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STABILITY CERTIFICATE

The detailed engineering and structure design of the proposed building comprising of **STILT+3** floors at **Neelagiri Therku Thottam Village Old T.S.No.336/1A1pt, New ward - 8, Block - 16, New T.S.No.6, Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur Corporation, Thanjavur Taluk, Thanjavur District – 613007** S.No.6 has been done by me/us based on the report of geotechnical investigation (soil test) done by Time Institute For Materials Testing and considering the functional requirement of the building.

2. It is certified that among other factors, the proposed building has been designed to resist earthquake. I/We have checked various parameters and found that the proposed building would be safe.

3. I/We.further certify that:

(i) The minimum grade of concrete is M25 (25MPa)

(ii) The design and analysis has been done using the code of practice for plain and reinforced concrete as per IS 456, design loads as per IS Codes No. IS: 875-1987 and design of earthquake resistant structure as per IS Code No IS: 1893-2002

4. The building will be safe and sound when used for the purpose for which it is designed.

Stamp and Signature

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Encl: Structural Design Calculation

110 NATCHTRA NAGAR, 3rd STREET, THANJAVUR-613005
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ENGINEERING CONSULTANTS

Structural Stability Certificate

11/11/2024

Project Name : STILT+03 FLOOR RESIDENTIAL BUILDING-THANJAVUR.

Location : PROPOSED CONSTRUTION OF STILT+03 WITH 12 DWELLING UNITS AT PLOT NO: 81, NATARAJAPURAM SOUTH, 6th CROSS, MEDICAL COLLEGE ROAD, THANJAVUR - 613007.

Type of structure: R.C.C FRAMED STRUCTURE - STILT +03

This is to certify that the proposed construction of the Residential building

- The structure is designed and constructed for minimum grade of Concrete M25 and for steel Fe500
- The structure is analyzed and designed to resist the Dead and Live Load
- The loading is taken as per the requirements of Code of practice IS-875
- The design of the Structure is done as per the latest code IS-456.

We have designed the structural members and details are issued, with latest ETABS model created by us.

Accordingly, we hereby issue the **"Structural Stability Certificate"**

Accordingly, we hereby issue the Structure is **"Sound and Safe".**

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CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
'Thalamuthu Natarajan Building', No.1, Gandhi Irwin Road,
Egmore, Chennai-600 008.

PROFESSIONAL REGISTRATION CERTIFICATE

This is to certify that **Thiru. SUGANRAJ. K P** has enrolled as **Registered Structural Engineer Grade-I (SE)** with Chennai Metropolitan Development Authority (CMDA) who has the qualification of **M.E., (Structural Engg.)** and experience in the relevant field for **5 years**.

He has been given the Registration No.**SE/GR-I/2022/06/323** on **06.06.2022.** He shall be required to comply with the duties and responsibilities prescribed by the Government of Tamil Nadu in Part-V, "Registration of Professionals", Tamil Nadu Combined Development and Building Rules, 2019 approved vide G.O.(Ms) No.18 MAWS (MA1) Dept. dated 04.02.2019.

This Registration is valid upto **05.06.2027.**



CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY * CHENNAI-600 008. *

6.6.2022

T. ARIVALAGAN
SUPERINTENDENT
CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
EGMORE, CHENNAI-600 008.

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Thanjavur - 613 005.

STRUCTURAL DESIGN DETAILS

OF

PROPOSED CONSTRUCTION OF STILT+03 WITH 12 DWELLING UNITS AT NEELAGIRI THERKU THOTTAM VILLAGE OLD T.S.NO.336/1A1PT, NEWWARD-8,BLOCK-16,NEW T.S.NO.6,PLOT NO.81 OF NATARAJAPURAM SOUTH 6TH STREET, MEDICAL COLLEGE ROAD, THANJAVUR CORPORATION, THANJAVUR TALUK, THANJAVUR DISTRICT – 613007

Designed And Detailed By:

Er. K.P.Suganraj, M.E., (Structural Engineering)
Structural Engineer Grade – I
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CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
CHENNAI-600 008.

6-6-2022

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STRUCTURAL DESIGN STABILITY CERTIFICATE

I hereby certify that the proposed construction of affordable residential apartment building at Neelagiri Therku Thottam Village Old T.S.No.336/1A1pt, New ward-8, Block-16,New T.S.No.6, Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur Corporation, Thanjavur Taluk, Thanjavur District – 613007. The building will withstand against the earth quake, (seismic zone-II as per IS1893 (part-1) 2002) loading stress parameters are within limits of national building code and bureau of Indian standards code of practice for concrete and loading.

The building consists of stilt + 3 floors with 12 dwelling units. For external and internal partition walls natural clay bricks are used.

The R.C.C building frame of the structure is designed as per the Indian standard code of practice for concrete and loading as follows:

1. IS: 456-2000 code of practice for plain and reinforced concrete.

2. IS: 875-1987 code of practice for design loads for buildings and structures.

3. IS: 1893-2002 criteria for earthquakes resistant design of structures part-I general provisions and buildings.

4. IS: 4326-1993 code of practice for earthquakes resistant design and construction of buildings.

5. IS:13920-1993 code of practice for ductile detailing of concrete structures subjected to seismic forces

6. Nation building code of india-2005

It is further certified that the above structure will be constructed from foundation to roof, as per structural designs and detailing of reinforcements furnished in our drawings the building will be safe and sound as per the design

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DESIGN BASIS REPORT

THE PROPOSED RESIDENTIAL BUILDING STILT + 3 AT NEELAGIRI THERKU THOTTAM VILLAGE OLD T.S.NO.336/1A1PT, NEW WARD-8, BLOCK-16, NEW T.S.NO.6, PLOT NO.81 OF NATARAJAPURAM SOUTH 6TH STREET, MEDICAL COLLEGE ROAD, THANJAVUR CORPORATION, THANJAVUR TALUK, THANJAVUR DISTRICT – 613007.

1. The least dimension of column size is 230mm

2. The min grade of concrete is M25

3. The design and analysis using the code of practice for loading standards as per IS -875 (part-2)1987 and seismic force per code IS 1893-2016 & IS 456-2000

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CONTENTS

Chapter 1 **INTRODUCTION** .....

1.1 General

1.2 Scope

Chapter 2 **BUILDING DESCRIPTION**.....

2.1 General

2.2 Description of building

Chapter 3 **LOADS & LOAD COMBINATIONS**.....

3.1 General

3.2 Description of types of loading Load calculation

3.3 Load combinations

Chapter 4 **MATERIAL PROPERTIES**.....

4.1 General

4.2 Elastic & Physical properties

4.3 Grade of Reinforcement

4.4 Unit weight of materials

Chapter 5 **ANALYSIS**.....

5.1 General

5.2 Mathematical modeling of structure

5.3 Approximations in modelling

5.4 Boundary Conditions

Chapter 6 **ANALYSIS RESULTS**.....

6.1 Structure Displacements.

6.2 Reaction Summary.

6.3 Seismic Analysis Results

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Chapter 7 **DESIGN OF RC MEMBERS**.....

7.1 General
7.2 Nominal clear cover to reinforcement
7.3 Foundation parameters
7.4 Design of Members

Chapter 8 **DESIGN OF RAFT FOUNDATION**.....

8.1 Design philosophy
8.2 Load combinations

Annexure.

Annexure 1 - Design Summary of Columns
Annexure 2 - Design Summary of Ground floor Roof Beam

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Chapter 1 INTRODUCTION

1.1 General

The work of analysis, design and detailing of the PROPOSED CONSTRUCTION OF RESIDENTIAL (STILT+3) STILT, FIRST, SECOND, THIRD AND TERRACE FLOOR AT NEELAGIRI THERKU THOTTAM VILLAGE OLD T.S.NO.336/1A1PT, NEW WARD-8, BLOCK-16, NEW T.S.NO.6, PLOT NO.81 OF NATARAJAPURAM SOUTH 6TH STREET, MEDICAL COLLEGE ROAD, THANJAVUR CORPORATION, THANJAVUR TALUK, THANJAVUR DISTRICT – 613007.

1.2 Scope

This report presents details of structural analysis and design for static & seismic loading. The sizes and details of the sections of RC elements are based on detailed analysis, which is elaborated in this report. This report specifies the details of structural layout, mathematical model, material properties, loads and load combinations, Static& Seismic analysis results, design summary for beams, columns and Foundation design calculations.

Chapter 2 DESCRIPTION OF BUILDING

The proposed residential building consists of S+3 Floors. Plan & dimension of the building as (ref architectural drg). Height of each floor is 3m, total height of building 11.8m from Ground level. Isolated foundation is provided. Of SBC 20T/SQM

Chapter 3 LOADS & LOAD COMBINATIONS

3.1 General

This chapter discusses applicable loading for structural analysis & design of the proposed building. The loading is classified and described in the following paragraphs

3.2 Description of types of loading & Load calculation

Dead load, Live Load & Seismic Loads is considered for analysis and design as per relevant Indian Standards and Specifications applicable to Chennai region.

The sizes of members have been fixed based on stiffness criterion and as suitable for architectural drawings.

3.2.1 Dead load comprises of self-weight of various structural elements indicated below:

- Self-weight of Columns, beams, Slabs, brick walls.
- Floor & roof finishes.

Self-weight of the modeled elements is calculated by ETABS through SELF WEIGHT command. The self-weight of slab and floor finishes is applied explicitly as floor loads and distributed on the beams as trapezoidal or triangular loads in two wav slabs and as

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Loads from components like brick walls are applied explicitly as member loads and UDL (Uniformly Distributed Load) as applicable.

Component	Unit weight (kN/m^3)	Thickness (mm)	Area load (kN/m^2)
RCC Slab	25	150	2
Floor Finish	20	75	1.5
Total Floor &Roof Load			**3.5**

Typical calculation of Brick wall.

Height of ACC wall = 2.6m

DL of 230mm tk. Brick wall = 12kN/m

DL of 230mm tk. Parapet wall = 1.2kN/m

Staircase deadload calculation

DL of waist slab & concrete step on supporting beam = 5.85kN/m^2

3.2.2 Live Loads are considered for the analysis in addition to dead loads of self-weights as follows,

Floor slab	-	2kN/Sqm
Staircase	-	4KN/Sqm
Toilet	-	2kN/Sqm
Terrace slab	-	1.5KN/Sqm

3.2.3 Seismic Loads

The seismic parameters considered for analysis are as follows:

Seismic Zone	=	II
Seismic Zone Factor, Z	=	0.10
Importance Factor, I	=	1.0
Response Reduction Factor, R	=	3(OMRF)

(OMRF- Ordinary Moment Resisting Frame, Designed & detailed as per IS456)

Percentage Damping	=	5%
Fundamental		
Average response acc. coefft. Sa/g	=	As per IS:1893 – 2016

As per IS 875 part 3, **Primary Load case**

1 –Pseudo static Load in X

2–Pseudo static Load in Z

3 –Slab dead load

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5 – Live Load

6– Seismic Load X (Response Spectrum) – (EQX)

7– Seismic Load Z – (EQZ)

Strength Load combinations

LOAD COMB 1 1.5DL+1.5LL

LOAD COMB 2 1.2DL+1.2LL+1.2SL+X

LOAD COMB 3 1 .2DL+1.2LL+1.2SL-X

LOAD COMB4 1.2DL+.2LL+1.2SL+Z

LAOD COMB 5 1.2DL+1.2LL+1.2SL-Z

LOAD COMB 61.5DL+1.5SL +X

LOAD COMB 71.5DL+1.5SL -X

LOAD COMB 81.5DL+1.5SL +Z

LOAD COMB 91.5DL+1.5SL -Z

LOAD COMB 10 0.9DL+1.5SL +X

LOAD COMB 11 .9DL+1.5SL -X

LOAD COMB 12 0.9DL+1.5SL +Z

LOAD COMB 13 0.9DL+1.5SL -Z

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Chapter 4 MATERIAL PROPERTIES

4.1 General

This chapter describes the physical and elastic properties for various materials used. These are used for defining the stiffness calculation of the modeled structural members and lumped mass calculations for static and dynamic analyses models.

4.2 Elastic & Physical Properties

The elastic properties of materials used are tabulated below in Table 1

Table.1 – **Elastic properties of materials**

S.No.	Material	Elastic Modulus (kPa)	Poisson's Ratio
1	Normal density reinforced concrete (M20Grade)	25×10^3 calculated using $5000\sqrt{fck}$	0.2

4.3 Grade of Reinforcement

Reinforcement of Grade Fe-500conforming to IS 1786 is used for RCC design.

