A Project Report on

Analysis and Design of Foundation for Rcc Structure With Varying Soil Strata

Submitted in partial fulfilment of the requirements

For the degree of

Bachelor of Engineering

by

Akbani Abdul Ahad (16DCES58)

Kazi Mubariz (16DCES70)

Bagwan Sakib (16DCES62)

Momin Muntazir Ahmed (16DCES78)

Under guidance of

Prof. Vedprakash Marlapalle

Department of Civil Engineering

School of Engineering and Technology

Anjuman-I-Islam's Kalsekar Technical Campus

New Panvel, Navi Mumbai. 41026

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CERTIFICATE

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School of Engineering and Technology

Anjuman-I-Islam's Kalsekar Technical Campus

Plot No. 2 3, Sector – 16, Near Thana Naka, Khanda Goon,
New Panvel, Navi Mumbai. 41026

2018-2019

This is to certify that, **Akbani Adul Aahad (16DCES58), Kazi Mubariz (16DCES70), Bagwan Sakib (16DCES62)** and **Momin Muntazir Ahmed (16DCES78)** has satisfactorily completed and delivered a Project report entitled, **"Analysis and Design of Foundation for RCC structure with varying soil strata"** in partial fulfilment for the completion of the **B.E.** in **Civil Engineering** Course conducted by the University of Mumbai in Anjuman-I-Islam's Kalsekar Technical Campus, New Panvel, Navi Mumbai, during the academic year 2018-19.

Prof. Vedprakash Marlapalle
Guide

Dr. Rajendra B. Magar
Head of Department

Dr. Abdul Razzak Honnutagi
Director

Project Report Approval for B.E.

This B. E. Project entitled **"Analysis and Design of Foundation for RCC Structure with varying soil strata** "by **Mr. Akbani Abdul Aahad, Mr. Kazi Mubariz, Mr. Bagwan Sakib** and **Mr. Momin Muntazir Ahmed** is approved for the degree of **"Bachelor ofEngineering"** in**"Department of Civil Engineering".**

Examiners

1 ________________________

2 ________________________

Supervisors

1 ________________________

2 ________________________

Chairman (Director)

____

Date:

DECLARATION

We declare that this written submission represents my ideas in our own words and where others ideas or words have been included; we have adequately cited and referenced the original sources. We also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Akbani Abdul Aahad	(16DCES58)
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Bagwan Sakib	(16DCES62)
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We deeply express our sincere thanks to our **Head of Department Dr. R.B.Magar** and our **DirectorDr. Abdul Razzak Honnutagi** for encouraging and allowing us to present the project on the topic **"Analysis and Design of Foundation for RCC structure with varying soil strata"** in partial fulfilment of the requirements leading to award of Bachelor of Engineering degree.

We take this opportunity to thank **all our Professors and non-teaching staff** who have directly or indirectly helped our project; we pay our respects and love to our parents and all other family members for their love and encouragement throughout our career. Last least we express our thanks to our friends for their cooperation and support.

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ABSTRACT

As time goes by, the development in the construction industry all over the world is progressing. Many structures are being built, both residential and non-residential, as well as roads and bridges. Foundations of any building or structure shall be designed and constructed to withstand safely all the dead, imposed and wind loads without impairing the stability or inducing excessive movement to the building or of any other building.When designing foundations for a structure there is a need to determine the bearing capacity of the underlying soil on which the foundations will be laid. This applies to all forms of foundations from a simple isolated footing to complex raft and pile cap foundations.The minimum investigation involves testing the bearing capacity of the supporting ground beneath a proposed building. This must be carried out by a suitably qualified professional or certified testing firm prior to the design of foundations. The method of testing varies depending on the sub- surface conditions. The type of ground and its bearing capacity determines the foundation requirements.

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Chapter 1

Introduction

1.1. General:

As time goes by, the development in the construction industry all over the world is progressing. Many structures are being built, both residential and non-residential, as well as roads and bridges. Just like many countries, the demand for new structures in India is highly increasing. High-tech and modernized designs are built and old buildings are demolished or renovated.

Foundations of any building or structure shall be designed and constructed to withstand safely all the dead, imposed and wind loads without impairing the stability or inducing excessive movement to the building or of any other building, street, land, slope or services. All structure is constructed on land are supported on a foundation. A foundation is, therefore, a connecting link between the structure proper and the ground which supports it.
A foundation is required for distributing the load of the super structure on a large area.
The foundation should be designed such that

1) Soil below does not fail in shear.
2) Settlement within the safe limits.

When designing foundations for a structure there is a need to determine the bearing capacity of the underlying soil on which the foundations will be laid. This applies to all forms of foundations from a simple isolated footing to complex raft and pile cap foundations. This understanding comes from an appreciation of the distribution of the materials in the ground, and their properties and behaviour under various influences and constraints during construction and lifetime of the structure. The forms of structure proposed in this modern day demands taller and heavier structures, deeper depth of foundation and underground excavation. There are also structural forms and problems involving technical solutions dealing with complex actions from the ground. In choosing the method for the determination of the ultimate capacity or for the estimation of settlement, care must be taken to ensure that the site investigation, testing, derivation of parameters, computations, method of construction and standards of acceptance are mutually compatible and consistent with such method.
Allowable bearing pressure The maximum allowable bearing pressure that may be applied at the base of the foundation, taking into account the ultimate bearing capacity of the soil or

rock, the magnitude and type of settlement expected and the ability of the structure to accommodate such settlement.

The minimum investigation involves testing the bearing capacity of the supporting ground beneath a proposed building. This must be carried out by a suitably qualified professional or certified testing firm prior to the design of foundations. The method of testing varies depending on the sub- surface conditions. The type of ground and its bearing capacity determines the foundation requirements. The design of the foundation, super structure and the characteristics of the ground are inter-related and should be studied as a whole. The study involves Geo-technical aspects of the supporting ground and the structural aspects of the foundation material. The aim is to proportion the foundation size in such a way that the net loading intensity of pressure coming on the soil does not exceed its safe bearing capacity and maximum stress in foundation is within the permissible limits. Visual examination of the soil exposed in suitably located trial pits at the site, combined with already established data for different types of soil is commonly used for deciding on the safe bearing capacity. While this procedure may be adequate for light or less important structures under normal conditions, relevant laboratory tests or field tests are essential in the case of unusual soil types and for all heavy and important structures.

1.2. Aim:

This project has been taken up to **Analysis & Design of Foundation for RCC Structure with Varying Soil Strata,** with the following objective.

1.2 . Objectives:

1) To study the bearing capacity of the soil.
2) To suggests types of foundations.

3) To know the nature of each stratum and engineering properties of the soil and rock, which may affect the design and mode of construction of proposed structure and foundation

Chapter 2

Review of Literature

2.1. Introduction

Technical papers from various well-known journals from all over the world are studied in this section and each relevant paper is summarised and presented in this chapter so as understand the existing work available on this topic.

2.2. Summaries of relevant technical paper:

A Tejchman (1976) presents the result of model test concerning the bearing capacity of a strip foundation resting on stratified subsoil. The subsoil assumed for the testing consist of a strong layer overlaying a weak one & the foundation loaded with vertical & inclined forces, acting axially and eccentrically. The basic aim of research work was to examine the influence of a weak soil layer and its depth below the strip foundation on the ultimate bearing capacity and deformation of subsoil in the case of vertical, inclined, & eccentric loads.

Three principal Problems that were investigated.

a) The effect of subsoil with a weak soil stratum on the foundation bearing capacity.

b) Effect of eccentric and inclined forces on the foundation bearing capacity.

c) The effect of stratified subsoil on the foundation bearing capacity.

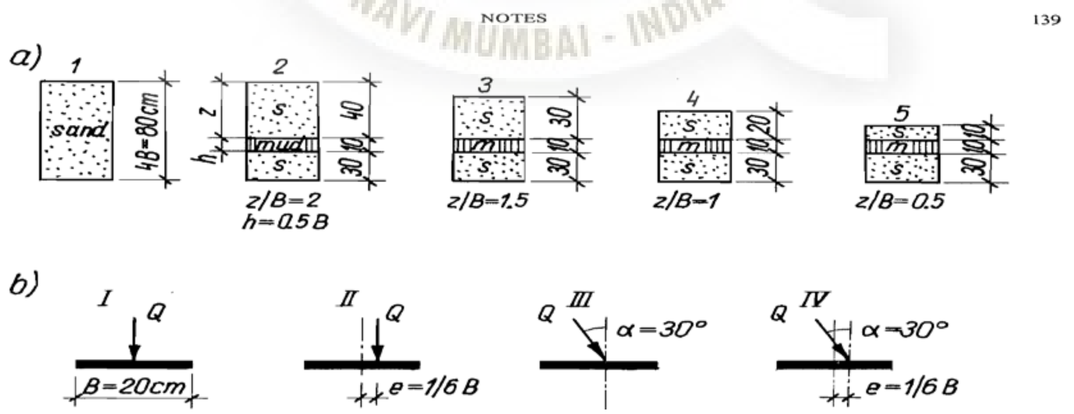

Fig: 2.1 application of loads on layered soil

Manish Dixit, Kailas Patil (2010) they present the factor influence the ultimate bearing capacity is the type of soil, the width of the foundation, soil weight in the shear zone & surcharge. Structural rigidity and the contact stress distribution do not greatly influence the bearing capacity. The bearing capacity analysis assumes a uniform contact pressure between the foundation & underlying soil. The paper present deals with the study of the effect of the shape of footing on bearing capacity of the soil. Similarly, the effect of depth of footing on bearing capacity of the soil is studied. The bearing capacity of soil goes increasing as depth or width of foundation increases. The comparison of bearing capacity of soil with the method of analysis given by Terzaghi & IS method is carried out for a different shape.

Jayant Kumar, Manash Chakraborty (2015) the bearing capacity solution available in the literature is generally meant for homogeneous soil deposit. In some cases, the foundation needs to be constructed over soft clay deposits for which the bearing capacity can be improved significantly by providing stone columns or layer of medium dense to dense below the footing base. In such cases, its necessary to assess the improvement in bearing capacity as well as the reduction in the settlement with an overlying sand layer.

The aim of the paper is to determine the ultimate bearing capacity with an overlying sand layer for circular footing lies over fully cohesive soil strata. Using the limit equilibrium approach, Meyerhof & Hanna proposed simplified expression for finding the ultimate bearing capacity of strip & circular footing with a sand layer overlying the clayey strata.

By performing an axisymmetric lower bound limit analysis in combination with finite element & linear optimization, the computation in this study revealed that the bearing capacity of circular footing laying over a soft clay improves significantly with the overlying sand layer.

Mansour Mosallanezhad, Hossein Moayedi (2017) presents the ultimate bearing capacity of shallow foundations a multilayered soil mainly being used. Determination of reliable ultimate bearing capacity of foundation in multilayered soil stratum is, required in the safety assessment & design analysis of a foundation structure. It has been found that a number of factors may influence bearing capacity of the soil such soil layer thickness, soil properties, applied stresses, and type of analysis which is not taken into consideration in traditional bearing capacity theories. The results unveil ultimate bearing capacity of layered soil varied largely based on soil properties or thickness of soil layer. located at top & foundation width the effect of upper stronger layer thickness optimized by a unique critical depth. The critical h/B point from the analytic, numerical & experimental method is equal to 2, 2.5, & 1.5 respectively.

B. Ravi Sankar etal (2016) the main of the project is to design size of the footing for cohesive and non cohesive soil for same type of the building and try to find which soil s economical so as to reduced cost of construction of building.

