PROPOSED RESIDENTIAL APARTMENT AT THIRU NAGAR, MADURAI

DESIGN BRIEF REPORT FOR STRUCTURAL SERVICES

Client : **Ms. RAMANIYAM REAL ESTATES Pvt Ltd**

Project Information : SURVEY NO : 121,121/1,121/2,121/3 & 121/1B, PLOT NO.A24, OLD DOOR NO.2/47,NEW DOOR NO.3, SUNDAR STREET, THIRUNAGAR
VILLAGE :THIRUPARANKUNDRAM
TALUK & DISTRICT : MADURAI.

Structural Consultant :

BURO ENGINNERS (I) PVT LTD
Civil & Structural Consultants
New No.31, (old No. 14), Besant Avenue,
Adyar, Chennai 600 020.

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1.0 INTRODUCTION

This Design Brief Report (DBR) is for the Proposed Residential Apartment at Thiru Nagar, Madurai, for M/s. Ramaniyam Real Estates Pvt Ltd.

The proposed residential building having Stilt + 5 storey + Roof.

This report provides the information on Codes of Practice, Design loadings, Material Strength considered for the Design and Analysis of the building. In addition this report includes Structural system, Foundation system, Method statement of structural analysis which will be adopted for design and analysis for the building.

1.1 Facilities:

Stilt floor: Parking, Lobby.

1st Floor to 5th floor: Residential units.

Terrace: Open terrace, OHT & LMR.

1.2 Floor to floor height:

Stilt floor	- 3.00m
1st to 5th floor each floor height	- 3.06m

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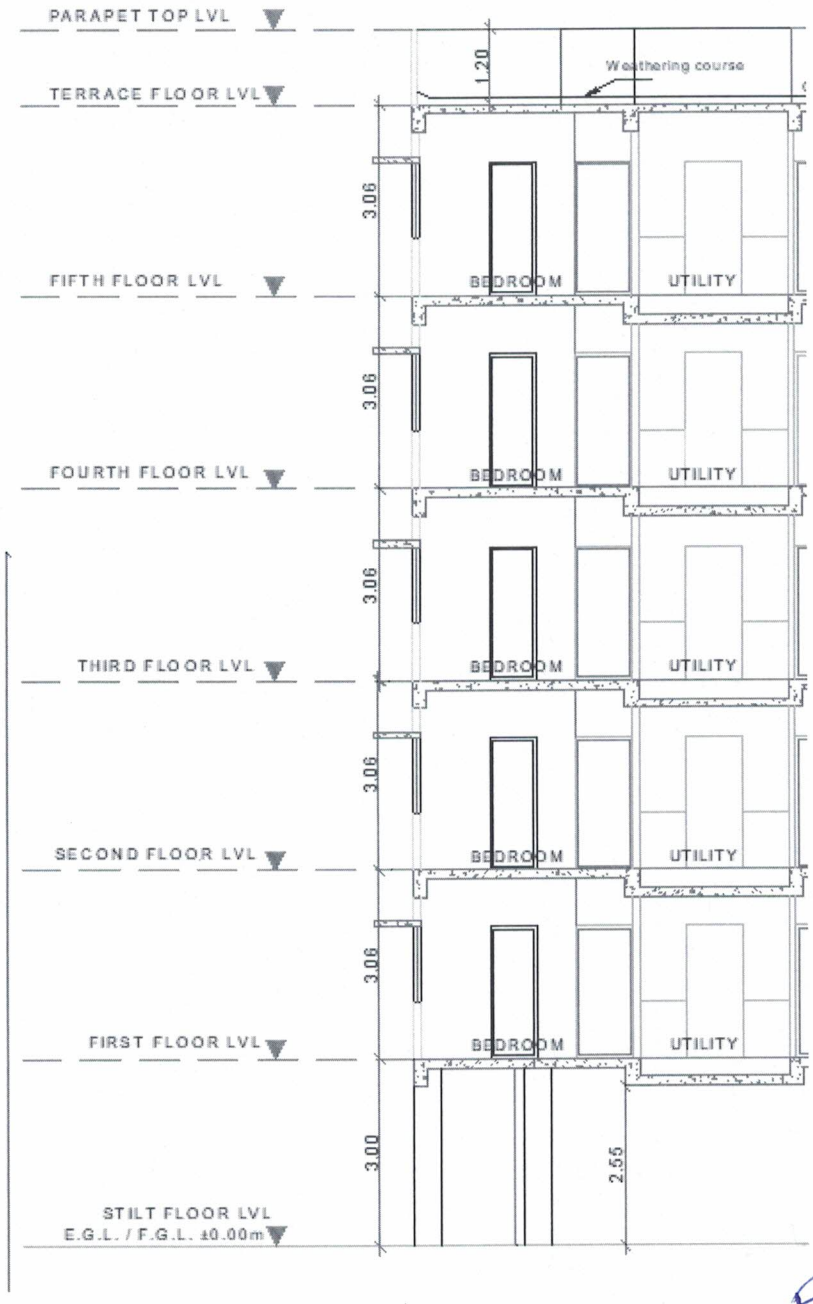

SECTION

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2.0 CODES OF PRACTICE

The relevant Indian Standard codes below are followed.

2.1 CODES, STANDARDS & REFERENCES

All design of structures shall comply with the requirements specified in the following.

a. Relevant Indian Standard Codes of Practice
b. National Building Code.
c. Local Building regulations.
d. Other relevant International codes where required.

All applicable latest edition of codes and standards will be referred and adopted in the analysis of structures and the design and detailing of structural members. All structural elements design shall be carried out primarily based on. Indian Standards and Codes with latest revision, with amendments if any, as on date.In addition, other international codes and standards shall also be referred when required and relevant.

In the analysis, design and detailing of the building, the following Indian Standard codes of latest amendment will be used.