4.4 Unit Weight Of Materials

Unit weight of various materials used are given below

Reinforced cement concrete	= 25 kN/m^3
Brick wall	= 20 kN/m^3
Steel grade Fe-500	= 78.50 kN/m^3

Chapter 5 ANALYSIS

5.1 General

The analysis of the structure is carried out by mathematical modeling of the structure in ETABS and performing analysis run.

5.2 Mathematical Modeling Of Structure

The building is modeled and analyzed and designed using ETABS. The physical structure of building is transformed into a mathematical model for structural analysis using 3D frame elements. Entire structure is composed of integrated three dimensional structure of beams and columns forming frames tied together to act as one unit responding to the loading on the structure. The discretization of the structure involves structural components such as RC columns, RC beams.

5.3 Approximations in Modeling

Following approximations are made in the modeling of the building:

1. Offset eccentricities between center-line of column & beams are ignored. Accordingly, nodal co-ordinates are fixed.
2. The non-structural components like brick walls are neglected in modeling, but their loading effect on the structure is accounted.
3. Column positions are shifted marginally for aligning them along the grid lines.

5.4. Boundary Conditions

For the purpose of analysis and design, the bottoms of the columns are pined at foundation level at 1.2m below the NGL.

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5.50 ANALYSIS FOR STATIC & SEISMIC LOADING

5.51 The static analysis is carried out to obtain the internal forces and moments on all the member of the structure under static loads. Analysis is performed for each of the load cases mentioned below.

1. Dead load
2. Live load

5.52 Seismic Analysis.

Seismic analysis is performed using Pseudo static method &Response spectrum method by using design spectrum as per IS 1893-2016. The design base shear (V_B) obtained from response spectrum method is compared with the base shear calculated using fundamental period (Ta) by Etabs itself. In case V_B is less than V_b, all the response quantities are multiplied by ratio V_b/V_B. Modeling for stiffness, mass and damping are considered as per code. For the purpose of lumping, 50% of live load on roofs are considered.

Chapter 6 ANALYSIS RESULTS

6.1 Structure Displacements

The analysis solution is carried out using ETABS package. The maximum nodal *displacements in horizontal directions observed from the analysis for various load* combinations are presented in the Table below

Maximum Lateral Displacement in the Structure.

6.2 Summary of Support Reactions for Static & Seismic Analysis

Chapter 7 DESIGNS OF RC MEMBERS

7.1 General

Limit State design using IS: 456-2000 is carried out for RC beams and columns using the forces obtained from the critical combination of loads from the analysis results in ETAB other components like pile foundations are designed using simplified provisions as per applicable codes with the help of spread sheets developed in house.

7.2 Nominal Clear Cover to Reinforcement

Nominal clear cover used for various elements are listed below:

Foundation	:	50 mm
Columns	:	*40mm*
Grade beams	:	25mm

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Floor & other beams : 25mm

Slabs & Staircase : 20mm

7.3 Foundation Parameters

The following parameters are used in the design of foundation.

SBC of soil 20t/sqm at depth of 2m from NGL

7.4 Design of Members.

RC Columns are designed using Limit State Method of design as per IS 456: 2000. Columns are designed as compression members subjected to combined axial load and biaxial bending. Minimum eccentricity is considered in design as per Clause 25.4 of IS 456: 2000.Columns are considered as braced due to provision of shear wall (lateral load resisting system). Effective length of column is taken as 1.0 and assigned to each column member in proportion to its total length. Slenderness of the column is checked as per Clause 25 of IS 456: 2000 and if necessary, additional moments are calculated as per Clause 39.7 of IS 456-2000to account for moment magnification due to slenderness effects. Limit States of Shear and Torsion are also considered in design. Etabs software is used to design the columns.

Chapter 8 DESIGN OFFOUNDATION

8.1 Design Philosophy

Super structure is analyzed using structural analysis software ETABS , The reactions corresponding to each load combinations obtained from the super structure analysis are applied as forces in the substructure model at the relevant support nodes. . The reaction is compared with capacity of the pile mentioned as per geotech. Report.

8.2 Approximations In Modeling

Following approximations are made in the modeling of the building:

1. Offset eccentricities between center-line of column & pile are ignored. Accordingly, nodal co-ordinates are fixed.

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Design of axially loaded pad footing

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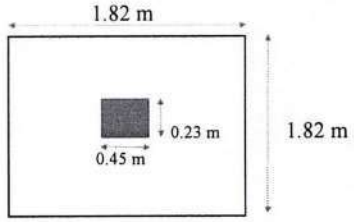
1) Basic data

Size of column	a_1	450	mm	=	0.45 m
	a_2	230	mm	=	0.23 m
Characteristic Load	P	700	KN		
Allowable Bearing Pressure of soil	ABP	250	KN/m^2		
Grade of concrete	fck	25	N/mm^2		
Grade of steel	fy	500	N/mm^2		
	X_{umax}/d	0.46			
Clear cover	c	50	mm		
Self weight of footing		70	KN		

$$\frac{X_{umax}}{d} = \frac{700}{1100 + 0.87 * fy}$$

2) Size of footing

Total load (including self wt.)		770	KN
Area of footing required	A	3.08	m^2
Dimensions of foundation required	=	1.755	m
	=	1.755	m
L/B = 1			
Dimensions of foundation provided	X	1.82	m
	Y	1.82	m
Area of footing provided		3.31	m^2

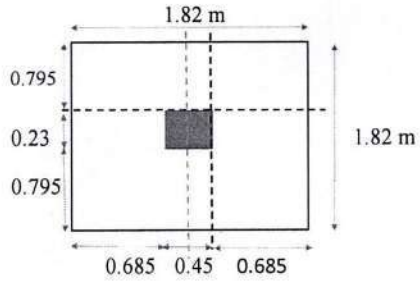


3) Net upward pressure

	p_o	316.991	KN/m^2

4) Moment steel

Cantilever length || to X	L_X	0.685	m
Cantilever length || to Y	L_Y	0.795	m
UDL on the cantilever length L_1	w_X	576.923	KN/m
UDL on the cantilever length L_2	w_Y	576.923	KN/m
Design BM along L_1	M_{ux}	135.353	KNm
Design BM along L_2	M_{uy}	182.315	KNm
Design BM	M_u	182.315	KNm
	Q_{lim}	3.20585	
Required depth of footing	d_{req}	176.768	mm
Provided overall depth of footing	D	450	mm
Assume Diameter of bar	φ	12	mm
Effective depth provided,	dx	394	mm
	dy	382	mm



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i) R/F along X

Bending Moment acting	M_{ux}	135.35	kNm	
Diameter of bar	φ	12	mm	
Percentage of steel req.	p_t	0.113	%	
Area of steel required	A_{streq}	808.359	mm^2	
No of bars required	N	7.15109		
No of bars provided	N_{prov}	8		
Area of steel provided	$A_{st,prov}$	904.32	mm^2	
Spacing required	S_{req}	125		
Spacing Provided	$S_{prov.}$	120	mm	
	$p_{tprov.}$	0.126	%	TRUE

Hence provide8-12mm @ 120mm c/c

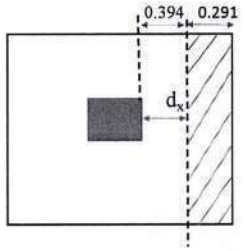
ii) R/F along Y

Bending Moment acting	M_{uy}	182.31	kNm	
Percentage of steel req.	p_t	0.16322	%	
Area of steel required	A_{streq}	1134.75	mm^2	
Diameter of bar	φ	12	mm	
No of bars required	N	10.0385		
No of bars provided	N_{prov}	11		
Area of steel provided	A_{st}	1243.44	mm^2	
Spacing Required	S_{req}	90.9091		
Spacing Provided	$S_{prov.}$	90	mm	
	$p_{tprov.}$	0.179	%	TRUE

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5) Check for one-way shear

i) Along X



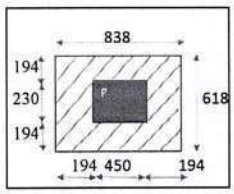
V_u	167.885	KN	
τ_v	0.23412		
β	25.6069		
τ_c	0.25631	N/mm^2	OK

ii) Along Y

V_u	238.269	KN	
τ_v	0.34272		
β	18.056		
τ_c	0.30015	N/mm^2	OK

6) Check for two way shear

average depth,	d	388	mm
Width at distance d/2 along X	b''_X	838	mm
Width at distance d/2 along Y	b''_Y	618	mm
Critical perimeter	b_0	2912	mm
Upward Pressure	w	316.991	KN/m^2
Total Area of foundation	A	3.31	m^2
Critical area for shear	a	0.51788	m^2
Factored shear force	V''_u	885.836	KN
Shear Stress	τ_v	0.77209	N/mm^2
Permissible Shear Stress	τ_c	1.25	N/mm^2 OK



7) Transfer of load from column to footing:

Factored compressive force at the base of column 1050 KN

As per cl 30.6 of IS:456-2000,limiting bearing stress

$$f_{br} = 0.45 * fck * \sqrt{\frac{A_1}{A_2}}$$

a) At column face

$A_1 = A_2 =$	103500	mm^2
f_{br}	11.25	N/mm^2

b) At footing face

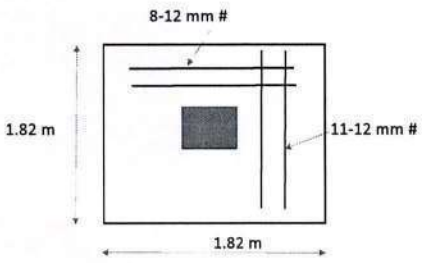
A_1	3312400	mm^2
A_2	103500	mm^2
$\sqrt{\frac{A_1}{A_2}}$	5.6571958	(the value is more than 2 hence use 2)
f_{br}	22.5	N/mm^2

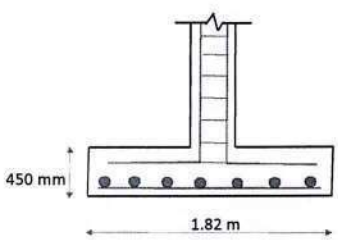
The crictical face is the column face

The limiting bearing resistance, 1164.375 KN < 1050 KN

Excess force required to resist **-114.375 KN**

The excess force may be resisted by providing dowel bars or by continuing the column bars into the footing.





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COLUMN E7

1) Input Data

Unfactored axial load	P_u	200	KN
Unsupported length	L	3	m
Grade of concrete	fck	25	N/mm^2
Grade of steel	fy	500	N/mm^2
Restrained conditions		3	(Refer to sheet on "effective length")
	K	1	
effective length	L_e =	3	m

2) Determine the size of the column

factored load		300	KN	
Self wt. of column		3	KN	(1% of factored load on column)
Total Factored Load	P_u	303	KN	
	p_t	3	%	(Assume value between 0.8% to 4%)
	$A_{required}$	15112.22	mm^2	
Assume	b	450	mm	
	D	230	mm	
	$A_{provided}$	103500	mm^2	OK

3) Check for slenderness ratio

	L_e/b	6.67
	L_e/D	13.04

NOT OK AND HENCE DESIGN AS LONG COLUMN

4) Estimate Longitudinal Reinforcement

	$A_{sc,required}$	-2185.07						
	$A_{st,min}$	828	mm^2	OK				
provide	4	bars of	20	mm dia. &	4	bars of	16	mm dia
	$A_{sc,prov.}$	2060.885	mm^2	OK				

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5) Check for minimum eccentricity

	$ex_{,min}$	21 mm	OK
	$ey_{,min}$	20 mm	OK

e_{min} should be less than 0.05*D and 0.05*b respectively

6) Design of lateral ties

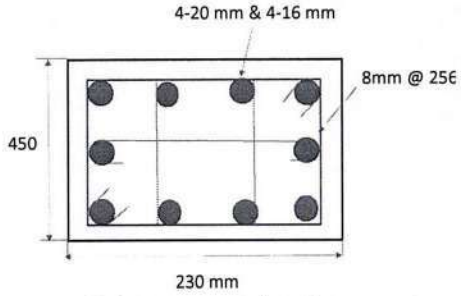
dia. of ties ϕ_{ties} 8 mm

Pitch is taken smaller of the following:

a)	LLD	=	450 mm
b)	$16*\phi_{SL}$	=	256 mm
c)	300 mm		300 mm

pitch provided = 256 mm

Design Summary	
b	450 mm
D	230 mm
Longitudinal bar details	4-20 mm & 4-16 mm
$A_{sc,provided}$	2060.88 mm^2
Dia. Of ties	8 mm
Pitch of ties	256 mm