Based on the field test and design consideration following conclusion were obtained, the size of the footing in cohesive and non cohesive soil the dimension are (2.5x2.5x0.205m) and (1.9x1.9x0.201m) respectively. The volumes of footing are 1.28m^3 and 0.72m^3 for cohesive and non cohesive soil with a percentage change in volume is 56.25%. So the volume of footing required in cohesive soil is 56.25% more than the volume required for non cohesive soil. It shows that in case of cohesive soils isolated footing is not advisable a it is two time costlier than non cohesive soils. So in cohesive soils we have gone for another type of foundation like pile grouping, well foundation etc.

H. Elarabi and E. yahya (2018) in this paper plate load test was used to study the effect of compacted fill layer on bearing capacity. The soil was classified as low plastic soil, silty or clay, the analysis of the result obtained from the experiments showed that the settlement of the layer decreases as the number of layer increase. The bearing capacity of layer increase as the number of layer increase, this situation is valid for certain thickness after which no considerable effect was recorded. The increment in bearing capacity can be achieved by adding more compacted layer.

B Deva kumar yadav (2017) in this paper G+10 storey building and the plan is symmetrical about both axis, the soil characteristics obtained is to weak (i.e. black cotton soil) the depth of hard strata obtained to be at 6m from the ground level, therefore providing foundation like isolated, combined, or raft will be more costlier therefore the optimum foundation will be pile foundation suitable for this condition. In this paper structure is analyzed using Etabs and pile is designed using SAFE the result obtained are in term of storey displacement, storey drift, lateral force, time period, storey shear etc. detailed seismic analysis revels that analysis and designed of multistory building are important in which ignoring seismic load will cause disaster in earthquake prone zone. Shear wall will increase the lateral stability of the building in turn reduced lateral displacement and increase the base shear.

2.3. Conclusion:

By studying the above technical papers, a lot of knowledge has been gained regarding the ultimate bearing capacity of the soil. Soil bearing capacity is one the most important factor in the design of foundation for the proposed structure. Without knowing the soil bearing capacity structure may cause unequal settlement which leads to a failure of the structure. All the technical papers which we have seen above most of them either conducted a model test or numerical approach to find ultimate bearing capacity for a foundation & safe settlement from that they can easily predict foundation types & which types of foundation suitable for that soil etc.

Chapter 3

Soil Investigation

3.1Introduction:

The present soil investigation report for residential building carried out at location karanjade, Panvel.

The investigation comprises of sinking four numbers of Boreholes of maximum depth of 20 m with a collection of samples and conducting relevant field and laboratory tests. Based on the investigation the subsoil condition at the location has been identified and an analysis has been done for the suitable foundation and Bearing capacities for the structure.

3.2 Field Investigation:

3.2.1 General:

For the finalization in the design of the foundation for the proposed structure to be constructed at the site, the geotechnical investigation was done.

The total investigation programme has two phases.

a) Field Works.

b) Laboratory Testing

In field work, the type of sub-surface deposits and their characterization have been revealed. Laboratory testing actually helps in determining relevant geotechnical properties of the subsurface deposits leading to finalisation of foundation depths and type of the structures and the bearing capacity with particular reference to the sub-surface types and their strength parameters and settlement potentials at the site.

3.2.2 Objectives of Geotechnical Investigation:

- Soil profile to know the sub surface conditions.
- To determine safe bearing capacity for foundation design.
- Foundation recommendation.

3.2.3 Boring/Sampling:

The different types of explorations, borings are the most practical and relatively correct method of obtaining sub-surface information. The most important aspect of the boring operations is to obtain information about the subsoil profiles, its nature and strength and to collect soil samples for strata identification and conducting laboratory tests.

The boreholes of 150 mm diameter were sunk as per specifications and IS 1892. Casings, as required, were used to retain the borehole. Bore Holes were taken at locations judiciously specified and were extended to a specified maximum depth around 10m. Boring was carried out by the shell and augur/wash boring method in the soil. Adequate care as per specification and Indian standard practice was taken to prevent any possible side collapse in boreholes.

The details of the borehole including field tests of Standard Penetration tests and also a collection of disturbed soil samples are given in Bore Log enclosed. All the representative samples of sub-surface deposits were collected from boreholes, labelled depth wise and placed in polyethene bags. Reference Numbers and depth of these samples are shown in Bore Log Data Sheets.

3.2.4 Standard Penetration Test (SPT):

The standard penetration tests were conducted as per IS 2131-1981. The split spoon sampler, connected with a string of drill rods, was lowered into the bottom of the borehole. The sampler was driven into the soil stratum up to a maximum depth of 450mm. by making use of 63.5 kg. Weight falling freely from a height of 750mm on to an anvil fixed on the top of drill rod. The number of blows required to penetrate each of the successive 150mm depths was counted to produce a total penetration of 450mm. To avoid seating errors, the blows required for the first 150mm of penetration was not taken into account. Those required increasing the penetration from 150mm to with a detachable core bit, which is of the diamond. All core bits were of 73mm size.

3.2.5 Details of Boreholes and Soil Samples Collected

Table 3.1: Bore log Data BH-01

depth (m)	penetration 15cm	15cm	15cm	N value	strata description	symbol	thickness	SAMPLES type	no.	depth	core recovery (%)	R.Q.D (%)	REMARK
0.00–0.50	4	6	9	14	TOP SOIL		0.5	D	0.5	0.5	0.0	0.0	
0.50–1.50	8	12	13	36	SANDY CLAY		1.0	D	2.0	0.5-1.0	0.0	0.0	
1.50–4.50	6	9	12	32	SILTY SAND		3.0	D	1	1.5-2.0	0.0	0.0	
								S	1	2.5-3.0	0.0	0.0	
								D	2	3.5-3.8	0.0	0.0	
								S	2	4.0	0.0	0.0	
								S	3	4.2-4.5	0.0	0.0	
4.50–14.50	9	13	16	42	SAND		10	D	1	1.5-2.0	0.0	0.0	
								S	1	2.5-3.0	0.0	0.0	
								D	2	3.5-3.8	0.0	0.0	
								S	2	4.0	0.0	0.0	
								S	3	4.2-4.5	0.0	0.0	
14.50–20.00	10	11	14	47	ROCK		5.5	C	1	3.5-3.8	18	13	
								C	2	4.0	20	20	
								C	3	4.2-4.5	26	40	

S=S.P.T | C=CORE | U=UNDISTURBED SAMPLE | D=DISTURBED SAMPLE | W=WATER SAMPLE | BGL=BELOW GROUND LEVEL

Table 3.2: Bore log Data BH-2

depth (m)	penetration 15cm	penetration 15cm	penetration 15cm	N value	strata description	symbol	thickness	SAMPLES type	SAMPLES no.	SAMPLES depth	core recovery (%)	R.Q.D (%)	REMARK
0.00 – 0.50	5	7	10	15	TOP SOIL		0.5	D	0.5	0.5	0.0	0.0	
0.50 – 1.50	6	9	12	37	SANDY CLAY		1.0	D	2.0	0.5-1.0	0.0	0.0	
1.50 – 4.50	9	11	15	33	SILTY SAND		3.0	D	1	1.5-2.0	0.0	0.0	
								S	1	2.5-3.0	0.0	0.0	
								D	2	3.5-3.8	0.0	0.0	
								S	2	4.0	0.0	0.0	
								S	3	4.2-4.5	0.0	0.0	
4.50 – 15.50	11	13	15	43	SAND		11	D	1	1.5-2.0	0.0	0.0	
								S	1	2.5-3.0	0.0	0.0	
								D	2	3.5-3.8	0.0	0.0	
								S	2	4.0	0.0	0.0	
								S	3	4.2-4.5	0.0	0.0	
15.50 – 20.00	10	12	14	48	ROCK		4.5	C	1	3.5-3.8	18	13	
								C	2	4.0	20	20	

S=S.P.T	C=CORE	U=UNDISTURBED SAMPLE	D=DISTURBED SAMPLE	W=WATER SAMPLE	BGL=BELOW GROUND LEVEL

Table 3.3: Bore log Data BH-3

depth (m)	penetration 15cm	penetration 15cm	penetration 15cm	N value	strata description	symbol	thickness	SAMPLES type	SAMPLES no.	SAMPLES depth	core recovery (%)	R.Q.D (%)	REMARK
0.00–0.50	6	8	11	16	TOP SOIL		0.5	D	0.5	0.5	0.0	0.0	
0.50–1.50	10	12	15	38	SANDY CLAY		1.0	D	2.0	0.5-1.0	0.0	0.0	
1.50–3.50	9	12	14	34	SILTY SAND		2.0	D	1	1.5-2.0	0.0	0.0	
								S	1	2.5-3.0	0.0	0.0	
								D	2	3.5-3.8	0.0	0.0	
								S	2	4.0	0.0	0.0	
3.50–15.50	12	13	15	45	SAND		12	S	3	4.2-4.5	0.0	0.0	
								D	1	1.5-2.0	0.0	0.0	
								S	1	2.5-3.0	0.0	0.0	
								D	2	3.5-3.8	0.0	0.0	
								S	2	4.0	0.0	0.0	
								S	3	4.2-4.5	0.0	0.0	
15.50–20.00	10	12	14	48	ROCK		4.5	C	1	3.5-3.8	20	15	
								C	2	4.0	25	23	

S=S.P.T; C=CORE; U=UNDISTURBED SAMPLE; D=DISTURBED SAMPLE; W=WATER SAMPLE; BGL=BELOW GROUND LEVEL

Table 3.4: Bore log Data BH-4

depth (m)	penetration			N value	strata description	symbol	thickness	SAMPLES			core recovery (%)	R.Q.D (%)	REMARK
	15cm	15cm	15cm					type	no.	depth			
0.00 0.50	7	9	12	17	TOP SOIL		0.5	D	0.5	0.5	0.0	0.0	
0.50 1.50	9	12	14	39	SANDY CLAY		1.0	D	2.0	0.5-1.0	0.0	0.0	
1.50 3.50	9	11	13	32	SILTY SAND		2.0	D	1	1.5-2.0	0.0	0.0	
								S	1	2.5-3.0	0.0	0.0	
								D	2	3.5-3.8	0.0	0.0	
								S	2	4.0	0.0	0.0	
3.50 16.00	10	12	15	44	SAND		12.5	S	3	4.2-4.5	0.0	0.0	
								D	1	1.5-2.0	0.0	0.0	
								S	1	2.5-3.0	0.0	0.0	
								D	2	3.5-3.8	0.0	0.0	
								S	2	4.0	0.0	0.0	
								S	3	4.2-4.5	0.0	0.0	
16.00 20.00	11	12	14	49	ROCK		4.0	C	1	3.5-3.8	20	15	
								C	2	4.0	25	23	
S=S.P.T		C=CORE		U=UNDISTURBED SAMPLE		D=DISTURBED SAMPLE			W=WATER SAMPLE		BGL=BELOW GROUND LEVEL		

3.3. Laboratory Testing:

For proper identification and classification of the sub-surface and for deriving adequate information regarding its relevant physical and geotechnical properties at the site under investigation, the following laboratory tests were conducted on the soil and rock samples collected from the boreholes.

For Soil Samples:

1. Grain size analysis (Sieve as well as Hydrometer).
2. Natural Moisture Content.
3. Bulk Density & Dry Density
4. Specific Gravity.
5. Liquid Limit.
6. Plastic Limit.
7. Triaxial Test (UU).
8. Consolidation Test.

For Rock Samples:

1. Bulk density, Specific Gravity & water absorption.
2. Unconfined Compression Strength Test.

The above-mentioned laboratory tests were done following the testing procedure is given in the relevant parts of IS: 2720 and other relevant codes. Results of all tests are furnished in Annexure of this report.

