KATHMANDU UNIVERSITY

SCHOOL OF ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

FINAL REPORT ON

DEMOSTRATIVE MODEL OF DIFFERENT TYPES OF FOOTINGS

SUBMITTED TO

Er. Sudip Bajgain

Teaching Assistant

Department of Civil Engineering

SUBMITTED BY

CIVIL 2nd year/1st semester

GROUP NUMBER: 06

Nilesh Jha (16)

Prabin Kumar Khadka (17)

Suraj Khadka (18)

Sarita Sapkota (44)

Prabin Shah (45)

Saras Mainali (63)

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CERTIFICATION

THIRD SEMESTER PROJECT ON

DEMONSTRATIVE MODEL OF ISOLATED AND COMBINED FOOTINGS

BY:

NILESH JHA (028056-20)

PRABIN KUMAR KHADKA (028057-20)

SURAJ KHADKA (028058-20)

SARITA SAPKOTA (028084-20)

PRABIN SHAH (028085-20)

SARAS MAINALI (027880-20)

APPROVED BY:

1. PROJECT SUPERVISOR

(Signature) (Name) (Date)

2. PROJECT COORDINATOR

(Signature) (Name) (Date)

3. HEAD OF DEPARTMENT

(Signature) (Name) (Date)

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Abstract

The project is focused on the preparation of the demonstrative model of isolated and combined footings used in the construction of different types of buildings and structures worldwide. The project model will be constructed on reduced scale and provide an outlook on the various footing types. This project will help us to understand the significance of footings and their applications and to be familiar with the construction process of the footings. In addition, the working mechanism as well as the load transfer mechanism of the footings under different circumstances will also be known.

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Chapter 1: Introduction

1.1. Footings

Footing is the lowest load bearing structure of the building which is usually situated under the ground level. It is the part of the foundation constructed with the concrete or brick work masonry and behaves as a base to the floor columns and floor walls. It mainly supports the foundation and the structures, prevents the settling. There are various types of footing used for different purposes depending of the type of building and the soil. Depending on Soil bearing capacity of a particular location. Different Types of Footings are selected and constructed.

1.2. Introduction to Foundation

Foundation is an important part of the structure which transfers the load of the structure to the foundation soil. The foundation distributes the load over a large area. So that pressure on the soil does not exceed its allowable bearing capacity and restricts the settlement of the structure within the permissible limits. Foundation increases the stability of the structure.

Footing is a part of foundation which is constructed with concrete or brickwork masonry and acts as a base to the floor columns and floor walls. The main function of footing is to transfer the vertical loads directly to the soil. The term footing is used in conjunction with Shallow foundation commonly.

Figure 1. Isolated Footing

Chapter 2: Objectives and Limitations

2.1. Objectives

- Primary Objective
    - To prepare the demonstrative model of different types of footings.
- Secondary Objective
    - To understand the application of footings in various circumstances
    - To know the load transfer mechanism in footings.

2.2. Limitations

- Some of the hooks of stirrups might not be perfectly bend in 135°.
- GI wire is used instead of Fe500TMT rods.

Chapter 3: Literature Review

Foundations is the lower portion the building, usually located below ground level, which transmits the load of the super structure to the sub soil a foundation is therefore that part of the structure which is in direct contact with the ground to which the loads are transmitted. A lowermost portion of the foundation which is in direct contact with the sub soil is called the footing.

Functions of foundations

1. Reduction of load intensity
2. Even distribution of load
3. Provision of level surface
4. Lateral stability
5. Safety against under mining
6. Protection against soil movements

Types of foundations

Foundations

Shallow Foundation

Its depth is equal to or less than its width

Deep Foundation

Its depth is equal to or greater than its width

Spread Footing

- Single Footing
- Stepped Footing
- Slopped Footing
- Wall Footing
- Stepped Wall Footing
- Grillage Foundation

Combined Footing

- Rectangular Combined Footing
- Trapezoidal Combined Footing
- Column-wall Footing

Strap Footing

Mat (Raft) Footing

- Solid Slab System
- Beam Slab System
- Cellular System

Deep Strip Footing

Pile Foundation

- Friction Pile
- Combined Pile
- Compaction Pile

Pier (drilled

- Masonry or concrete pier
- Drilled Caissons

Wall (caissons)

- Circular foundations
- Rectangular Foundations

Different kinds of footings are designed based on the soil type, the type of structure, the site topography, and other local requirements arising during the design process.

