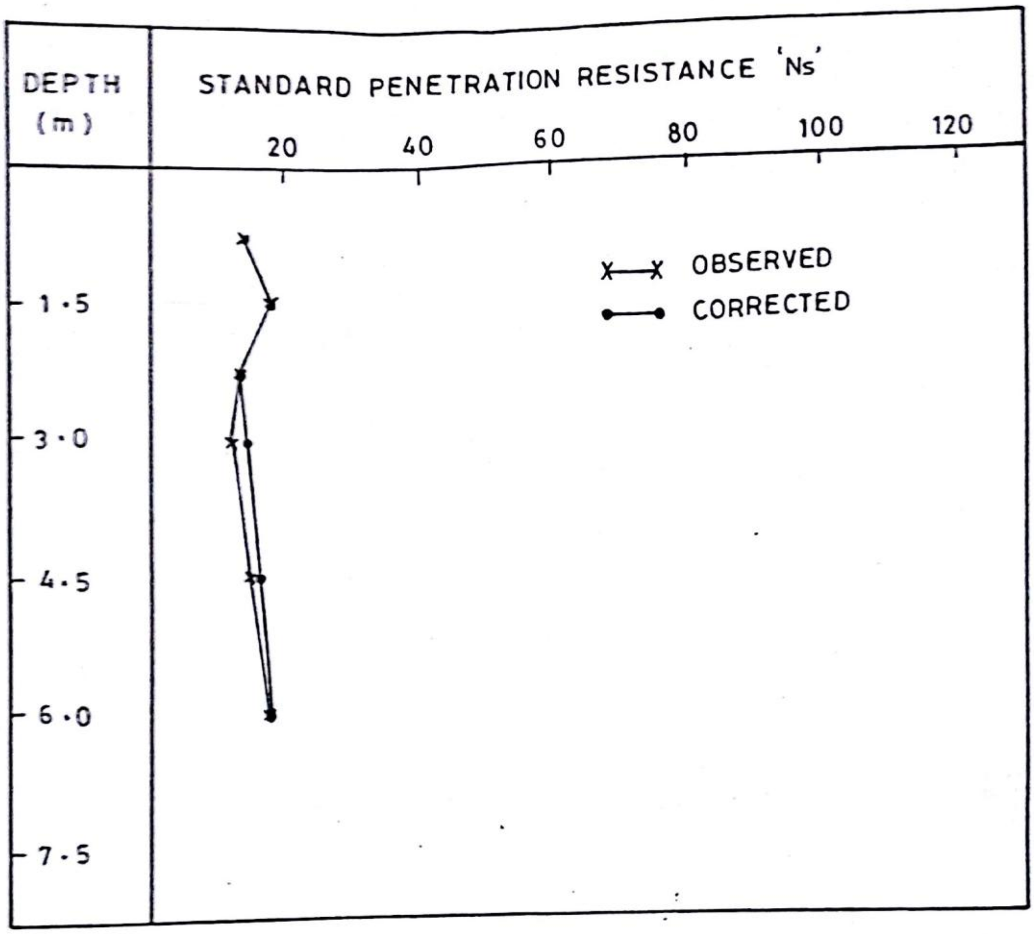


Fig.9 Standard penetration resistance vs depth

Bearing Capacity of soil at a depth of foundation 1.5 m.

Terzaghi's Analysis-

Shear criteria-

Net ultimate bearing capacity ,

$$q_{nu}= cN_cS_c + q(N_q -1) + 0.5\gamma BN_\gamma S_\gamma$$

For undrained cohesive soil-

ϕ_u=0

N_γ= 0

$N_q = 1$

$N_c = 5.14$

For strip footing

$S_c = S_\gamma = 1$

From SPT data –

SPV=14

Unconfined compressive strength of clay =2 kg/cm^2

(Table 2)

Table 2: Correlation with N value for cohesive soil

N VALUE	UNCONFINED COMPRESSIVE STRENTH(kg/CM^2)	CONSISTENCY
<2	<0.25	VERY SOFT
2-4	0.25 – 0.50	SOFT
4-8	0.50 – 1.0	MEDIUM
8-16	1.0 – 2.0	STIFF
16-32	2.0 – 4.0	VERY STIFF
>32	>4.0	HARD

C_u=100 KN/m^2

q_{nu}= 514 KN/m^2

q_{ns}= 205 KN/m^2

q_{ns}=20.5 t/m^2

Settlement criteria-

The following shows the relation between settlement and width of footing.

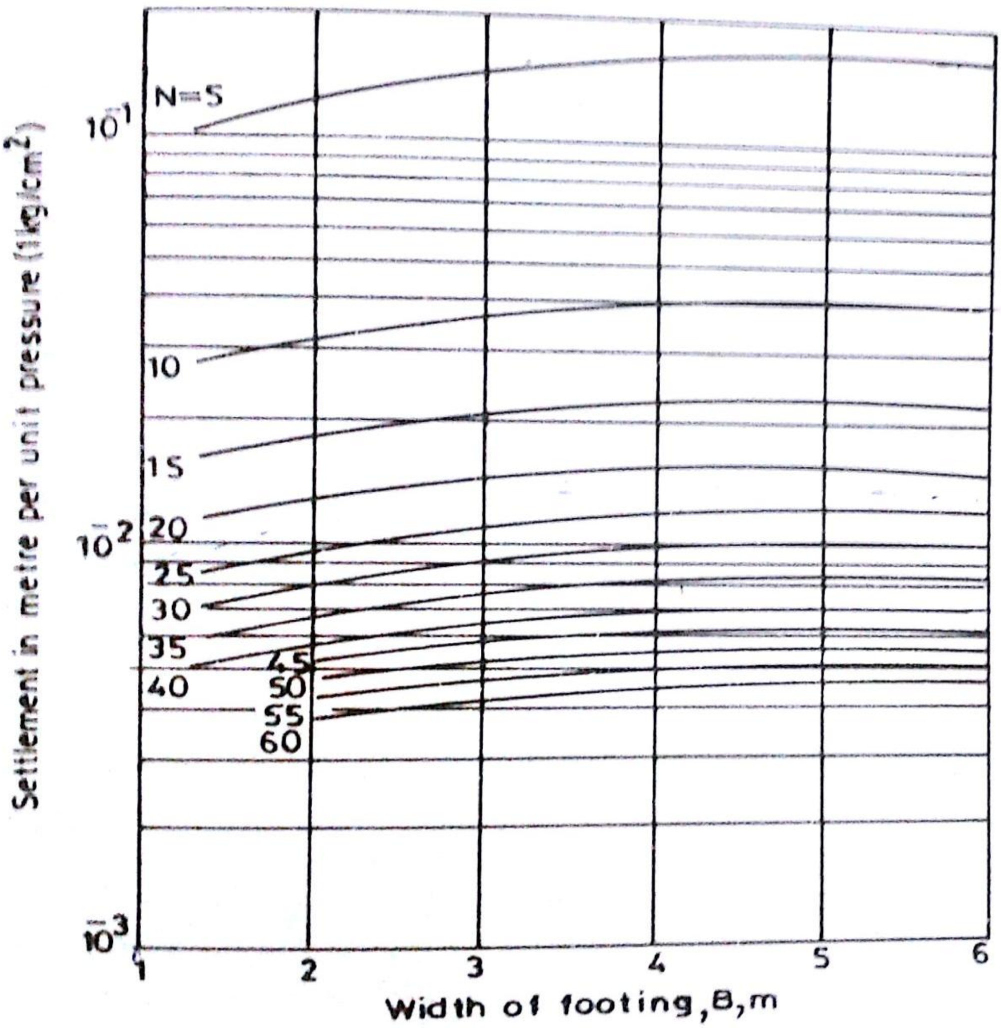


Fig. 10 Settlement vs width of footing curve

N=15, B=1.5m

Permissible settlement =50 mm

q_{np} =285.7 KN/m^2 .

q_{np} =28.57 t/m^2

q_{nabp}= min.(q_{ns}, q_{np})

q_{nabp}=20.5 t/m^2

3.3 Dynamic Cone Penetration Test

The following is the test data obtained when performed DCPT test on the soil,

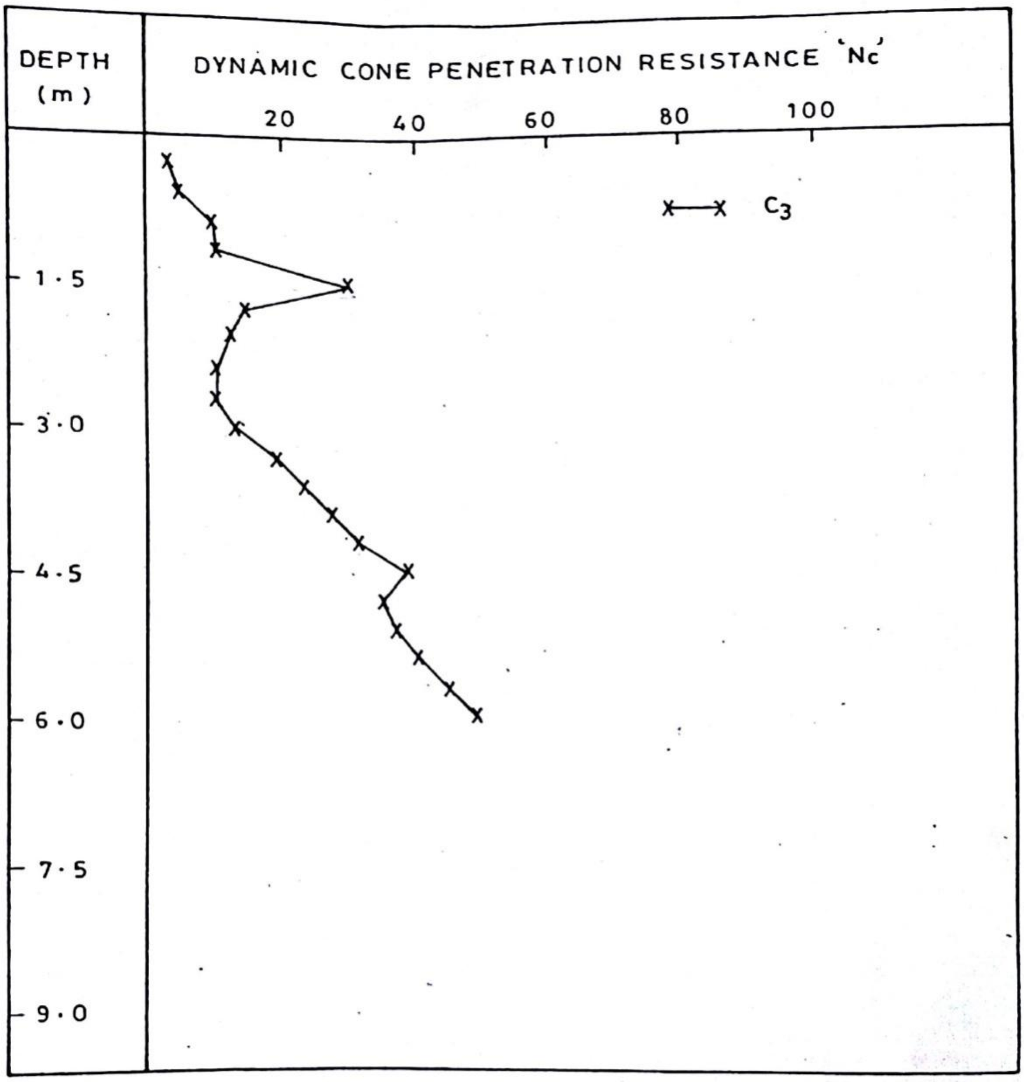


Fig. 11 Dynamic cone penetration resistance vs depth

Table 3: DCPT Test Data

DEPTH	N (SPT)	N (DCPT)	N (CON.,SPT)	Cn	N'	N"
0.5	12	5	3.33	1.84	6	6
1	15	10	6.66	1.61	11	11
1.5	20	30	20	1.47	30	22
2	13	17	11.33	1.38	16	15
2.5	11	12	8	1.30	10	10
3	14	14	9.33	1.24	12	12
3.5	15	22	12.57	1.19	15	15
4	15	30	17.14	1.15	20	17
4.5	16	37	21.14	1.11	24	19
5	16	38	21.71	1.07	23	19
5.5	17	42	24	1.04	25	20
6	18	48	27.42	1.02	28	21