Reinforcement details

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BEAM ALONG GRID E

1) Basic data	b	230	mm
Clear span of the beam	L	3.7	m
Width of support		450	mm
Grade of concrete	F_{ck}	25	N/mm^2
Grade of steel	F_y	500	N/mm^2
Clear cover		30	mm
Super-imposed load	w	12	KN/m
Assume Diameter of bars		16	mm
Number of bars		3	No's
Depth to width ratio	d/b ratio	1.5	
	d_{prov}	345	mm
	D	383	mm

2) Effective span of the beam

	c/c dist.	4.15	m
	L + d	4.045	m
	$L_{eff.}$	**4.045**	m

3) Factored B.M and S.F

Self-wt of beam		2.20	KN/m
Factored load	w_u	21.30	KN/m
Factored B.M	M_u	43.57	KNm
Factored S.F	V_u	43.09	KN

4) Design factors

	$x_{umax/d}$	0.46	
	Q_{lim}	3.32	
	d_{bal}	238.94	mm
	d_{prov}	345.00	mm OK
	$p_{t,req}$	0.40	%
	p_{tlim}	0.94	%
	$A_{st,req}$	315.57	mm^2
	$A_{st,lim}$	748.67	mm^2
	$A_{st,provided}$	602.88	mm^2
	$p_{t,prov.}$	0.76	
	$M_{u,lim}$	90.84	KNm

OK since Mu<Mulim and hence designed as SRB

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5) Design of shear reinforcement

Shear Design parameters	β	3.82			
	τ_c	0.58	N/mm^2		
	τ_v	0.54	N/mm^2		OK
Assume dia. Of stirrups	φ	8	mm		
	fy	500	N/mm^2		
No. of legs of stirrups		2			
	A_{sv}	100.48	mm^2		
	S_v	-5478.14	mm c/c	≈	-5480 mm c/c

Maximum spacing of shear reinforcement (As per cl 26.5.1.5 of IS 456-2000)

258.75 mm
300.00 mm
475.10 mm

Therefore OK since Sv satisfies maximum spacing criteria

$S_{v,provided}$ -5480 mm c/c

6) Check for deflection

As per IS 456-2000, to satisfy the deflection critieria, $(L/d)_{actual} < (L/d)_{permissible}$

Now ,	$(L/d)_{permissible}$	20* M.F	
	Fs	151.798022	Mpa
	M.F	1.1	
therefore	$(L/d)_{permissible}$	22	
and,	$(L/d)_{actual}$	10.7246377	

Hence OK since (L/d)actual < (L/d)permissible

7) Check for development length

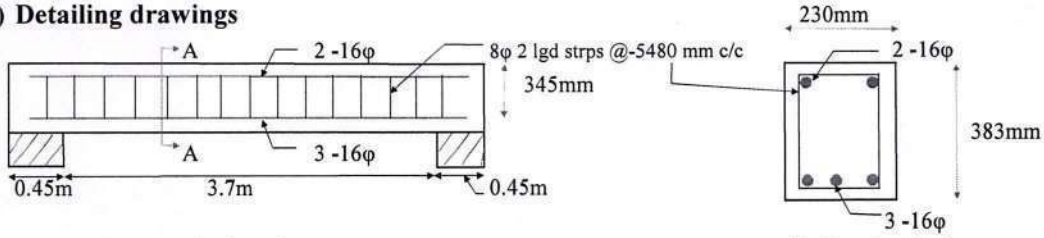
	L_d	752	mm
	x_u	126.69	mm
	M_1	76.52	KNm
	V	43.09	KN
	L_0	345	mm
	$1.3M_1/V + L_0$	2653.85 mm	OK

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8)

Design Summary	
Width of beam, b	230 mm
Overall depth of beam	383 mm
Dia. of Bars at bottom	16 mm
No. of Bars at bottom	3 Nos.
Dia. of holding bars at top	16 mm
No. of holding bars at top	2 Nos.
$A_{st,provided}$	602.88 mm^2
Dia. Of Stirrups	8
No. of legs of stirrups	2 Legged
Spacing of Stirrups	-5480 mm
Development length	752 mm

9) Detailing drawings



a) Elevation

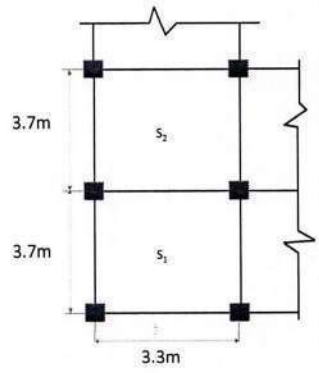
b) Section A-A

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DESIGN OF RESTRAINED TWO WAY SLABS

1 Basic data

Dimensions of slab	Ly	3.7	m	longer span
	Lx	3.3	m	shorter span
Thickness of supports	longer	0.23	m	
	shorter	0.23	m	
Grade of concrete	fck	25	N/mm^2	M25
Grade of steel	fy	500	N/mm^2	Fe415
clear cover		20	mm	



2 Design factors

x_{umax}/d	0.46	N.A. factor	
Q_{lim}	3.32	M.R. factor	
P_{tmax}	0.94	% r/f	

3 Aspect ratio

Ly/Lx 1.121212121

Check Ly/Lx ≤2 TRUE DESIGN SLAB AS TWO WAY SLAB

4 Assumptions for the depth of slab

MF 1.3

$$d = \frac{L_x}{26 * MF}$$

d 97.63 mm

$d_{assumed}$ 100 mm

$D_{assumed}$ 125 mm

cl 24.1, pg-39
for Lx ≤ 3.5 m
& LL ≤ 3 KN/m^2

$$\frac{L}{d} = 40 * M.F \quad (Fe-250)$$

$$\frac{L}{d} = 40 * M.F * 0.8 \quad (Fe-500)$$

else use cl 23.2.1, pg-37

5 Computation of loading and B.M

S.Wt.	3.125	KN/m
F.F	0.8	KN/m
L.L	4	KN/m

Total Load	W	7.925	KN/m
Factored load	Wu	11.8875	KN/m

6 Effective spans $L_{effective}$: (as per cl 22.2, pg-34, IS 456-2000)

For Lx_{eff}

a.	c/c between supports	3.53	m
b.	clear span + d	3.4	m
	Lx_{eff}	3.4	m

For Ly_{eff}

a.	c/c between supports	**3.93**	
b.	clear span + d	**3.8**	
	L_{yeff}	3.8	m

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7 Type of panel

TWO ADJACENT EDGE DISC.		
Ly/Lx	1.12	
α_x (Cont. edge)	0.056	
α_x (Mid-span)	0.042	
α_y (Cont. edge)	0.047	
α_y (Mid-span)	0.035	

INTERPOLATED VALUE:

Ly/Lx	αx (Cont.edge)	αx (Mid-span)
1.2	0.06	0.045
1.12	0.056	0.042
1.3	0.065	0.049

For span Lx

$M_{ux,mid\text{-}span}$	5.73	KNm	$Mux = \alpha_x * w * l^2{}_x$
$M_{ux,cont.edge}$	7.68	KNm	

for span Ly

$M_{uy,mid\text{-}span}$	4.81	KNm	$Muy = \alpha_y * w * l^2{}_x$
$M_{uy,cont.edge}$	6.46	KNm	

8 Required depth of slab

M_{umax}	7.68	KNm	
d_{req}	48.11	mm	$d_{req} = \sqrt{\frac{M_u}{Q_{lim} * b}}$
check $d_{req} < d_{assumed}$	TRUE		
$d_{provided}$	100	mm	
$D_{provided}$	125	mm	

9 R/F area at bottom

In middle-strip

Direction	$Ast_{required}$ in mm^2	ϕ (mm)	$S_{required}$ in mm	$S_{provided}$ in mm	$Ast_{provided}$ in mm^2
SHORT (X)	135.49	10	579.68	300	261.80
LONG (Y)	113.18	8	444.10	300	167.55

Edge strip R/F along continuous edge

Direction	$Ast_{required}$ in mm^2	ϕ (mm)	$S_{required}$ in mm	$S_{provided}$ in mm	$Ast_{provided}$ in mm^2
SHORT (X)	183.35	10	428.37	300	261.80
LONG (Y)	153.25	10	512.50	300	261.80

Minimum R/F A_{stmin} 150 mm^2 OK

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10 At discontinuous edges at top

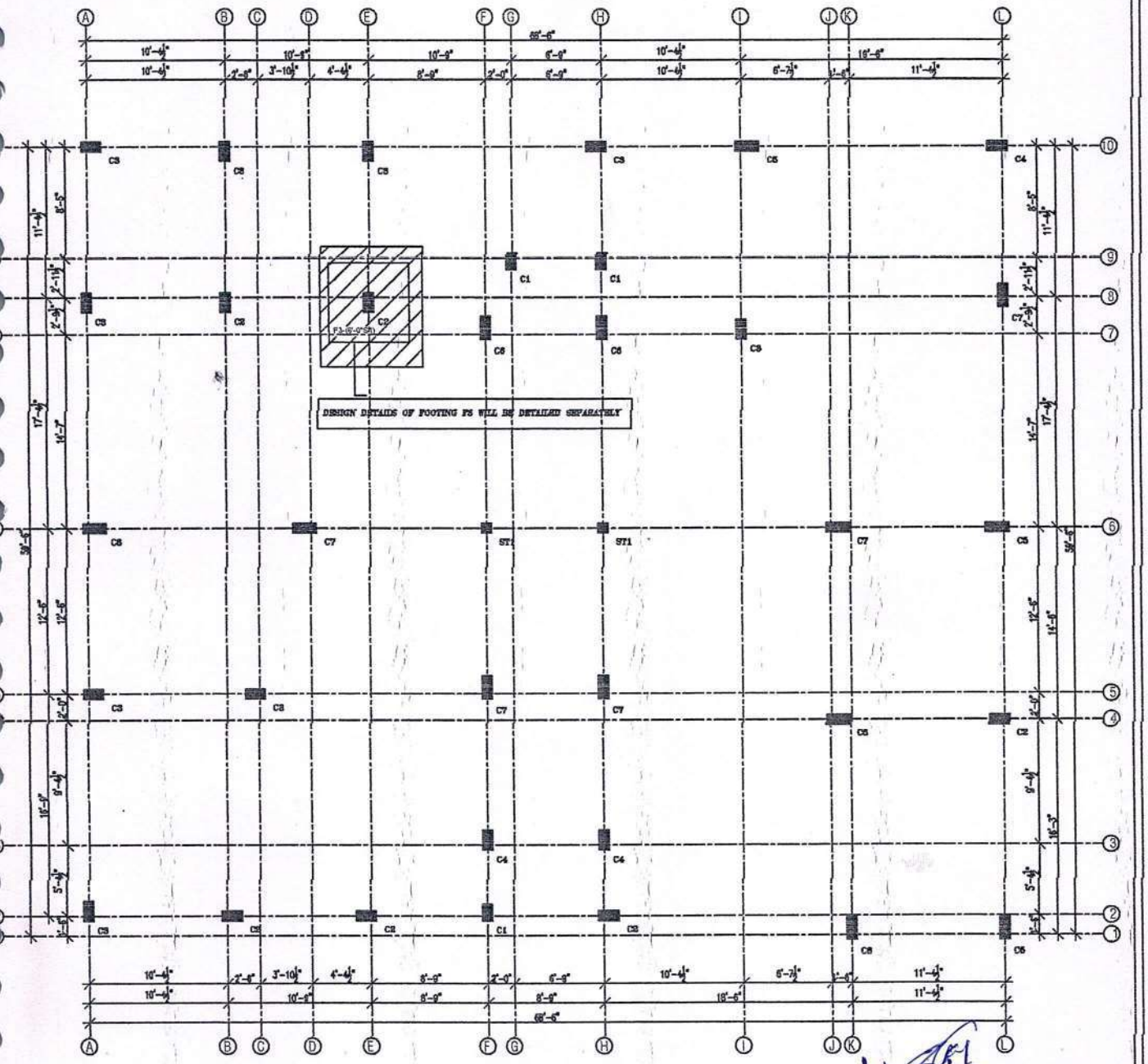
provide 50% of +ve R/F at top =	130.90	mm^2
NOT OK since the R/F value is less than min. value		
Therefore, at discontinuos edges required R/F area =	150.00	mm^2
ϕ	10	mm
$S_{required}$	523.33	mm c/c
$S_{provided}$	300	mm c/c