3.4 Subsoil Profile:

The subsoil is characterized by medium dense, silty sand layer at the top followed by a layer of weathered rock and that continued up to the terminating depth of all boreholes. Around

Table No 3.5: Subsoil profile

Depth	Parameters of soil	Ground
0 to 0.5m	γ = 18 kN/m C = 20kN/m ϕ = 30 , Ka = 0.33 Kp = 3	Top Soil
0.5m to 1.5	γ = 15 kN/m C = 0 kN/m ϕ = 35 Ka = 0.27 Kp = 3	Sandy Clay
1.5m to 4.5m	γ = 20.3 kN/m C = 0 kN/m ϕ = 32 Ka = 0.31 Kp = 3.25	Silty sand
4.5m to 10m	γ = 15 kN/m C = 0 kN/m ϕ = 38 Ka = 0.3 Kp = 3	Sand

3.5 Determination of Bearing Capacity:

The Net Ultimate Bearing Capacity is given as (As per IS 6403):

qnu = (C Nc Sc Dc) + (q (Nq - 1) Sq Dq) + (0.5γNγSγDγ)

Ultimate bearing capacity of soil (qu):

From field & laboratory test we find out different property of soil such as cohesion (C), ϕ, unit weight of soil (γ) etc.

qu = CNcScdcic + γ D(Nq-1)Sqdqiq + 0.5B γ NγSγdγiγ.

Where,

C = cohesion, γ= unit weight of soil.

Nc, Nq, Nγ are the bearing factor.

Sc,Sq,Sγ are the Shape factor.

dc, dq, dγ are the depth factor.

Nc = (Nq - 1)xcotϕ

Nγ = 2(Nq - 1)xtanϕ

Nq = $tan^2(45+\frac{\phi}{2})$ x$e^{\pi tan\emptyset}$

Assuming size of square footing as 1m x 1m x 1m

L = 1m, B = 1, D_f = 1m

For square footing shape factor are,

Sc = 1.3, Sq = 1.2, Sγ = 0.8

For square footing depth factor are,

dc= 1+0.2x$\frac{D}{B}$ x$\sqrt{N\phi}$

Where $\sqrt{N\phi}$ = tan^2x(45+$\frac{\phi}{2}$) = tan^2x (45+$\frac{38}{2}$) = 4.2

dc= 1+0.2x$\frac{1}{1}$ x$\sqrt{4.2}$ = 1.409

dq = dγ = 1+0.1x$\frac{1}{1}$ x$\sqrt{4.2}$ = 1.205

Inclination factor ic = iq = iγ = 1

For square footing bearing factor are,

Nq = $tan^2(45+\frac{\phi}{2})$ x $e^{\pi tan\emptyset}$

Nq = $tan^2(45+\frac{38}{2})$ x $e^{\pi tan38}$ = 48.93

Nγ = 2(Nq - 1)xtanϕ

Nγ = 2(48.93 - 1) x tan38 = 76.02

Nc = (48.93 - 1) x cot38 = 61.34

qnu = (C Nc Sc Dc) + (γD (Nq - 1) Sq Dq) + (0.5BγNγSγDγ)

Where C = 0

qnu = 0 + (16.5x1.5 (48.93 - 1) 1.2x1.205) + (0.5x1x16.5x76.02x0.8x1.205)

= 1715.342 + 604.587

= **2320 kN/m²**

Assuming Factor of safety (FOS) = 5

Qsafe = $\frac{\text{ultimate bearing capacity (qnu)}}{FOS} = \frac{2320}{5}$ = **464 kN/m²**

Therefore allowable bearing capacity of sandy soil is 464 kN/m²

Above bearing capacity of sandy soil calculated for different layer soil data, factor and constant value considered in bearing capacity calculation, and value of SBC used for foundation design.

3.6 Foundation recommendation:

Pile foundation

Pile foundation is required when the soil bearing capacity is not sufficient for the structure to withstand. This is due to the soil condition or the order of bottom layers, type of loads on foundations, conditions at site and operational conditions.

Many factors prevent the selection of surface foundation as a suitable foundation such as the nature of soil and intensity of loads, we use the piles when the soil have low bearing capacity or intensity of loading is high or in building or in water like bridges and dams. A pile foundation consists of two components; pile cap and single or group of piles. Pile transfers the loads from structures to the hard strata, rock or soil with high bearing capacity. These are long slender members whose length cab be more than 15m.

Piles can be made from concrete, wood or steel depending on the requirements. These piles are then driven, drilled or jacked into the ground and connected to the pile caps. Pile foundations classified based on material of pile construction, type of soil, and load transmitting characteristic of piles.

Function of pile foundation is:

- To transmit the building loads to the foundation and the ground soil layers whether these loads vertical or inclined.
- To install loose cohesion less soil through displacement and vibration.
- To control the settlements, this can be accompanied by surface foundation.
- To increase the factor of safety for heavy loads buildings.

3.7 limitations of soil investigation:

- This report has been based on project details as provided to us at the time of investigation. It therefore applied only to the site investigated and to a specific set of project requirement as understood by us.
- If there are changes to the project you need to advise us in order that the effect of the changes on the report recommendation can be adequately assessed.
- It is important to remember that the surface condition described in the report represent the state of the site at the time of the investigation. Natural processes and the activities of man can results in changes to the site conditions e.g. ground water levels can change or

fill can be placed on the site after the investigation is completed. If there is a possibility that conditions may have changed with time.

- The site investigation only identifies the actual surface conditions at the location and time when samples were taken.

Chapter 4

Shallow foundation Design

4.1 General:

Foundation design is the creation of a construction plan for a building foundation. It is highly specialized function and usually performed by a structural engineer. The foundation is the structural base that stands on the ground and supports the rest of the building. Therefore, foundation design must involve extensive study of the ground below the foundation as well as the design and materials used on the foundation itself. Foundations are designed to have an adequate load capacity depending on the type of subsoil/rock supporting the foundation by a geotechnical engineer and the footing itself may be designed structurally by a structural engineer. The primary design concerns are settlement and bearing capacity. When considering settlement, total settlement and differential settlement is normally considered. Differential settlement is when one part of a foundation settles more than another part. This can cause problems to the structure which the foundation is supporting. Expansive clay soils can also cause problems.

There are many types of building foundation with the exception of slab-on-grade foundations, which are laid at ground level, most foundations may be installed at a variety of depths. The required depth of any foundation can depend on several factors:

- **Soil bearing capacity.** This determines how much load (weight or force) the existing soil can withstand.
- **Soil type.** Different types of soil have different properties that can affect their suitability for supporting a foundation.
- **Frost depth.** The depth to which the soil freezes in the coldest time of the year, known as the frost depth or frost line, often is used to determine the minimum depth for many types of foundations.
- **Groundwater table.** A high groundwater table can limit the foundation depth as well as the type of foundation that can be used. Groundwater height is usually included in a soil study.
- **Minimum depth.** Disregarding other factors, the minimum depth of a foundation typically is not less than 18 inches to allow for removal of topsoil and variations in ground level.

4.2 Purpose:

Foundations provide the structure's stability from the ground.

- To distribute the weight of the structure over large area so as to avoid over-loading of the soil beneath.
- To anchor the structures against the changing natural forces like Earthquakes, floods, frost-heave, tornado or wind.
- To load the sub-stratum evenly and thus prevent unequal settlement.
- To provide a level surface for building operations.
- To take the structure deep into the ground and thus increase its stability, preventing overloading.
- Specially designed foundation helps in avoiding the lateral movements of the supporting material.

4.3 Foundation Load Transfer:

Foundations must be designed so that loads imposed by the building are transferred uniformly to the contact surface to transmit the sum of the dead load, live load, and wind load to the ground. The net loading capacity coming into the soil should not exceed the bearing capacity of the soil. Foundation design also must take into account expected settling from the building to ensure that all movement is controlled and uniform to prevent damage to the structure. In addition, the overall design of the foundation, superstructure, and characteristics of the ground should be studied to identify potentially beneficial construction strategies.

4.4 Types of Foundation:

Foundations are classified as shallow and deep foundations. Types of foundations under shallow and deep foundations for building construction and their uses are discussed. It is advisable to know suitability of each types of foundation before their selection in any construction project.

4.4.1 Types of Foundation and their uses:

Following are different types of foundations used in construction:

1. **Shallow foundation**
   a. Individual footing or isolated footing
   b. Combined footing
   c. Strip foundation
   d. Raft or mat foundation
2. **Deep Foundation**

a. Pile foundation

b. Drilled Shafts or caissons

1. **Shallow foundation:**

Shallow foundations, often called footings, are usually embedded about a metre or so into soil. One common type is the spread footing which consists of strips or pads of concrete (or other materials) which extend below the frost line and transfer the weight from walls and columns to the soil or bedrock. Another common type of shallow foundation is the slab-on-grade foundation where the weight of the structure is transferred to the soil through a concrete slab placed at the surface.

a. Individual footing or isolated footing individual footing or an isolated footing is the most common type of foundation used for building construction. This foundation is constructed for single column and also called as pad foundation. The shape of individual footing is square or rectangle and is used when loads from structure is carried by the columns. Size is calculated based on the load on the column and safe bearing capacity of soil.

b. **Combined footing** Combined footing is constructed when two or more columns are close enough and their isolated footings overlap each other. It is a combination of isolated footings, but their structural design differs. The shape of this footing is rectangle and is used when loads from structure is carried by the columns.

c. **Strip foundation** Spread footings are those whose base is wider than a typical load bearing wall foundations. The wider base of this footing type spreads the weight from the building structure over more area and provides better stability.

d. **Raft or mat foundations** are the types of foundation which are spread across the entire area of the building to support heavy structural loads from columns and walls. The use of mat foundation is for columns and walls foundations where the loads from structure on columns and walls are very high. This is used to prevent differential settlement of individual footings, thus designed as a single mat (or combined footing) of all the load bearing elements of the structure. It is suitable for expansive soils whose bearing capacity is less for suitability of spread footings and wall footings. Raft foundation is economical when one-half area of the structure is covered with individual footings and wall footings are provided. These foundations should not be used where the groundwater table is above the bearing surface of the soil. Use of foundation in such conditions may lead to scour and liquefaction.

4.5 layout of G+5 residential building using AutoCAD:

AutoCAD or computer Aided Design is very helpful tool in drafting and designing any structure. AutoCAD uses a Graphical User Interface for the purpose of drafting and designing any structure. The software has various inbuilt tools for complex drafting. Also AutoCAD can be used for 2D, 3D and for perspective design.

With the help of AutoCAD all the drafting for the project has been done.

4.5.1 Details of the project:

The plot size of the project was 28x22mts. Accordingly the building has been laid in the centre of the plot leaving ample space on all sides for landscaping and pathways for cars and for visitors parking's.

Table No 4.1: General Building Layout Details

Area of plot	28x22mts.
FSI	2
Number of floors	G+5
Number of units	4
Type Apartment	1BHK
Area of Each Apartments	546 Sqft

Fig 4.1 print

4.5.2 Layout using AutoCAD:

The layout has been mostly completed using line command. The unit for the layout is meters with accuracy of "0.000". Below is a screen shot of the line diagram showing the centre line for beam and column layout.

Fig 4.2 beam and column layout plan

In the above picture the yellow line signify the beam centre line while the blue rectangular boxes signify the column. The beams have cross section of 230mmx600mm. The columns have a cross section of 230mmx450mm. Slabs have a uniform thickness of 150mm, while the staircase slab has a thickness of 200mm. The floor to floor height kept at 3m.