Shear criteria:

From here,

$N_{corrected} = 16$

C_u=100 KN/m^2 (Table 2)

$q_{nu} = cN_cS_c + q(N_q - 1) + 0.5\gamma BN_\gamma S_\gamma$

For undrained cohesive soil-

$\phi_u = 0$

$N_\gamma = 0$

$N_q = 1$

$N_c = 5.14$

For strip footing

$S_c = S_\gamma = 1$

q_{nu}= 514 KN/m^2

q_{ns}= 205 KN/m^2

q_{ns}=20.5 t/m^2

Settlement criteria

N=16, B=1.5m

Permissible settlement =50 mm

q_{np} =333.3KN/m^2 .

q_{np} =33.33 t/m^2 .

q_{nabp}= min.($q_{ns,}$ q_{np}) (Fig. 10)

q_{nabp}=20.5 tn/m^2

Now the following curve is plotted.

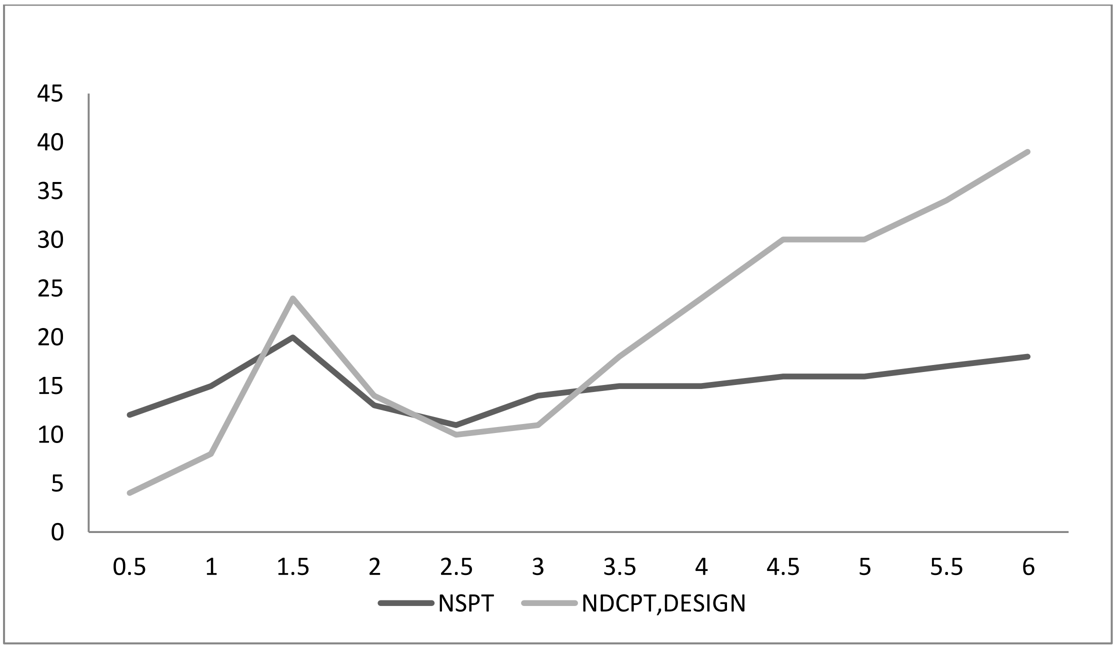


Fig. 12 N values vs depth

3.4 Plate Load Test.

The following is the test data obtained when performed DCPT test on the soil,

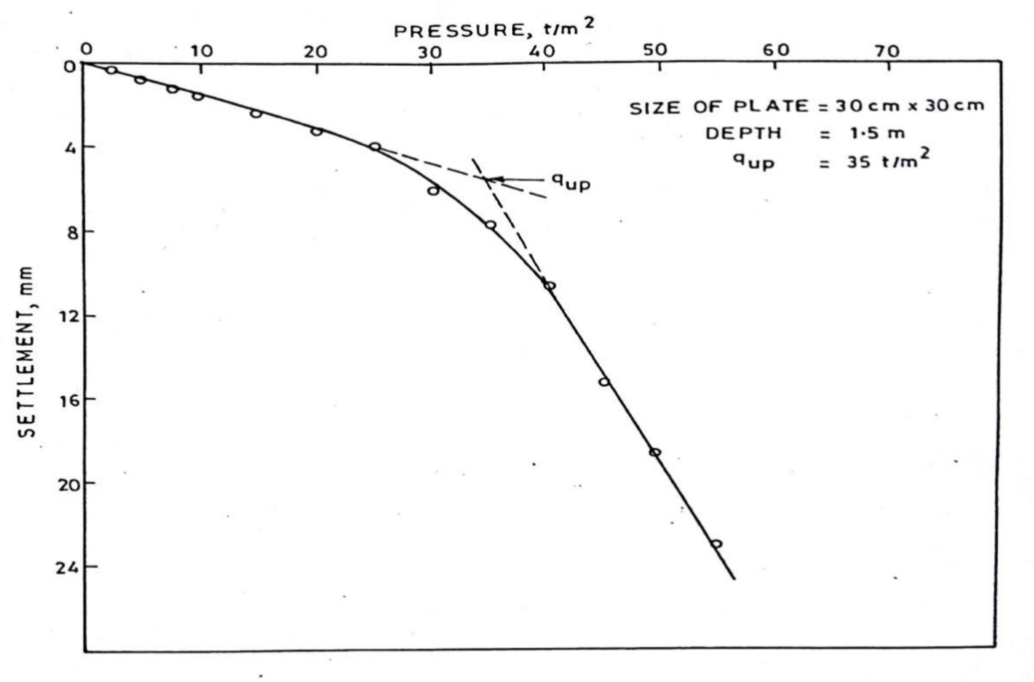


Fig.13 Settlement curve

Plotting graph between load and settlement and applying tangent method we get.

Shear criteria

(q_{nu}) plate =35 t/m^2

For clays;

(q_{nu}) plate = (q_{nu}) footing

(q_{nu}) footing = 35 t/m^2

q_{ns}= 14 t/m^2

q_{nabp}= 14 t/m^2

.

Settlement criteria

q_{np}=38 t/m^2

$Sf/Sp = Bf/Bp$

$Sp = (0.05 \times 0.3)/1.5$

$= 0.1m$

$= 10mm$

Corresponding to 10 mm penetration net allowable bearing pressure = 15.5 t/m^2.

Minimum net allowable bearing pressure from SPT,DCPT and PLT test data from above is,

$q_{nabp} = 14\ t/m^2$.

CHAPTER 4: DESIGN OF A STORAGE UNIT AND ITS FOUNDATION

4.1 Assumptions:

- Live load on structure =4 KN/m^2
- Dead Load on structure =1.5 KN/m^2
- Thickness of masonry wall =230 mm
- Depth of water table =4.5 m(Very Deep)
- Diameter of bar used =8 mm
- Length of footing =8 m
- Depth of footing =1.5 m
- Height of superstructure =5 m
- Width of superstructure =3 m
- Provided a Strip footing
- Fe 415 grade HYSD Reinforcement
- M-25 grade Concrete

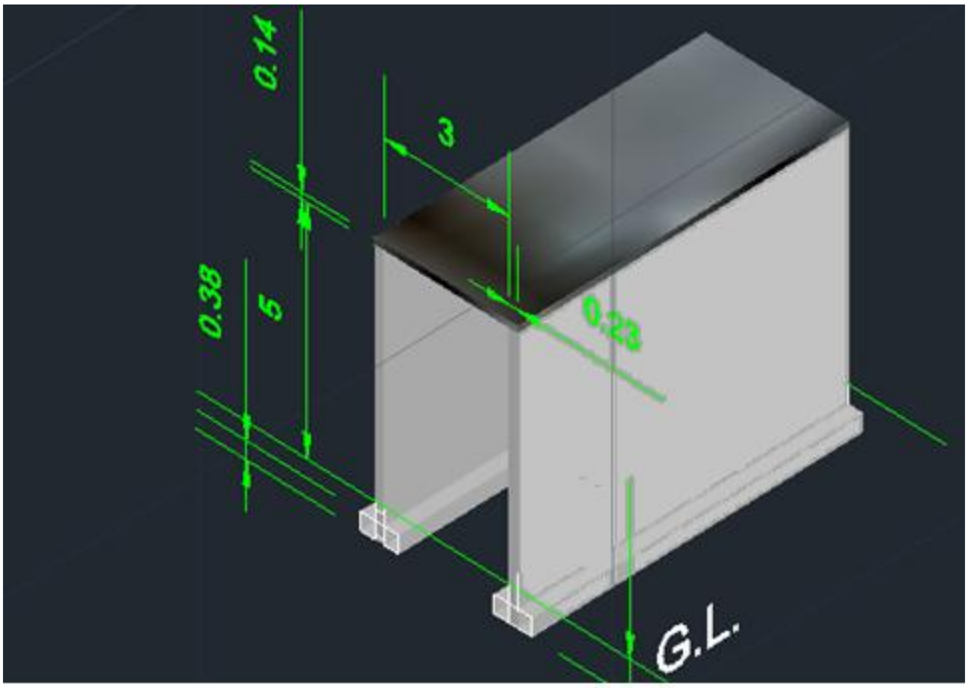


Fig. 14 Isometric view of storage unit (all dimensions in meter)

4.2 Calculations:

Span between centers of bearing = $3000 + \frac{230}{2} + \frac{230}{2}$ = 3.23 m

Assuming P_t = 0.3%, Modification factor = 1.4 and slab is simply supported.

$$\frac{\text{Span}}{\text{Effective Depth}} = 20 \times \text{M.F.}$$

$$d_{eff} = \frac{230}{20\times1.4}$$

= 115.35 mm

d_{eff} provided = 116 mm

Provide 8mm diameter bars at a clear cover of 15mm.

Effective cover = 15+8/2 = 19mm

Overall depth required = 116+19 = 135mm

Provided overall depth = 140mm

Now, d_{eff} = 140-19 =121mm

Dead load due to slab = 25×0.140 = 3500 N/m^2

Dead load due to finish partition = 1500 N/m^2

Total load = D.L. + L.L.