3.1.1 Continuous wall footing

The footing which supports a long masonry or RCC wall is known as a continuous footing. It can be either simple or stepped.

Generally, width of the footing should be at least equal to twice the width of wall that is rested on it. In this case, the width of the footing is smaller than the length of the footing, offering continuous vertical support to the structure. Basically, it runs throughout the length of the wall. This type of footing is not economical.

Use of Continuous Wall Footing: Continuous wall footings are used to support the foundation walls and load-bearing walls.

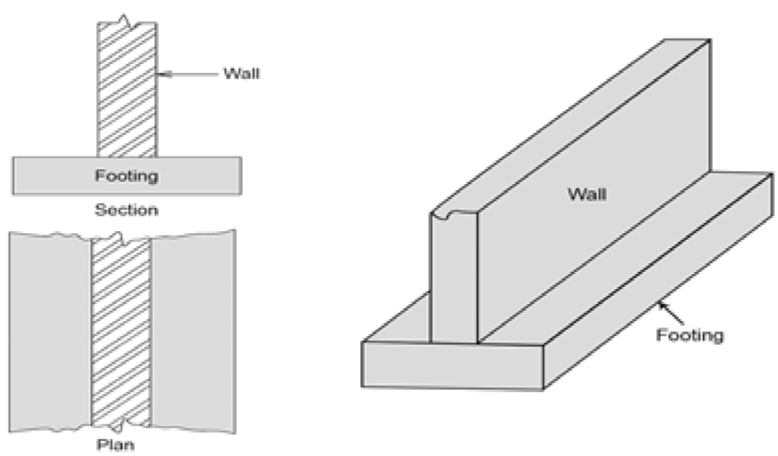

Figure 2. Continuous footing

Source: https://gharpedia.com/blog/various-types-of-footings-for-your-house/

3.1.2 Isolated footing

A footing that supports an individual column is known as an isolated footing. This kind of footing can be Pad, stepped, sloped or with isolated beam and slab. Where good soil is available, these footings are economical. Use of Isolated Footing: Isolated footings are used as shallow foundation in order to transfer concentrated loads to the ground.

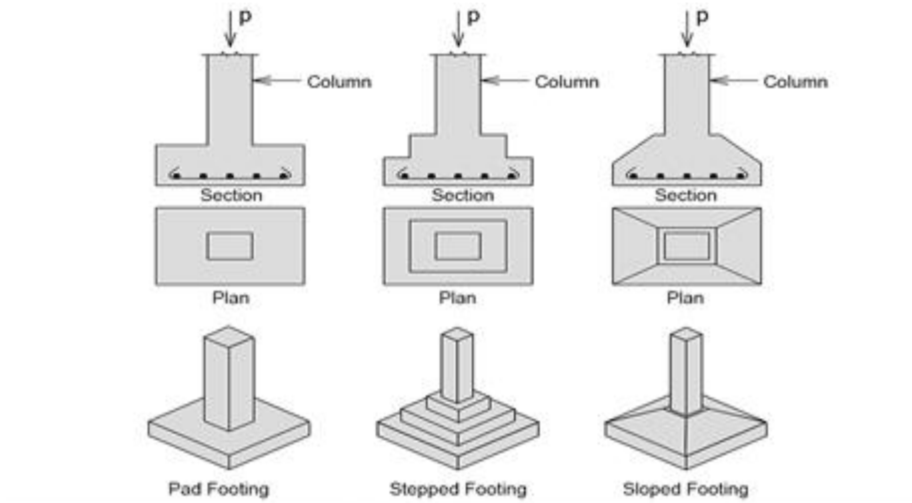

Figure 3. Isolated footing

Source: https://gharpedia.com/blog/various-types-of-footings-for-your-house/

3.1.3 Combined Footing

A footing that supports two or more columns is known as a combined footing. It is used when two or more columns are close to each other or two or more individual footings of a column would overlap. Combined footing may be trapezoidal or rectangular in plan. A trapezoidal footing is provided when the load of one column is greater than the other.