11 Torsional reinforcement

Torsion R/F at corner with both edge discontinuous	196.35	mm^2	provide 4- 8 mm #
Torsion R/F at corner with one edge discontinuous	98.17	mm^2	provide 2- 8 mm #
Torsion R/F at corner with both edge continuous	0.00	mm^2	

DESIGN SUMMARY		
Depth of slab, D	125	mm
Effective depth, d	100	mm
R/F along X-direction (SHORT)		
$A_{st,middle,bottom}$	10# @ 300 mm c/c	
$A_{st,cont.edge,top}$	10# @ 300 mm c/c	
R/F along Y-direction (LONG)		
$A_{st,middle}$	8# @ 300 mm c/c	
$A_{st,cont.edge}$	10# @ 300 mm c/c	
R/F at discont. edges on top in both directions		
$A_{st,edge,top}$	10# @ 300 mm c/c	
AREA OF TORSION REINFORCEMENT		
At corner with both edge disc.	provide 4- 8 mm #	
At corner with one edge disc.	provide 2- 8 mm #	
At corner with both edge cont.	N.A	

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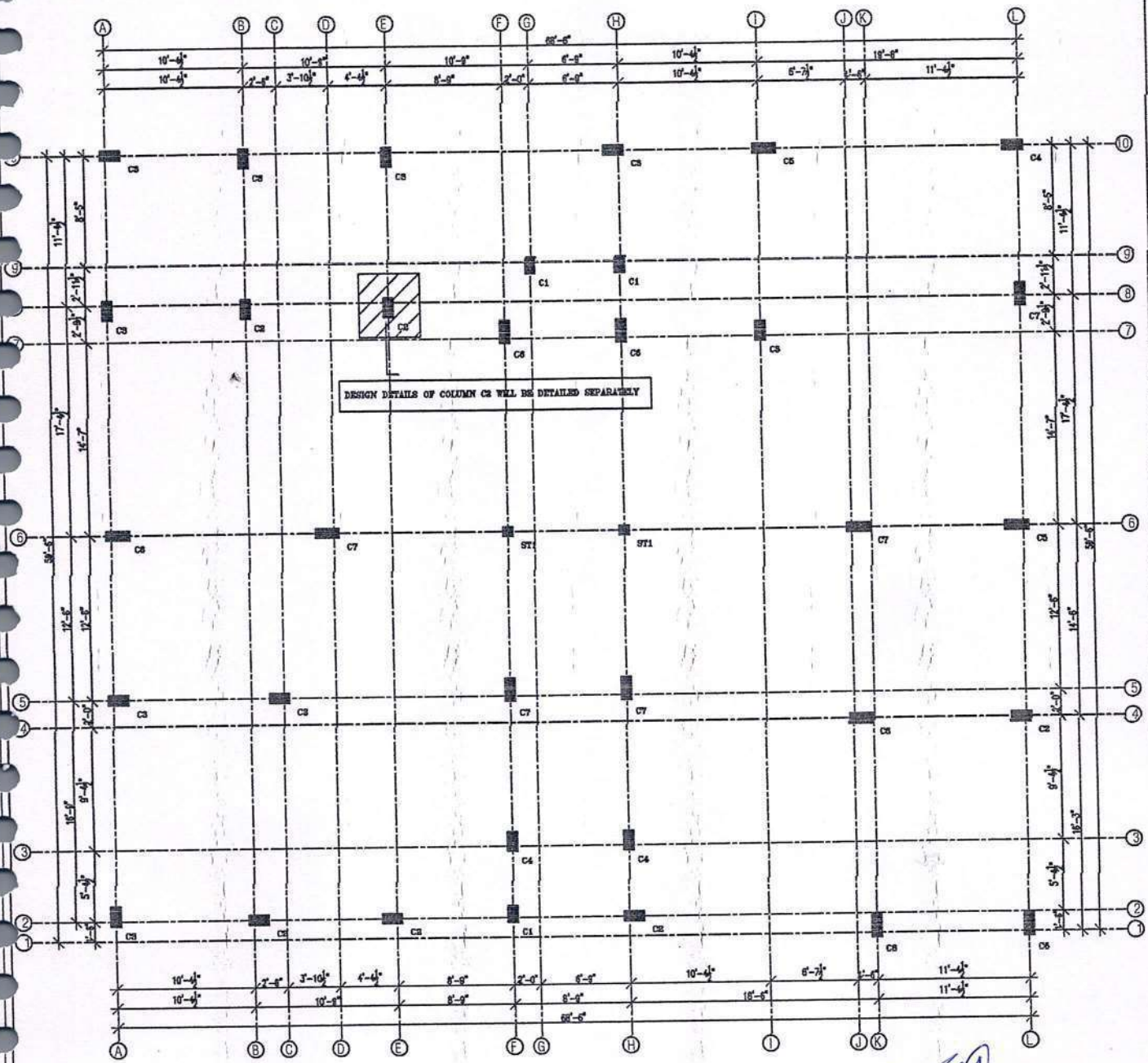
LAYOUT OF FOOTING

DESIGNED FOOTING

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NOTES :

1. All dimensions are in feet & inches.
2. This drawing shall be read in conjunction with relevant architectural drawings.
3. All dimensions shall be checked and verified before execution of works.
4. Concrete mix grade :
   For all structural member M-25 (1:1:2)
   * If ready mixed concrete is being used, client/ Contractor /Client shall send us cube test results to substantiate the concrete mix grade. shall cast concrete cubes independently at site and send cube results thus obtained to us.
5. Reinforcement : FE 550 TOR STEEL for ø8mm & above conforming to IS 1786 (latest revision) M.S.ROUNDS for ø6mm conforming to IS 432-part1 (latest revision)
6. Clear concrete cover to main bars : for footings - 2" ; for columns - 1 1/2" ;
7. Use stone aggregates and sand conforming to stone aggregate size - 20mm and down grade
8. Use good water for concrete mixing and curing conforming to IS 456(latest revision)
9. Maximum water cement ratio :
   for mix 1:2:4 - 0.50
   for mix 1:1 1/2:3 - 0.45
10. S.B.C. assumed in design of footings is 25T/m^2
11. Foundation designed for S+3 Floor
12. Use ordinary portland cement conforming to IS 8112 (latest revision) for 43 grade cement & IS 12269 for 53 grade cement
13. The centering and shuttering to support structural concrete must be sufficiently strong and rigidly braced. Horizontal ties shall be provided at every 1.5m height.
14. The stability of supports and strength of the centering and formwork should be ensured by the Contractor and Site Engineer before placing concrete.



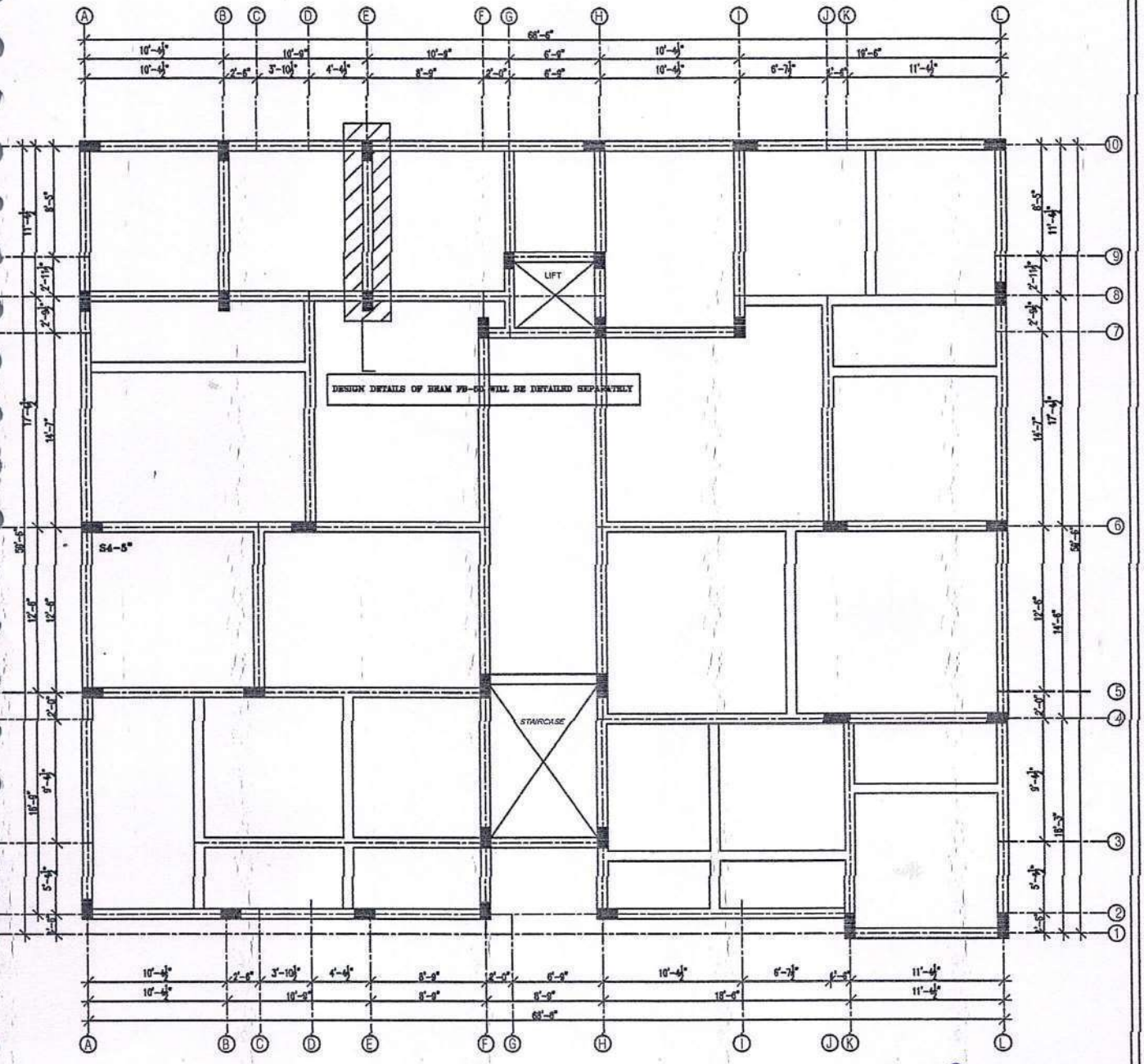
LAYOUT OF COLUMN

DESIGNED COLUMN

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12. Use ordinary portland cement conforming to IS 8112 (latest revision) for 43 grade cement & IS 12269 for 53 grade cement
13. The centering and shuttering to support structural concrete must be sufficiently strong and rigidly braced. Horizontal ties shall be provided at every 1.5m height.
14. The stability of supports and strength of the centering and formwork should be ensured by the Contractor and Site Engineer before placing concrete.