= (3500+1500)+4000

=9000 N/m^2

Design load = Factored load

= 1.5×9000

= $13500 \ N/m^2$

Effective span = min (Distance between centers of bearing, clear span + effective depth)

= min (3.23, 3+0.121)

=3.121m

Consider 1m wide strip of slab,

Factored moment $M_u = \frac{w_u \times l^2}{8}$

$= \frac{13500 \times 3.121^2}{8}$

= 16437.33 N-m

Moment of resistance $M_{u,limit}$ for Fe 415

$M_{u,limit} = 0.138 f_{ck} b d^2$

$M_u = M_{u,limit}$

$16437.33 \times 10^3 = 0.138 \times 25 \times 1000 \times d^2_{eff}$

$d_{eff} = 69$ mm

d_{eff} provided = 121 mm (safe as d_{eff} provided > d_{eff})

$M_u/bd^2 = 1.1226$

Percentage of steel required, $P_t = 50 \times \left[\frac{1 - \sqrt{1 - \frac{4.6 \times M_u}{f_{ck} b d^2}}}{f_{y/f_{ck}}} \right]$

=0.33%

$\frac{A_{st}}{b \times d_{eff}} \times 100 = 0.33\%$

$A_{st} = 400 \ mm^2$

Spacing of 8 mm dia. bars = $\frac{1000 \times \frac{\pi}{4} \times 82}{400}$

=125.21 mm

Spacing of bars = 125 mm c/c.

Number of bars = $\frac{1000}{\text{spacing}} \approx 8$

Actual area of steel provided, $A_{st,\ provided} = \frac{\pi}{4} \times 8^2 \times 8 = 402.12 \ mm^2$

Actual percentage of steel provided = $\frac{402.12}{1000 \times 121} \times 100$

$= 0.332\%$

Modification factor corresponding to 0.332% steel (Fe 415) = 1.39 (by interpolation)

⇨ $\frac{\text{span}}{d_{eff} \times M.F.} = 20$

⇨ $d_{eff} = 111.83$ mm

d_{eff} provided = 121mm

Hence the design is safe in serviceability conditions.

4.3 Check For Shear:

Nominal shear stress, $\tau_v = \frac{V_u}{bd}$

$V_u = \frac{1350 \times 3 \times 1}{2}$

$= 20250$ N

$\tau_v = \frac{20250}{1000 \times 121} = 0.166$ N/ mm^2

Percentage of steel available near support = 0.332/2

= 0.166%

Design shearing strength of concrete corresponding to 0.16% of steel, $\tau_c = 0.3$N/mm^2

For 140 mm thick slab K = 1.30

$\tau_c' = K\,\tau_c$

$= 1.30 \times 0.3$

$= 0.39$N/mm^2

$\tau_v < \tau_c'$

So the design is safe against shear.

4.4 Distribution Steel:

A_{st} of distribution bar ≥ 0.12% of gross area for Fe 415

A_{st} of distribution bar = $0.0012 \times 1000 \times 140$

= 168 mm^2

Spacing of 8mm dia. bars = $\frac{50 \times 1000}{168}$

=297.6mm

Provide 8 mm dia. bars @ 290mm c/c spacing.

4.5 Design of Main Bars:

No. of bars = 8000/125 ≈ 64

No. of equally spaced bars = (64-1) = 63

Total spacing between first and last bars = 63×125 = 7875 KN/m^3

Development length = 40.3×ø = 40.3 × 8 ≈ 322 mm

Length = 3460-(15+15) = 3430mm

Volume of steel used in main reinforcement = Area × Length

V_{st} main bars = 11034278.71mm^3

Weight = Volume × γ_{steel}

= 866.169 N

4.6 Design of Distribution Bar:

No. of bars = $\frac{3460}{290}$

≈ 12

No. of uniform spaced bars = 11×290

= 3190mm

Clear cover provided = 15mm

Development length = 40.3×ø = 40.3 × 8 ≈ 322 mm

Length of distribution bar = 8000 - (15 + 15) = 7970mm

Vol. of steel used in distribution bars = $12\times\frac{\pi}{4}\times8^2\times7970$ = 4807390.74mm^3

Weight of steel used in distribution of bars = 377.38 N

4.7 Load Calculations:

Total load (Weight of slab) = 9000×8×3.46 + 377.38 + 866.169

= 250363.55 N or 250.36 KN

Load distribution:-

Weight of slab on one masonry wall = 125.81 KN

Load per unit length of masonry wall = 15.64 KN/m

Unit length volume of masonry wall = 0.23×5×1 = 1.15 m^3 per m length of the wall.

Unit weight of bricks = 16 KN/m^3

Weight of bricks = 16×1.15 = 18.4 KN/m

Total load on foundation, Q = 18.4 + 15.64 = 34.04 KN/m

4.8 Design of RCC Footing

Minimum net allowable bearing pressure from SPT,DCPT and PLT test data from above is,

q_{nabp}= 14 t/m^2

Width of the foundation-

q_{nabp} =Q/A

Q =34 KN/m

A =B×1 m^2

B (Calcuated) = 0.25 m

Provided width B= 1 m

Net upward soil pressure = $\frac{34}{1\times1}$ = 34 KN/m^2

Factored upward soil pressure per meter length, P_o = 1.5×34×1 = 51 KN/m

The critical section for moment is at the face of the wall.

$M_{u,\,lim} = \frac{P_0}{8} \times (B-b)^2$

$= \frac{51}{8} \times (1-0.23)^2$

= 3.77 KN-m

$M_{u,\,lim} = M_u$

$3.77\times10^6 = 0.138\ f_{ck}bd^2$

$= 0.138\times25\times1000\times d^{2+}$

d = 35 mm

Provided depth = 1.4 × 35 = 47 mm

But according to IS 456, minimum footing depth should be 150 mm.

Actual depth provided, D = 150mm

Take clear cover of 50mm and dia. of bar 8mm.

d_{eff} = 150-50-4 = 96mm

$M_u/bd^2 = \frac{3.8167\times10^6}{1000\times96^2} = 0.4319$

Percentage of steel required, $P_t = 50 \times \left[\frac{1-\sqrt{1-\frac{4.6\times M_u}{f_{ck}bd^2}}}{f_{y/f_{ck}}}\right]$

=0.12%

A_{st} = 0.0012 × 1000 × 150 = 180 mm^2

No. of bars provided of 8mm dia. = 4

Spacing = 288 mm c/c. (spacing should be less than 2 times depth=300mm => safe)

4.9 Check For Shear:

V_u= = P_o × ($\frac{B-b}{2}$ - d) = 51×10^3×[((1-0.23)/2) – 0.096] = 14.739 KN

τ_{v} = V_u/b'd'

=0.153 KN/m^2

Design shearing strength of concrete corresponding to 0.12% of steel, τ_c = 0.29N/mm^2.

$\tau_c > \tau_v$. => Design is safe.

4.10 Development Length:

$L_d = \frac{0.87\times f_y\times \emptyset}{4\times\tau_{bd}}$

$= \frac{0.87\times415\times8}{4\times1.4\times1.6}$

=322.36mm.

4.11 Consolidation Settlement in Clay-

$\Delta H = \frac{c_c}{1+e_0} H \log_{10} \frac{\boldsymbol{\sigma_v}+\Delta\sigma_v}{\boldsymbol{\sigma_v}}$

C_c= Compression index =.009(w_L-10)

$\boldsymbol{\sigma}_v$ = Effective initial overburden pressure .

$\Delta\sigma_V$=Vertical stress increment due to footing load.

H=Thickness of clay layer (m)

Assuming Load dispersion at 30˚ from the vertical.

B', B'' and B''' are width of load spread in meter .

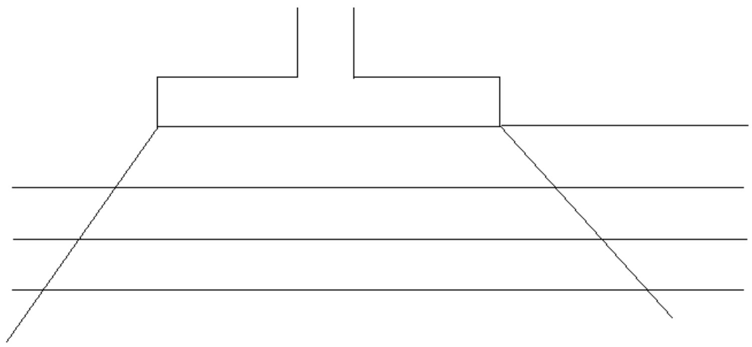


Fig.15 Pressure distribution through soil

$B' = 1+(.216\times2) = 1.433$ m

$B'' = 1+(.577\times2) = 2.154$ m

$B''' = 1+(.866\times2) = 2.73$ m

Table 4: Settlement calculation

LAYER	DEPTH OF C.L.(m)	THICKNESS OF THE CLAY LAYER H(m)	$\boldsymbol{\sigma}_v$ KN/m^2	$\Delta\sigma_v$ KN/m^2	$\mathbf{C}_c$	$\mathbf{e}_0$	SETTLEMENT ΔH (mm)
1	1.875	0.75	33.75	23.72	0.122	0.799	11.7
2	2.5	0.5	45	15.78	0.126	0.779	4.62
3	3	0.5	54	12.44	1.117	0.832	2.88

TOTAL SETTLEMENT=19.2mm

Consolidation Settlement in clay layer = 19.2 mm which is less than allowable settlement in clays that is 50 mm. Hence the design is safe.

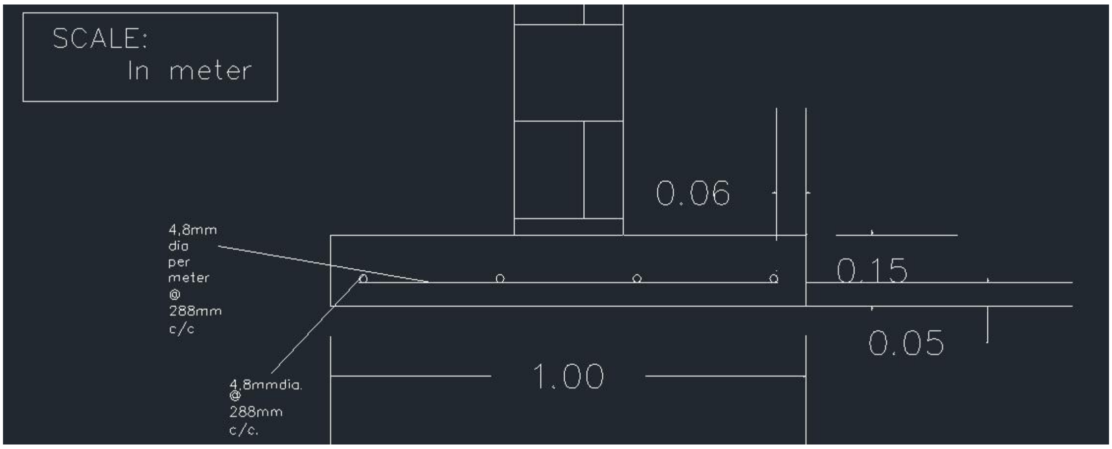


Fig.16 Cross-section of the foundation

CHAPTER 5: DESIGN OF FOUNDATION FOR A SHOPPING COMPLEX IN GHAZIABAD

5.1 SPECIFICATIONS:

- Shopping complex have 8 shops(2 storeyed).
- Floor area 4m X 8.5m of each shop.
- Site location is Pratap Vihar, Ghaziabad, U.P.
- Height of each shop is 3m.
- Live load is 4KPa.
- Dead load due to finish, partition etc is 1.5 KPa.
- Fe 415 grade HYSD reinforcement and M25 grade concrete.
- Thickness of slab is 150mm.
- Column size is 300mmx300mm.
- Beam size is 230mmx250mm.