All the work has been done in layers in AutoCAD, for easy editing and viewing. Layers make it easy to manipulate each individual layers making it visible and invisible for clarity as well as locking the layer to prevent editing in them.

The plan for the proposed project has 4 apartments in each floor having a 1BHK layout along with a living with a balcony, kitchen, and bedroom with a common bath and toilet with the rest of the apartment. There are total of 4 apartment divided in 5 floors. The ground floor of the building will be used as parking. The staircase width m with riser of mm and a tread of mm the landing is size of 1m and a shear wall is provided for Lift size of 230mmx

4.6 Analysis and Design using Etabs 2016:

The layout from AutoCAD is transferred to Etabs 2016 using a DXF file.

The above figure shows the beam and column layout in plan and 3D view in Etabs 2016 that has been transferred from AutoCAD. The total width of the building is m while the length around m. The fig also shows the X, Y, Z direction. Here Y direction taken as the vertical component. The X, Y, and Z coordination is also same as coordinate system used in AutoCAD.

Table No 4.2 Structural details

Length of building	19.14mts
Width of building	13.350mts
Height	18
Grade of concrete	M30
Grade of steel	F500
Column size	230x450mm
Beam size	230x600mm
Slab thickness (Floors)	150mm

Staircase slab	200mm
Total number of Columns	29
Total number of Beams	141
Dead Load (wall loads)	11.60 kN/m^2
Dead load (Floor Slabs)	1.5 kN/m^2
Live Load (Floor Slabs)	2 kN/m^2
Dead load and Live Load for staircase	2 kN/m^2 & 4 kN/m^2

Using above table data initially in Etab beam and column assign with respect to their sizes and grades. And the loading is applied to structure as the same value give in above table. Assign the structure as fixed supports to it base. After assigning all members and loads to the structure the model is applied for “RUN” that is analysing the structure for the loads. After the Etabs has completed analysing the whole structure, we can now proceeds to the design part of a structure. Etabs can design a structure for various types of material like concrete, steel etc. We will choose RCC “Reinforced Cement Concrete” for designing our structure. After completion of the analysis we go back to modelling mode and click on Design Tabs where we select Concrete as the material. Once that is done we select the design code which is to be followed. We select IS456-2000.

After the completion of the analysis we got the design values for the various members in the form of written data. To get the entire schedule of members we have just click the detailing Tab and click the member and we well get the schedule for that member.

Fig 4.3 Etabs model and 3D view print

Table No 4.3 Design loads for Footing Design

Sr No	Column No	Design Loads (kN)
1	C-3	1587
2	C-4	1220
3	C-5	1185
4	C-6	1287
5	C-7	1584
6	C-8	1434
7	C-10	1576
8	C-11	1275
9	C-13	2122
10	C-14	1868
11	C-15	1748
12	C-16	2095
13	C-17	1592
14	C-18	2044
15	C-19	1530
16	C-20	1762
17	C-21	1598
18	C-22	2259
19	C-23	1235
20	C-24	1981
21	C-25	2342

22	C-26	1591
23	C-27	1584
24	C-28	2248
25	C-30	736
26	C-31	927
27	C-32	1108
28	C-33	1206
29	C-34	1177

Using above table value that is designed loads used for the Footing design. By seeing above table we can say that column C-30 having least load of 736 kN and Column C-25 carries maximum load of 2342kN. Therefore round off the maximum value to higher for design purpose. By referring above table value we designed footing for two different load combinations.

Table No 4.4 Load Combinations for Footing Design

SR NO	COLUMN NO	LOAD RANGE KN	DESIGN LOAD KN	NUMBER OF COLUMN
1	C-4, C-5, C-6, C-8, C-11,C-23,C-30,C-31 ,C-32,C33,C34	736 TO 1500	1500	11
2	C-3,C-7, C-10, C-13, C-14, C-15,C-16,C-17,C-18, C-19,C-20,C-21,C-22, C-24,C25,C-26,C-27,C-28	1500 TO 2500	2500	18

4.7 Foundation designed for G+5 Building

In chapter 3 we have found a soil bearing capacity (SBC) for the site and G+5 building was constructed on that site for which we have to suggest suitable types of foundation for the structure and complete design of a foundation for that site. By taking reference of soil report or loading we suggest that shallow foundation is suitable for the site. Therefore provide a Isolated Footing Foundation just below all column.

4.7.1 Isolated Footing Design As per IS456-2000:

Table No 4.5 design constant and structural member

Column size	230mmx450mm
Ultimate load on column	1500kN
Grade of concrete	M20
Grade of steel	Fe415
Load Factor	1.5
SBC	464kN/m^2

Axial Load = $\frac{\mathbf{1500}}{\mathbf{1.5}}$ = 1000kN

Width (b) = 0.23m (Smaller Dimension of Column)

Length (D) = 0.45m (Larger Dimension of Column)

Total Vertical load = axial load + 10% of Axial load consider as Self weight of footing.

Total Vertical Load (P) = 1000 + 100 = 1100 kN

Ultimate Vertical Load (Pu) = 1500kN

Area of Footing required = $\frac{\text{P}}{\text{SBC}} = \frac{1100}{464}$ = 2.370m^2

Here we are providing a rectangular footing for all columns; therefore we need to find length and width footing by length width ratio.

$\frac{b}{D} = \frac{B}{L}$ $\frac{0.23}{0.45} = \frac{B}{L}$

Therefore, B = 0.511 x L

Area of Footing Required = B x L

2.370 = 0.511 x L^2

Therefore L = 2.15m and B = 0.511 x 2.15 = 1.098m

Therefore round it off length and width of Footing to a higher side and find Area of Footing provided.

B = 2.2m and L 1.2m.

Therefore, Area of Footing provided = 2.2 x 1.2 = 2.64m^2 > 2.370 m^2 ok

Upward Soil Pressure = $\frac{\text{Pu}}{\text{Area of Footig Provided}} = \frac{1500}{2.64}$ = 568.18kN/ m^2

Depth of Footing can be calculated by considering three criteria.

1. Depth of Footing By Bending Moment Criteria
2. Depth of Footing One-Way Shear Criteria
3. Depth of Footing Two-Way Shear Criteria

1. Depth of Footing by Bending Moment Criteria

While Depth of Footing by Bending Moment Criteria consider that critical section from BM is consider on the face of column

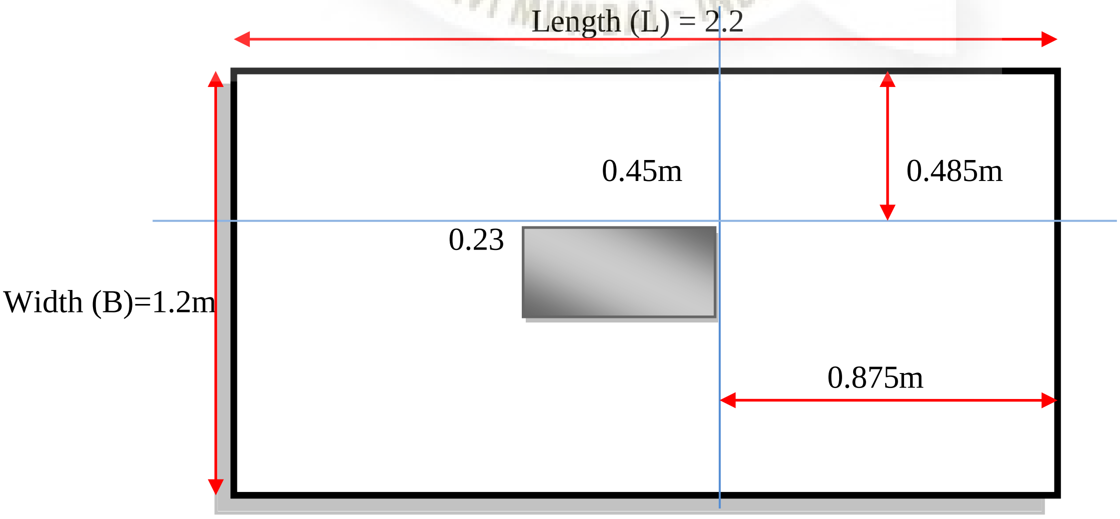

Fig No 4.4: B.M Criteria

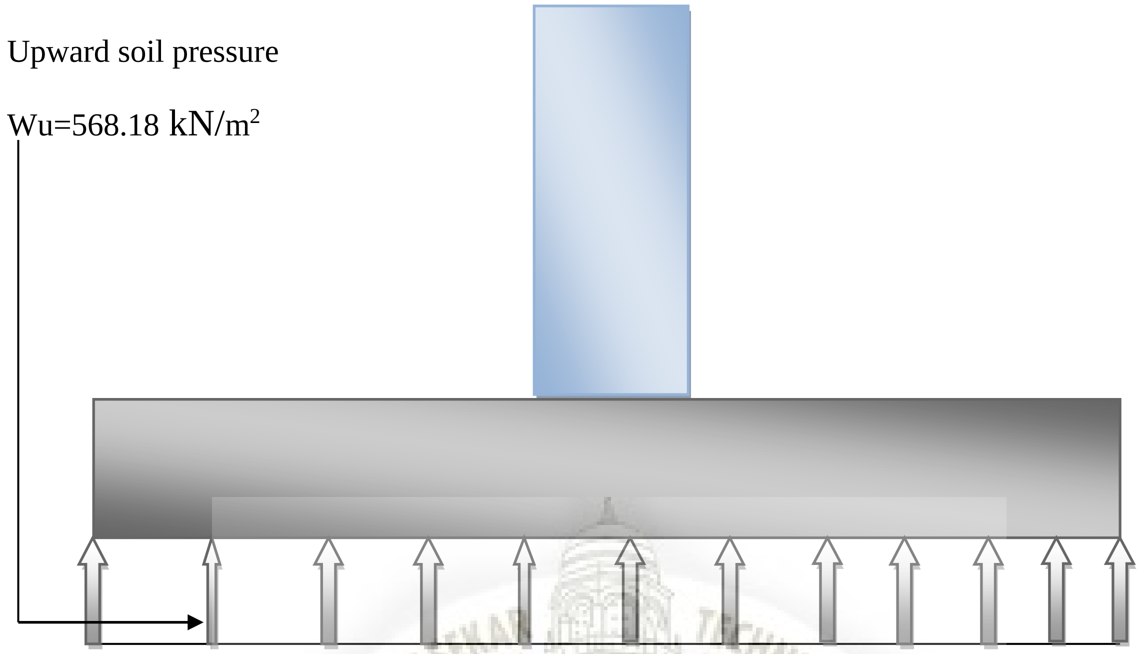

Fig No 4.5: Upward soil pressure diagram

Moment along Width (Mux) = $\frac{\text{Wu x } l^2}{2} = \frac{568.18 \text{ x } 0.485^2}{2}$ = 66.82kN.m

Moment along length (Muy) = $\frac{\text{Wu x} l^2}{2} = \frac{568.18 \text{ x} 0.485^2}{2}$ = 217.50kN.m

For Fe415,

$0.138 f_{ck} b d^2$ = Muy

$0.138 \text{x} 20 \text{x} 1000 \text{x } d^2 = 217.50 \text{ x } 10^6$ and solve for d

Therefore d = 280.72mm ≅ 300mm

2. Depth of Footing One-Way Shear Criteria:

Depth of Footing One-Way Shear Criteria along length, Critical section for one-way shear lies at a distance “d” from face of the column.