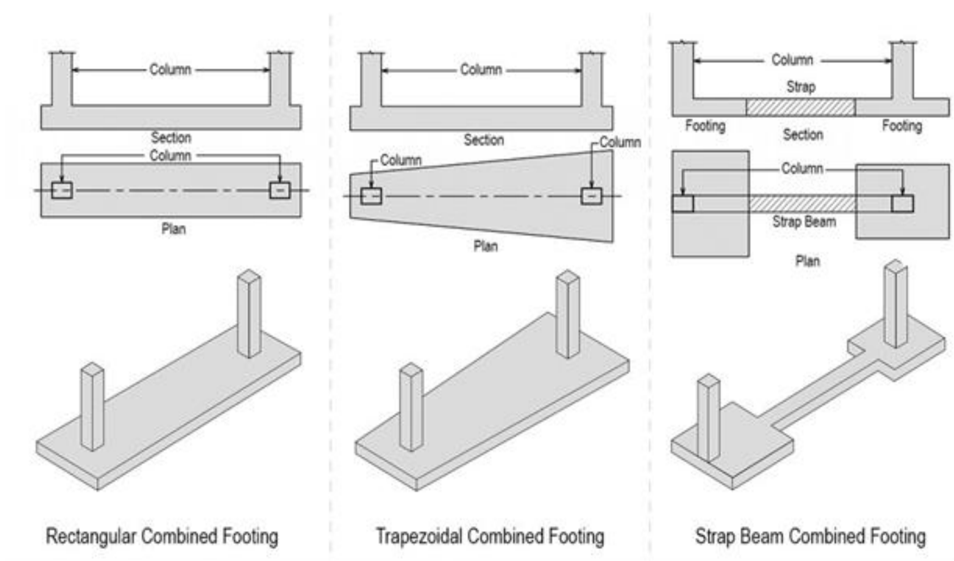

Figure 4. Combined Footing

Source: https://gharpedia.com/blog/various-types-of-footings-for-your-house/

Use of Combined Footing: Combined footings are used to transfer loads of closely spaced column to the ground or when the column faces the boundary of plot.

3.1.4 Strip footing

A footing which supports a number of columns in a line has to be a combined footing known as strip footing. It is used when the row of a column is closely spaced and their spread footings overlap with each other. A strip footing is also known as a continuous footing.

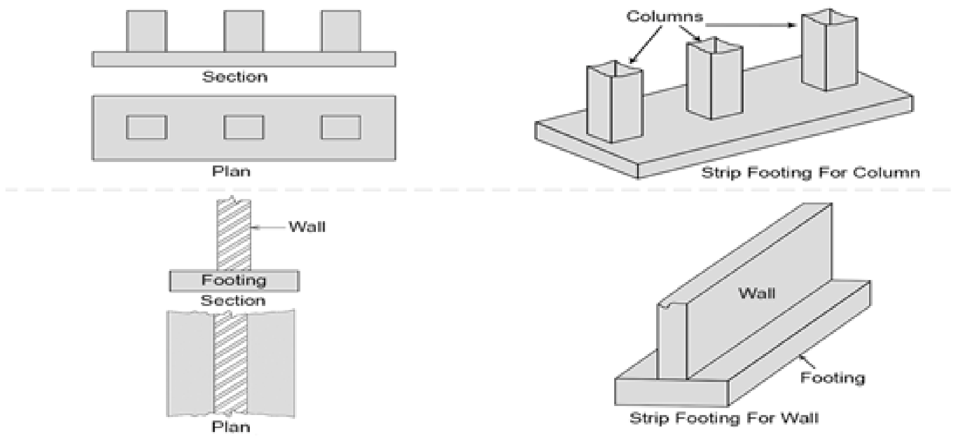

Figure 5. Strip Footing

Source: https://gharpedia.com/blog/various-types-of-footings-for-your-house/

Use of Strip Footing: Strip footings are used to transfer loads of closely spaced raw of columns to the ground.

3.1.5 Strap footing

When a distance between the two columns supported on combined footing becomes large, the cost increases rapidly. The strap footing is an economical option in such cases.

Use of Strap Footing: Generally, strap footings are used in conjunction with columns of adjoining property.

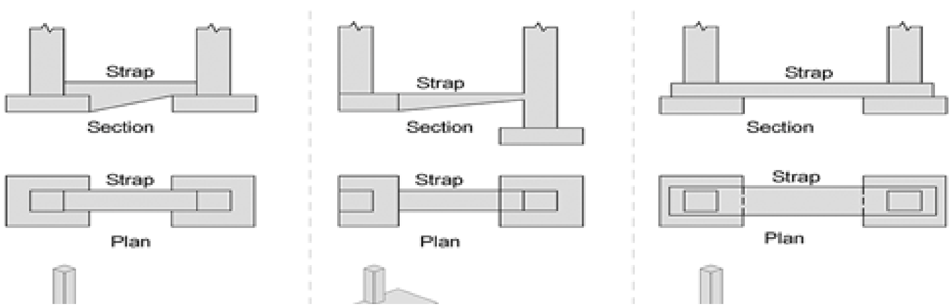

Figure 6. Strap Footing

Source:https://gharpedia.com/blog/various-types-of-footings-for-your-house

3.1.6 Raft footing

If loads transmitted by the columns in a structure are heavy and the allowable soil pressure is small then footing requires more area. In such a case, it may be better to provide continuous footing under all columns and walls. Such kind of footing is called a Raft Footing.