CODE	DESCRIPTION
IS 875(Part 1) 1987	Code of practice for Design Loads (other than earthquake) for buildings and structures – Unit weights of buildings materials and stored material
IS 875 (Part 2) 1987	Code of practice for Design Loads (other than earthquake) for buildings and structures – Imposed Loads
IS 875 (Part 3) 2015	Code of practice for Design Loads (other than earthquake) for buildings and structures – Wind Loads
IS 875 (Part 5) 1987	Code of practice for Design Loads (other than earthquake) for buildings and structures – Special Loads and load combinations
IS 456 – 2000	Code of Practice for Plain and Reinforced Concrete
IS 16700 – 2017	Criteria for Structural Safety of Tall Concrete Buildings
IS 1343 – 2012	Code of Practice for Prestressed Concrete

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IS 1893 – 2016	Criteria for earthquake resistant design of structures
IS 4326 –1993	Code of practice for Earthquake Resistant Design and Construction of Buildings
IS 3370 – 2009	Code of Practice for Concrete structures for the storage of liquids
IS 1904-1995	Code of Practice for design and construction of Foundation
IS 1080 – 1997	Code of Practice for design and construction of shallow Foundation
IS 2950 - 1998	Code of Practice for design and construction of Raft Foundation
IS 800 – 2007	Code of practice for General Construction in steel
BS 8110 : 1997	Plain and reinforced concrete-code of practice(British standard)
ACI 318	Plain and reinforced concrete-code of practice (American standard)
IS 13920: 2016	Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
SP24	Explanatory Hand book on Indian standard code of practice
SP34	Handbook on concrete reinforcement and detailing

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3.0 DESIGN OF LOADINGS

a) SUPERIMPOSED DEAD LOADS AND LIVE LOADS

The following are the imposed loads such as SDL and LL to be considered for the design of floor system depending usage floor. In addition to these loads, self-weight of structural elements will be considered depending member sizes shown in the floor plans.

LOADINGS	DEAD LOAD (KN/m2)				LIVE LOAD (KN/m2
	FINISHES	SERVICES	SDL / Non Reduce LL	PARTITION	
STAIRCASE	1.50	0.00	1.80 (STEP)	0.00	3.00
TOILET	7.35	0.00	0.00	0.00	2.00
BALCONY	1.80	0.00	0.00	0.00	3.00
UTILITY ROOM	4.50	0.00	0.00	0.00	2.00
LOBBY & CORRIDOR	2.40	0.00	0.00	0.00	3.00
BED,LIVING,DINNING & KITCHEN	1.20	0.00	0.00	0.00	2.00
TERRACE	3.60	0.00	0.00	0.00	2.00
LMR	3.60	0.00	12.40	0.00	0.00
OHT	1.80	0.00	10 X WATER HEIGHT	0.00	0.00

Permissible reduction in imposed load on each floor is considered for design of columns and footings as per IS 875 Part (2).

b) SUPER IMPOSED DEAD LOADS (kN/m^2)

For apartment floor Finishes of 50 mm thickness have been considered on all the typical floors. Filling is considered for toilet 325mm (typical floor), utility=200mm, balcony-75mm.

TERRACES (Load in kN/m2)

Waterproofing + Screed 3.60 (0.15(average finishes Thk.) x 24=3.60)

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c) **SELF-WEIGHT OF POROTHERM BLOCK WALLS (kN/m)**

Infill walls (20mm for External wall & internal wall 15mm plastering on Either side)

(i) 150mm thick wall	2.20kN/m
(ii) 100mm thick wall	1.75kN/m
Water Tank	Water height x 10

d) **Material Density**

Unit weight of materials are as per IS: 875 (Part-I) 1987.

Unit weight of concrete	-	25 KN / Cum.
Unit weight of steel	-	78.5 KN / Cum.
Screed concrete	-	24 KN / Cum.
Unit weight of dry soil	-	18 KN / Cum.
Unit weight of saturated soil	-	20 KN / Cum.
Unit weight of Glass	-	27.2 KN / Cum.
Unit weight of water	-	9.81 KN / Cum.
Unit weight of Porotherm wall	-	10 KN / Cum.
Light weight concrete filling	-	16 KN / Cum.

e) SEISMIC LATERAL FORCE

Design of lateral force under seismic condition shall be as per IS1893 – 2016. Total lateral force (base shear) of the building shall be estimated at ground floor level as per clause 7.2.1 of IS1893 – 2016 which provides by

Base shear Vb = Ah W

Ah is horizontal seismic coefficient and W is seismic weight of the building, Horizontal seismic coefficient depends on location of the building (Zone factor Z), usage of the building (Importance factor, I), building lateral resisting system (Response reduction factor, R) and design acceleration coefficient (Sa /g) which is based on subsoil condition and fundamental natural period (Ta).

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For the proposed development is for Residential use. Considering it, the seismic weight is summation of total dead load and 25% of live load where live load is equal and less than 3 kN/sq.m.

1) The lateral load resisting system of the buildings is ordinary shear wall with ordinary moment resisting frames.
2) As per IS 1893:2016 code, Madurai lies in Zone II with Zone factor Z = 0.1
3) The Design Base Shear is given by V_b = Ah x W, Where

   Ah = Z / 2 x I / R x S_a / g

   I = Importance Factor = 1.0

   Soil Type 1 (Weathered Rock)

   R (Response reduction factor) = 3.0. Building with ordinary RC structural and ordinary RC Moment resisting frames with reference to IS: 1893-2016, Table-9 and the frames are designed to carry the design lateral load.

   Sa/g = Average Response acceleration coefficient

   With reference to IS 1893 - 2016 clause 7.6.2 (c) the time period for building each directions are as follows,

The fundamental natural period (Ta) for building,

For X and Y direction the time period is calculated

c) All other buildings:

$$T_a = \frac{0.09h}{\sqrt{d}}$$

where

h = height of building, as defined in **7.6.2**(a), in m; and

d = base dimension of the building at the plinth level along the considered direction of earthquake shaking, in m.

Tower-1 Time period Calculation:

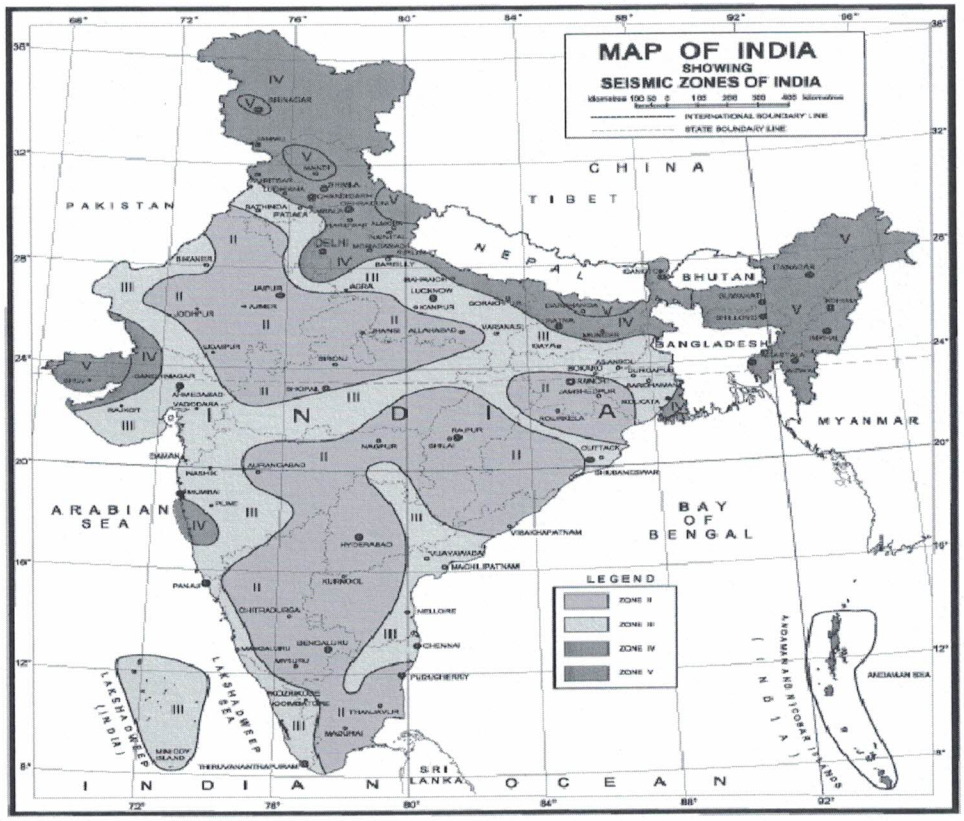
dx = 22.8m,

dy = 36.0m,

H = 18.3m

T_a = 0.345 (along X direction)

T_a = 0.275 (along Y direction)



Dynamic Analysis

Response spectrum method of Dynamic Analysis carried out with following parameters pertaining to dynamic analysis.

Number of modes Considered	: 12 Numbers (Min)
Modal Combination Method Used	: Complete Quadratic combination (CQC).
Directional Combination Method used	: Square root of the sum of Square (SRSS).
Modal case type	: Ritz vector Method

Cut off frequency in case response spectrum method of analysis - 33 Hz.

Mass participation is 90% as per our analysis

Damping 5%is used for seismic analysis

Dynamic analysis of building is carried out. The members are designed accordingly.

f) WINDS LOADS

The wind pressure shall be calculated based on the basic wind speed and other provisions laid in IS 875 Part(3) - 2015

Design Wind speed $V_Z = V_b x k_1 x k_2 x k_3 x k_4$

V_b ⟶ Basic Wind velocity for Madurai = 39m/s

k_1 ⟶ Risk coefficient for all general buildings = 1.00

k_2 ⟶ Terrain category 2 = To suit the height of the structure for terrain

[k_2 (H=31.2m -GF to Roof including parapet wall) = 1.10]

k_3 ⟶ Topography factor = 1.00

k_4 ⟶ Importance Factor = 1.00

Based on the above,

Max. design wind speed (V_Z) ($V_b x k_1 x k_2 x k_3 x k_4$) = 42.9m/s

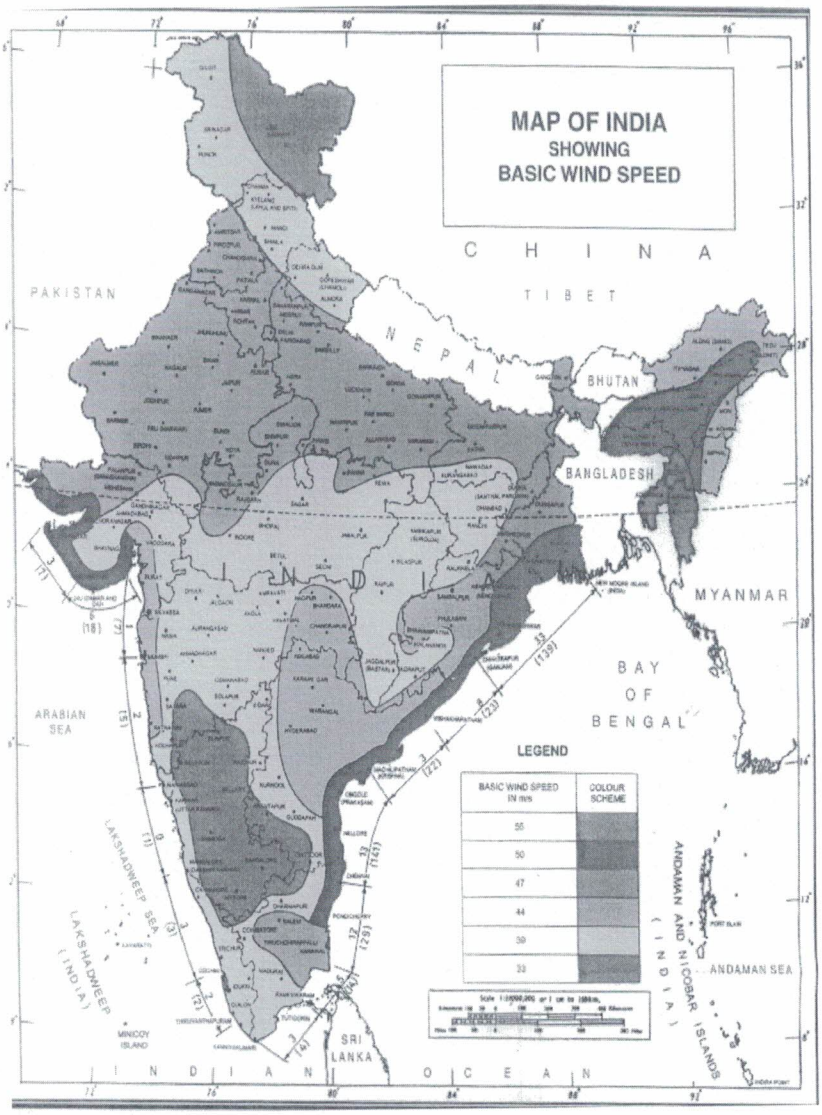
Max. design wind pressure (Pz) $= 0.6 \times V_z^2$ = 1104.25 N/m2

Design wind pressure: pd = Pz x Kax Kd x Kc = 805N/m2

Kd ⟶ Wind directionality factor = 0.90

ka ⟶ Area averaging factor = 0.90

k_c ⟶ Combination factor = 0.90



g) TEMPERATURE LOAD

The building is completely covered with brick work on the sides. So there will be no appreciable differential temperature during the service life of building. The roof slab and the podium of building is to be analyzed for ± 15°C difference in temperature is applied to Etabs model and necessary load combinations are considered in analysis & Design of the building. The roof slab is assign as semi rigid diaphragm for ultimate load combination.