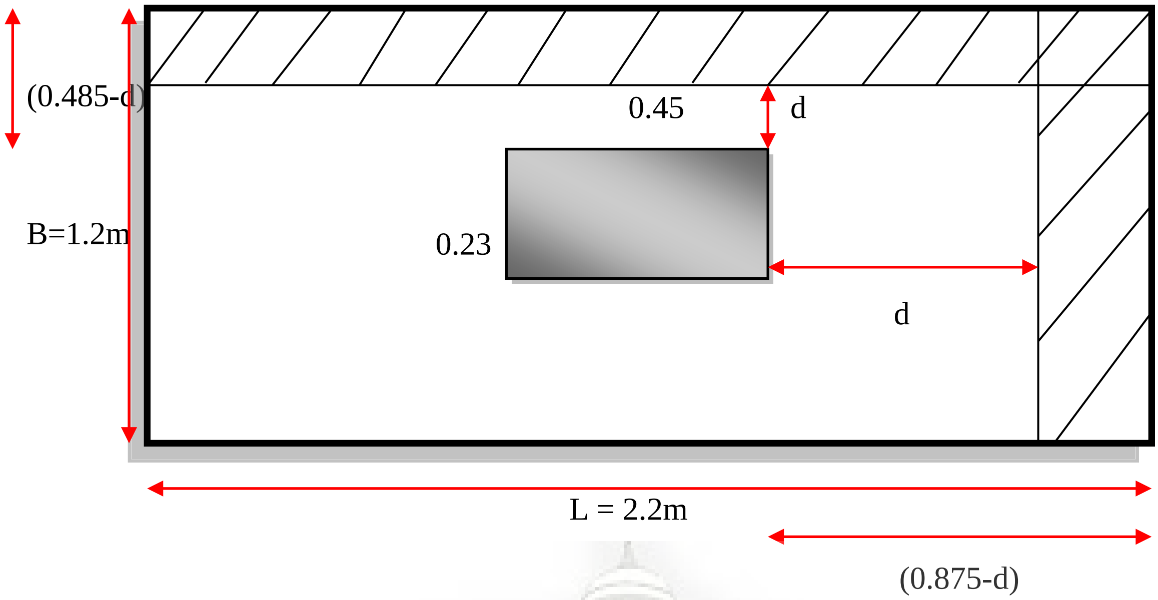

Fig No 4.6: One way shear criteria

Area of Critical section = 1.2x $\left(\left(\frac{2.2-0.45}{2}\right)-d\right)$

S.F on critical section = Area of Critical Section x Upward Soil Pressure (Wu)

S.F on critical section = 1.2x $\left(\left(\frac{2.2-0.45}{2}\right)-d\right)$ x 568.18 ----------→ (1)

Shear capacity of Concrete (Vc) = Ksxτcbd

Where Ks≥1

Ks = (0.5+β) where $\beta = \frac{0.23}{0.45} = 0.5111$

Ks = (0.5+0.511) = 1.0111

Therefore Adopt Ks = 1

$\tau c = 0.25x\sqrt{fck} = 0.25x\sqrt{20} = 1118\ kN/m^2$

Vc = 1 x 11x8 x 1.2 x d ----------→ (2)

Equating Equation 1 and 2 and solve for d

(1.2x $\left(\left(\frac{2.2-0.45}{2}\right)-d\right)$ x 568.18) = 1 x 11x8 x 1.2 x d

Therefore d = 0.2948m or 294.80m ≅ 300mm

Depth of Footing One-Way Shear Criteria along Width, Critical section for one-way shear lies at a distance "d" from face of the column.

Depth of Footing One-Way Shear Criteria along Width, for Critical section for one-way shear Refer above diagram.

Area of Critical section = {2.2 x $((\frac{1.2-0.23}{2})$-d}

S.F on critical section = Area of Critical Section x Upward Soil Pressure (Wu)

S.F on critical section = 2.2 x $((\frac{1.2-0.23}{2})$-d) x 568.18 → 1

Shear capacity of Concrete (Vc) = Ksxτcbd

Where Ks≥1

Ks = (0.5+β) where $\beta = \frac{0.23}{0.45} = 0.5111$

Ks = (0.5+0.511) = 1.0111

Therefore Adopt Ks = 1

$\tau c = 0.25x\sqrt{fck} = 0.25x\sqrt{20} = 1118\ kN/m^2$

Vc = 1 x 11x8 x 2.2 x d → 2

Equating Equation 1 and 2 and solve for d

(2.2x $((\frac{1.2-0.23}{2})$-d) x 568.18) = 1 x 11x8 x 2.2 x d

Therefore d = 0.1643m or 164.30m ≅ 170mm

2. Depth of Footing Two-Way Shear Criteria:

Critical section Two way shear lies $\frac{d}{2}$ from face of column

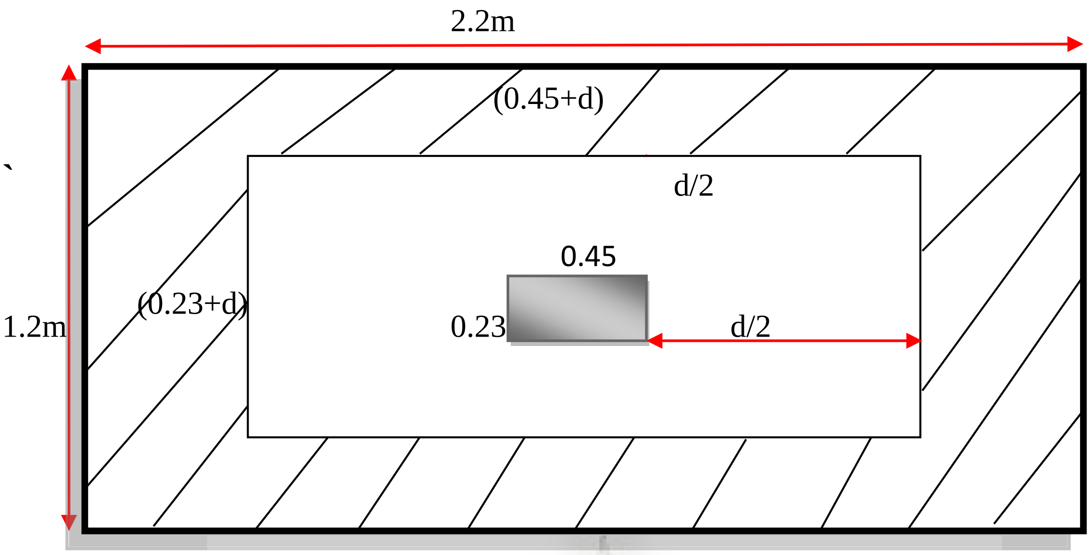

Fig No 4.7: Two-way Shear criteria

Area of critical section = (Area of outer rectangular portion)–(Area of inner rectangular portion)

Area of critical section = (BxL – (b+d) x (D+d))

Area of critical section (A) = {1.2x2.2-(0.23+d) x (0.45+d)}

S.F on critical section = A x Upward soil Pressure (Wu)

S.F on critical section = {1.2x2.2-(0.23+d) x (0.45+d)} x 568.18 ----------> (1)

Shear Capacity of concrete (Vc) = Ksxτcbd

Where b = perimeter of Critical section

b = 2 x {(D+d) + (b+d)} = 2 x {(0.45+d) + (0.23+d)}

b = 1.36 + 4d

Therefore, Vc = 1x1118x (1.36+4d) x d ----------> (2)

Equating Equation 1 and 2 and solve for d

{1.2x2.2-(0.23+d) x (0.45+d)} x 568.18 = 1x1118x (1.36+4d) x d

Therefore, d = 0.3780m or 378.04 ≅ 400mm

By comparing depth from one-way, two-way shear and Bending moment criteria adopt maximum depth

Maximum depth obtaining from two way shear criteria, therefore for d = 400mm

Assuming effective cover to reinforcement = 50mm

Therefore overall depth (D) = 450mm

Reinforcement calculation:

Reinforcement required along length,

Mux = 66.82 kN.m

$$Astx = \frac{0.5xfckxbd}{fy} \text{ x } (1 - \sqrt{1 - \frac{4.6xMux}{fckbd\text{^}2}})$$

$$Astx = \frac{0.5x20x1000x400}{415} \text{ x } (1 - \sqrt{1 - \frac{4.6x66.82}{20x1000x400\text{^}2}})$$

Astx = 474.59mm^2

Minimum reinforcement required = $\frac{0.12}{100}$ x b x D

Astmin = $\frac{0.12}{100}$ x 1000 x 450 = 540 mm^2 $>$ Astx

Minimum reinforcement required in along length less than reinforcement required.

Therefore provide minimum reinforcement along length.

Assuming 12mmϕ bar along length

Therefore, spacing along length = $\frac{\text{ast}}{\text{Astx}}$ x 1000

Spacing = $\frac{\frac{\pi}{4}x12^2}{540}\,x$ 1000 = 209.43 ≅ 200mm

Check for spacing: i) 3d ii) 300mm iii) calculated spacing

Therefore, providing 12mmϕ @ 200mm c/c as main reinforcement along the length.

Reinforcement required along Width,

Muy = 217.50 kN.m

Asty = $\frac{0.5xfckxbd}{fy}$ x (1 – $\sqrt{1-\frac{4.6xMux}{fckbd\text{^}2}}$)

Asty = $\frac{0.5x20x1000x400}{415}$ x (1 – $\sqrt{1-\frac{4.6x217.50}{20x1000x400\text{^}2}}$)

Asty = 1647.59mm^2

Minimum reinforcement required = $\frac{0.12}{100}$ x b x D

Astmin = $\frac{0.12}{100}$ x 1000 x 450 = 540 mm^2 $<$ Astx

Therefore provide required reinforcement along width.

Assuming 20mmϕ bar along width

Therefore, spacing along length = $\frac{ast}{Astx}x$ 1000

Spacing = $\frac{\frac{\pi}{4}x20^2}{1647.59}x$ 1000 = 190.678 ≅ 190mm

Check for spacing: i) 3d ii) 300mm iii) calculated spacing

Therefore, providing 20mmϕ @ 190mm c/c as main reinforcement along the Width.

4.7.2 Reinforcement Scheduling:

Table No 4.6 Reinforcement Calculation Details

Sr No	Column No.	No. Of Column	Load kN	d mm	D mm	Eff. cover mm	Φ Mm	Spacing mm	Ast mm^2	Length (L) (m)	Width (B) (mt)
1	C-4, C-5, C-6, C-8, C-11,C-23,C-30,C-31 ,C-32,C33,C34	11	1500	400 (Two-way criteria)	450	50	12	200	540 along length	2.2	1.2
							20	190	1647.59 along Width		
2	C-3,C-7, C-10, C-13, C-14, C-15,C-16,C-17,C-18, C-19,C-20,C-21,C-22, C-24,C25,C-26,C-27,C-28	18	2500	550 (Two-way criteria)	600	50	12	150	720 along length	2.8	1.5
							20	130	2263.49 along width		

4.7.3 Footing Reinforcement Detailing:

2500kN load print

1500 kN load print

Chapter 5

Deep Foundation Design

5.1 General:

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

Pile foundation Pile foundation is a type of deep foundation which is used to transfer heavy loads from the structure to a hard rock strata much deep below the ground level. Pile foundations are used to transfer heavy loads of structures through columns to hard soil strata which are much below ground level where shallow foundations such as spread footings and mat footings cannot be used. This is also used to prevent uplift of structure due to lateral loads such as earthquake and wind forces.

Drilled Shafts or caissons Drilled shafts, also called as caissons, is a type of deep foundation and has action similar to pile foundations discussed above, but are high capacity cast-in-situ foundations. It resists loads from structure through shaft resistance, toe resistance and / or combination of both of these. The construction of drilled shafts or caissons is done using an auger.