Mat foundation is a suitable solution for the construction of the building where the soil bearing capacity is very low, as it transfers the weight of the building over the entire footprint of the building.

Use of raft footing: It is widely used when soil has low load bearing capacity.

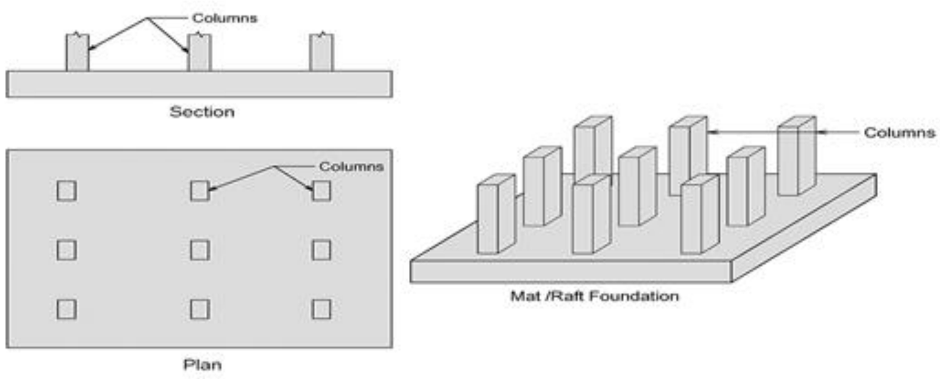

Figure 7. Raft Footing

Source: https://gharpedia.com/blog/various-types-of-footings-for-your-house/

3.1.7 Pile footing

It’s a type of deep foundation used in low bearing capacity of soil. It supports load either by skin friction , end bearing or by end cum bearing.

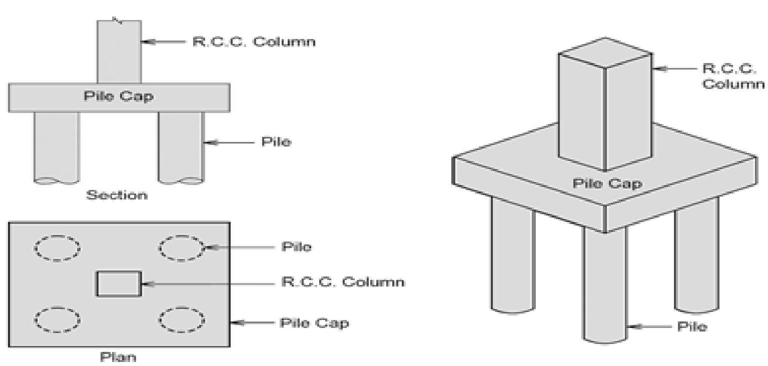

Figure 8. Pile Footing

Source: https://gharpedia.com/blog/various-types-of-footings-for-your-house

3.2 Types of loads on building

3.2.1 Dead load

It is the load of the material used for the various components of a building such as walls, floors, roofs, etc. all permanent loads are thus included in dead load. The calculation of dead loads of each structure are calculated by the volume of each section and multiplied with the unit weight. Dead loads are permanent or stationary loads which are transferred to structure throughout the life span.

3.2.2 Live Load / Imposed load

This is the movable load on the floor and hence it`s variable. It's also sometimes known as the super imposed load. It includes the load of persons standing on a floor, weight of the material stored on a floor, weight of snow on a roof etc.

3.2.3 Wind Load

In case of tall buildings, the effect due to wind should be considered. For low rise building say up to four to five stories, the wind load is not critical because the moment of resistance provided by the continuity of floor system to column connection and walls provided between columns are sufficient to accommodate the effect of these forces. Wind load is primarily horizontal load caused by the movement of air relative to earth.

3.2.4 Snow Loads (SL)

Snow loads constitute to the vertical loads in the building. But these types of loads are considered only in the snow fall places

3.2.5 Earthquake Loads (EL)

Earthquake forces constitute to both vertical and horizontal forces on the building. The response of the structure to the ground vibration is a function of the nature of foundation soil, size and mode of construction and the duration and intensity of ground motion The movement in vertical direction do not cause forces in superstructure to any significant extent. But the horizontal movement of the building at the time of earthquake is to be considered while designing.