3.1 LOAD COMBINATIONS

The various loads combinations used for design in accordance with IS 1893-2016 are as follows

1. 1.5 (DL + LL)
2. 1.2 (DL + LL ± SPECX)
3. 1.2 (DL + LL ± SPECY)
4. 1.2 (DL + LL ± WindX)
5. 1.2 (DL + LL ± WindY)
6. 1.5 (DL ± SPECX)
7. 1.5 (DL ± SPECY)
8. 1.5 (DL ± WindX)
9. 1.5 (DL ± WindY)
10. 0.9DL ± 1.5SPECX
11. 0.9DL ± 1.5SPECY
12. 0.9DL ± 1.5WindX
13. 0.9DL ± 1.5WindY
14. 0.75 (1.4DL + 1.7LL ± 1.4TEMP)
15. 0.75 (1.4DL + 1.4LL ± 1.4SPECX ± 1.4TEMP)
16. 0.75 (1.4DL + 1.4LL ± 1.4SPECY ± 1.4TEMP)
17. 0.75 (1.4DL + 1.4LL ± 1.4WindX ± 1.4TEMP)
18. 0.75 (1.4DL + 1.4LL ± 1.4WindY ± 1.4TEMP)
19. 0.75 (1.4DL ± 1.4TEMP) ± 1.2SPECX
20. 0.75 (1.4DL ± 1.4TEMP) ± 1.2SPECY
21. 0.75 (1.4DL ± 1.4TEMP) ± 1.2WindX
22. 0.75 (1.4DL ± 1.4TEMP) ± 1.2WindY
23. 0.9DL + 0.75 (±1.4TEMP ± 1.4SPECX)
24. 0.9DL + 0.75 (±1.4TEMP ± 1.4SPECY)
25. 0.9DL + 0.75 (±1.4TEMP ± 1.4WindX)
26. 0.9DL + 0.75 (±1.4TEMP ± 1.4WindY)
27. 1.4 DL ± 1.4TEMP

27A. 1.05DL±1.05TEMP+1.28LL

The various service loads combinations of structure as per IS 456 are as follows

28. 1.0DL +1.0 LL
29. 1.0DL ± 1.0SPECX
30. 1.0DL ± 1.0SPECY
31. 1.0DL ± 1.0WindX
32. 1.0DL ± 1.0WindY
33. 1.0DL ± 1.0TEMP
34. 1.0DL + 0.8LL ± 0.8SPECX
35. 1.0DL + 0.8LL ± 0.8SPECY
36. 1.0DL + 0.8LL ± 0.8WindX
37. 1.0DL + 0.8LL ± 0.8WindY
38. 1.0DL + 0.75LL ± 0.75TEMP
39. 1.0DL + 0.5LL ± 0.75TEMP ± 0.75SPECX
40. 1.0DL + 0.5LL ± 0.75TEMP ± 0.75SPECY
41. 1.0DL + 0.5LL ± 0.75TEMP ± 0.75WindX
42. 1.0DL + 0.5LL ± 0.75TEMP ± 0.75WindY

Where, DL - Dead load,
LL - Live load (Live>3kN/m2, Live1<=3kN/m2)
WindX- Wind load in x - direction
WindY- Wind load in y-direction
SPECX - Earthquake load in x-direction
SPECY - Earthquake load in y-direction
TEMP - Temperature load

4.0 MATERIAL GRADES

i) CONCRETE

Grade M30 (fck = 30 N/mm²) for Isolated & Combined foundation, Shear wall, Column, Overhead Water Tank, UG Water Tank, Pump Room, Beam & Slab

ii) REINFORCEMENT

Reinforcement bars of grade Fe550D conform to IS 1786-2008.

5.0 COVER AND FIRE RATING

Fire rating considered - 2hrs.

Cover to reinforcement considered for various element

Isolated footing	50 mm (Very severe exposure condition)
Columns	40 mm (2 hours fire resistance)
Tank walls	45 mm (Severe exposure condition)
Shear Walls	30 mm (2 hours fire resistance)
Beams (simply supported)	40 mm (2 hours fire resistance & Moderate)
Beams (continuous)	30 mm (2 hours fire resistance & Moderate)
Slabs (simply supported)	35 mm (2 hours fire resistance & Moderate)
Slabs (continuous)	25 mm (2 hours fire resistance & Moderate)

6.0 STRUCTURAL SYSTEM

SUPER STRUCTURE

The structural system for the super structure is R.C.C Beam with R.C.C slab. The slab thicknesses are to be 125mm.

7.0 DEFLECTION CRITERIA

7.1 Lateral Deflection (Wind)

Overall Deflection	<	Height/500
Storey Deflection	<	Storey height/500

7.2 Lateral Deflection (Seismic)

Overall Drift	<	H / 250
Storey Drift	<	0.004 times storey height

7.3 Vertical Deflection of Beams and Slabs due to Gravity Loads

Total Deflection (DL + LL)	<	Span/250
Deflection including the effects of Temperature, Creep and Shrinkage Occurring after erection of partitions and the application of finishes	<	Span/350 or 20mm whichever is less

8.0 STRUCTURAL ANALYSIS

Computer-aided analysis using finite element method (FEM) shall be carried out for the design of structural elements. For 3D or 2D structural frame analysis latest version of software ETABS or SAFE shall be used, Prokon, RCDC and verified in-house spreadsheets will be used for the design of reinforced concrete (RC) and steel elements in consideration of flexure, shear and axial forces.

Assumptions for 3D model analysis using ETABS

Column	:	Frame Element
RC Wall	:	Wall (Shell) Element
Beam Element	:	Frame Element
Slab	:	Shell Element

The following are general parameters adopted in the analysis and design,
Modulus of Elasticity of Concrete -5000$\sqrt{fck}$
Consideration of Diaphragm - Rigid Diaphragm.
Slab/Wall element considered as Shell element

Stiffness modification factors are adopted in the analysis as per IS -16700-2017, Table.6.