5.2 PLAN FOR THE BUILDING:

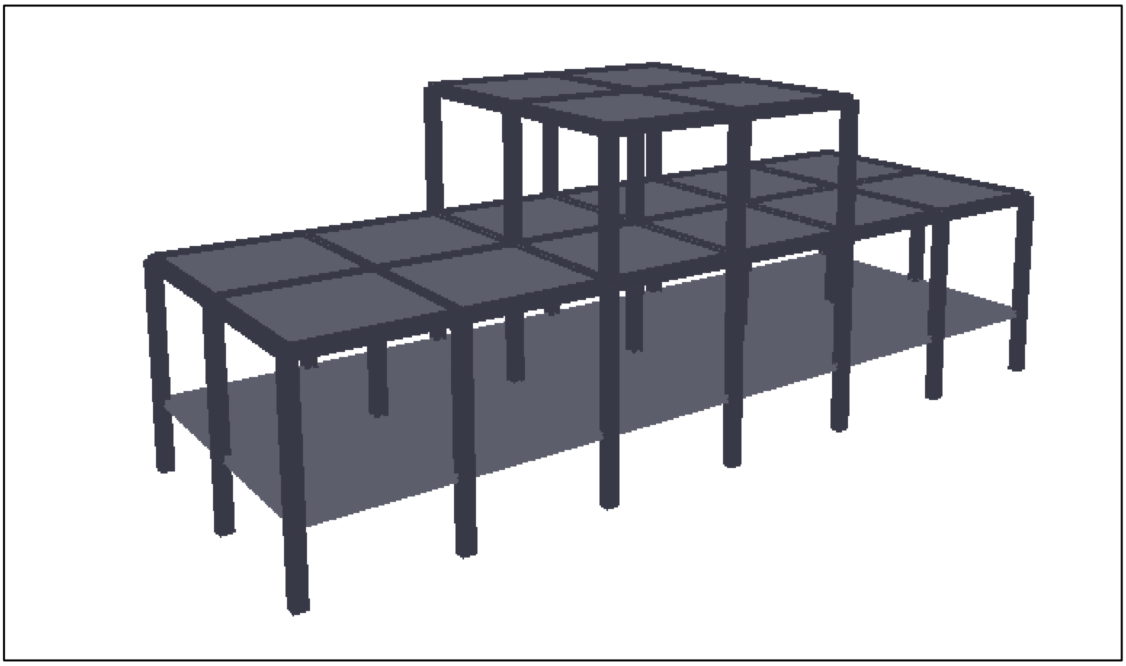
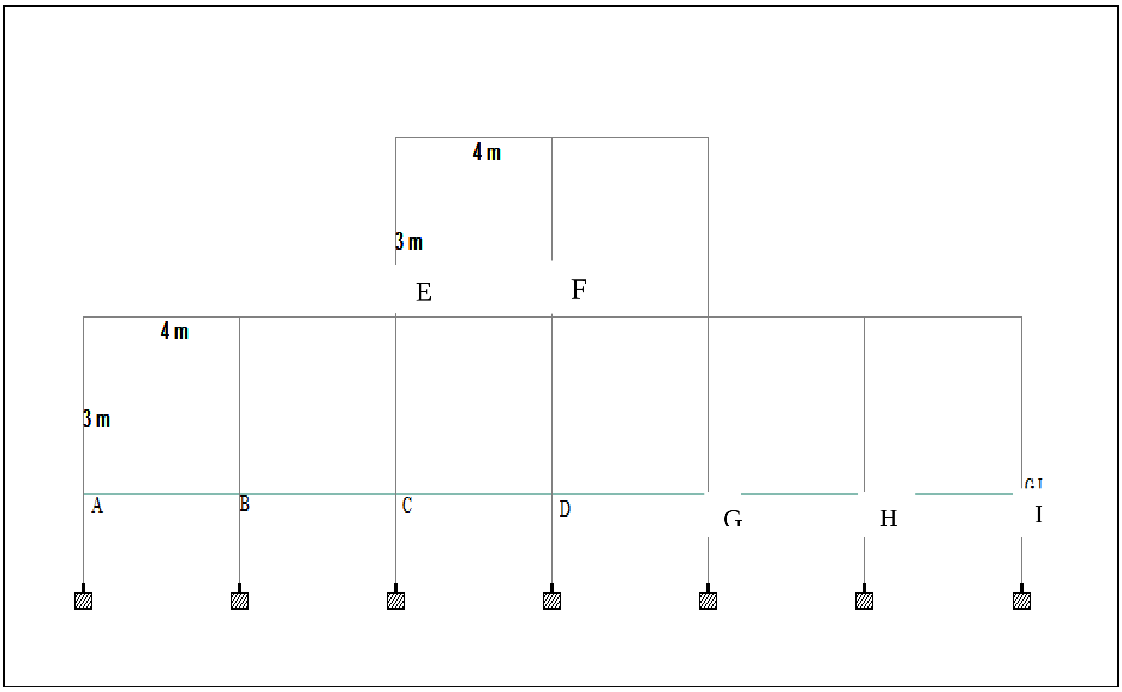
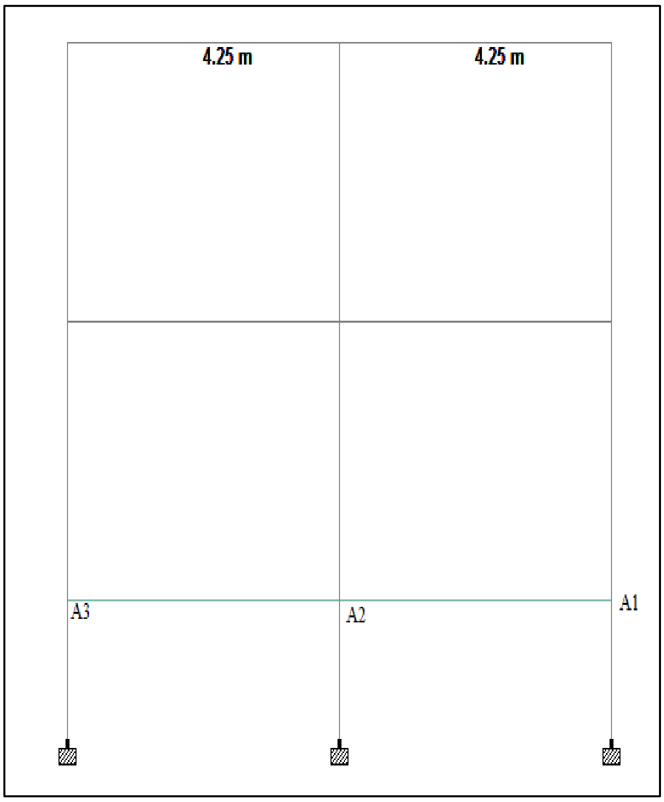


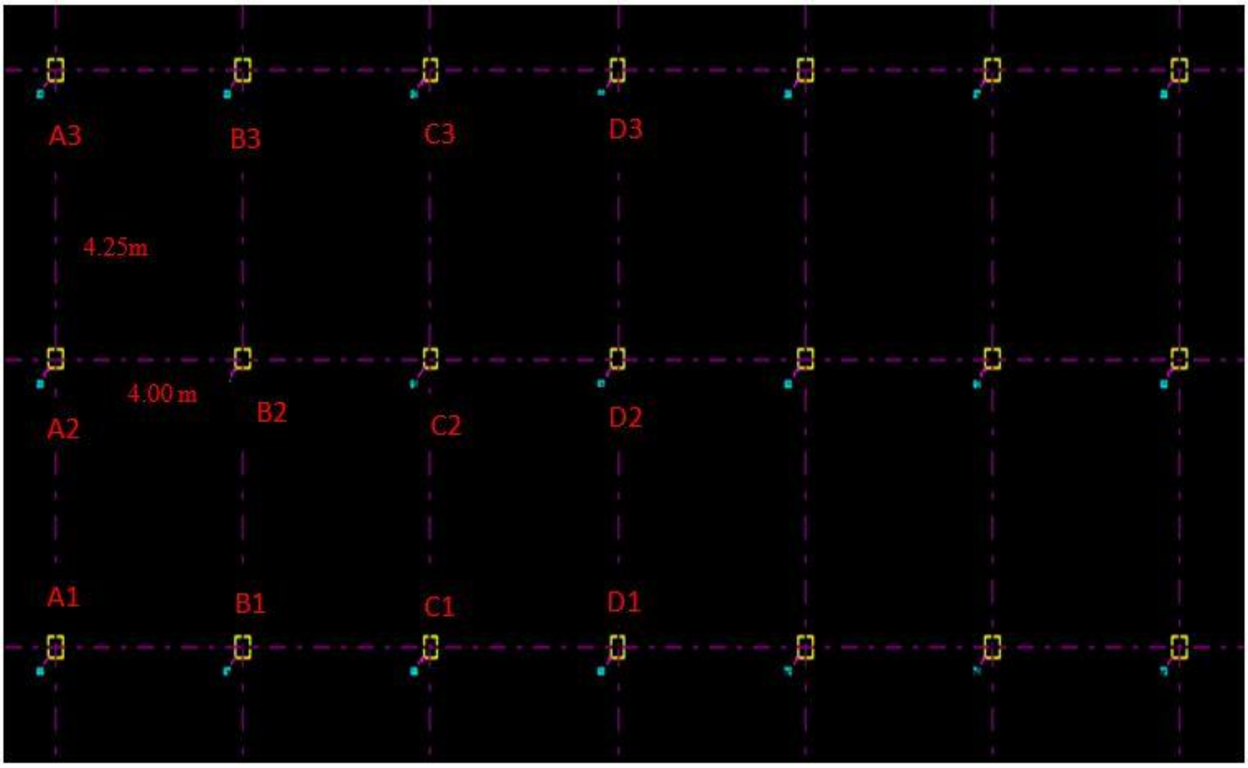
Fig. 17 Isometric view of the shopping complex



(a)



(b)



(c)

Fig.18: (a) Front view (b) Side view (c) Top view

5.3 CALCULATIONS:

For the following calculations refer figure 18.