LAYOUT OF STILT FLOOR SLAB

DESIGNED BEAM

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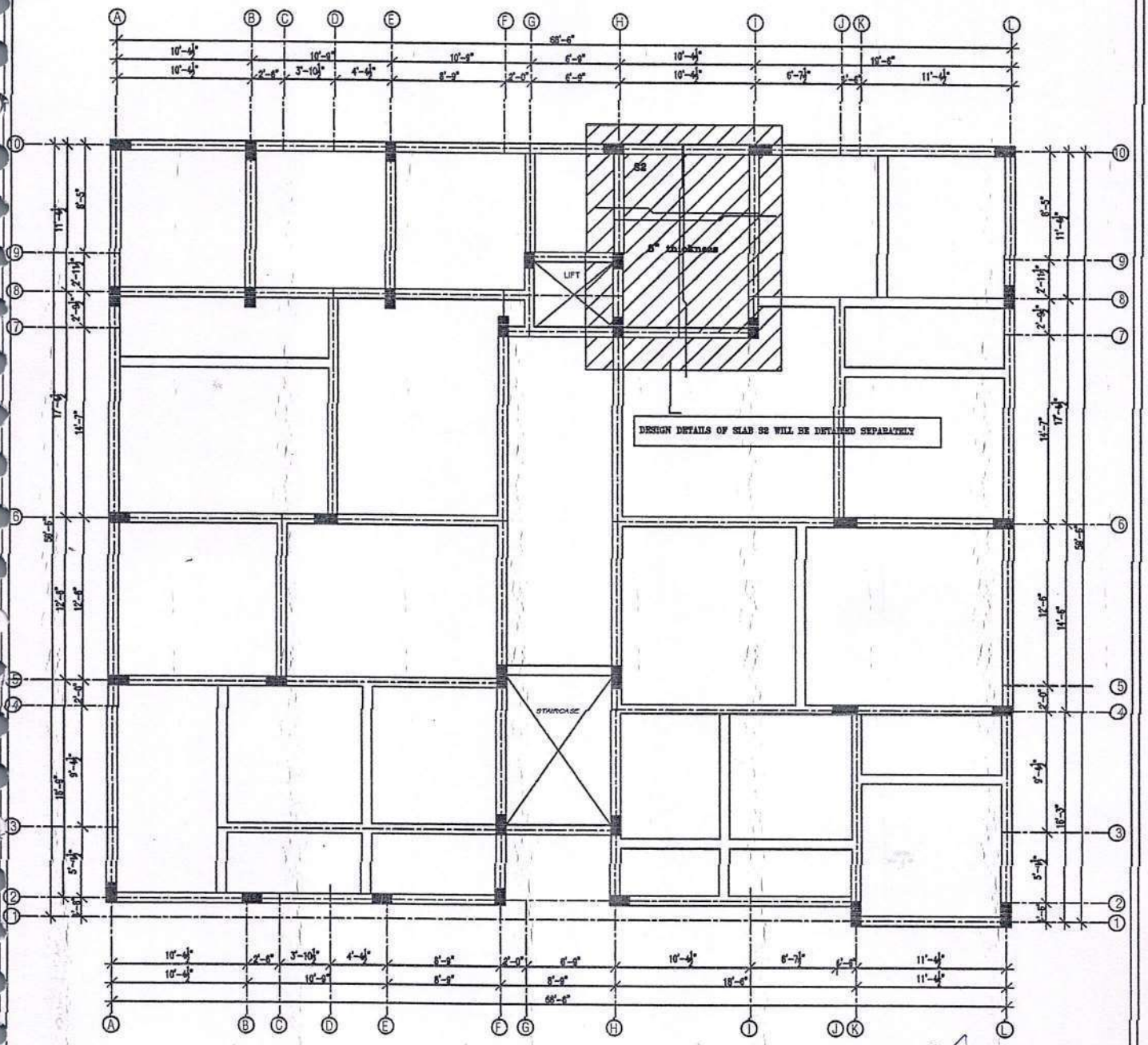
NOTES :

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3. All dimensions shall be checked and verified before execution of works.
4. Concrete mix grade :
   For all structural member M-25 (1:1:2)
   * If ready mixed concrete is being used, client/ Contractor /Client shall send us cube test results to substantiate the concrete mix grade. shall cast concrete cubes independently at site and send cube results thus obtained to us.
5. Reinforcement : FE 550 TOR STEEL for ø8mm & above conforming to IS 1786 (latest revision) M.S.ROUNDS for ø6mm conforming to IS 432-part1 (latest revision)
6. Clear concrete cover to main bars :
   for Beam - 1" ; columns - 1 1/2" ; Slab - 3/4"
7. Use stone aggregates and sand conforming to stone aggregate size - 20mm and down grade
8. Use good water for concrete mixing and curing conforming to IS 456(latest revision)
9. Maximum water cement ratio :
   for mix 1:2:4 - 0.50
   for mix 1:1 1/2:3 - 0.45
10. The lap length must be 50 times dia of Bar
11. Use ordinary portland cement conforming to IS 8112 (latest revision) for 43 grade cement & IS 12269 for 53 grade cement
12. The centering and shuttering to support structural concrete must be sufficiently strong and rigidly braced. Horizontal ties shall be provided at every 1.5m height.
13. The stability of supports and strength of the centering and formwork should be ensured by the Contractor and Site Engineer before placing concrete.
14. Curing for RCC works minimum 14 days & maximum 21 days

Removal of form work:

1) For slabs:
   a) Spanning upto 4.5m (15'-0") 7 Days
   b) Spanning over 4.5m (15'-0") 14 Days
2) For beams & Arches:
   a) Spanning upto 6m (20'-0") 14 Days
   b) Spanning over 6m (20'-0") 21 Days

*Spacer bar should be used in second layer at 3'0"c/c



LAYOUT OF STILT FLOOR SLAB

DESIGNED SLAB

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   for mix 1:1 1/2:3 - 0.45
10. The lap length must be 50 times dia of Bar
11. Use ordinary portland cement conforming to IS 8112 (latest revision) for 43 grade cement & IS 12269 for 53 grade cement
12. The centering and shuttering to support structural concrete must be sufficiently strong and rigidly braced. Horizontal ties shall be provided at every 1.5m height.
13. The stability of supports and strength of the centering and formwork should be ensured by the Contractor and Site Engineer before placing concrete.
14. Curing for RCC works minimum 14 days & maximum 21 days

Removal of form work:

1) For slabs:
   a) Spanning upto 4.5m (15'-0") 7 Days
   b) Spanning over 4.5m (15'-0") 14 Days
2) For beams & Arches:
   a) Spanning upto 6m (20'-0") 14 Days
   b) Spanning over 6m (20'-0") 21 Days

*Spacer bar should be used in second layer at 3'0"c/c

REPORT

ON

SOIL INVESTIGATION FOR CONSTRUCTION OF RESIDENTIAL APARTMENT BUILDING AT NEELAGIRI THERKU THOTTAM VILLAGE OLD T.S.NO.336/1A1PT, NEWWARD-8,BLOCK-16,NEW T.S.NO.6,PLOT NO.81 OF NATARAJAPURAM SOUTH 6TH STREET, MEDICAL COLLEGE ROAD, THANJAVUR CORPORATION, THANJAVUR TALUK, THANJAVUR DISTRICT – 613007

Client

Mr. G. Murali,
Mrs. K. Sathya Veni,
No. 81, 6th Street,
Natharajapuram South Colony,
Thanjavur.

By

Time

TIME INSTITUTE FOR MATERIALS TESTING
NO.25, SANJEEVI NAGAR,
TRICHY – CHENNAI BYEPASS ROAD,
TIRUCHIRAPPALLI – 620 002.
Ph: 0431 2401326

NOVEMBER 2022

Dr.S. Senthamil Kumar, ME, Ph.D, FIGS, MIEI
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SUMMARY

Project	:	Construction of Residential Apartment Building at Natarajapuram South Colony, Thanjavur
Project Reference	:	Time /61/ Soil Test / November 2022
Owner	:	Mr. G. Murali & Mrs. K. Sathya Veni, No. 81, 6th Street, Natharajapuram South Colony, Thanjavur. Type of Structure :
R.C.C. Framed construction		
Location	:	Neelagiri Therku Thottam Village Old T.S.No.336/1A1pt, New ward-8, Block-16,New T.S.No.6, Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur Corporation, Thanjavur Taluk, Thanjavur District – 613007
Scope	:	Geotechnical investigation for the entire area of construction
Test conducted	:	Two explanatory bore hole up to 5m & 4.5m depth was made and conducted standard penetration tests at every 1.5m depth. The undisturbed soil samples were collected at every 1.5m depth for laboratory test.

FINDINGS

Soil at shallow depth	:	Laterite soil with gravels mixed exists up to 4.5m depth
Hard stratum	:	No trace of rock exists up to 5m depth
Ground water table	:	Ground water was not encountered during the investigation up to 5m depth

FOUNDATION	:	Based on the existing soil condition, it is recommended to provide foundation at 3m depth

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CONTENTS

1. INTRODUCTION ON SOIL TEST

1.1 – Introduction - 1
1.2 – Investigation Programme, Procedure and Data - 2
1.3 – Review of Field and Laboratory Results - 3
1.4 – Conclusions & Recommendation - 4

2. SOIL PROFILES

2.1 – Plan of Bore Hole 1 & 2 - 5
2.2 – Bore log details for Bore Hole 1 & 2 - 6
2.4 – Summary of Engineering Geo Properties for Bore Hole 1 & 2 - 8
2.5 – Summary of Laboratory test results for Bore Hole 1 & 2 - 11
2.6 – Shear Parameters for different layers of Bore Hole 1 & 2 - 12

3. SIEVE ANALYSIS REPORT

3.1 – Sieve Analysis report of sample from Borehole No 1 & 2 - 13

4. CALCULATION OF SAFE BEARING CAPACITY OF THE SOIL

4.1 – Safe bearing capacity calculation based on settlement and Shear - 15
4.2 – Safe Bearing capacity of soil based on SPT values - 19
4.3 – Safe Bearing capacity of soil based on Shear Failure Criteria Through Direct Shear - 20
4.4 – Comparison of safe bearing capacity of soil Through shear and settlement - 21

5. RESULT

5.1 – Recommended safe bearing capacity values at different depths - 22

6. SOIL SAMPLE PHOTOS

7. SITE PHOTOS

ANNEXURE

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SOIL INVESTIGATION

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AMERICAN GLOBAL STANDARDS

Time Institute for Materials Testing

टाइम इन्स्टिट्यूट चीज़े शोध केलिए

ACCREDITED ISO - 17025:2005

B.N. Krishnaswami, M.E., (Struct. Engg.), Ph.D., Soil & Structural Consultant, Construction Materials Testing Lab
Former Faculty, NIT, Trichy

November 30, 2022

To

Mr. G. Murali,
Mrs. K. Sathya Veni,
No. 81, 6th Street,
Natharajapuram South Colony,
Thanjavur.

REPORT ON SOIL INVESTIGATION

(Ref: TIME/61/ SOIL TEST/ NOVEMBER 2022)

Sub: Soil Investigation for Construction of Residential Apartment Building at Natarajapuram South Colony, Thanjavur – reg.,

Ref: Based on letter dated: 26.11.2022

1.1 Introduction:

It is proposed to construct a **Residential Apartment Building at Neelagiri Therku Thottam Village Old T.S.No.336/1a1pt, Newward-8,Block-16,New T.S.No.6,Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur Corporation, Thanjavur Taluk, Thanjavur District – 613007.** A detailed soil investigation was suggested for estimating the safe bearing capacity of the soil, so that suitable type of foundation can be decided for the proposed structure. Time Institute for Materials Testing (TIME) has been requested to undertake the soil investigation at the proposed site. The study was carried out by TIME on **28.11.2022.** This report presents complete investigation data and discusses the results to recommend the bearing capacity values at different depths for the proposed structure.

Section 2 describes the soil profile and bore log details of two explanatory bore holes. Section 3 of this report gives the Grain size distribution curves and its analysis. Section 4 of this report presents the calculated safe Bearing capacity values of soil at various depths. Section 5 of this report reviews the test results and the recommended safe bearing capacity values for design of foundation. Section 6 of this report presents the Soil sample photos. Section 7 of this report presents the Site Photos.

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Mob : + 91 94433 27936. Email: tmaterialstesting@yahoo.co.in Web: www.timeinstitute.net

1.2 Investigation Programme, Procedure and Data:

Investigation was carried out in two locations at the site through exploratory bore holes. Soil samples were collected from each bore hole at different depths for conducting laboratory test. Standard Penetration test was conducted at regular intervals and 'N' values were recorded. Undisturbed soil samples were collected and were preserved and transported to the laboratory for detailed identification tests. Based on the field and laboratory tests on the samples collected, the results are furnished in this report.

An exploratory bore hole was advanced from the existing ground level using truck mounted rotary drilling techniques supplemented by Betonies mud circulation. This drilling procedure with mud circulation is found most suitable for making exploratory bore hole. The mud circulation was employed through the drill rods and letting it out though the side jets provided in the cutting tool thus preventing any disturbance at the bore hole bottom. Mud circulation was used to stabilize the sides and the bottom of the bore hole, and then to bring the soil cuts to the surface. It is important to note that the mud jet is not used to cut the soils as in the case of wash boring technique. Use of drilling mud will also help in preventing the disturbance to the soil at the bore hole bottom during drilling operations. Diameter of the bore hole is about 150mm.

Bore hole was always kept full with the drilling mud so that a positive head is maintained in the bore hole thus preventing any disturbance to the soil within the test zone.

The field tests included Standard penetration test, Disturbed and undisturbed soil sampling, identification of different soil layers, Ground water table observation, complete logging of the bore hole, etc.

Laboratory investigation consisted of classification tests like grain size distribution analysis, determination of specific gravity etc. Unconfined Compression test and Direct shear was conducted on preserved soil samples. All the field and laboratory tests were conducted according to the procedures stipulated in relevant IS codes.