Drilled shafts can transfer column loads larger than pile foundations. It is used where depth of hard strata below ground level is location within 10m to 100m.
Drilled shafts or caisson foundation is not suitable when deep deposits of soft clays and loose, water-bearing granular soils exist. It is also not suitable for soils where caving formations are difficult to stabilize, soils made up of boulders, artesian aquifer exists.

5.2 Layout of G+20 residential building using AutoCAD:

AutoCAD or computer Aided Design is very helpful tool in drafting and designing any structure. AutoCAD uses a Graphical User Interface for the purpose of drafting and designing any structure. The software has various inbuilt tools for complex drafting. Also AutoCAD can be used for 2D, 3D and for perspective design.
With the help of AutoCAD all the drafting for the project has been done.

5.3 Details of the project:

The plot size of the project was 28x22mts. Accordingly the building has been laid in the centre of the plot leaving ample space on all sides for landscaping and pathways for cars and for visitors parking's.

Table No 5.1 General building layout details.

Area of plot	28x22mts.
FSI	2
Number of floors	G+20
Number of units	4
Type Apartment	1BHK
Area of Each Apartments	546Sqft

Fig 5.1 G+20 Architectural plan print

5.4 Layout using AutoCAD:

The layout has been mostly completed using line command. The unit for the layout is meters with accuracy of “0.000”. Below is a screen shot of the line diagram showing the centre line for beam and column layout.

Fig 5.2 Beam and Column layout plan print

In the above picture the yellow line signify the beam centre line while the Red rectangular boxes signify the column. The beams have cross section of 230mmx600mm. The columns have a cross section of 230mmx450mm. Slabs have a uniform thickness of 150mm, while the staircase slab has a thickness of 200mm. The floor to floor height kept at 3m.

All the work has been done in layers in AutoCAD, for easy editing and viewing. Layers make it easy to manipulate each individual layers making it visible and invisible for clarity as well as locking the layer to prevent editing in them.

The plan for the proposed project has 4 apartments in each floor having a 1BHK layout along with a living with a balcony, kitchen, and bedroom with a common bath and toilet with the rest of the apartment. There are total of 4 apartment divided in 5 floors. The ground floor of the building will be used as parking. The staircase width m with riser of mm and a tread of mm the landing is size of 1m and a shear wall is provided for Lift size of 230mmx

5.5 Analysis and Design using Etabs 2016:

The layout from AutoCAD is transferred to Etabs 2016 using a DXF file.

The above figure shows the beam and column layout in plan and 3D view in Etabs 2016 that has been transferred from AutoCAD. The total width of the building is m while the length around m. The fig also shows the X, Y, Z direction. Here Y direction taken as the vertical component. the X,Y,Z coordination is also same as coordinate system used in AutoCAD.

Table No 5.2 Structural details

Length of building	19.14m
Width of building	13.350m
Height	60m
Grade of concrete	M30
Grade of steel	F500
Column size	230x450mm
Beam size	230x600mm
Slab thickness (Floors)	150mm

Staircase slab	200mm
Total number of Columns	29
Total number of Beams	141
Dead Load (wall loads)	11.60 kN/m^2
Dead load (Floor Slabs)	1.5 kN/m^2
Live Load (Floor Slabs)	2 kN/m^2
Dead load and Live Load for staircase	2 kN/m^2 & 4 kN/m^2

Using above table data initially in Etab beam and column assign with respect to their sizes and grades. And the loading is applied to structure as the same value give in above table. Assign the structure as fixed supports to it base. After assigning all members and loads to the structure the model is applied for "RUN" that is analysing the structure for the loads. After the Etabs has completed analysing the whole structure, we can now proceeds to the design part of a structure. Etabs can design a structure for various types of material like concrete, steel etc. We will choose RCC "Reinforced Cement Concrete" for designing our structure. After completion of the analysis we go back to modelling mode and click on Design Tabs where we select Concrete as the material. Once that is done we select the design code which is to be followed. We select IS456-2000.

After the completion of the analysis we got deign values for the various members in the form of written data. To get the entire schedule of members we have just click the detailing Tab and click the member and we well get the schedule for that member.

Fig 5.3 Etabs model and 3d view of g+20

Table No 5.3 Loads on all Columns

Sr No	Column Number	Loads (kN)
1	C-3	5906
2	C-4	4834
3	C-5	5231
4	C-6	5523
5	C-7	4685
6	C-8	5065
7	C-10	5054
8	C-11	5572
9	C-13	5888
10	C-14	5492
11	C-15	6049
12	C-16	6318
13	C-17	4749
14	C-18	5954
15	C-19	5148
16	C-20	6219
17	C-21	6079
18	C-22	6014
19	C-23	5134
20	C-24	6075
21	C-25	6123

22	C-26	5097
23	C-27	4711
24	C-28	6212
25	C-30	3303
26	C-31	2871
27	C-32	3016
28	C-33	4878
29	C-34	5406

Using above table value that is designed loads used for the Pile design. By seeing above table we can say that column C-31 having least load of 2871 kN and Column C-16 carries maximum load of 6318kN. Therefore round off the maximum value to higher for design purpose. By referring above table value we designed Pile for two different load combinations.

Table No 5.4: Load Combination for Pile Design

SR NO	COLUMN NO	LOAD RANGE KN	DESIGN LOAD KN	NUMBER OF COLUMN
1	C-30, C-32, C-31	2871 TO 4500	4500	3
2	C-3,C-4, C-5, C-6,C-7, C-8, C-10, C-11, C-13, C-14, C-15,C-16,C-17,C-18, C-19,C-20,C-21,C-22, C-24,C25,C-26,C-27,C-28, C-33, C-34, C-23	4500 TO 6500	6500	26

5.6 Foundation recommendation and designed for G+20 Building:

In chapter 3 we have found a soil bearing capacity (SBC) for the site and G+20 building was constructed on that site for which we have to suggest suitable types of foundation for the structure and complete design of a foundation for that site. By taking reference of soil report or loading we suggest that Deep foundation is suitable for the site. Therefore provide a Pile Foundation just below all columns. In the beginning of the project is to be constructed for high rise building therefore soil investigation was carried as per there consideration but in the beginning of the project it is approved up to G+5 storey building, so we recommend a isolated footing for the corresponding structure is enough to transfer all structural load to the ground without being excessive settlement. After completion of a isolated footing design, foundation construction work has to executed within few days but in between them developer or owner gets approval of construction of high rise building owner to the higher authority or developer wishes to be constructed same structure as G+20 without any changes in the architectural plan approved by the engineers.

By referring to the previous chapter 3 which approved by geotechnical engineer geotechnical engineer recommended that the soil bearing capacity calculated in chapter 3 is less or it can without stand structural loads transferring to the ground are much more, so pile foundation is to be recommended for the G+20 storey building as foundation member.

5.7 Earth pressure calculation:

Top soil layer thickness of 0 to 0.5m

When z = 0

$\sigma h_1 = Ka x \gamma x h_1 - 2c\sqrt{Ka} = 0 - 2x20\sqrt{0.33} = -22.97$

When z = 0.5

$\sigma h_1 = 0.33x18x0.5 - 2c\sqrt{Ka} = 0 - 2x20\sqrt{0.33} = -20$

Earth pressure for layer 2 (0.5 to 1.5)

When z at 0.5m i.e. z = 0

$\sigma h_2 = Ka_2 x \gamma x h_2 = 0.33x18x0.5 = 2.97$

When z is at 1.5m i.e. z = 1m

$\sigma h_2 = Ka_2 x \gamma x h + Ka_2 x \gamma_2 x h_2$

σh_2 = 0.33x18x0.5 + 0.33x15x0.5 = 7.92

When z at 1.5m to 4.5m

When z is at 1.5m i.e. z = 0

σh_2 = Ka3 x (18x0.5+15x1) Ka3 x 20.3 x z

σh_2 = 0.31x24+0.31x20.3x0 = 7.44

When z is at 3m i.e. z = 1.5m (at water table)

σh_3 = 0.31x (18x0.5+15x1) +0.31x20.3x1.5 = 16.88

When z is at 4.5m i.e. z= 3m

σh_3 = 0.31 x (18x0.5+15x1) + 0.31x20.31x1.5+6.31 x (20.3-10) x 1.5

σh_3 = 7.44 + 9.44 + 4.79 = 21.67

For layer 4,

z is at 4.5m to 10m

When z is at 4.5m i.e. z = 0

σh_4 = 0.24 x {18x0.5+15x1 + 20.3x 1.5 + (20.3-10) x 1.5)} + 0.24 x (15-10) x1.5 x 0

σh_4 = 16.77

When z is at 10m i.e. z = 5.5m

σh_5 = {0.24 x ((18x0.5) + (15x1) + (20.3x1.5) + (10.3x1.5) + (5x5.5)}

σh_5 = 23.37

Table No 5.5: Calculation of Force and Moment from active earth pressure diagram

Sr No	Forces (kN)	Lever arm distance (z)	Moment kNm
1	2.47 x 1 = 2.97	8.5 + $^1/_2$ = 89	26.73
2	$^1/_2$ x 4.95 x 1 = 2.475	8.5 + ($^1/_2$ x 1) = 8.83	21.85
3	1.5 x 7.44 = 11.16	7 + $^{1.5}/_2$ = 7.75	86.5
4	$^1/_2$ x (16.88-7.44) x 1.5 = 7.08	7 + $^1/_3$ x 1.5 = 7.5	53.1
5	1.5 x 16.88 = 25.32	5.5 + $^{1.5}/_2$ = 6.25	158.25
6	$^1/_2$ x (21.67 – 16.88) x 1.5 = 3.592	5.5 + ($^1/_3$ x 1.5) = 6	21.55
7	5.5 x 16.77 = 92.23	$^{5.5}/_2$ = 2.75	253.63
8	$^1/_2$ X (23.37 – 16.77) x 5.5 = 18.15	$^1/_3$ x 5.5 = 1.83	33.21
9	$^1/_2$ x 70 x 7 = 245	$^1/_3$ x 7 = 2.33	570.85
TOTAL	**388 kN**	**130.41m**	**1225.67 kN.m**

Load per meter run = $\frac{1225.67}{10}$ = 122.56 kN per meter.

Ultimate moment (Mu) = 1.5 x 1225.67 = 1838.50 kN.

Fig 5.4 Earth pressure diagram print

5.8 Pile Foundation Design:

Table No 5.6: Pile Design Data

Column	230x450mm
Ultimate Load (Pu)	6500 kN
Ultimate Moment (Mu)	1838.50 kN.m
Grade of Concrete (fck)	M40
Grade of Steel (Fe)	Fe500
Diameter of pile (D)	800mm or 0.8m
Water table position	3.5m
Length of Pile	10m

5.8.1 Pile Capacity:

$A_b = \frac{\pi}{4} \times D^2 = \frac{\pi}{4} \times 0.8^2 = 0.502 m^2$

$A_s = \pi \times D \times L = \pi \times 0.8 \times 10 = 25.13\ m^2$

$Qu = (A_b \times \sigma v \times Nq) + (As \times \sigma a \times k \times \tan\delta)$

Where Qu = Ultimate Safe capacity of Pile

A_b = Area of Pile at Base ($\frac{\pi}{4} \times D^2$).

σv = effective vertical stress at tip level

Nq = bearing capacity factor & depend on ϕ value.

As = surface area of pile (π x D x L)

σa = average effective vertical pressure for the depth consider.

K = lateral earth pressure coefficient

δ = angle of friction between pile and soil.