Load on A1:

Live Load = (Live Load in kN/m^2) x (Area)

$$= \frac{4.25}{2} * 2 * 4$$

= 17 kN

Dead Load = Length x Breadth x Height x Density of RCC

Dead weight of slab= (4.25/2 × 2 × 0.15) × Unit wt of concrete

= (4.25/2 × 2 × 0.15) × 25 kN

= 15.94 kN

Dead weight of column = $0.3 * 0.3 * (0.3 - 0.15) * 25$

= 6.19 kN

Dead weight of Beam = 0.23×0.25× (4.25/2 + 2) × 25

= 5.92 kN

Dead weight of floor slabs = 15.94 kN

Dead weight due to finish = $\frac{4.25}{2} * 2 * 1.5 = 6.375$ kN

Total Load = Dead weight of slab + Dead weight of Beam + Dead weight of column + Dead load due to finish + Live load + Dead weight of floor slabs

=67.285 kN

Load on A2:

Live Load = (Live Load in kN/m^2) x (Area)

$= \frac{4.25}{2} * 2 * 4 * 2$

= 34 kN

Dead Load = Length x Breadth x Height x Density of RCC

Dead weight of slab = $\frac{4.25}{2} * 2 * 2 * 0.15 * 25 = 31.8$ kN

Dead weight of column = $0.3 * 0.3 * (0.3 - 0.15) * 25$

= 6.186 kN

Dead weight of beams = $0.23 * 0.25 * (4.25 + 2) * 25 = 8.984$ kN

Dead weight of floor slabs = 15.94*2 = 31.8 kN

Dead weight of finish = $\frac{4.25}{2} * 2 * 1.5 * 2 = 12.7$ kN

Total Load = Dead weight of slab + Dead weight of Beam + Dead weight of column + Dead load due to finish + Live load + Dead weight of floor slabs

= 125.24 kN

Load on A3:

Live Load = (Live Load in kN/m^2) x (Area)

$= \frac{4.25}{2} * 2 * 4$

= 17 kN

Dead Load = Length x Breadth x Height x Density of RCC

Dead weight of slab= (4.25/2 × 2 × 0.15) × Unit wt of concrete

= (4.25/2 × 2 × 0.15) × 25 kN

= 15.94 kN

Dead weight of column = $0.3 * 0.3 * (0.3 - 0.15) * 25$

= 6.19 kN

Dead weight of Beam = 0.23×0.25× (4.25/2 + 2) × 25

= 5.92 kN

Dead weight of floor slabs = 15.94 kN

Dead weight due to finish = $\frac{4.25}{2} * 2 * 1.5 = 6.375$ kN

Total Load = Dead weight of slab + Dead weight of Beam + Dead weight of column + Dead load due to finish + Live load + Dead weight of floor slabs

=67.285 kN

Load on B1:

Live Load = (Live Load in kN/m^2) x (Area)

$= \frac{4.25}{2} * 2 * 4 * 2$

= 34 kN

Dead Load = Length x Breadth x Height x Density of RCC

Due to slab = $\frac{4.25}{2} * 2 * 2 * 0.15 * 25 = 31.8$ kN

Due to column = $0.3 * 0.3 * (0.3 - 0.15) * 25$

= 6.186 kN

Due to beams = $0.23 * 0.250 * \left(\frac{4.25}{2} + 4\right) * 25 = 9.8$ kN

Due to floor slabs = 15.94*2 = 31.8 kN

Due to partition = $\frac{4.25}{2} * 2 * 1.5 * 2 = 12.7$ kN

Total Load = Dead weight of slab + Dead weight of Beam + Dead weight of column + Dead load due to finish + Live load + Dead weight of floor slabs

=126.28 kN

Load on B2:

Live Load = (Live Load in kN/m^2) x (Area)

$= \frac{4.25}{2} * 2 * 4 * 4$

= 68 kN

Dead Load = Length x Breadth x Height x Density of RCC

Due to slab = $\frac{4.25}{2} * 2 * 2 * 0.15 * 25 * 2 = 63.76$ kN

Due to column = $0.3 * 0.3 * (0.3 - 0.15) * 25$

= 6.186 kN

Due to beams = $0.23 * 0.25 * (4.25 + 4) * 25 = 11.85$ kN

Due to floor slabs = 15.94*2*2 = 63.76 kN

Due to partition = $4 * \frac{4.25}{2} * 1.5 * 2 = 25.5$ kN

Total Load = Dead weight of slab + Dead weight of Beam + Dead weight of column + Dead load due to finish + Live load + Dead weight of floor slabs

=239.056 kN

Load on B3:

Live Load = (Live Load in kN/m^2) x (Area)

$= \frac{4.25}{2} * 2 * 4 * 2$

= 34 kN

Dead Load = Length x Breadth x Height x Density of RCC

Due to slab = $\frac{4.25}{2} * 2 * 2 * 0.15 * 25 = 31.8$ kN

Due to column = $0.3 * 0.3 * (0.3 - 0.15) * 25$

= 6.186 kN

Due to beams = $0.23 * 0.250 * \left(\frac{4.25}{2} + 4\right) * 25 = 9.8$ kN

Due to floor slabs = 15.94*2 = 31.8 kN

Due to partition = $\frac{4.25}{2} * 2 * 1.5 * 2 = 12.7$ kN

Total Load = Dead weight of slab + Dead weight of Beam + Dead weight of column + Dead load due to finish + Live load + Dead weight of floor slabs

=126.28 kN

Load on E:

Load on column E1 = Load on A1

= 67.285 kN

Load on column E2 = Load on A2

=125.24 kN

Load on column E3 = Load on A1

= 67.285 kN

Load on F:

Load on column F1 = Load on B1

= 126.28 kN

Load on column F2 = Load on B2

= 239.056 kN

Load on column F3 = Load on B1

= 126.28 kN

Load on D:

Load on column D1 = 2*Load on B1

= 222.12 kN

Load on column D2 = 2*Load on B2

= 408.112 kN

Load on column D3 = 2*Load on B1

= 222.12 kN

For C:

Load on column C1 = Load on (E1+B1)

= 177.66 kN

Load on column C2 = Load on (E2+B2)

= 332.41 kN

Load on column C3 = Load on (E1+B1)

= 177.66 kN

Since our structure is symmetric about the column number D, therefore loads on the foundation will also be symmetric about D column:-

Load on G1 = Load on C1 = 177.67 kN

Load on G2 = Load on C2 = 332.41 kN

Load on G3 = Load on C3 = 177.67 kN

Load on H1 = Load on B1 = 126.28 kN

Load on H2 = Load on B2 = 239.056 kN

Load on H3 = Load on B3 = 126.28 kN

Load on I1 = Load on A1 = 67.285 kN

Load on I2 = Load on A2 = 125.24 kN

Load on I3 = Load on A3 = 67.285 Kn

5.4 CALCULATION OF WIDTH OF FOOTING

Taking depth of footing (D_f) from ground level = 1.5m

(as test performed was on depth of 1.5m)

Net Safe Bearing Capacity (q_{ns}) of soil at depth 1.5m = 140 kN/m^2 (From PLT test)

Surcharge above the footing = $\gamma \times D_f$

= 18 kN/m^2 × 1.5m

= 27 kN/m^2

Assuming footing to be square of width B, Area of footing= B^2

$$Q_{ns} = \frac{Load\ on\ foundation}{area\ of\ footing} = \frac{Load}{B \times B}$$

$$B^2 = \frac{Load}{Qns}$$

But considering Soil Surcharge, we get empirical formula,

$$B = \sqrt{\frac{Load - 2.83}{113}}$$

Calculating width of Foundations based on the loads calculated:-

For Foundation A1 -

Load = 67.285 kN

B = $\sqrt{\frac{Load-2.83}{113}} = \sqrt{\frac{67.285-2.83}{113}} = 0.75$m

For Foundation A2 -

Load = 125.24 kN

B = $\sqrt{\frac{Load-2.83}{113}} = \sqrt{\frac{130-2.83}{113}} = 1.06$m

For Foundation A3 -

Load = 67.285 kN

B = $\sqrt{\frac{Load-2.83}{113}} = \sqrt{\frac{67.285-2.83}{113}} = 0.75$m

For Foundation B1 -

Load = 126.28 kN

B = $\sqrt{\frac{Load-2.83}{113}} = \sqrt{\frac{126.28-2.83}{113}} = 1.04$m

For Foundation B2 -

Load = 239.056 kN

B = $\sqrt{\frac{Load-2.83}{113}} = \sqrt{\frac{239.056-2.83}{113}} = 1.44$m

For Foundation B3 -

Load = 126.28 kN

B = $\sqrt{\frac{Load-2.83}{113}} = \sqrt{\frac{126.28-2.83}{113}} = 1.04$m

For Foundation C1 -

Load = 177.67 kN

$$B = \sqrt{\frac{Load - 2.83}{113}} = \sqrt{\frac{177.67 - 2.83}{113}} = 1.24\text{m}$$

For Foundation C2 -

Load = 332.41 kN

$$B = \sqrt{\frac{Load - 2.83}{113}} = \sqrt{\frac{332.41 - 2.83}{113}} = 1.71\text{m}$$

For Foundation C3 -

Load = 177.67 kN

$$B = \sqrt{\frac{Load - 2.83}{113}} = \sqrt{\frac{177.67 - 2.83}{113}} = 1.24\text{m}$$

For Foundation D1 -

Load = 222.12 kN

$$B = \sqrt{\frac{Load - 2.83}{113}} = \sqrt{\frac{222.12 - 2.83}{113}} = 1.39\text{m}$$

For Foundation D2 -

Load = 408.112 kN

$$B = \sqrt{\frac{Load - 2.83}{113}} = \sqrt{\frac{408.112 - 2.83}{113}} = 1.89\text{m}$$

For Foundation D3 -

Load = 222.12 kN

$$B = \sqrt{\frac{Load - 2.83}{113}} = \sqrt{\frac{222.12 - 2.83}{113}} = 1.39\text{m}$$

Since we are considering the foundations as shallow foundations, and according to Terzaghi analaysis which is valid only for shallow foundations, the width of the footing should be equal to or greater than Depth of the foundation. Therefore minimum width of foundation for our structure will be equal to 1.5m (Depth of foundation).

Table 5: Calculations

COLUMN	NET LOAD,KN	D_f,m	q_{us},KN/m2	WIDTH(B), m	B PROVIDED,m
A1	67.285	1.5	140	0.75	1.5
A2	125.24	1.5	140	1.06	1.5
A3	67.285	1.5	140	0.75	1.5
B1	126.28	1.5	140	1.04	1.5
B2	239.056	1.5	140	1.44	1.5
B3	126.28	1.5	140	1.04	1.5
C1	177.67	1.5	140	1.24	1.5
C2	332.41	1.5	140	1.71	2
C3	177.67	1.5	140	1.24	1.5
D1	222.12	1.5	140	1.39	1.5
D2	408.112	1.5	140	1.89	2
D3	222.12	1.5	140	1.39	1.5

5.5 SETTLEMENT CALCULATIONS:

Assuming Load dispersion at 30˚ from the vertical,

The settlement due to primary consolidation is given by:

$$S_c = \frac{C_c}{1+e_0} H_0 \log \frac{\sigma_0 + \Delta\sigma}{\sigma_0}$$

Where, $C_c = 0.009(w_L - 10)$

σ_o = Effective initial overburden pressure = $\gamma \times (D_f + C.L.)$

$\Delta\sigma$ =Vertical stress increment due to footing load = $\frac{Load}{Area\ of\ spread}$

Area of spread = B’× B’, B’=Width of footing at C.L.