The Design Steps followed in the Design of Footings are:

1. Decide the location of columns & foundation and type of loads acting on them. (e.g. deal load, live load or wind load)
2. Estimate allowable bearing pressure of soil using ground investigation report.
3. Decide depth of foundation
4. Calculate foundation area
5. Determine variation in vertical stresses
6. Calculate settlement

Chapter 4: Methodology

This topic is chosen to understand the building foundation and its related terminologies. We are particularly focused on trapezoidal isolated footing and combined footing. The collected data are from authentic source NBC 105:2020, IS 456:2000 and it is reduced to appropriate scale. Foundation study and model construction will enhance our academic and practical understanding. It would be further helpful and would be base for foundation engineering and structural analysis in our upcoming academia.

The method that will be used in the development of this project is as follows:

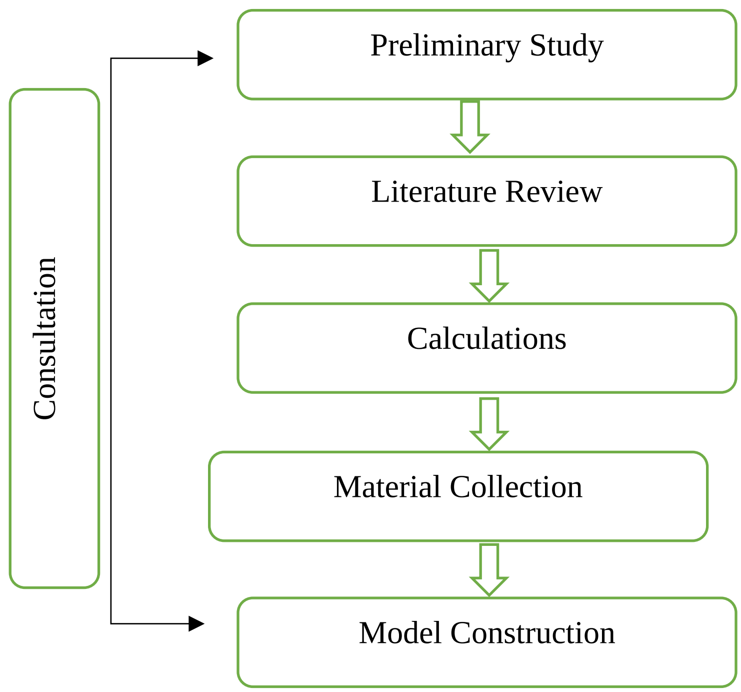

Figure 9. Methodology

Preliminary Study

Preliminary study is an initial exploration of issues related to a proposed quality review or evaluation. We have web surfed on the different types of footings and the methods of load transfer through the column and to the footings. With the consultations with our supervisor, we have planned to prepare the demonstrative model of different types of footings, in particular isolated footing and combined footing.

Dimension

Table 1.Calculation of R.F.

Name of the Components	Actual Dimension	Reduce Dimension	R.F.
Footing	150×150 cm^2	30×30 cm^2	1:5
Footing depth	150 cm	30 cm	1:5
Brick soiling	230×115×57 mm3	50×25×12 mm^3	1:5
PCC	7.5 cm	1.5 cm	1:5
Lower portion volume	150×150×25 cm^3	30×30×5 cm^3	1:5
Height of Truncated Pyramid	25cm	5 cm	1:5
Pedestal	50×50 cm^2	10×10 cm^2	1:5
Column	30×30 cm^2	6×6 cm^2	1:5

Table 2. Calculation of RF of Combined Footing

Name of the Components	Actual Dimension	Reduce Dimension	R.F.
Footing	(300×150) cm2	50×25 cm3	1:6
Footing Depth	150 cm	25cm	1:6
Brick Soiling	230×115×57 mm3	50×25×15 mm3	1:5
PCC	7.5 cm	1.25 cm	1:6
Lower portion area	(300×150) cm2	50×25 cm2	1:6
Height of lower rectangular portion	150 cm	10 cm	1:15
Column	(30×30) cm2	5×5 cm2	1:6
Distance between the center of columns	150 cm	25cm	1:6

Calculations:

Volume of PCC = 0.3×0.3×0.0015 = 0.00135 m^3

Volume of trapezoidal footing =$\frac{1}{3} \times h(A_1 + A_2 + \sqrt{A_1 \times A_2}\,)$ = 0.0026m^3