Therefore capacity of Pile is given by,

Qu = (A_b x σv x Nq) + (As x σa x k x tanδ)

Qu = (0.502 x 97.4 x 51.84) + {(25.13 x 48.7 x 2 x tan15) + (25.13 x 48.7 + 48.7 x 2 x tan17.5) + (25.13 + 48.7 x 2 x tan16) + (25.13 x 48.7 x 2 x tan19)}

Qu = (2534.70) + {(655.84) + (771.74) + (701.85) + (842.79)}

Qu = 5506.92 kN

Assuming Factor of Safety = 1.5

Therefore safe vertical capacity of a Pile is given by $\frac{\text{Qu}}{\text{FOS}}$

Q = $\frac{\text{Qu}}{\text{FOS}} = \frac{5506.92}{1.5}$ = **3671.28 kN**

Number of Pile required = $\frac{\text{Ultimate load on Column}}{\text{Safe Vertical Capacity of Pile}} = \frac{6500}{3671.28} = 1.770 \cong \mathbf{2}$

Therefore providing 2 pile of 800mm diameter below the column carries load range of 4500 kN to 6500 kN.

Table No 5.7: Recommended vertical pile capacity

Sr No	Diameter of pile (mm)	Length of embedded below G.L (m)	Safe Vertical Capacity of Pile (Q) (kN)	Ultimate Load on Column (kN)	Number of Pile Provided (Nos)
1	800	10	3671.28	6500	2
2	700	10		4500	2

5.8.2 Structural Design of pile:

5.8.2.1 Designing for 0.8m diameter:

Pu = 6500 kN

Mu = 1838.50 kN.m

$$\frac{Pu}{fckxD2} = \frac{6500}{40x800^2} = 0.253$$

$$\frac{Mu}{fckxD3} = \frac{1835.50x10^6}{40x800^6} = 0.089$$

Assuming effective cover d'= 40mm

d'/D ratio $= \frac{40}{800} = 0.05$

$f_y = 500N/mm^2$ (Grade of Steel)

From S.P-16: 1980, Chart no 59 page No – 144

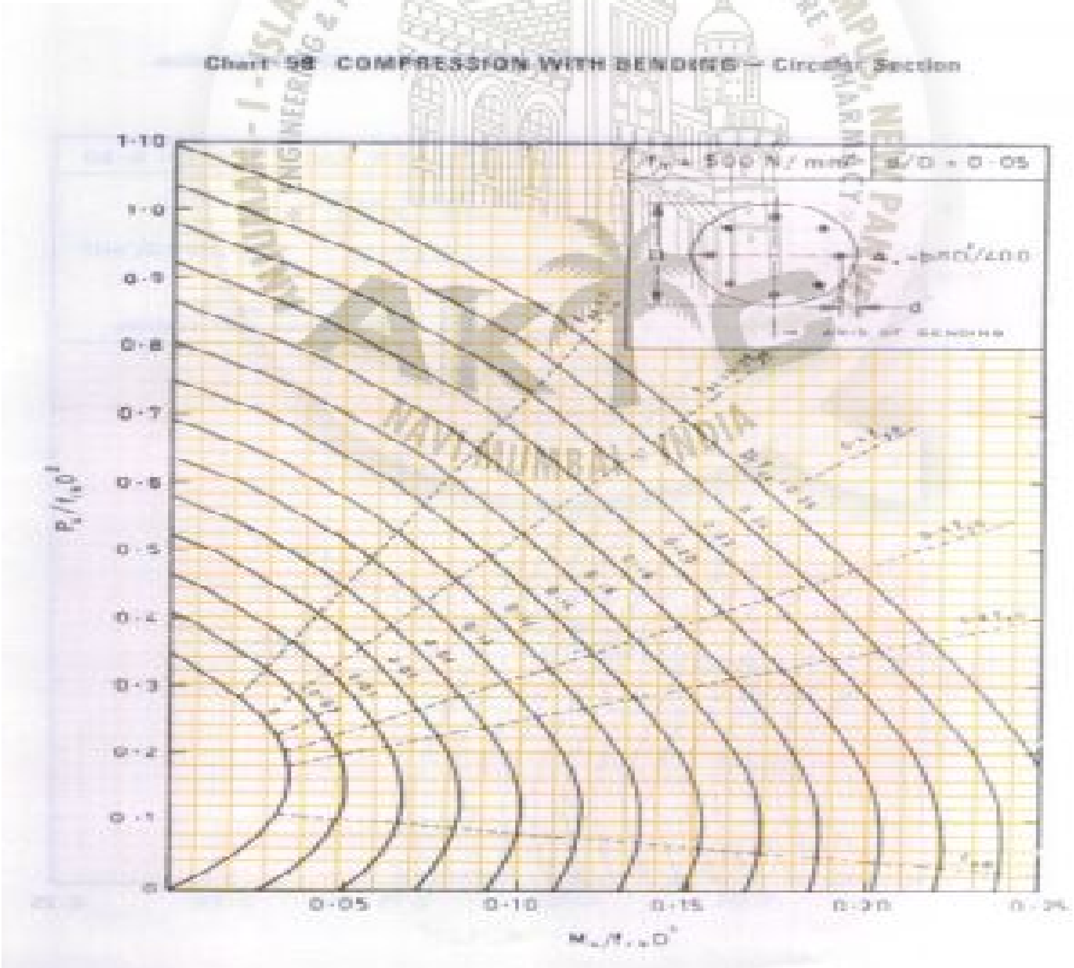

Fig No 5.5: S.P 16 charts No 59

For d'/D ratio = 0.05 & fy = 500 N/mm^2

$\frac{Pt}{fck}$ = 0.08 from chart

Pt = 0.08 x fck

Pt = 0.08x40 = 3.2% (Pt = percentage of steel)

Pt% = $\frac{Asc}{\pi/4xd^2}$ x 100

3.2 = $\frac{Asc}{\pi/4x800^2}$ x 100 and solve for Asc

Ast = 16084.95 mm^2 (Asc = Area of Steel required)

Assuming 32mmϕ bar

No of bars = $\frac{Asc}{ast} = \frac{16084.95}{\pi/4x32^2}$

= 19.99 ≅ **20**

Check for minimum Asc: (IS 456:2000)

Here minimum value of Asc is 0.80% of Ag and maximum value of Asc is 6% of Ag, our Asc value lies between these percentages, so we can say that reinforcement required to the pile is safe.

Therefore, Ascprovided = 20 x$\frac{\pi}{4}$ x 32^2 = **16084.95 mm^2**

Therefore providing 20 numbers of bars 32mmϕ @800mm dia of pile as Main Vertical Reinforcement in Pile.

P_{uz} = 0.45fckxAc + 0.75fyAsc

Where P_{uz} = Ultime load carrying capacity of Pile (kN)

f_{ck} = Grade of Concrete

Ac = Area of Concrete

f_y = grade of Steel

Asc = Area of Steel of Compression.

Where Ag = $\frac{\pi}{4}$ x 800^2 = 502624.82 mm^2

P_{uz} = 0.45 x 40 x (502624.82 – 16084.95) + 0.75 x 500 x 16084.95

P_{uz} = 14789.56kN

$\frac{Pu}{Puz} = \frac{6500}{14789.56}$ = 0.44

From the standard values given by IS code

$\alpha_n = 1$ for $\frac{Pu}{Puz} \leq 0.2$

$\alpha_n = 2$ for $\frac{Pu}{Puz} \geq 0.8$

$\frac{Pu}{Puz}$	α_n
0.2	1
0.44	αn =
0.8	2

Solve α = 0.44 by doing interpolation,

Therefore αn = 1.4

From SP-16, Chart number: 59. (Referring same figure)

For $\frac{Pu}{fck \times D^3} = 0.253$ and $\frac{p}{fck} = 0.08$

Therefore, $\frac{Mux1}{fck \times D^3} = 0.09$

Mux1 = 40 x 800³ x 0.09 = 1843.2 KN.M

$(\frac{Mux}{Mux})^{\alpha n} = (\frac{1838.50}{1843.2})^{1.4} = 0.996 \leq 1$, Therefore, Ok.

Design of helical reinforcements:

Dia of helical ties = ½ x 32 = 8mm or 8mm whichever is more.

Therefore, providing 10mmϕ as helical Reinforcement.

Dia of Core = D – (2 x effective Cover) – (2 x helical reinforcement)

Dia of Core = 800 – (2 x 40) – (2 x 10) = **700mm**

Pitch calculation:

- ≤ 75 mm
- ≤ x 1/6 x Core Dia = 1/6 x 700 = 116.67

- ≥ 25mm
- 3 x Dia of helical reinforcement = 3 x 10 = 30mm

Therefore providing pitch =50mm

Length of helical reinforcement = $\sqrt{(\text{pitch})^2 + (\pi \text{ x core dia})^2}$

Length of helical reinforcement = $\sqrt{(50)^2 + (\pi \text{ x } 700)^2}$ = **2199.68mm**

Volume of helical reinforcement = Area of helical r/f x length of helical r/f

Volume of helical reinforcement = $\frac{\pi}{4} x 10^2$ x 2199.68 = **172762.71mm^3**

Volume of core per pitch = $\frac{\pi}{4} x 700^2$ x 50 = **19242255mm^3**

Check

$$\frac{\text{Volume of helical R/f}}{\text{Volume of Core}} \nless 0.36 \text{ x } (\frac{\text{Ag}}{\text{Ac}} - 1) \text{ x } \frac{\text{fck}}{\text{fy}}$$

$$\frac{172762.71}{19242255} \nless 0.36 \text{ x } (\frac{502654.82}{384845.100} - 1) \text{ x } \frac{40}{500}$$

$$0.00897 \nless 0.00881$$

Hence safe.

Therefore complete structural of Pile having 800mm dia @ 10m in length satisfy all the checks. Therefore providing 2 Pile of 800mm dia for load of 6500kN.

5.9 Pile Foundation Design:

Table No 5.8: Pile Design Data

Column	230x450mm
Ultimate Load (Pu)	4500 kN
Ultimate Moment (Mu)	1838.50 kN.m
Grade of Concrete (fck)	M40
Grade of Steel (Fe)	Fe500
Diameter of pile (D)	700mm or 0.7m
Water table position	3.5m
Length of Pile	10m

5.9.1 Pile Capacity:

$A_b = \frac{\pi}{4}$ x D^2 = $\frac{\pi}{4}$ x 0.7^2 = 0.0.384m^2

$A_s = \pi$ x D x L = π x 0.7 x 10 = 21.99 m^2

Qu = (A_b x σv x Nq) + (As x σa x k x tanδ)

Where Qu = Ultimate Safe capacity of Pile

A_b = Area of Pile at Base ($\frac{\pi}{4}$ x D^2).

σv = effective vertical stress at tip level

Nq = bearing capacity factor & depend on ϕ value.

As = surface area of pile (πxDxL)
σa = average effective vertical pressure for the depth consider.
K = lateral earth pressure coefficient
δ = angle of friction between pile and soil.

Therefore capacity of Pile is given by,

Qu = (A_b x σv x Nq) + (As x σa x k x tanδ)

Qu = (0.384 x 97.4 x 51.84) + {(21.99 x 48.7 x 2 x tan15) + (21.99 x 48.7 + 48.7 x 2 x tan17.5) + (21.99 + 48.7 x 2 x tan16) + (21.99 x 48.7 x 2 x tan19)}

Qu = (1938.89) + {(573.9) + (675.31) + (614.15) + (737.49)}

Qu = 4539.74 kN

Assuming Factor of Safety = 1.5

Therefore safe vertical capacity of a Pile is given by $\frac{\text{Qu}}{\text{FOS}}$

Q = $\frac{\text{Qu}}{\text{FOS}} = \frac{\mathbf{4539.74}}{1.5}$ = **3026.5 kN**

Number of Pile required = $\frac{\text{Ultimate load on Column}}{\text{Safe Vertical Capacity of Pile}} = \frac{4500}{3026.5}$ = 1.4860 $\cong \mathbf{2}$

Therefore providing 2 pile of 700mm diameter below the column carries load range of 500 kN to 4500 kN.