Table 6 Cracked RC Section Properties
(Clause 7.2)

Sl No.	Structural Element	Un-factored Loads		Factored Loads	
		Area	Moment of Inertia	Area	Moment of Inertia
(1)	(2)	(3)	(4)	(5)	(6)
i)	Slabs	1.0 A_g	0.35 I_g	1.00 A_g	0.25 I_g
ii)	Beams	1.0 A_g	0.7 I_g	1.00 A_g	0.35 I_g
iii)	Columns	1.0 A_g	0.9 I_g	1.00 A_g	0.70 I_g
iv)	Walls	1.0 A_g	0.9 I_g	1.00 A_g	0.70 I_g

The following parameters and methods are adopted in creating ETABS 3D model for the buildings and design of structural elements.,

- The 3D ETABS model generated based on the preliminary floor plans (shuttering drawings) prepared using preliminary sizes.
- Sectional properties are assigned to all the structural elements as per the preliminary floor plans (shuttering drawings).
- External & Internal in fill wall loads are assigned as uniformly distributed line load on beams and as area load if the wall is intending to distribute on slab directly.
- Slabs are modelled as shell element if floor system and slabs are assigned with horizontal diaphragms.
- Live Load reduction is considered in the design of Foundation and Column as per the Code: IS 875-1987 (Part-II), clause.3.2.1.
- Area design load i.e. Live load/SDL or any other load is applied at floor relevant to its usage.
- All lateral loads & parameters are assigned as per Codes IS 1893-2016 & IS 875-Part-3, 2015.
- Temperature loads are applied on to the terraces and to areas directly exposed to atmosphere.
- Beams under Torsion is required to maintain Equilibrium will be designed for Torsion in accordance with IS 456-2000, clause 41.1 to 41.4 and for all other beams torsional stiffness is neglected in the analysis by applying stiffness modifier as 0.000001 to torsional constant "J". Hence no specific design for Torsion is required for these beams.
- Concrete cover to reinforcement complied accordance with IS 456-2000, Tabl.16 & 16A.
- All vertical wall elements are assigned with auto meshing/manual messing appropriately in order to achieve accuracy in results.

Design approach of structural elements

Shear wall/Column:

RC Structural Walls & Columns which are supporting both vertical loads and lateral forces are designed for the most adverse load conditions and envelope of the forces which will be the maximum for that structural element from the load combinations considered in the 3D Etabs Model.

RCDC a design software will be used to design the element for the maximum forces obtained from the Etabs model analysis results.

Beams:

Each Beam will be designed for maximum forces from the 3D analysis using Etabs and RCDC Softwares.

Area Load & Application:

Applied as uniformly distributed area load with intensity proportionate to its usage as mentioned in the Loading items in the DBR.

Line (Wall) Load & Application:

Non load bearing or infill wall loads are calculated appropriately and applied as uniformly distributed line load.

9.0 FOUNDATION

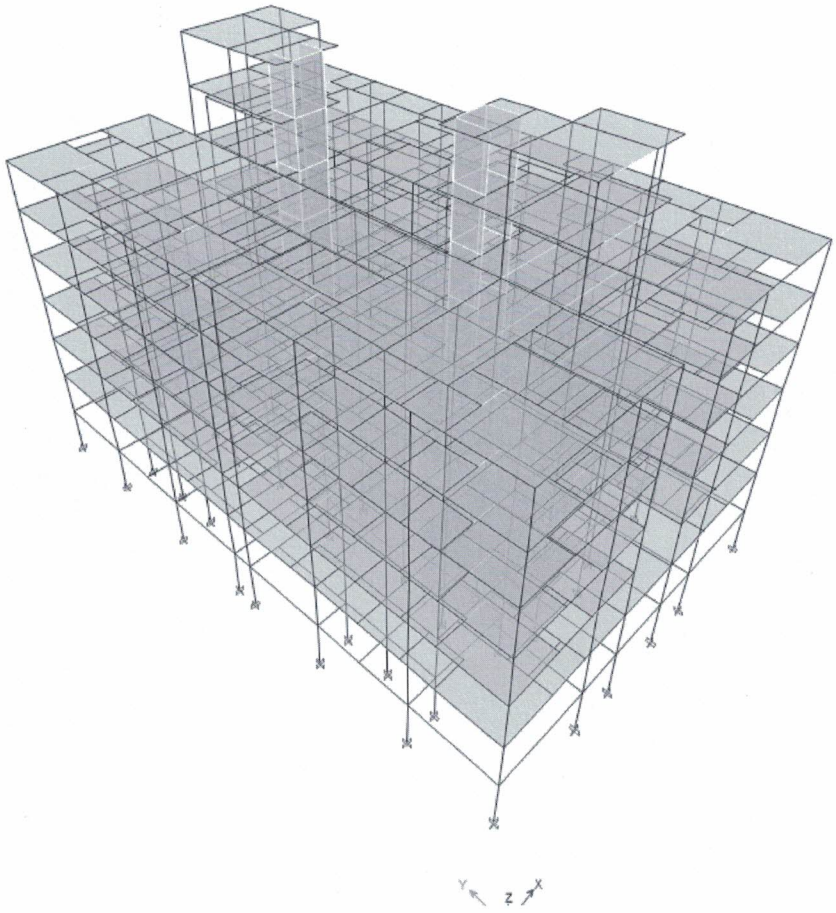
Proposed Foundation system is Isolated & combined footing and the SBC considered for the design is 180kN/m2 the founding depth is to be 1.8m from the natural ground level with reference to the soil investigation report No-386 from M/s.Geomatrix Consultancy.

10.0 COMPUTER PROGRAMS

The following Software / spreadsheet to be used to carry out Structural analysis and design.

1. PROKON Ver 2.3 - Wall & Beam design
2. ETABS Ver 19.1 - Three Dimensional Program
3. SAFE Ver 20.0 - Raft Analysis / Strip Analysis
4. In-House Spreadsheet - one way/ two way slab design
5. Rapt-6 - Post Tensioning Analysis & Design
6. RCDC - Beam Design, Isolated footing design, Column design and Wall design
7. STAAD PRO & ETABS - Structural Steel Design.

ETABS®



Summary Report

1 Structure Data

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

1.1 Story Data

Table 1.1 - Story Definitions

Tower	Name	Height m	Master Story	Similar To	Splice Story	Color
T1	LMR COVER	3.05	No	None	No	Cyan
T1	LMR BASE	3	No	None	No	Red
T1	ROOF	3.05	No	None	No	Magenta
T1	5TH	3.05	No	None	No	Yellow
T1	4TH	3.05	No	None	No	Gray8Dark
T1	3RD	3.05	No	None	No	Blue
T1	2ND	3.05	No	None	No	Green
T1	1ST	3.05	No	None	No	Cyan
T1	GROUND	3	No	None	No	Red

2 Loads

This chapter provides loading information as applied to the model.