Where, A_1= Lower Portion Area

A_2= Upper Portion Area

Volume of Cuboid = 0.3×0.3×0.05 = 0.0045 m^3

Volume of Column= 0.06×0.06×0.3 =0.00108 m^3

Total volume of combined footing = 0.012833m^3

Total volume = 0.00135 + 0.00216 + 0.0045 + 0.00108+0.012833 = 0.021923 m^3

Now,

For M_{25} (C:S:A = 1:1:2)

Dry Volume= 1.54

Density of Cement = 1440 kg/m^3

Density of Sand =1600 kg/m^3

Density of Coarse Aggregate =1800 kg/m^3

Volume of Cement =$\frac{1}{4} \times 1.54$ = 0.385m^3

=0.385×0.021923 =8.440× $10^{-3}m^3$

Mass of Cement = Volume of Cement×1440 =12.15≈ 12.2kg

Volume of Sand = $\frac{1}{4} \times 1.54$ = 0.385m^3

= 0.385×0.021923 =8.440× $10^{-3}m^3$

Mass of Sand = Volume of Sand × 1600 = 13.50kg

Volume of Aggregate = $\frac{2}{4} \times 1.54$ = 0.77×0.021923 m^3

= 0.01688m^3

Mass of Aggregate = Volume of Aggregate × 1800= 30.38kg ≈ 30.4kg

Water Cement Ratio = 0.55

Volume of water = 6.7 L

BBS (Bar Bending Schedule)

For isolated footing

No. of bars = (effective length/spacing) + 1

Clear cover = 1cm

Effective length= Total length-both side cover

= 30 - (2*1)

= 28

Spacing = 3cm

No. of bars in x direction = (28/3) + 1

= 10.33 = 10 bars

Since, the length in x and y direction are same

10 bars each on x and y direction are used

Cutting length of bar along (x) direction

= (Effective length + bend) - Bend deductions

= {28+2(5-1-1) - (2*2*0.26)}

= (28+2*3-1.04)

= 32.96 cm

Same cutting length in (y) direction as length is same as in x direction i.e.

Cutting length of bar in y direction =32.96 cm

For the combined footing

Clear cover = 8.5 mm

= 0.85 cm

Spacing = 2.5 cm

Effective length = Total length - both side cover

= 50 - (2*0.85)

= 4 8.3 cm

No. of bars in x direction = (48.3/2.5) + 1 = 20.32 = 20

Cutting length in the x-direction: = {48.3+2 (15-0.85-0.85) - (2*2*0.26)

= 48.3+2(3.3)-1.04

= 48.3+6.6-1.04 = 53.86 cm

In Y-direction

Effective length = Total length-Both sides cover

=25-(2*0.85) =23.3 cm

No. of bars = (23.3/2.5) + 1

= 10.32 = 10

Cutting length in Y direction = {23.3+2(3.3) - 1.04

= 23.3 + 6.6 - 1.04

= 28.86 cm

Cutting length of stirrups:

For Isolated footing

Diameter of GI wire = 1.2 mm=0.12cm

Clear cover = 8mm = 0.8cm

Here,

a = Total length - (2* clear cover) - (2* diameter of wire)

= 6 - (2*0.8) - (2*0.12)

=6-1.6-0.24

=4.16 cm

b=4.16cm

Cutting length = 2 (a + b) + (No. of hooks*10d) - (No. of bends*2d)

= 2 4.16+4.16) + (2*10*0.12) - (3*2*0.12)

= 2*8.32 + 2.4 - 0.72

= 18.32 cm (For 1 stirrups)

For combined,

Clear cover = 0.6 cm

a = Total length - (2* clear cover) - (2* diameter of wire)

= 5 - (2*0.6) - (2*0.12)

= 5 - 1.2 - 0.24

= 3.56 cm

b = 3.56 cm

Cutting length =2(3.56+3.56) + (2*10*0.12) - (3*2*0.12)

= 14.24 + 2.4 - 0.72

= 15.92 cm = 16 cm (For 1 stirrups)

Cutting length of vertical bars = height of column + development length – 90degree bend

= 40 + 10 – (2*0.26)

= 50 – 0.52 = 49.98 cm (For both isolated and combined footing)