H_o = Thickness of clay layer (m)

$e_0 = \frac{G \times \gamma_w}{\frac{\gamma}{1+w}} - 1$,   G= Specific gravity = 2.65,   w = water content

γ_w = Saturated unit wt = 10kN/m^3

Table 6: Settlement Calculation

LAYER	DEPTH OF C.L.(m)	THICKNESS OF THE CLAY LAYER H(m)	σ_v ,KN/m^2	C_c	e_0
1	1.75	0.5	31.5	0.11	0.799
2	2.25	0.5	40.5	0.099	0.779
3	2.875	0.75	51.75	0.13	0.832

Table 7: Calculation for total settlement

Foundation	Layer	Depth of layer (m)	Layer thickness (m)	σ_v KN/m^2	$\Delta\sigma_v$ KN/m^2	C_c	e_0	Settlement ΔH (mm)	Total Settlement (mm)
A1	1	1.75	0.50	31.5	21.96	0.11	0.799	7	15.68
	2	2.25	0.50	40.5	13.28	0.099	0.779	3.41	
	3	2.875	0.75	51.75	8.14	0.13	0.832	5.28	
A2	1	1.75	0.50	31.5	40.89	0.11	0.799	11	22.66
	2	2.25	0.50	40.5	24.74	0.099	0.779	5.66	
	3	2.875	0.75	51.75	15.15	0.13	0.832	6	
A3	1	1.75	0.50	31.5	21.96	0.11	0.799	7	15.68
	2	2.25	0.50	40.5	13.28	0.099	0.779	3.41	
	3	2.875	0.75	51.75	8.14	0.13	0.832	5.28	
B1	1	1.75	0.50	31.5	41.23	0.11	0.799	11.2	23.26
	2	2.25	0.50	40.5	24.94	0.099	0.779	5.72	
	3	2.875	0.75	51.75	15.27	0.13	0.832	6.34	
B2	1	1.75	0.50	31.5	78.04	0.11	0.799	16.54	36.71
	2	2.25	0.50	40.5	47.20	0.099	0.779	9.18	
	3	2.875	0.75	51.75	28.91	0.13	0.832	10.4	
B3	1	1.75	0.50	31.5	41.23	0.11	0.799	11.2	23.26
	2	2.25	0.50	40.5	24.94	0.099	0.779	5.72	
	3	2.875	0.75	51.75	15.27	0.13	0.832	6.34	
C1	1	1.75	0.50	31.5	58.01	0.11	0.799	13.85	29.48
	2	2.25	0.50	40.5	35.09	0.099	0.779	7.45	
	3	2.875	0.75	51.75	21.49	0.13	0.832	8.17	
C2	1	1.75	0.50	31.5	108.53	0.11	0.799	20	45.5
	2	2.25	0.50	40.5	65.65	0.099	0.779	12	
	3	2.875	0.75	51.75	40.21	0.13	0.832	13.5	
C3	1	1.75	0.50	31.5	58.01	0.11	0.799	13.85	29.48
	2	2.25	0.50	40.5	35.09	0.099	0.779	7.45	
	3	2.875	0.75	51.75	21.49	0.13	0.832	8.17	

D1	1	1.75	0.50	31.5	75.52	0.11	0.799	14.12	32.6
	2	2.25	0.50	40.5	43.87	0.099	0.779	8.65	
	3	2.875	0.75	51.75	26.87	0.13	0.832	9.82	
D2	1	1.75	0.50	31.5	133.44	0.11	0.799	19.5	47
	2	2.25	0.50	40.5	80.72	0.099	0.779	13	
	3	2.875	0.75	51.75	49.44	0.13	0.832	14.6	
D3	1	1.75	0.50	31.5	75.52	0.11	0.799	14.12	32.6
	2	2.25	0.50	40.5	43.87	0.099	0.779	8.65	
	3	2.875	0.75	51.75	26.87	0.13	0.832	9.82	

Allowable total settlement in clay is 75mm as per IS 1904-1986), Code of practice for design and construction of foundation on soils and our maximum settlement is 47mm for D2 which is in permissible limit. Hence our design is safe in settlement.

5.6 RCC DESIGN OF FOOTINGS

DESIGN PARAMETERS:

Concrete and Rebar Properties

Unit Weight of Concrete : 25 kN/m3

Strength of Concrete : 25 N/mm2

Yield Strength of Steel : 415 N/mm2

Minimum Bar Size : Ø6

Maximum Bar Size : Ø32

Minimum Bar Spacing : 50 mm

Maximum Bar Spacing : 500

Footing Clear Cover (F, CL) : 50 mm

Soil Properties

Soil Type : Un-Drained

Unit Weight : 18 kN/m3

Soil Bearing Capacity : 140 kN/m2

Soil Surcharge : 0 kN/m2

Depth of Soil above Footing : 1500 mm

Un-drained Shear Strength : 100 kN/m2

Design Calculations

Initial Length (L_o) = 1.5 m

Initial Width (W_o) = 1.5 m

Area from initial length and width, $A_o = L_o \times W_o$ = 2.250 m^2

Min. area required from bearing pressure, A min = P / q_{max} = 0.826 m^2

Moment Calculation

Check Trial Depth against moment (w.r.t. X Axis)

Effective Depth = $D - (cc + 0.5 \times d_b)$ =0.053m

Governing moment (M_u) = 6.174 kNm

As Per IS 456 2000,

Limiting Factor1 (K_{umax}) = $\frac{700}{1100+0.87f_y}$ = 0.479

Limiting Factor2 (R_{umax}) = 0.36x f_{ck}x K_{umax}x(1-0.42x K_{umax}) = 3444.29 KN/m^2

Limiting moment of reaction (M_{umax}) = R_{umax} xBxd_o^2

=14.51KNm

M_u <= M_{umax} hence, safe

Check Trial Depth against moment (w.r.t. Z Axis)

Effective Depth = $D - (cc + 0.5 \times d_b)$ =0.053m

Governing moment (M_u) = 6.163 kNm

As Per IS 456 2000,

Limiting Factor1 (K_{umax}) = $\frac{700}{1100+0.87f_y}$ = 0.479

Limiting Factor2 (R_{umax}) = 0.36x f_{ck}x K_{umax}x(1-0.42x K_{umax}) = 3444.29 KN/m^2

Limiting moment of reaction (M_{umax}) = R_{umax} xBxd_o^2

=14.51KNm

$M_u <= M_{umax}$ hence, safe.

Shear Calculation

Check Trial Depth for one way shear (Along X Axis) (Shear Plane Parallel to X Axis)

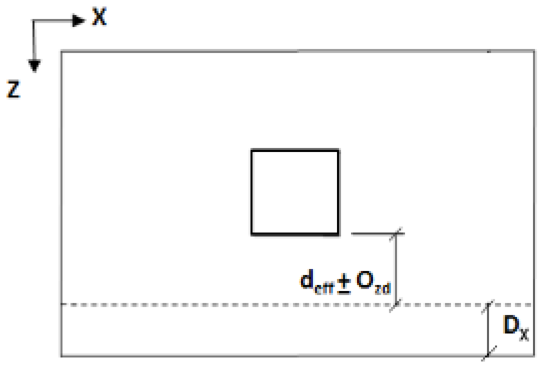


Fig. 19 One way shear along X axis

D_X = 0.053 m

Shear Force(S) = 18.7 kN

Shear Stress (T_v) = 235.9 kN/m^2

Percentage Of Steel (P_t) = 0.44

As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete (T_c) = 462.420 kN/m^2

$T_v < T_c$ hence, safe.

Check Trial Depth for one way shear (Along Z Axis) (Shear Plane Parallel to Z Axis)

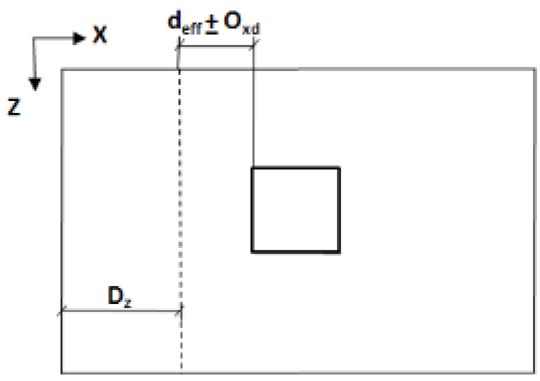


Fig. 20 One way shear along X axis

$D_Z = 0.053$ m

Shear Force(S) = 18.72 kN

Shear Stress(T_v) = 235.5 kN/m2

Percentage Of Steel(P_t) = 0.4376

As Per IS 456 2000 Clause 40 Table 19

Shear Strength Of Concrete(T_c) = 462.776 kN/m^2

$T_v < T_c$ hence, safe.

Check Trial Depth for two way shear

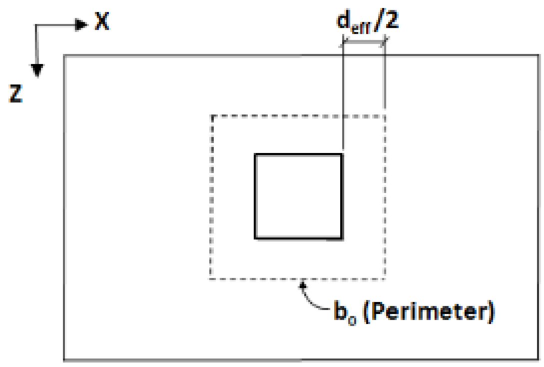


Fig. 21 Two way shear

Shear Force(S) = 48.47 kN

Shear Stress(T_v) = 647.7 kN/m^2

As Per IS 456 2000 Clause 31.6.3.1

K_s = min [(0.5+β),1]= 1

Shear Strength(T_c)= $0.25 x\sqrt{f_{ck}}$ = 1250 kN/m^2

K s x T c = 1250 kN/m^2

$T_v \le K_s$ x T_c hence, safe.

<u>Reinforcement Calculation</u>

Calculation of Maximum Bar Size

Along X Axis

Bar diameter corresponding to max bar size (d_b) = 12 mm

As Per IS 456 2000 Clause 26.2.1

Development Length(l_d) = $\frac{d_o X 0.87 X f_y}{4 X \tau_{bd}}$ = 0.484 m

Allowable Length(l_{db}) = $[\frac{B-b}{2} - cc]$ = 0.55 m

l_{db} >=l_d hence, safe

Along Z Axis

Bar diameter corresponding to max bar size(d_b)= 12 mm

As Per IS 456 2000 Clause 26.2.1

Development Length(l_d) = $\frac{d_o X 0.87 X f_y}{4 X \tau_{bd}}$ = 0.484 m

Allowable Length(l_{db}) = $\frac{H-h}{2} - cc$ = 0.55 m

L_{db} >= l_d hence, safe

<u>Bottom Reinforcement Design</u>

Along Z Axis

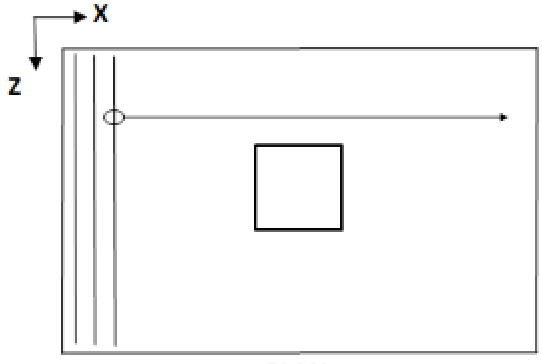


Fig. 22 Bottom reinforcement design along Z axis

For moment w.r.t. X Axis (M_x)

As Per IS 456 2000 Clause 26.5.2.1

Minimum Area of Steel (A_{stmin}) = 190.8 mm^2

Calculated Area of Steel (A_{st}) = 347.90 mm^2

Provided Area of Steel ($A_{st,Provided}$) = 347.90 mm^2

A_{stmin} <= $A_{st,Provided}$ Steel area is accepted

Selected bar Size (d_b) = Ø6

Minimum spacing allowed (S_{min})= 46.0 mm

Selected spacing (S)= 116.16 mm

S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size.

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø6 @ 115 mm c.c.

Along X Axis

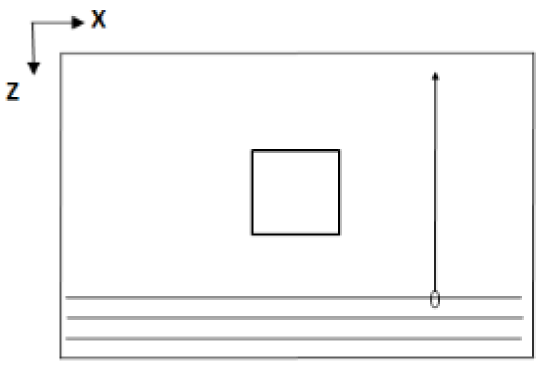


Fig. 23 Bottom reinforcement design along X axis

For moment w.r.t. Z Axis (M_z)

As Per IS 456 2000 Clause 26.5.2.1

Minimum Area of Steel (A_{stmin}) = 190.8 mm^2

Calculated Area of Steel (A_{st}) = 347.26 mm^2

Provided Area of Steel ($A_{st,Provided}$) = 347.26 mm^2

A_{stmin} <= $A_{st,Provided}$ Steel area is accepted

Selected bar Size (d_b) = Ø6

Minimum spacing allowed (S_{min})= 50.0 mm

Selected spacing (S)= 116.16 mm

S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size.