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1.3 Review of Field and Laboratory Results:

Sub soil Profile

The original ground level in the presently investigated area was plain terrain.

Bore Hole 1:

The soil below the existing ground level is filled up soil. This layer is extended up to 0.2m depth. Red soil exists from 0.2m to 0.9m depth. Below which laterite soil with gravels mixed exists from 0.9m to 5m depth from the existing ground level. The soil stratification and its variation under present investigation are available in bore log details. The 'N' value is progressively increasing towards depth due to the soil stratification.

Bore Hole 2:

The soil below the existing ground level is filled up soil. This layer is extended up to 0.3m depth. Red soil exists from 0.3m to 1m depth. Below which laterite soil with gravels mixed exists from 1m to 4.5m depth from the existing ground level. The soil stratification and its variation under present investigation are available in bore log details. The 'N' value is progressively increasing towards depth due to the soil stratification.

Ground Water Table

Ground water table was not encountered during the investigation up to 5m depth from the ground level.

Shear Strength

Standard Penetration test blow counts 'N' is measured at different levels in the bore hole. Mainly these 'N' values are used to assess the shear strength of different soil layers.

Cohesive layers: The classification of 'N' values in moderate to high plasticity medium clay deposits developed by Terzaghi is used for estimating the unconfined compression strength and untrained shear strength of clay and sandy clay layers. The consistency between the N values and the liquidity index values is reviewed while assigning undrained shear strength for soft to medium clay layers.

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Non - Cohesive Layers: The sand layers towards depth are of residual type and suitable modifications are made to take care of the presence of plastic fines in the residual soil. Conventional method of estimating the angle of shearing resistance ϕ corresponding to the relative density and the grain size distribution as per the classification suggested by Peck and suitably modified by the R.K. Hough to account for the influence of grain size distribution is adopted here.

1.4 Conclusions & Recommendation:

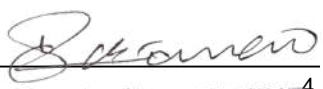
Shear strength parameters and compressibility parameters of different soil layers are established from the field and laboratory tests.

Based on the existing soil condition, it is recommended to provide foundation at 3m depth.

For Time Institute for Materials Testing

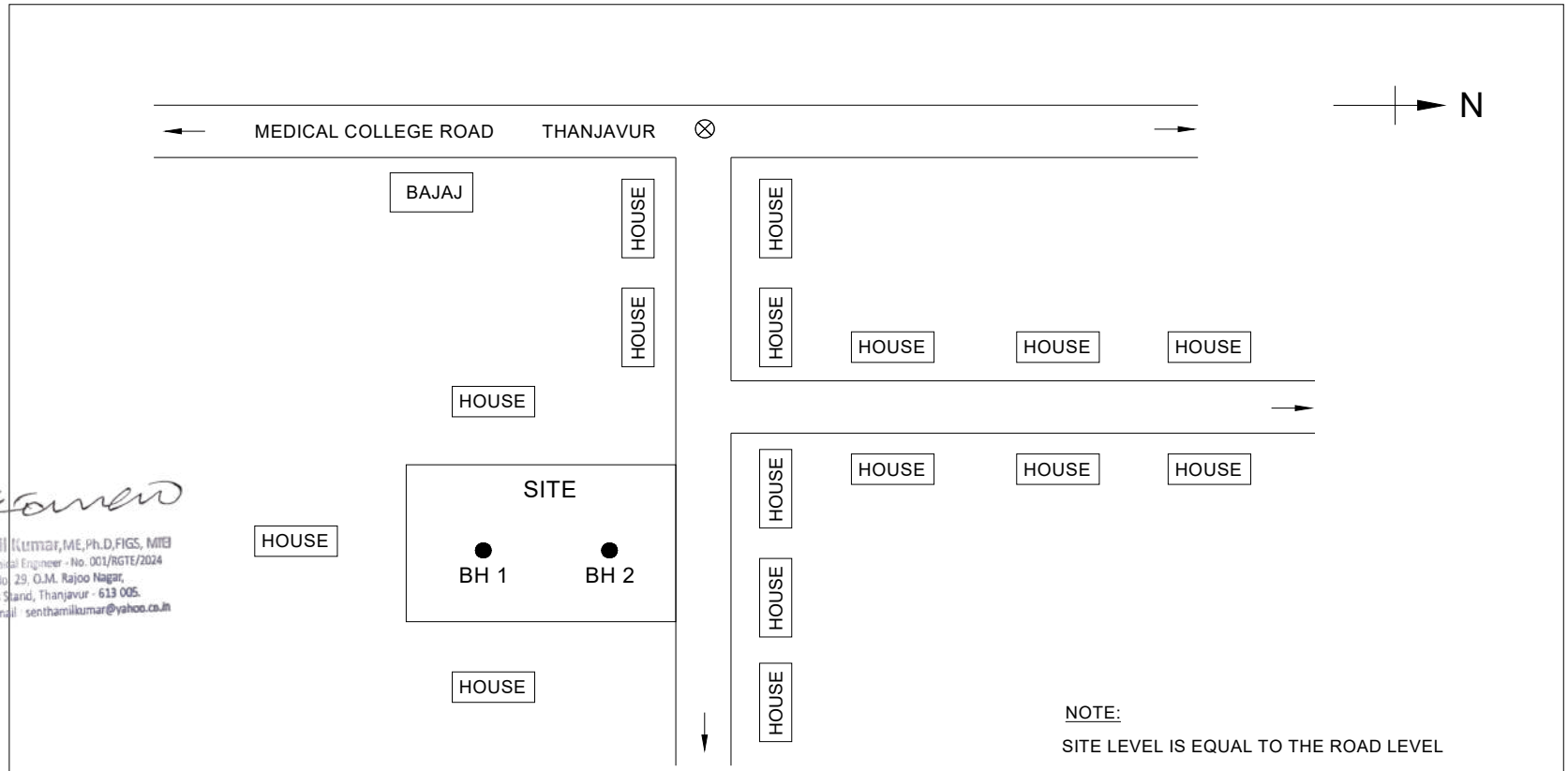


30th November 2022 **Dr. B.N. Krishnaswami.**



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SITE LOCATION PLAN



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NOTE:

SITE LEVEL IS EQUAL TO THE ROAD LEVEL

LEGEND:

● BORE LOG LOCATION

⊗ SITE LOCATION

SITE PLAN

CLIENT	Mr. G. Murali & Mrs. K. Sathya Veni, No. 81, 6th Street, Natharajapuram South Colony, Thanjavur.	
SOIL CONSULTANT	TIME Institute for Materials Testing No 25, Sanjeevi Nagar, Trichy - Chennai Byepass road , Trichy - 620002. PHONE : 0431 - 2401326(OFF)	
DATE OF SURVEY	28.11.2022	TITLE PLAN OF BORE HOLE AND SITE DETAILS AT NATARAJAPURAM SOUTH COLONY, THANJAVUR
SCALE	NTS	DRG.NO DRAWING - 01

BORE LOG DETAILS

2.2 BORE LOG DETAILS FOR BORE HOLE 1

Project : Report on soil investigation for Construction of Residential Apartment Building

Location : Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur– 613007

Started on : 28.11.2022 **Ended on** : 28.11.2022

Depth of G.W.T : Nil

Type of Boring : Calyx drilling

Site Level : Equal to the road level

Lithology of Bore Hole			SPT Data					Graphical representation of penetration Resistance ('N' Value)
Depth below G.L. (m)	Profile	Soil Description	Depth of SPT (m)	0-15cm	15-30cm	30-45cm	N Value	0 20 40 60 80
0 - 0.2m		Filled up soil						
0.2m - 0.9m		Red soil						
0.9m - 5m		Laterite soil with gravels mixed	**1.5**	Rebound			**50**	
			3.0	Rebound			**52**	
			4.5	Rebound			**54**	
			5.0	Rebound			**56**	

Bore terminated at 5m depth from the existing ground level

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2.3 BORE LOG DETAILS FOR BORE HOLE 2

Project : Report on soil investigation for Construction of Residential Apartment Building

Location : Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur– 613007

Started on : 28.11.2022 **Ended on** : 28.11.2022

Depth of G.W.T : Nil

Type of Boring : Calyx drilling

Site Level : Equal to the road level

Lithology of Bore Hole			SPT Data					Graphical representation of penetration Resistance ('N' Value)
Depth below G.L. (m)	Profile	Soil Description	Depth of SPT (m)	0-15cm	15-30cm	30-45cm	N Value	0 20 40 60 80
0 - 0.3m		Filled up soil						
0.3m - 1m		Red soil						
1m - 4.5m		Laterite soil with gravels mixed	**1.5**	Rebound			**51**	
			3.0	Rebound			**53**	
			4.5	Rebound			**55**	

Bore terminated at 4.5m depth from the existing ground level

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2.4 Summary of Engineering Geo Properties

Natural Moisture Content:

The natural water content also called the natural moisture content is the ratio of the weight of water to the weight of the solids in a given mass of soil. This ratio is usually expressed as percentage.

$$W = [(W2-W3)/(W3-W1)] \times 100$$

Where,

W_1 = Weight of container gm

W_2 = Weight of container +wet soil gm

W_3 = Weight of container +dry soil

Bulk Density:

The total, or wet, density of soil, $_t$, is the ratio of the total mass of soil to its total volume and can be defined as follows:

$$\gamma_{bulk} = M / V$$

Where

M_t = Total Mass of soil

V_t = Total Volume

Dry Density:

The soil dry density, $_b$, is the ratio of the mass of the solid phase of the soil (i.e., dried soil) to its total volume (solid and pore volumes together) and is defined as follows:

$$\gamma_{dry} = M_b / V_b$$

Where

M_b = Total Mass of dried soil

V_b = Total Volume

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Specific gravity:

Specific gravity is the ratio of the weight of a given volume of a material at a standard temperature to the weight of an equal volume of distilled water at the same stated temperature.

The specific gravity G of the soil = $(W_2 – W_1) / [(W_4 – W_1)-(W_3-W_2)]$

Where

W_1 = Weight of density bottle
W_2 = Weight of density bottle + dry soil
W_3 = Weight of bottle + dry soil + water at temperature
W_4 = Weight of density bottle + Water

Void Ratio:

Soil void ratio (e) is the ratio of the volume of voids to the volume of solids:

$$e = (Vv) / (Vs)$$

Where
Vv is the volume of the voids (empty or filled with fluid),
Vs is the volume of solids.

Porosity:

Soil porosity (η) , which is defined as the ratio of the volume of voids to the total volume of the soil.
The porosity and the void ratio are inter-related as follows:

$$\eta = (1 – (\gamma_d/G_s))*100$$

$$e = \eta/(1-\eta) \;\&\; \eta = e / (1+e)$$

Where
γ_d = Dry Density
G_s = Specific gravity

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Summary of Engineering Geo Properties for Bore Hole 1 & 2

Bore hole No.	Depth (m)	Soil Description	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry Density (gm/cc)	Specific gravity	Porosity (%)	Void Ratio
Bore Hole 1	1.5	Laterite soil with gravels mixed	11.75	2.00	1.79	2.65	32	0.48
	3.0		11.40	2.01	1.80	2.65	32	0.47
	4.5		11.19	2.02	1.82	2.65	31	0.46
	5.0		10.80	2.03	1.83	2.65	31	0.45
Bore Hole 2	1.5	Laterite soil with gravels mixed	11.60	2.01	1.80	2.65	32	0.47
	3.0		11.35	2.03	1.82	2.65	31	0.45
	4.5		10.90	2.04	1.84	2.65	31	0.44

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2.5 Summary of Laboratory Test Results for Bore Hole 1

Bore hole No.	Depth (m)	Soil Description	Gravel (%)	Coarse sand (%)	Medium Sand (%)	Fine sand (%)	Silt (%)	Clay (%)
Bore Hole 1	1.5	Laterite soil with gravels mixed	18.9	16.7	30.1	24.7	6.5	3.1
	3.0		19.6	18.1	30.9	22.8	5.2	3.4
	4.5		20.4	19.6	32.8	19.6	4.9	2.7
	5.0		22.1	21.9	31.7	17.1	4.8	2.4
Bore Hole 2	1.5	Laterite soil with gravels mixed	19.5	15.4	29.7	25.2	6.4	3.8
	3.0		19.9	16.2	31.6	22.9	5.1	4.3
	4.5		21.5	17.8	31.0	21.4	5.2	3.1

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2.6 Shear Strength Parameters for Different layers of Bore Hole 1 & 2