2.1 Load Patterns

Table 2.1 - Load Pattern Definitions

Name	Is Auto Load	Type	Self Weight Multiplier	Auto Load
~LLRF	Yes	Other	0	
DEAD	No	Dead	1	
EQX	No	Seismic	0	IS 1893:2016
EQY	No	Seismic	0	IS 1893:2016
LIVE	No	Live	0	
SDL	No	Super Dead	0	
WALL	No	Other	0	
WX	No	Wind	0	Indian IS 875:2015
WY	No	Wind	0	Indian IS 875:2015

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQX according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = X

Structural Period

Period Calculation Method = User Specified

User Period — T = 0.345sec

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3] — Z = 0.1

Response Reduction Factor, R [IS Table 9] — R = 3

Importance Factor, I [IS Table 8] — I = 1

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a/g [IS 6.4.2] — $\frac{S_a}{g} = 2.5$ — $\frac{S_a}{g} = 2.5$

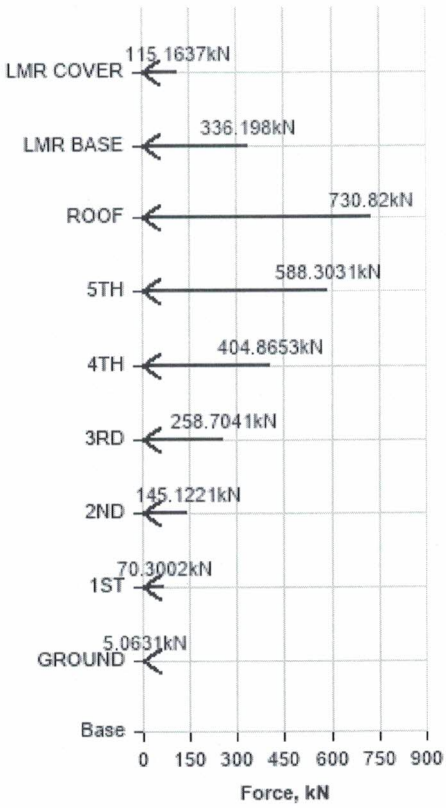
Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] — $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	0.345	63708.9501	2654.5396

Lateral Load to Stories - X



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
LMR COVER	27.35	115.1637	0
LMR BASE	24.3	336.198	0
ROOF	21.3	730.82	0
5TH	18.25	588.3031	0
4TH	15.2	404.8653	0
3RD	12.15	258.7041	0
2ND	9.1	145.1221	0
1ST	6.05	70.3002	0
GROUND	3	5.0631	0
Base	0	0	0

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQY according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = Y

Structural Period

Period Calculation Method = User Specified

User Period $T = 0.275\text{sec}$

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3] $Z = 0.1$

Response Reduction Factor, R [IS Table 9] $R = 3$

Importance Factor, I [IS Table 8] $I = 1$

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a/g [IS 6.4.2] $\frac{S_a}{g} = 2.5$ $\frac{S_a}{g} = 2.5$

Equivalent Lateral Forces

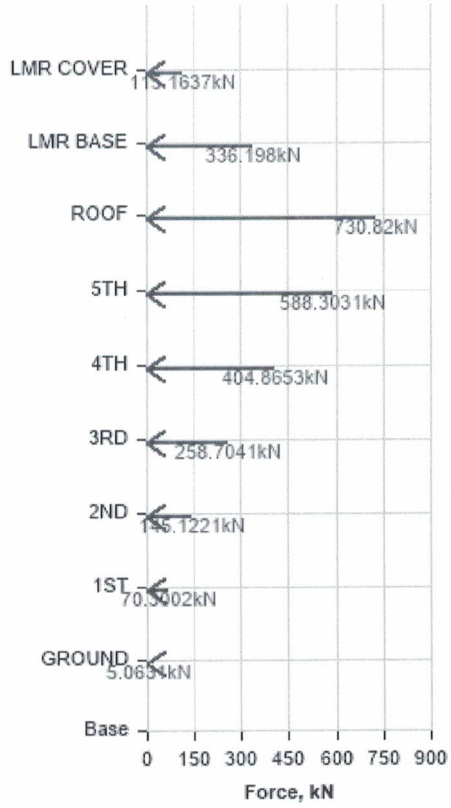
Seismic Coefficient, A_h [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	0.275	63708.9501	2654.5396

Applied Story Forces

Lateral Load to Stories - Y



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
LMR COVER	27.35	0	115.1637
LMR BASE	24.3	0	336.198
ROOF	21.3	0	730.82
5TH	18.25	0	588.3031
4TH	15.2	0	404.8653
3RD	12.15	0	258.7041
2ND	9.1	0	145.1221
1ST	6.05	0	70.3002
GROUND	3	0	5.0631
Base	0	0	0

FOOTING DESIGN CALCULATIONS

Design Code	:	IS 456 : 2000 + IS 13920 : 2016	
Footing No	:	FC5	
Column No	:	C5	(450mm X 230mm)
Analysis No	:	C76	
Concrete Grade	:	M30	N/sqmm
Steel Grade	:	Fe550	N/sqmm
Clear Cover	:	50	mm
Df	:	1.8 M	
Dw	:	0 M	
Density of Soil	=	18	kN/cum
Soil Bearing Capacity	=	180	kN/sqm
Permissible SBC Increase for EQ	=	25	%
Permissible SBC Increase for Wind	=	25	%
Live Load Reduction	=	0	%
Permissible area of loss of contact	=	0	%
Design cross section by	:	Average pressure	
Footing Type	:	Pad	
Footing Size (L x B x D)	:	2600mm X 2400mm X 600mm	

Without considering Effect of Water Table

Footing Self Wt., F1	=	93.60	kN
Soil Weight, S1	=	0.00	kN
Total Weight, W1	=	F1 + S1	
	=	93.6	kN
Offset Along L (Loff)	=	1075	mm
Offset Along B (Boff)	=	1085	mm

Check For Maximum Soil Pressure:

Critical Load Combination	=	[3] : (Dead) +(SDL) +(WALL) +(Live) -(SPECXMax)
Pcomb	=	1119.86 kN

P	=	Pcomb + W1	
P	=	1213.46	kN
Mx	=	-31.64	kNm
My	=	0.11	kNm
P/A	=	194.46	kN/sqm
Mx/Zx	=	-11.7	kN/sqm
My/Zy	=	0.04	kN/sqm
Maximum Soil Pressure	=	206.21	kN/sqm
Allowable Soil Pressure	=	1.25x180	kN/sqm
	=	225	kN/sqm

Check For Minimum Soil Pressure:

Critical Load Combination	=	[2] : (Dead) +(SDL) +(WALL) +(Live) +(SPECXMax)	
Pcomb	=	882.91	kN
P	=	Pcomb + W1	
P	=	976.51	kN
Mx	=	30.93	kNm
My	=	0.39	kNm
P/A	=	156.49	kN/sqm
Mx/Zx	=	11.44	kN/sqm
My/Zy	=	0.15	kN/sqm
Minimum Soil Pressure	=	144.9	kN/sqm
	>	0	

Design For Bending:

Bottom Reinforcement Along L:

Critical Load Combination	=	[20] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) -1.5 (SPECXMax)	
Pu	=	1501.24	kN
Mux	=	-47.78	kNm
Muy	=	0.13	kNm
P/A	=	240.58	kN/sqm
Mx/Zx	=	-17.67	kN/sqm

My/Zy	=	0.05	kN/sqm
Deff	=	542	mm
Beff	=	2400	mm
SPu	=	258.25	kN/sqm
Mu	=	SPu X B X Loff X Loff / 2	
	=	358.13	kNm
Pt	=	0.133	%
Ast Rqd (BM)	=	1728	sqmm
Ast Prv (Distributed Across Total Width)	=	T10 @ 100	
	=	1806	sqmm

Bottom Reinforcement Along B:

Critical Load Combination	=	[10] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) +1.5 (Live)	
Pu	=	1502.07	kN
Mux	=	-0.53	kNm
Muy	=	0.37	kNm
P/A	=	240.72	kN/sqm
Mx/Zx	=	-0.2	kN/sqm
My/Zy	=	0.15	kN/sqm
Deff	=	526	mm
Leff	=	2600	mm
SPu	=	240.87	kN/sqm
Mu	=	SPu X L X Boff X Boff / 2	
	=	368.62	kNm
Pt	=	0.137	%
Ast Rqd (BM)	=	1872	sqmm
Ast Prv (Distributed Across Total Length)	=	T10 @ 100	
	=	1884	sqmm

Design For Shear:

One Way Shear Along L:

Critical Section @ d from Column Face

	=	542	mm
Critical Load Combination	=	[20] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) -1.5 (SPECXMax)	
Pu	=	1501.24	kN
Mux	=	-47.78	kNm
Muy	=	0.13	kNm
P/A	=	240.58	kN/sqm
Mx/Zx	=	-17.67	kN/sqm
My/Zy	=	0.05	kN/sqm
Deff	=	542	mm
Beff	=	2400	mm
SPu	=	258.25	kN/sqm
Vu	=	SPu X (Loff - d) X B	
	=	330.36	kN
Tv	=	Vu / (Beff X Deff)	
	=	0.25	N/sqmm
Tc	=	0.28	N/sqmm
Tv	<	Tc	

<u>One Way Shear Along B:</u>

Critical Section @ d from Column Face

	=	526	mm
Critical Load Combination	=	[10] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) +1.5 (Live)	
Pu	=	1502.07	kN
Mux	=	-0.53	kNm
Muy	=	0.37	kNm
P/A	=	240.72	kN/sqm
Mx/Zx	=	-0.2	kN/sqm
My/Zy	=	0.15	kN/sqm
Deff	=	526	mm

Leff	=	2600	mm
SPu	=	240.87	kN/sqm
Vu	=	SPu X (Boff - d) X L	
	=	350.07	kN
Tv	=	Vu / (Leff X Deff)	
	=	0.26	N/sqmm
Tc	=	0.28	N/sqmm
Tv	<	Tc	

Design For Punching Shear:

Critical Section @ d/2 from Column Face

	=	267	mm

Critical Load Combination	=	[10] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) +1.5 (Live)	
Pu	=	1502.07	kN
Mux	=	-0.53	kNm
Muy	=	0.37	kNm
P/A	=	240.72	kN/sqm
Mx/Zx	=	-0.2	kN/sqm
My/Zy	=	0.15	kN/sqm

Deff	=	534	mm
Leff	=	984	mm
Beff	=	764	mm
Punching Perimeter	=	3496	mm
Punching Area	=	1866864	sqmm
SPu	=	Average Pressure	
	=	240.72	kN/sqm
Vu	=	SPu X ((L X B)-(Leff X Beff))	
	=	1321.11	kN
Tv	=	Vu / Punching Area	
	=	0.708	N/sqmm
Tc	=	1.369	N/sqmm
Tv	<	Tc	

Load Transfer Check For Load Transfer From Column To Footing

Critical Load Combination	=	[10] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) +1.5 (Live)	
Pu	=	1502.07	kN
A2	=	0.1	sqm
A1	=	7.5	sqm
Base Area	=	6.24	sqm
A1	>	Base Area	
Thus, A1	=	6.24	
Modification Factor	=	SquareRoot(A1/A2) < = 2	
SquareRoot(A1/A2)	=	7.8994	
Thus, Modification Factor	=	2	
Concrete Bearing Capacity	=	0.45 X Fck X Modification Factor X Column Area	
	=	2794.5	kN
Concrete Bearing Capacity	>	Pu, Hence Safe.	

COLUMN DESIGN CALCULATIONS

General Data

Column No.	:	C2,C5,C56,C59	
Level	:	Base To GROUND	
Design Code	=	IS 456 : 2000 + IS 13920 : 2016	
Grade Of Concrete	=	M30	N/sqmm
Grade Of Steel (Main)	=	Fe550	N/sqmm
Grade Of Steel (Shear)	=	Fe415	N/sqmm
Grade Of Steel - Flexural Design	=	Fe550	N/sqmm
Grade Of Steel - Shear Design	=	Fe415	N/sqmm
Column B	=	300	mm
Column D	=	450	mm
Clear Cover	=	40	mm
Clear Floor Height @ B	=	2550	mm
Clear Floor Height @ D	=	2400	mm
No Of Floors	=	1	
No Of Columns In Group	=	4	
Code defined D/B ratio	:	4	
D/B Ratio	:	1.5 <= 4 Hence, Design as Column	

Flexural Design (Analysis Forces)

Analysis Reference No.	=	C59	
Load Combination	=	[11] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) -1.5 (SPECXMax)	
Critical Location	=	Bottom Joint	
Pu	=	1616.73	kN
Mux	=	-77.48	kNm
Muy	=	-2.12	kNm
Vux	=	0.01	kN
Vuy	=	-43.7	kN

Effective Length Calculation

Calculation Along Major Axis Of Column

Joint	Column Stiffness	Beam Sizes		Beam Stiffness		Beta
		Beam 1 (Length x Width x Depth)	Beam 2 (Length x Width x Depth)	Beam 1	Beam 2	
	N-m x 10^6	mm	mm	N-m x 10^6	N-m x 10^6	
Bottom	83.185	No Beam	No Beam	-	-	1
Top	83.185	6300 x 230 x 600	2850 x 230 x 600	71.986	159.128	0.417