Materials Required

1. Cement
2. Ply wood
3. Coarse and Fine Aggregate
4. Brick
5. Binding wire
6. GI-wire

Tools Required

1. Hammer
2. Pliers
3. Tamping Rod
4. Trowel
5. Tray
6. Sieve (12.5mm, 10mm)
7. Pressure Gun

Chapter 5: Work Schedule

Table 3. Work Schedule

Work	Week																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Consultation and Literature Review																	
Calculation																	
Proposal Defense																	
Material Collection																	
Model Construction																	
Mid term Presentation																	
Finishing																	
Final Report Submission and Presentation																	

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Work Completed	

Chapter 6: Expenditure

Table 4. Estimated Budget

S.N.	Materials	Quantity (kg)	Rate (Nrs)	Total Cost (Nrs)	Remarks
1.	GI-Wire	3	230.00	690.00	
2.	Binding Wire	1	200.00	200.00	
3.	Cement	12.21	60.00	-	Provided by construction lab
4.	Fine Aggregate	13.56	3710 per m^3	-	
5.	Coarse Aggregate	30.45	3750 per m^3	-	
Grand Total				890.00	

Chapter 7: Conclusion

Model of Isolated and Combined footing was prepared in time within our estimated budget.

The demonstrative model of both isolated and combined footing was successfully completed. Through this project we have learnt the calculations of mixed design and the different terms regarding the reinforcements. The various applications of footings in a building structure were known. We were also familiar with the load transfer mechanism in the footings. The detailed knowledge of various types of footings were known. Also, the knowledge on different types of load acting on the footings were gained

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- IS 456:2000

Annex-I (Drawing of the Project)