Bore Hole No.	Depth below G.L. (m)	Soil Description	N	Shear Strength 'Ø' (in degrees)
Bore Hole 1	1.5	Laterite soil with gravels mixed	50	37.61
	3.0		52	37.82
	4.5		54	38.23
	5.0		56	38.43
Bore Hole 2	1.5	Laterite soil with gravels mixed	51	37.82
	3.0		53	38.02
	4.5		55	38.43

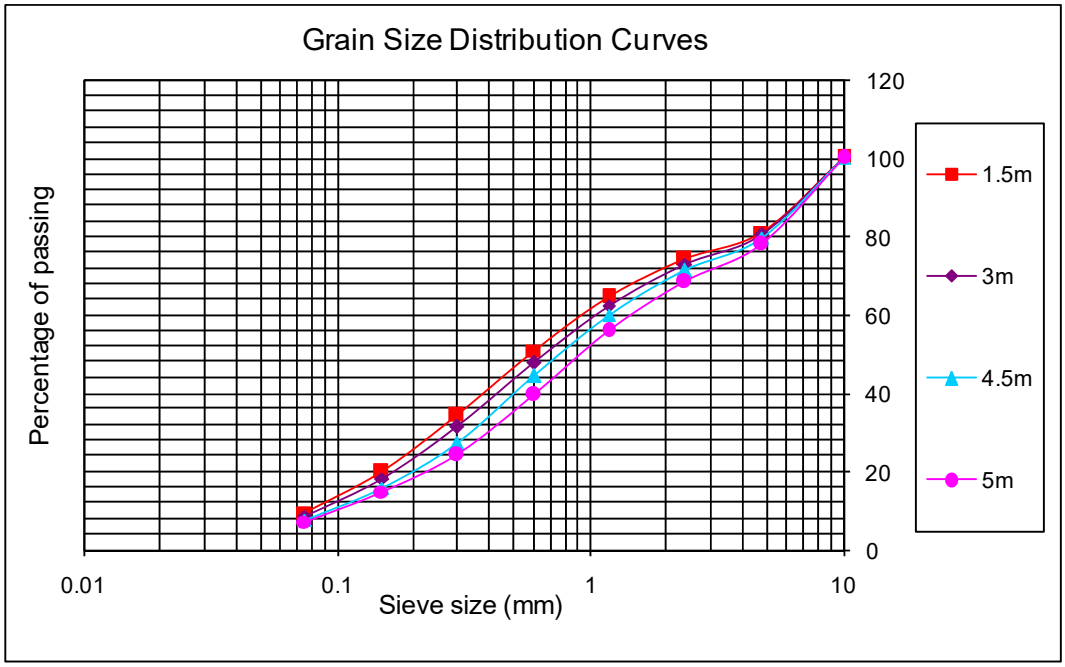
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GRAIN SIZE ANALYSIS

3.1 TEST REPORT ON SIEVE ANALYSIS OF SAMPLE

Bore Hole – 1 @ 1.5m to 5m

SIEVE SIZE	PERCENTAGE OF PASSING			
	1.5m Depth	3m Depth	4.5m Depth	5m Depth
10 mm	100	100	100	100
4.75 mm	81.1	80.4	79.6	77.9
2.36 mm	74	72.9	71.3	68.3
1.18 mm	64.4	62.3	60	56
600 micron	50.8	47.8	44.4	39.5
300 micron	34.3	31.4	27.2	24.3
150 micron	19.7	18.2	15.8	14.8
75 micron	9.6	8.6	7.6	7.2



Description	1.5m Depth	3m Depth	4.5m Depth	5m Depth
Fineness modulus	2.661	2.784	2.941	3.120

Observation:

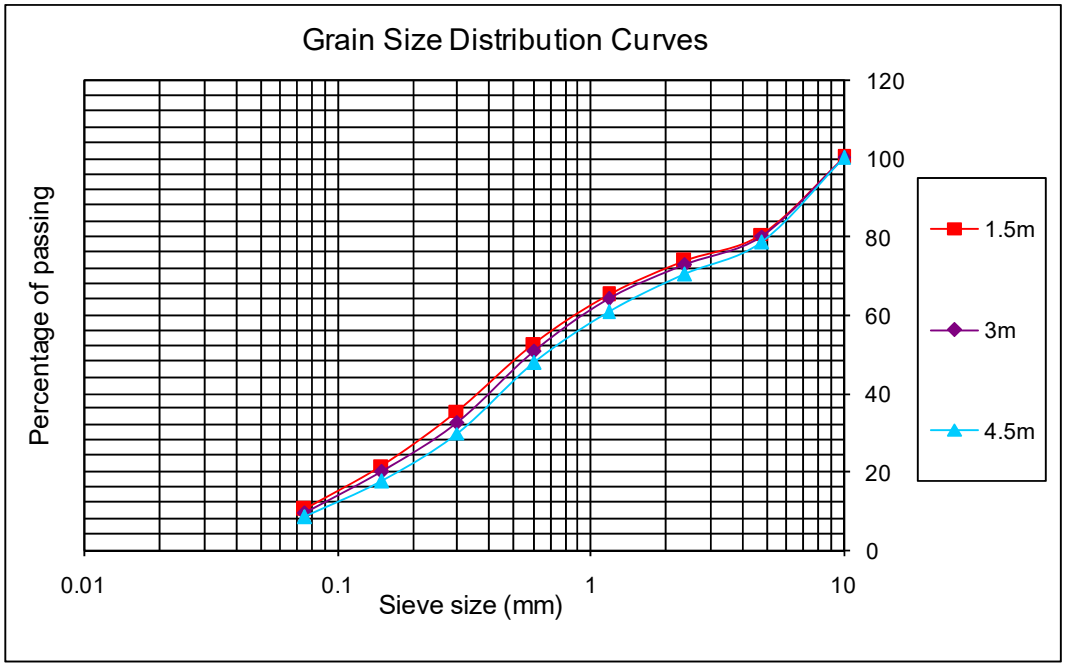
The inference from the graph shows that the sand with gravels mixed exists up to 5m depth.

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3.2 TEST REPORT ON SIEVE ANALYSIS OF SAMPLE

Bore Hole – 2 @ 1.5m to 4.5m

SIEVE SIZE	PERCENTAGE OF PASSING		
	1.5m Depth	3m Depth	4.5m Depth
10 mm	100	100	100
4.75 mm	80.5	80.1	78.5
2.36 mm	73.6	72.6	70.3
1.18 mm	65.1	63.9	60.7
600 micron	52.7	50.5	47.6
300 micron	35.4	32.3	29.7
150 micron	21.6	20	17.5
75 micron	10.2	9.4	8.3



Description	1.5m Depth	3m Depth	4.5m Depth
Fineness modulus	2.609	2.712	2.874

Observation:

The inference from the graph shows that the sand with gravels mixed exists up to 4.5m depth.

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CALCULATION

OF

SAFE BEARING CAPACITY

4. CALCULATION OF SAFE BEARING CAPACITY

4.1 Safe bearing capacity calculation based on settlement and Shear

Safe Bearing Capacity calculations based on settlement consideration (SPT value):

Safe Bearing Capacity calculations for shallow foundation will vary based on the width of foundation.

For example, in the case of Individual footing such as isolated, combined etc., we are supposed to use the formula as mentioned below. (Using Teng's Modified formula)

$$q_{na} = 51.4 \times (N - 3) \times \left(\frac{B + 0.3}{2B}\right)^2 \times R_w \times C_d$$

Where,

q_{na}	=	Net safe bearing capacity of soil (kN/m^2) (for 2.5cm permissible settlement)
N	=	Corrected SPT values
B	=	Width of foundation (m) (let us assume 2m)
R_w	=	Correction factor for water table level
C_d	=	Correction factor for depth of embedment

For Bore Hole 1 @ 3m depth SPT 'N' Value = 52

$\Rightarrow$ **q_{na} = 51.4 x (52- 3) x ((2 + 0.3)/(2 x 2))^2 x 0.5 x 1 = 416.35 kN/m^2**

$\therefore$ **q_{na} = 41.63 t/m^2**

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Safe Bearing Capacity calculations based on shear consideration (Direct Shear):

As Per IS 6403:1981

At 3m depth (Bore Hole 1)

Proving Ring capacity 200kg = 966.2 division

Area of the shear box = 6cm x 6cm = 36cm^2

Normal Stress (kg/cm^2)	No. of Division	Stress
0.5	24	0.138
1.0	92	0.529
1.5	159	0.914

Stress = Load / Area

= (200/966.2) * 24* (1/36) = 0.138

Ø = $\tan^{-1}$ (0.914-0.138) = 37.82°

Net safe bearing capacity of the soil (for general shear failure as per IS 6403:1981)

$$q_{ult} = C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_\gamma S_\gamma d_\gamma i_\gamma W'$$

Where

	C	=	Cohesion in t/m^2
N_c, Nq, N_γ		=	Bearing Capacity Factors (From Table 1 of IS 6403 – 1981)
S_c, S_q, S_γ		=	Shape Factors (From Table 2 of IS 6403 – 1981)
d_c, d_q, d_γ		=	Depth Factors
i_c, i_q, i_γ		=	Inclination Factors
	q	=	Effective surcharge at the base level of foundation in t/m^2
	B	=	Width of footing, diameter of circular footing in m
	γ	=	Bulk unit weight of soil in t/m^3
	W'	=	Correction factor for location of water table

At 3m depth (Bore hole 1), the Soil profile is Laterite soil with gravels mixed

If	C	=	0 (Since no Cohesion)
	Φ	=	37.82 (based on laboratory test)
Therefore	N_c	=	62.583;
	N_q	=	50.727;
	N_γ	=	82.647

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Applying these parameters in the above equation

$$q_{ult} = C N_c S_c d_c i_c + q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_\gamma S_\gamma d_\gamma i_\gamma W'$$

Where $C = 0$ **(Since no Cohesion)**

Therefore, $$q_{ult} = q (N_q - 1) S_q d_q i_q + 0.5 B \gamma N_\gamma S_\gamma d_\gamma i_\gamma W'$$

Bearing Capacity calculation through shear density of soil 'γ'

There are two relationships of weight of soil to Volume of soil as

i) Total density or Bulk density

ii) Dry density

Therefore, Total Bulk density, $$\gamma_t = \frac{\text{Total Weight of soil}}{\text{Total Volume of soil}} = \frac{W}{V}$$

Dry Density $\gamma_d = W_s/V$; Whereas W_s = Total weight of solids

In a particular case the **total density** will be known as **saturated density**, when the soil is saturated. Another density of soil will be known as submerged or buoyant density, γ_b when the soil is submerged in water.

$$\gamma_b = \gamma_t - \gamma_w$$

Where γ_w = Density of water = 1 g/cc or 1 t/m^3

Mostly soils submerged in water are saturated.