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø6 @ 115 mm c.c.

Top Reinforcement Design

Along Z Axis

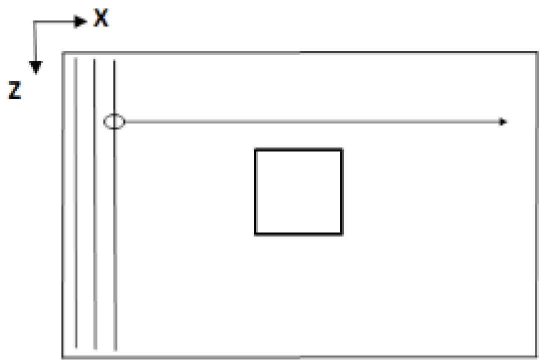


Fig. 24 Top reinforcement design along Z axis

Minimum Area of Steel (A_{stmin}) = 190.8 mm^2

Calculated Area of Steel (A_{st}) = 521.67 mm^2

Provided Area of Steel ($A_{st,Provided}$) = 521.67 mm^2

A_{stmin} <= $A_{st,Provided}$ Steel area is accepted

Governing Moment = 8.89 KNm

Selected bar Size (d_b) = Ø6

Minimum spacing allowed (S_{min})= 50.0 mm

Selected spacing (S)= 77.44 mm

S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size.

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø6 @ 75 mm c.c.

Along X Axis

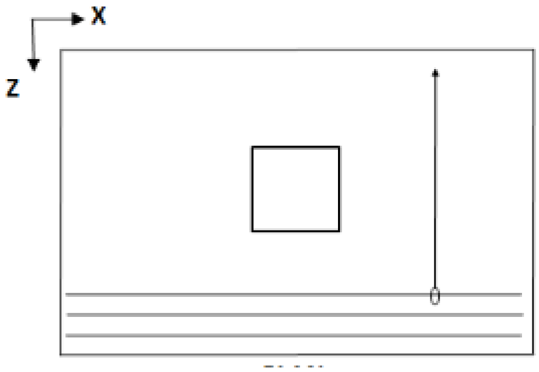


Fig. 25 Top reinforcement design along X axis

Minimum Area of Steel (A_{stmin}) = 190.8 mm^2

Calculated Area of Steel (A_{st}) = 190.8 mm^2

Provided Area of Steel ($A_{st,Provided}$) = 190.8 mm^2

A_{stmin} <= $A_{st,Provided}$ Steel area is accepted

Governing Moment = 8.89 KNm

Selected bar Size (d_b) = Ø6

Minimum spacing allowed (S_{min})= 50.0 mm

Selected spacing (S)= 232.33 mm

S_{min} <= S <= S_{max} and selected bar size < selected maximum bar size.

The reinforcement is accepted.

Based on spacing reinforcement increment; provided reinforcement is

Ø6 @ 230 mm c.c.

Similarly, for other foundations have also be calculated and are represented in following table,

Table 8: Reinforcement Details

Footing No.	Footing Reinforcement			
	Bottom Reinforcement (Mz)	Bottom Reinforcement (Mx)	Top Reinforcement (Mz)	Top Reinforcement (Mx)
A1	Ø6 @ 115 mm c/c	Ø6 @ 115 mm c/c	Ø6 @ 230 mm c/c	Ø6 @ 75 mm c/c
A2	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 195 mm c/c	Ø6 @ 75 mm c/c
A3	Ø6 @ 115 mm c/c	Ø6 @ 115 mm c/c	Ø6 @ 230 mm c/c	Ø6 @ 75 mm c/c
B1	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 170 mm c/c	Ø6 @ 75 mm c/c
B2	Ø6 @ 65 mm c/c	Ø6 @ 65 mm c/c	Ø6 @ 150 mm c/c	Ø6 @ 150 mm c/c
B3	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 170 mm c/c	Ø6 @ 75 mm c/c
C1	Ø6 @ 95 mm c/c	Ø6 @ 95 mm c/c	Ø6 @ 150 mm c/c	Ø6 @ 150 mm c/c
C2	Ø6 @ 50 mm c/c	Ø6 @ 50 mm c/c	Ø6 @ 115 mm c/c	Ø6 @ 150 mm c/c
C3	Ø6 @ 95 mm c/c	Ø6 @ 95 mm c/c	Ø6 @ 150 mm c/c	Ø6 @ 150 mm c/c
D1	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 150 mm c/c	Ø6 @ 150 mm c/c
D2	Ø6 @ 60 mm c/c	Ø6 @ 60 mm c/c	Ø6 @ 110 mm c/c	Ø6 @ 110 mm c/c
D3	Ø6 @ 75 mm c/c	Ø6 @ 75 mm c/c	Ø6 @ 150 mm c/c	Ø6 @ 150 mm c/c

Table 9: Foundation Geometry

Footing No.	Foundation Geometry		
	Length(m)	Width(m)	Thickness(m)
A1	1.5	1.5	0.106
A2	1.5	1.5	0.106
A3	1.5	1.5	0.106
B1	1.5	1.5	0.106
B2	1.5	1.5	0.156
B3	1.5	1.5	0.106
C1	1.5	1.5	0.156
C2	1.5	1.5	0.156
C3	1.5	1.5	0.156
D1	1.5	1.5	0.156
D2	1.5	1.5	0.206
D3	1.5	1.5	0.156

5.7 STAAD PRO ANALYSIS

STAAD Pro is a structural design and analysis tool which was developed by Research Engineers. Research Engineers was later bought by a Pennsylvania based CAD/CAM software company Bentley Systems. STAAD Pro is considered number 1 structural analysis tool and is widely used all over the world. STAAD Pro is the ultimate choice of more than a million structural engineers all over the world and the reason being the number one choice is its ease of use and availability of all the necessary tools which are required to complete an analytic process on different structures. STAAD Pro is the professional's choice for steel, concrete, timber, aluminum and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels, bridges, piles and much more.

Features of STAAD Pro:

- "Concurrent Engineering" based user environment for model development, analysis, design, visualization and verification
- Full range of analysis including static, P-delta, pushover, response spectrum, time history, cable (linear and non-linear), buckling and steel, concrete and timber design included with no extra charge
- Object-oriented intuitive 2D/3D graphical model generation
- Pull down menus, floating tool bars, tool tip help
- Quick data input through property sheets and spreadsheets

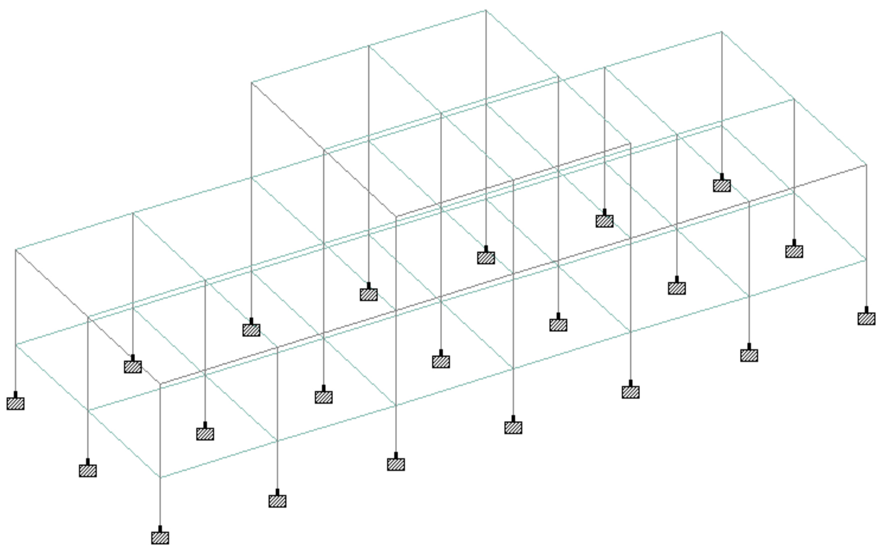


Fig.26 Shopping complex

Load Calculation on STAAD Pro:

Table 10: Load calculated from STAAD Pro

Reactions

		Horizontal	Vertical	Horizontal
Node	L/C	FX (kN)	FY (kN)	FZ (kN)
52	1:DL	-0.039	51.314	-0.089
	2:LL	0.062	17.094	0.058
53	1:DL	0.178	91.151	-0.021
	2:LL	0.063	34.263	0.092
54	1:DL	0.113	124.820	0.214
	2:LL	0.063	51.791	0.157
55	1:DL	0.000	149.190	0.187
	2:LL	0.000	68.424	0.143
56	1:DL	-0.113	124.820	0.214
	2:LL	-0.063	51.791	0.157
57	1:DL	-0.178	91.151	-0.021
	2:LL	-0.063	34.263	0.092
58	1:DL	0.039	51.314	-0.089
	2:LL	-0.062	17.094	0.058
59	1:DL	-0.092	91.051	-0.000
	2:LL	0.057	33.981	-0.000
60	1:DL	0.318	166.679	-0.000
	2:LL	0.110	67.775	-0.000
61	1:DL	0.179	222.452	0.000
	2:LL	0.101	101.263	0.000

Table 10 (contd.)

62	1:DL	0.000	265.278
	2:LL	0.000	132.524
63	1:DL	-0.179	222.452
	2:LL	-0.101	101.263
64	1:DL	-0.318	166.679
	2:LL	-0.110	67.775
65	1:DL	0.092	91.051
	2:LL	-0.057	33.981
66	1:DL	-0.039	51.314
	2:LL	0.062	17.094
67	1:DL	0.178	91.151
	2:LL	0.063	34.263
68	1:DL	0.113	124.820
	2:LL	0.063	51.791
69	1:DL	0.000	149.190
	2:LL	0.000	68.424
70	1:DL	-0.113	124.821
	2:LL	-0.063	51.791
71	1:DL	-0.178	91.151
	2:LL	-0.063	34.263
72	1:DL	0.039	51.314
	2:LL	-0.062	17.094

Load was also calculated manually initially, the following table shows a comparison,

Table 11: Comparison

COLUMN	NET LOAD,KN (from calculation)	NET LOAD,KN (from STAAD)
A1	67.06	68.4
A2	125.24	125.03
A3	67.05	68.4
B1	125.06	125.41
B2	238.83	234.42
B3	125.06	125.41
C1	182.11	176.61
C2	328.07	323.71
C3	182.11	176.61
D1	221.12	217.61
D2	408.66	397.79
D3	222.12	217.61