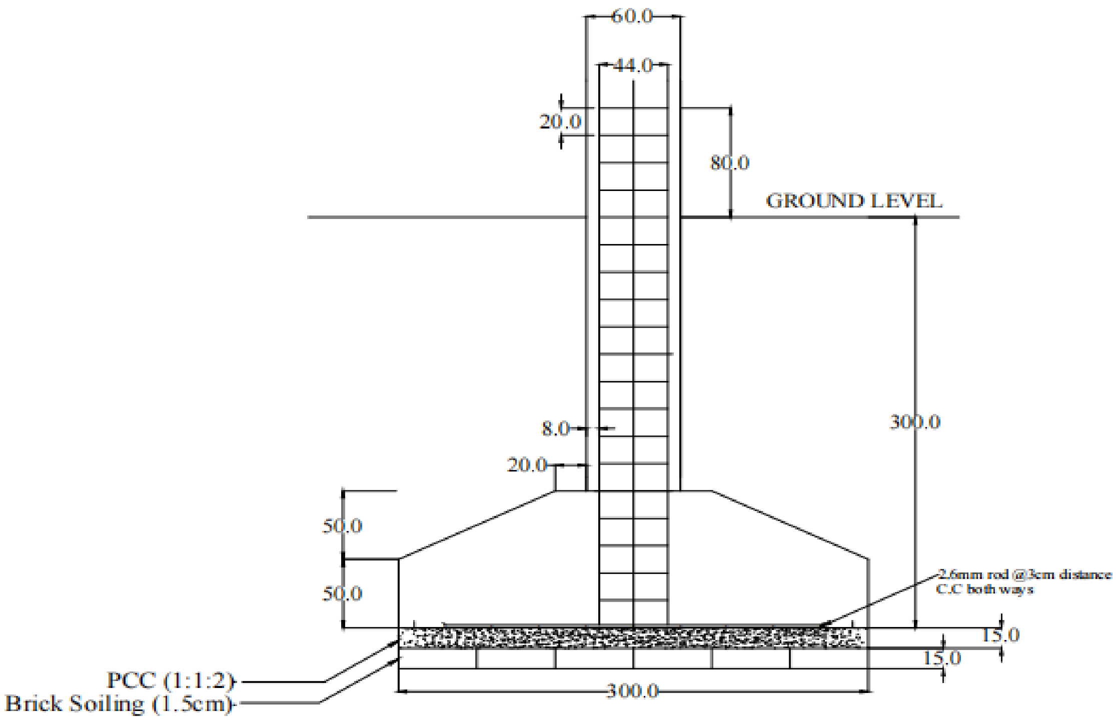

Fig: Side view of section of Isolated Footing

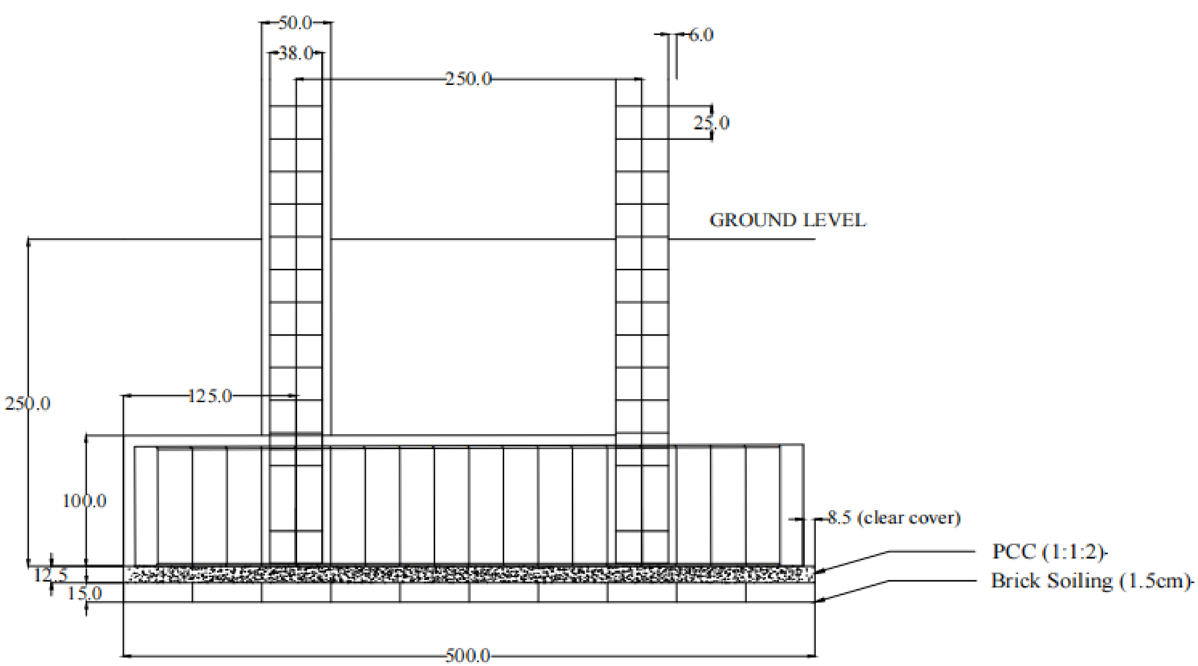

Fig: Side view of section of combined footing

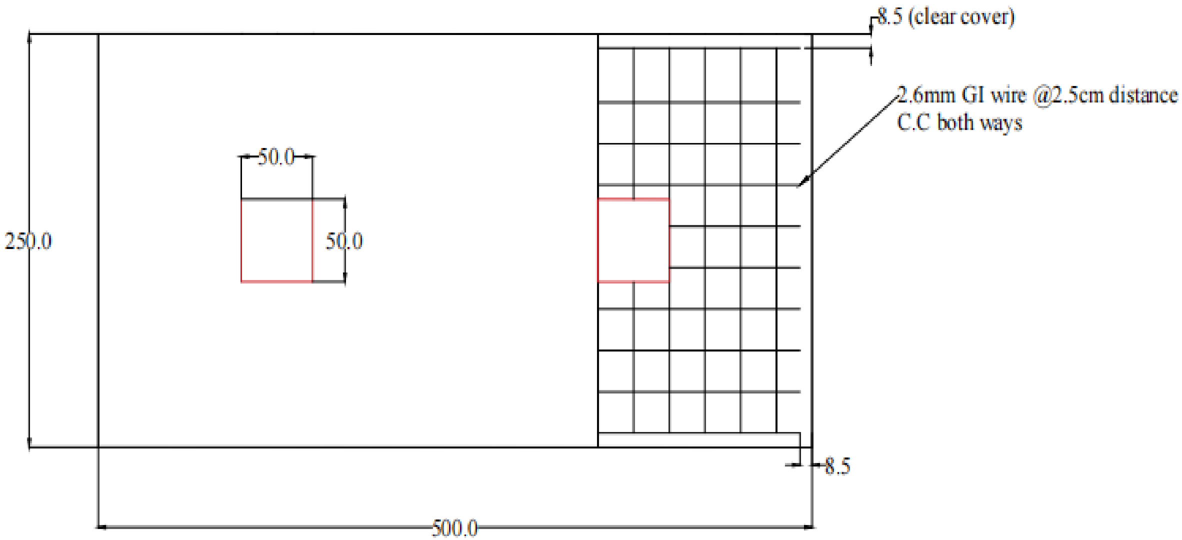

Fig: Top view of section of combined footing

Annex-II

Figure 10. Model Construction

Figure 11. Model Consstruction