5.9.2 Structural Design of pile:

5.9.2.1 Designing for 0.7m diameter:

Pu = 4500 kN

Mu = 1838.50 kN.m

$\frac{Pu}{fckxD2} = \frac{4500}{40x700^2}$ = 0.23

$\frac{Mu}{fckxD3} = \frac{1835.50x10^6}{40x700^2}$ = 0.134

Assuming effective cover d'= 35mm

d'/D ratio $= \frac{35}{700}$ = 0.05

f_y = 500N/mm^2 (Grade of Steel)

From S.P-16: 1980, Chart no 59 page No – 144

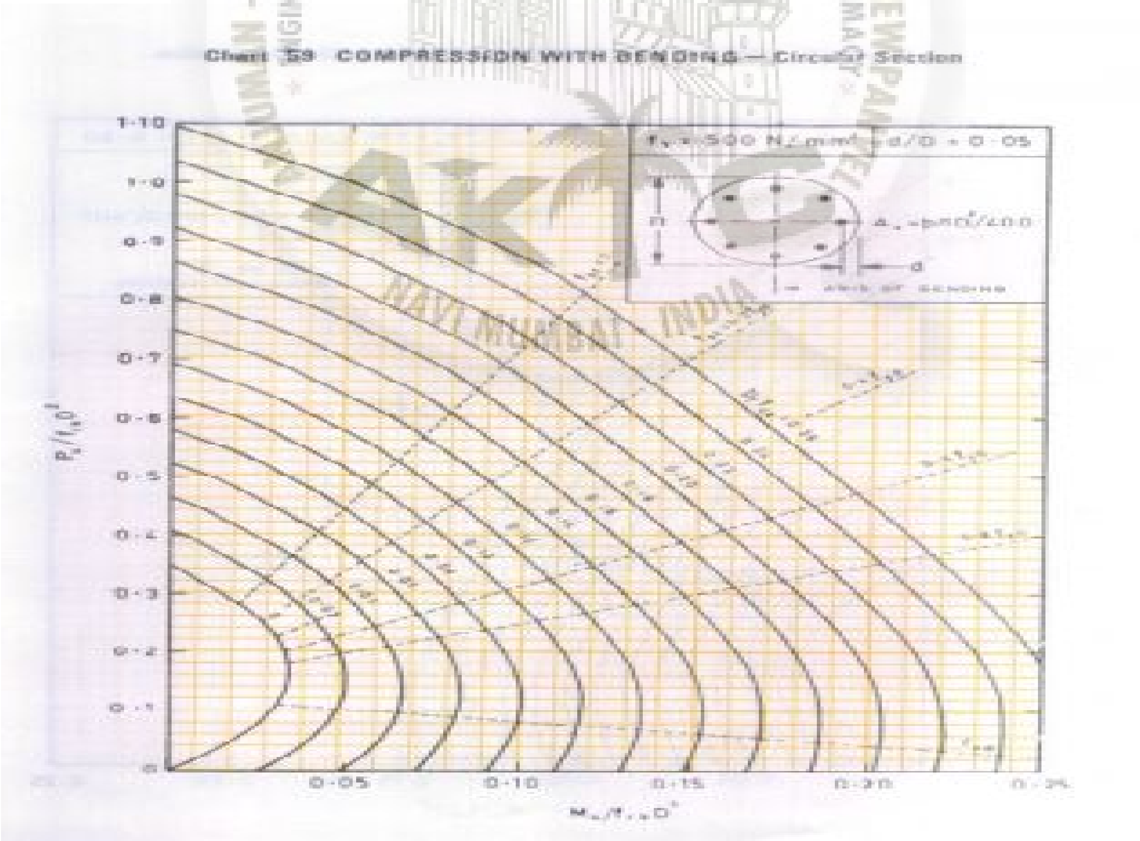

Fig No 5.6: S.P 16 Charts No 59

For d'/D ratio = 0.05 & fy = 500 N/mm^2

$\frac{Pt}{fck}$ = 0.13 from chart

Pt = 0.13 x fck

Pt = 0.13x40 = 5.2% (Pt = percentage of steel)

Pt% = $\frac{Asc}{\frac{\pi}{4} xd^2}$ x 100

5.2 = $\frac{Asc}{\frac{\pi}{4} x700^2}$ x 100 and solve for Asc

Asc = 20011.95 mm^2 (Asc = Area of Steel required)

Assuming 32mmϕ bar

No of bars = $\frac{Asc}{ast} = \frac{20011.95}{\pi/4x32^2}$

= 24.88 ≅ **25**

Check for minimum Asc: (IS 456:2000)

Here minimum value of Asc is 0.80% of Ag and maximum value of Asc is 6% of Ag, our Asc value lies between these percentages, so we can say that reinforcement required to the pile is safe.

Therefore, $Asc_{provided}$ = 25 x$\frac{\pi}{4}$ x 32^2 = **20106.9 mm^2**

Therefore providing 25 numbers of bars 32mmϕ @800mm dia of pile as Main Vertical Reinforcement in Pile.

P_{uz} = 0.45 x fck x Ac + 0.75 x fy x Asc

Where P_{uz} = Ultime load carrying capacity of Pile (kN)

f_{ck} = Grade of Concrete

Ac = Area of Concrete

f_y = grade of Steel

Asc = Area of Steel of Compression.

Where Ag = $\frac{\pi}{4}$ x 800^2 = 502624.82 mm^2

P_{uz} = {0.45 x 40 x (384854.10 – 20106.9)} + {0.75 x 500 x 20106.9}

P_{uz} = 14105.12kN

$\frac{Pu}{Puz} = \frac{4500}{7870.89}$ = 0.319

From the standard values given by IS code

α_n = 1 for $\frac{Pu}{Puz} \leq 0.2$

α_n = 2 for $\frac{Pu}{Puz} \geq 0.8$

$\frac{\textbf{Pu}}{\textbf{Puz}}$	α_n
0.2	1
0.319	αn =
0.8	2

Solve α_n by doing interpolation,

Therefore α_n = 1.198

From IS: SP-16, Chart number: 59. (Referring same figure)

For $\frac{Pu}{fck \times D^3}$ = 0.23 and $\frac{p}{fck}$ = 0.13

Therefore, $\frac{Mux1}{fck \times D^3}$ = 0.135

$Mux_1 = 40 \times 800^3 \times 0.135$ = 1852.2 KN.M

$\left(\frac{Mux}{Mux1}\right)^{\alpha n} = \left(\frac{1838.50}{1852.2}\right)^{1.198}$ = 0.988 ≤ 1, Therefore, Ok.

Design of helical reinforcements:

Dia of helical ties = ½ x 32 = 8mm or 8mm whichever is more.

Therefore providing 10mmϕ as helical Reinforcement.

Dia of Core = D – (2 x effective Cover) – (2 x helical reinforcement)

Dia of Core = 700 – (2 x 35) – (2 x 10) = **610mm**

Pitch calculation:

- $\leq$ 75 mm
- $\leq$ x 1/6 x Core Dia = 1/6 x 610 = 116.67
- $\geq$ 25mm
- 3 x Dia of helical reinforcement = 3 x 10 = 30mm

Therefore providing pitch =50mm

Length of helical reinforcement = $\sqrt{(\text{pitch})^2 + (\pi \text{ x core dia})^2}$

Length of helical reinforcement = $\sqrt{(50)^2 + (\pi \text{ x } 610)^2}$ = **1917.023mm**

Volume of helical reinforcement = Area of helical r/f x length of helical r/f

Volume of helical reinforcement = $\frac{\pi}{4} x 10^2$ x 1917.023 = **150562.63mm^3**

Volume of core per pitch = $\frac{\pi}{4} x 610^2$ x 50 = **14612332.83mm^3**

Check

$$\frac{\text{Volume of helical R/f}}{\text{Volume of Core}} \nless 0.36 \text{ x } (\frac{\text{Ag}}{\text{Ac}} - 1) \text{ x } \frac{\text{fck}}{\text{fy}}$$

$$\frac{150562.63}{14612332.83} \nless 0.36 \text{ x } (\frac{384845.100}{292246.65} - 1) \text{ x } \frac{40}{500}$$

$$0.01030 \nless 0.0912$$

Hence safe.

Therefore complete structural of Pile having 700mm dia @ 10m in length satisfy all the checks. Therefore providing 2 Pile of 700mm dia for load of 4500kN.

5.9.3 Reinforcement Details:

Table No 5.9 Reinforcement scheduling

Sr No	Column	No of column (No)	Dia of Pile (mm)	No of Pile	Ultimate load on Pile (kN)	Vertical Capacity of Pile (kN)	R/f dia ϕ (mm)	No of R/f	Length of Pile (m)
01	C-30, C-32, C-31	03	700	02	4500	3026.5	32	25	10
02	C-3,C-4, C-5, C-6,C-7, C-8, C-10, C-11, C-13, C-14, C-15,C-16,C-17,C-18, C-19,C-20,C-21,C-22, C-24,C25,C-26,C-27,C-28, C-33, C-34, C-23	26	800	02	6500	5506.92	32	20	10

5.9.3.1 Pile layout Plan print

5.9.3.2 Pile Reinforcement Detailing:

For 4500 kN Load & 6500 kN

Chapter 6

Conclusion

Discussion:

The purpose of this project is to assess or study the bearing capacity of soil for R.C.C structure and to suggest the suitable types of foundation for the structure. In initial stages bearing capacity of soil is found to be low for the multi-storey structure. The existing site is to be developed for G+5 residential building and later is to be allowed for, multi-storey building construction. In case of G+ 5 structures shallow foundation is suitable as bearing capacity of soil is enough to withstand the all structural load coming toward ground without excessive settlement, but for G+20 multi-storey building soil bearing capacity is not enough to counteract the ultimate load coming from G+20 building toward the ground, to overcome this difficulty pile foundation is suitable for the G+20 residential building.

Conclusion:

The report concluded that recommendation and analysis and design of foundation for R.C.C residential building by using bore log report of the site and testing result of the soil. First the soil bearing capacity, foundation recommendation, footing designed, vertical capacity of pile is to be determined using earth pressure diagram and moment at the base of the pile, design of pile foundation.

1. For G+5 residential building isolated footing is to be provided in two load combinations.

In 1st combination of load, there are 11 columns which carries 1500kN load and footing size provided (2.2x1.2x0.45m) with 5 bars of 12mmϕ bar @ 200mm centre to centre along length and 6 bars of 20mmϕ bar @ 190mm centre to centre along width.

In 2nd combination of load, there are 18 columns which carries 2500kN load and footing size is provided (2.8x1.5x0.60m) with 7 bars of 12mmϕ bar @ 150mm centre to centre along length and 8 bars of 20mmϕ bar @ 130mm centre to centre along width.

2. For G+20 residential Building Pile foundations is to be provided for a length of 10m in two groups.

   In case 1, there are two groups of pile is provided with 700mm diameter below 3 column with 25bars of 32mmϕ as main reinforcement and helical reinforcement of 10mmϕ @ 50mm centre to centre.

   In Case 1, there are two groups of pile is provided with 800mm diameter below 26 column with 20bars of 32mmϕ as main reinforcement and helical reinforcement of 10mmϕ @ 50mm centre to centre.

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