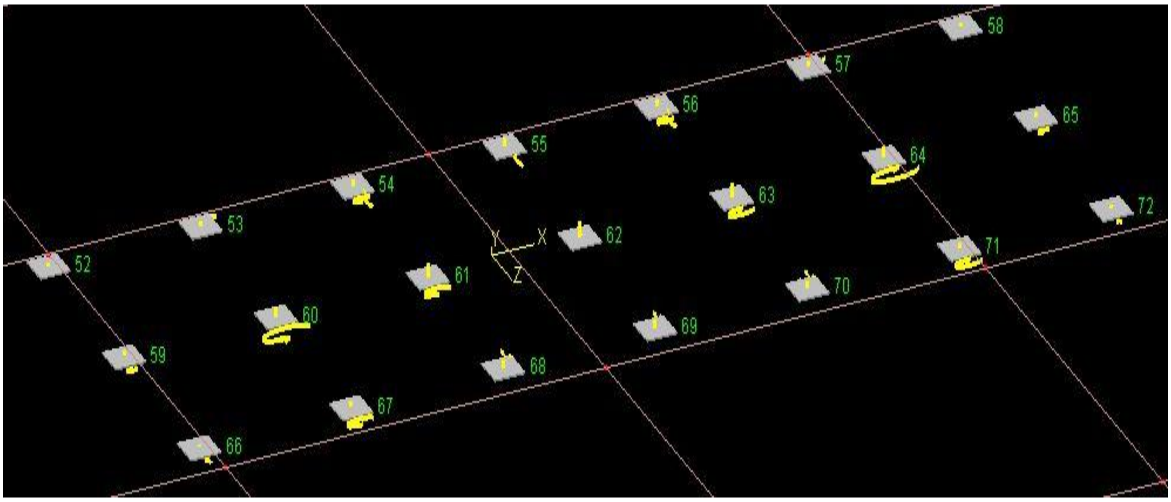


Fig 27: Foundation diagram for table 10

RESULTS AND CONCLUSIONS

Test data of three tests namely- PLT, SPT, DCPT conducted by technicians from IIT-Roorkee is provided and safe bearing capacity of the soil at different depths is calculated on basis of the test data

After analyzing the soil from different test data, bearing Capacity of the soil according to 3 performed tests that is Plate Load test, Standars penetration test and Direct cone penetration test are calculated. From PLT value is , from SPT value is , from DCPT value is . Minimum net allowable bearing pressure is from PLT.

From the calculated N value which is 18, value of unconfined compressive strength (20 t/m^2) and unconfined shear strength (10 t/m^2) is known. Also it can be said that our soil is stiff clay.

PLT can be considered as the most effective and easy to perform test. Effective in the sense that it gives the direct relationship between allowable pressure and settlement at the depth of the footing also this test does not give the ultimate settlement particularly in case of cohesive soil as it is a short duration test.

There is a great variation in bearing capacity due to variation in ground water level and every method deals with this effect differently.

All the calculation related to soil analysis has been done, like bearing capacity and allowed settlement from various tests is known also the soil layer at which footing has to be designed is clay of low compressibility.

This project helped us to study, analyse and calculate the Bearing capacity of the soil of a real life location, Pratap Vihar in Ghaziabad, Uttar Pradesh. Safe bearing capacity(SBC) at depth of 1.5 m is coming out to be 140 kN/m^2. Based on the calculation of SBC, isolated (shallow) foundation is designed for a proposed shopping complex on the same soil profile at depth = 1.5m.

Total load on each foundation is calculated by considering every Load combination and are also compared among calculated ones and computed ones from STAAD. Dimensions of footings are also calculated for Safe bearing Capacity. Footing depth is calculated by considering all the criteria stated in Indian Codes. R.C.C Design for all the foundations is done and steel required is calculated. Settlement for each footing is calculated by Indian Standards and settlements are within permissible limits.

According to design conducted manually and by use of software the final result for the design of shopping complex in the given locality are as follows,

Table 12: Final results

Foundation	**Total Load (kN)**	**Dimensions (L × B × H)**	**Settlement (mm)**
A1	67.285	1.5m ×1.5m×0.106m	15.68
A2	125.24	1.5m ×1.5m×0.106m	22.68
A3	67.285	1.5m ×1.5m×0.106m	15.68
B1	126.28	1.5m ×1.5m×0.106m	23.26
B2	239.056	1.5m ×1.5m×0.156m	36.71
B3	126.28	1.5m ×1.5m×0.106m	23.26
C1	177.67	1.5m ×1.5m×0.156m	29.48
C2	332.41	2.0m ×2.0m×0.156m	45.5
C3	177.67	1.5m ×1.5m×0.156m	29.48
D1	222.12	1.5m ×1.5m×0.156m	32.6
D2	408.112	2.0m ×2.0m×0.206m	47
D3	222.12	1.5m ×1.5m×0.156m	32.6

REFERENCES

- IS 1904-1986 (reaffirmed 2006), General requirements for foundation.
- IS 456-2000, Plain and reinforced concrete-code of practice.
- IS 6403-1981(reaffirmed 2002), Code of practice for determination of bearing capacity of soil of shallow foundations.
- IS 8009 part 1- 1976 (reaffirmed 2003), for calculation of settlement.
- Limit state design, by B.C. Punmia.
- Soil mechanics and foundation, by B.C. Punmia.
- Soil testing for engineers by S. Mittal, JP Shukla.
- Table 10, Table 4 from Basic and Applied Soil Mechanics, Ranjan and Rao.

APPENDIX

STAAD COMMAND FILE:

STAAD SPACE

START JOB INFORMATION

ENGINEER DATE 06-Apr-15

END JOB INFORMATION

INPUT WIDTH 79

UNIT METER KN

JOINT COORDINATES

1 0 0 0; 2 4 0 0; 3 8 0 0; 4 12 0 0; 5 16 0 0; 6 20 0 0; 7 24 0 0; 8 0 3 0;

9 4 3 0; 10 8 3 0; 11 12 3 0; 12 16 3 0; 13 20 3 0; 14 24 3 0; 15 0 0 4.25;

16 4 0 4.25; 17 8 0 4.25; 18 12 0 4.25; 19 16 0 4.25; 20 20 0 4.25;

21 24 0 4.25; 22 0 3 4.25; 23 4 3 4.25; 24 8 3 4.25; 25 12 3 4.25;

26 16 3 4.25; 27 20 3 4.25; 28 24 3 4.25; 29 0 0 8.5; 30 4 0 8.5; 31 8 0 8.5;

32 12 0 8.5; 33 16 0 8.5; 34 20 0 8.5; 35 24 0 8.5; 36 0 3 8.5; 37 4 3 8.5;

38 8 3 8.5; 39 12 3 8.5; 40 16 3 8.5; 41 20 3 8.5; 42 24 3 8.5; 43 8 6 0;

44 12 6 0; 45 16 6 0; 46 8 6 4.25; 47 12 6 4.25; 48 16 6 4.25; 49 8 6 8.5;

50 12 6 8.5; 51 16 6 8.5; 52 0 -1.5 0; 53 4 -1.5 0; 54 8 -1.5 0; 55 12 -1.5 0;

56 16 -1.5 0; 57 20 -1.5 0; 58 24 -1.5 0; 59 0 -1.5 4.25; 60 4 -1.5 4.25;

61 8 -1.5 4.25; 62 12 -1.5 4.25; 63 16 -1.5 4.25; 64 20 -1.5 4.25;

65 24 -1.5 4.25; 66 0 -1.5 8.5; 67 4 -1.5 8.5; 68 8 -1.5 8.5; 69 12 -1.5 8.5;

70 16 -1.5 8.5; 71 20 -1.5 8.5; 72 24 -1.5 8.5;

MEMBER INCIDENCES

1 8 9; 2 9 10; 3 10 11; 4 11 12; 5 12 13; 6 13 14; 7 1 8; 8 2 9; 9 3 10;

10 4 11; 11 5 12; 12 6 13; 13 7 14; 14 22 23; 15 23 24; 16 24 25; 17 25 26;

18 26 27; 19 27 28; 20 15 22; 21 16 23; 22 17 24; 23 18 25; 24 19 26; 25 20 27;

26 21 28; 27 36 37; 28 37 38; 29 38 39; 30 39 40; 31 40 41; 32 41 42; 33 29 36;

34 30 37; 35 31 38; 36 32 39; 37 33 40; 38 34 41; 39 35 42; 40 8 22; 41 9 23;

42 10 24; 43 11 25; 44 12 26; 45 13 27; 46 14 28; 47 22 36; 48 23 37; 49 24 38;

50 25 39; 51 26 40; 52 27 41; 53 28 42; 54 10 43; 55 11 44; 56 12 45; 57 24 46;

58 25 47; 59 26 48; 60 38 49; 61 39 50; 62 40 51; 63 43 46; 64 46 49; 65 49 50;
66 50 51; 67 51 48; 68 48 45; 69 45 44; 70 44 43; 71 46 47; 72 47 48; 73 44 47;
74 47 50; 115 1 52; 116 2 53; 117 3 54; 118 4 55; 119 5 56; 120 6 57; 121 7 58;
122 15 59; 123 16 60; 124 17 61; 125 18 62; 126 19 63; 127 20 64; 128 21 65;
129 29 66; 130 30 67; 131 31 68; 132 32 69; 133 33 70; 134 34 71; 135 35 72;
ELEMENT INCIDENCES SHELL
75 8 9 23 22; 76 9 10 24 23; 78 10 11 25 24; 80 11 12 26 25; 81 12 13 27 26;
82 13 14 28 27; 83 22 23 37 36; 84 23 24 38 37; 86 24 25 39 38; 88 25 26 40 39;
89 26 27 41 40; 90 27 28 42 41; 99 43 46 47 44; 100 46 49 50 47;
101 50 51 48 47; 102 48 45 44 47; 103 1 2 16 15; 104 2 3 17 16; 105 3 4 18 17;
106 4 5 19 18; 107 5 6 20 19; 108 6 7 21 20; 109 15 16 30 29; 110 16 17 31 30;
111 17 18 32 31; 112 18 19 33 32; 113 19 20 34 33; 114 20 21 35 34;
ELEMENT PROPERTY
75 76 78 80 TO 84 86 88 TO 90 99 TO 102 THICKNESS 0.15
103 TO 114 THICKNESS 0.15
DEFINE MATERIAL START
ISOTROPIC CONCRETE
E 2.17185e+007
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
TYPE CONCRETE
STRENGTH FCU 27579
END DEFINE MATERIAL
MEMBER PROPERTY AMERICAN
7 TO 13 20 TO 26 33 TO 39 54 TO 62 115 TO 135 PRIS YD 0.3 ZD 0.3
1 TO 6 14 TO 19 27 TO 32 40 TO 53 63 TO 74 PRIS YD 0.25 ZD 0.23
CONSTANTS
MATERIAL CONCRETE ALL
SUPPORTS
52 TO 72 FIXED
LOAD 1 LOADTYPE Dead TITLE DL
ELEMENT LOAD

```
78 80 86 88 103 TO 114 PR GY -1.5
SELFWEIGHT Y -1
LOAD 2 LOADTYPE Live REDUCIBLE TITLE LL
ELEMENT LOAD
78 80 86 88 103 TO 114 PR GY -4
PERFORM ANALYSIS
START CONCRETE DESIGN
CODE INDIAN
BRACE 0 ALL
CLEAR 0.025 ALL
FC 25000 ALL
FYMAIN 415000 ALL
FYSEC 415000 ALL
TRACK 1 ALL
DESIGN BEAM 1 TO 6 14 TO 19 27 TO 32 40 TO 53 63 TO 74
DESIGN COLUMN 7 TO 13 20 TO 26 33 TO 39 54 TO 62 115 TO 135
DESIGN ELEMENT 75 76 78 80 TO 84 86 88 TO 90 99 TO 114
END CONCRETE DESIGN
PERFORM ANALYSIS
FINISH
```