Hence $$\gamma_{buoyant} = \gamma_{sat} - \gamma_w$$

Based on the above equations,

$\gamma = \gamma_{sat} = 1.8$ t/m^3

$d = 3$m

Here, $\gamma_b = \gamma_{sat} - 1 = 1.8 - 1 = 0.8$ t/m^3

Therefore, $q = \gamma_b \times d = 0.8 \times 3 = 2.4$ t/m^2

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$S_q = S_\gamma$ = Shape factor which is equal to 1

$d_q = d_\gamma$ = $1 + 0.1 \frac{df}{B} \sqrt{N\emptyset}$

= 1 (Minimum value of 1 can be taken)

i_q = inclination factor $(1 - \alpha/90)^2$

Where α = inclination of the load to the vertical in degree which is equal to zero

i_q = 1

B = Width of footing (2m)

W' = 0.5

Applying in the above equation

q_{ult} = $q (Nq- 1) S_q d_q i_q + 0.5 B \gamma N_\gamma S_\gamma d_\gamma i_\gamma W'$

= 2.4 x (50.727 - 1) x 1 x 1 x 1 + 0.5 x 2 x 1.8 x 82.647 x 1 x 1 x 1 x 0.5

= 193.727 t/m^2

Applying factor of safety as 3

Then allowable bearing capacity

q_{na} = 193.727 / 3

= 64.58 t/m^2

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SAFE BEARING CAPACITY

RESULTS

4. Calculation of Safe bearing capacity of the soil:

4.2 Safe Bearing capacity of soil based on SPT values for Bore Holes 1 & 2

Bore Hole No.	Depth (m)	SPT value	Safe Bearing capacity of soil	
			KN/m^2	t/m^2
BH – 1	1.50	50	399.36	39.93
	3.00	52	416.35	41.63
	4.50	54	433.35	43.33
	5.00	56	450.34	45.03
BH – 2	1.50	51	407.85	40.78
	3.00	53	424.85	42.48
	4.50	55	441.84	44.18

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4.3 Safe Bearing capacity of soil based on Shear Failure Criteria:

Through Direct Shear test

Bore Hole No.	Depth (m)	Normal Stress (kg/cm^2)	Division	Ø (in degrees)	Safe Bearing Capacity of Soil (t/m^2)
BH – 1	1.50	0.5 1.0 1.5	24 91 158	37.61°	43.42
	3.00	0.5 1.0 1.5	24 92 159	37.82°	64.58
	4.50	0.5 1.0 1.5	24 93 161	38.23°	89.00
	5.00	0.5 1.0 1.5	24 93 162	38.43°	98.39

BH – 2	1.50	0.5 1.0 1.5	24 91 159	37.82°	44.69
	3.00	0.5 1.0 1.5	24 92 160	38.02°	66.34
	4.50	0.5 1.0 1.5	24 93 162	38.43°	91.25

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4.4 Comparison of Safe bearing capacity of soil through Shear and Settlement consideration:

Bore Hole no.	Depth (m)	Safe Bearing Capacity (t/m^2)	
		Shear consideration (Direct Shear)	Settlement consideration
BH – 1	1.50	43.42	39.93
	3.00	64.58	41.63
	4.50	89.00	43.33
	5.00	98.39	45.03
BH – 2	1.50	44.69	40.78
	3.00	66.34	42.48
	4.50	91.25	44.18

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5. Result:

5.1 Recommended Safe bearing capacity values at different depths

Considering the lesser value of the above, the Safe Bearing Capacity, values at different depths are recommended below:

Bore Hole	Depth (m)	Safe Bearing Capacity (t/m^2)
BH – 1	1.50	39.93
	3.00	41.63
	4.50	43.33
	5.00	45.03
BH – 2	1.50	40.78
	3.00	42.48
	4.50	44.18

The above test data and findings are relevant and applicable only for the soil conditions existing at the test site. Any change in the soil strata observed during excavation may be reported to the laboratory, which will redefine the safe bearing capacity of the soil.

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SOIL SAMPLE PHOTOS

0



5m

Bore Hole No: 1

Depth : 0 to 5m

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0



4.5m

<u>Bore Hole No: 2</u>

Depth : 0 to 4.5m

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SITE PHOTO



Site: Neelagiri Therku Thottam Village Old T.S.No.336/1A1pt, New ward-8, Block-16,New T.S.No.6, Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur Corporation, Thanjavur Taluk, Thanjavur District – 613007

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ANNEXURE

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Annexure - A

NATURAL MOISTURE CONTENT

(As per IS 2720 (Part - 2) - 1973)

Project Name : Report on soil investigation for Construction of Residential Apartment Building at Neelagiri Therku Thottam Village Old T.S.No.336/1A1pt, New ward-8, Block-16,New T.S.No.6, Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur Corporation, Thanjavur Taluk, Thanjavur District – 613007

Bore Hole No. : 1

Depth : 3m

Trial	Wt of container (W) gm	Wt of container +wet soil (W_1) gm	Wt of container + Dry soil (W_2) gm	Wt of Water ($W_3 = W_1-W_2$) gm	Wt of Dry Soil ($W_4 = W_2-W$) gm	Water Content (%) = (W_3-W_4)*100
1	23.10	56.20	52.80	3.4	29.7	11.45
2	20.50	48.90	46.00	2.9	25.5	11.37
3	22.30	50.70	47.80	2.9	25.5	11.37

Natural Moisture Content = 11.40

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Annexure - B

SPECIFIC GRAVITY TEST
(As per IS 2720 (Part - 3) - 1980)

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Bore Hole No. : 1

Depth : 3m

Trial	Bottle Wt (W1) gm	Bottle + Sample (W2) gm	Bottle + Sample + Water (W3) gm	Bottle + Water (W4) gm	Specific Gravity
1	32.6	92.4	118.1	80.8	2.658
2	32.6	92.9	118.4	80.8	2.656
3	32.6	93.3	118.6	80.8	2.651

Specific gravity of Fine Aggregate = 2.65

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Annexure - C

DENSITY CALCULATION

Project Name : Report on soil investigation for Construction of Residential Apartment Building at Neelagiri Therku Thottam Village Old T.S.No.336/1A1pt, New ward-8, Block-16,New T.S.No.6, Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur Corporation, Thanjavur Taluk, Thanjavur District – 613007

Bore Hole No. : 1

Depth : 3m

Sl. No.	Description	Reading
1	Weight of Empty Box (gm)	630.00
2	Weight of Box + Soil (gm)	811.00
3	Weight of Soil (gm)	181.00
4	Volume of Box (cm^3)	90.00
5	**Bulk Density (gm/cm^3)**	**2.01**
6	Weight of Container (gm)	23.10
7	Weight of Container + Wet Soil (gm)	56.20
8	Weight of Container + Dry Soil (gm)	52.80
9	Moisture Content (%)	11.45
10	**Dry Density (gm/cm^3)**	**1.80**

Result

Bulk Density of Soil = 2.01

Dry Density of Soil = 1.80

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POROSITY & VOID RATIO

Annexure - D

Project Name : Report on soil investigation for Construction of Residential Apartment Building at Neelagiri Therku Thottam Village Old T.S.No.336/1A1pt, New ward-8, Block-16,New T.S.No.6, Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur Corporation, Thanjavur Taluk, Thanjavur District – 613007

Bore Hole No. : 1

Depth : 3m

Sl. No.	Description	Reading
1	Dry Density γ_d (gm/cm^3)	1.80
2	Specific gravity (G_s)	2.65
	Porosity (%)	($1 – (\gamma d/Gs)$)*100
		(1-(1.80/2.65)) x 100 = 32.07
3	**Porosity (%)**	**32**
	Void Ratio, (e)	η/(1-η)
		0.3207/(1-0.3207)
4	**Void Ratio**	**0.47**

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FINENESS MODULUS TEST

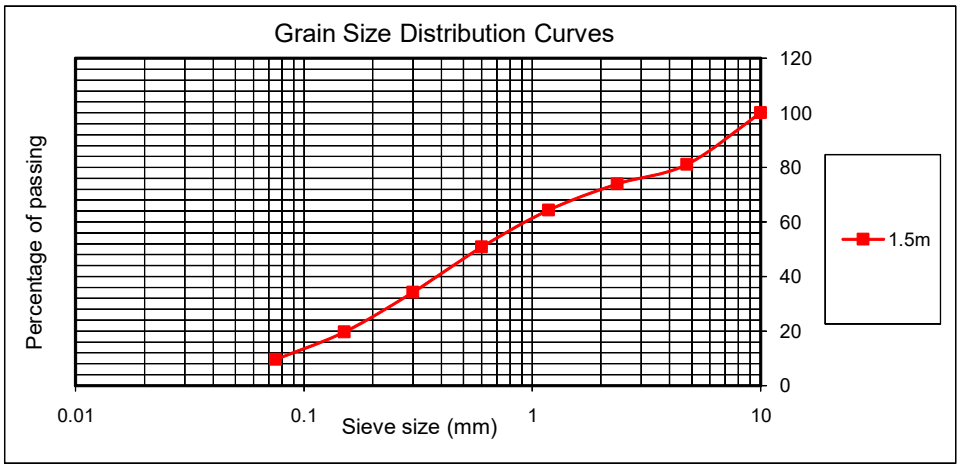
(As per IS 2720 (Part - 4) - 1985)

Annexure - E

Project Name : **Report on soil investigation for Construction of Residential Apartment Building at Neelagiri Therku Thottam Village Old T.S.No.336/1A1pt, New ward-8, Block-16,New T.S.No.6, Plot No.81 Of Natarajapuram South 6th Street, Medical College Road, Thanjavur Corporation, Thanjavur Taluk, Thanjavur District – 613007**

Bore Hole No. : **1**
Depth : **1.5m**

Sieve size (mm)	Weight retained	Cumulative Weight retained (gm)	Percentage cumulative weight retained (gm)	Percentage of passing
10	0	0.0	0.0	100.0
4.75	18.9	18.9	18.9	81.1
2.36	7.1	26.0	26.0	74.0
1.18	9.6	35.6	35.6	64.4
0.6	13.6	49.2	49.2	50.8
0.3	16.5	65.7	65.7	34.3
0.15	14.6	80.3	80.3	19.7
0.075	10.1	90.4	90.4	9.6
Pan	9.6	100.0	100.0	0.0



Based on Gradation Curve, the percentge component of each materials in the soil sample obtained are as follows (As per IS 1498 - 1970).

Gravel (%)	18.9
Coarse Sand (%)	16.7
Medium Sand (%)	30.1
Fine sand (%)	24.7
Silt & Clay (%)	9.6

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Annexure - F

Direct Shear Test (IS 2720 - Part 13 -1986)

Bore Hole	1
Depth (m)	3m
Date of Test	30.11.2022

L.C. Of Dial Gauge	0.002
Proving ring Constant	0.206996
Area of the specimen (cm^2)	36

Trial 1

Normal Stress: 0.5 kg/cm^2

Horizontal Gauge Reading	Proving Ring Reading	Shear Deformation	Shear Stress (kg/cm^2)
0	0	0.00	0.000
50	9	0.50	0.052
100	11	1.00	0.063
150	13	1.50	0.075
200	15	2.00	0.086
250	17	2.50	0.098
300	19	3.00	0.109
350	22	3.50	0.126
400	24	4.00	0.138

Trial 2

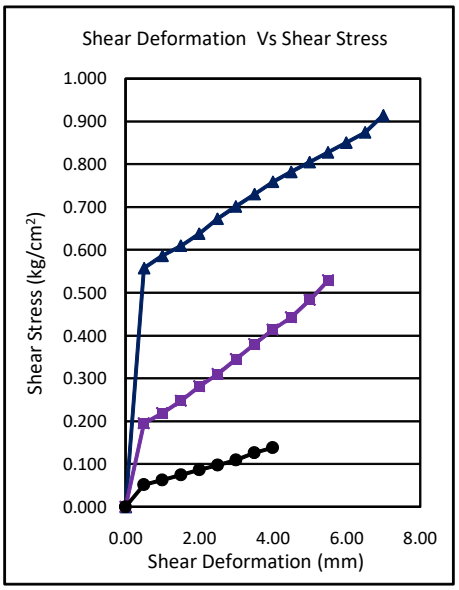
Normal Stress: 1 kg/cm^2

Horizontal Gauge Reading	Proving Ring Reading	Shear Deformation	Shear Stress (kg/cm^2)
0	0	0.00	0.000
50	34	0.50	0.195
100	38	1.00	0.218
150	43	1.50	0.247
200	49	2.00	0.282
250	54	2.50	0.310
300	60	3.00	0.345
350	66	3.50	0.379
400	72	4.00	0.414
450	77	4.50	0.443
500	84	5.00	0.483
550	92	5.50	0.529

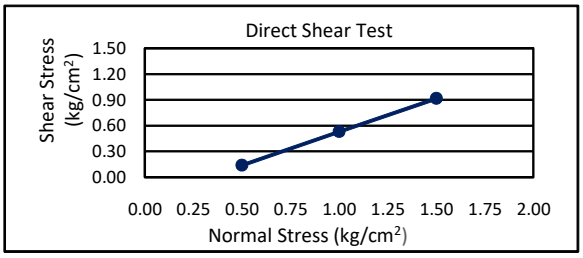
Trial 3

Normal Stress: 1.5 kg/cm^2

Horizontal Gauge Reading	Proving Ring Reading	Shear Deformation	Shear Stress (kg/cm^2)
0	0	0.00	0.000
50	97	0.50	0.558
100	102	1.00	0.586
150	106	1.50	0.609
200	111	2.00	0.638
250	117	2.50	0.673
300	122	3.00	0.701
350	127	3.50	0.730
400	132	4.00	0.759
450	136	4.50	0.782
500	140	5.00	0.805
550	144	5.50	0.828
600	148	6.00	0.851
650	152	6.50	0.874
700	159	7.00	0.914



Normal Stress (Kg/cm^2)	Proving Ring Reading at failure	Shear Stress (kg/cm^2)
0.50	24	0.138
1.00	92	0.529
1.50	159	0.914



Ø = $\tan^{-1}$ (0.914 - 0.138)

Angle of Shearing Resistance (Ø) = 37.82 °

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