Sway Condition (as per Stability Index)	=	Non Sway	
Effective Length Factor along Major Axis	=	1	

Calculation Along Minor Axis Of Column

Joint	Column Stiffness	Beam Sizes		Beam Stiffness		Beta
		Beam 1 (Length x Width x Depth)	Beam 2 (Length x Width x Depth)	Beam 1	Beam 2	
	N-m x 10^6	mm	mm	N-m x 10^6	N-m x 10^6	
Bottom	36.971	No Beam	No Beam	-	-	1
Top	36.971	No Beam	5450 x 230 x 450	-	35.106	0.676

Sway Condition (as per Stability Index)	=	Non Sway	
Effective Length Factor along Minor axis	=	1	

Minimum Eccentricity Check

Since Axial Force is compressive, Min. Eccentricity check to be performed
Most critical case is with Min. Eccentricity check in Y-direction
Minimum Eccentricity Along B :

Minimum Eccentricity	=	Unsupported Length / 500 + B / 30	
	=		15.1 mm
Mminy	=	Pu x Minimum Eccentricity	
	=		32.33 kNm

Slenderness Check

Max Slenderness Ratio(L/B)	=		8.5
	<		60 (Hence Ok)

Column Is Unbraced Along D
Slenderness Check Along D:

Effective Length Factor	=		1
Slenderness Ratio	=	Effective Length / D	
	=	5.33, Column not Slender Along D	

Column Is Unbraced Along B
Slenderness Check Along B:

Effective Length Factor	=		1
Slenderness Ratio	=	Effective Length / B	
	=	8.5, Column not Slender Along B	

Calculation of Design Moment

Direction	Manalysis	Mmin (Abs)	Mdesign	MsIndx (Abs)	Mdesign-final
	A	B	C	E	F
Major Axis - Mux	-77.48	---	-77.48	0	-77.48
Minor Axis - Muy	-2.12	32.33	-32.33	0	-32.33

Where

A	=	Moments directly from analysis
B	=	Moments due to minimum eccentricity
C	=	Maximum of analysis moment and min. eccentricity = Max (A,B)
E	=	Moment due to slenderness effect
F	=	Final design Moment = Max(C- Top Bottom , D- Top Bottom) + E

Final Critical Design Forces

Pu	=	1616.73 kN
Mux	=	-77.48 kNm
Muy	=	-32.33 kNm

Interaction Principle (Discrete Action)

Moment Capacity Check

Pt Calculated	=		1.82
Reinforcement Provided	=	4-T20 + 6-T16	
Load Angle	=	Tan^{-1}(Muy/Mux)	
	=		22.65 deg

Corresponding NA angle (β)	=		46.44 deg
MRes	=		83.96 kNm
MCap	=		137.65 kNm
Capacity Ratio	=	MRes/ MCap	
	=	0.61 <= 1	

Shear Calculation	Along D	Along B
Critical Load Combination	[18] : 0.9 (Dead) +0.9 (SDL) +0.9 (WALL) +1.5 (SPECXMax)	[18] : 0.9 (Dead) +0.9 (SDL) +0.9 (WALL) +1.5 (SPECXMax)
Design shear force, Vu (kN)	41.3182	0.4179
Pu (kN)	548.3	548.3
Deff , Beff (mm)	400	250
Design shear stress, Tv	Vu / (B x Deff)	Vu / (D x Beff)
Tv (N/sqmm)	0.3443	0.0037
Pt (%)	0.912	0.912
Design shear strength, Tc (N/sqmm)	0.6329	0.6329
Shear Strength Enhancement Factor (Compressive Force)	1 + 3 x Pu / (B x D x Fck)	
	1.4061	1.4061
Shear Strength Enhancement Factor (Tensile Force)	-	-
Shear Strength Enhancement Factor (max)	1.5	1.5
Shear Strength Enhancement Factor	1.4061	1.4061
Enhanced shear strength, Tc-e (N/sqmm)	0.89	0.89
Design shear check	Tv < Tc x Enhancement factor	Tv < Tc x Enhancement factor
Shear Links Design	**Shear Links Not Required**	**Shear Links Not Required**

Design Of Links

Links in the zone where special confining links are not required

Normal Links

Diameter of link	=		8 mm
	>	Max. longitudinal bar dia / 4	
	=		5 mm

Table For Links

	Required			Provided	
	Normal Design	Shear Design	Ductile Design	Normal Zone	Ductile Zone
Link Dia.	8	8	8	8	8
Spacing	250	125	100	250	100

General Data

Column No.	:	C2,C5,C56,C59	
Level	:	1ST FLOOE LEVEL To 3RD FLOOR LEVEL	
Design Code	=	IS 456 : 2000 + IS 13920 : 2016	
Grade Of Concrete	=	M30	N/sqmm
Grade Of Steel (Main)	=	Fe550	N/sqmm
Grade Of Steel (Shear)	=	Fe415	N/sqmm
Grade Of Steel - Flexural Design	=	Fe550	N/sqmm
Grade Of Steel - Shear Design	=	Fe415	N/sqmm
Column B	=		230 mm
Column D	=		450 mm
Clear Cover	=		40 mm

Clear Floor Height @ B	=		3050 mm
Clear Floor Height @ D	=		2450 mm
No Of Floors	=		1
No Of Columns In Group	=		4
Code defined D/B ratio	:		4
D/B Ratio	:	1.96 <= 4 Hence, Design as Column	

Flexural Design (Analysis Forces)

Analysis Reference No.	=	C5	
Load Combination	=	[11] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) -1.5 (SPECXMax)	
Critical Location	=	Bottom Joint	
Pu	=		1242.35 kN
Mux	=		-142.71 kNm
Muy	=		21.16 kNm
Vux	=		13.29 kN
Vuy	=		-91.55 kN

Effective Length Calculation

Calculation Along Major Axis Of Column

Joint	Column Stiffness	Beam Sizes		Beam Stiffness		Beta
		Beam 1 (Length x Width x Depth)	Beam 2 (Length x Width x Depth)	Beam 1	Beam 2	
	N-m x 10^6	mm	mm	N-m x 10^6	N-m x 10^6	
Bottom	62.73	6300 x 230 x 600	2850 x 230 x 600	71.986	159.128	0.385
Top	62.73	6300 x 230 x 600	2850 x 230 x 600	71.986	159.128	0.352

Sway Condition (as per Stability Index)	=	Sway	
Effective Length Factor along Major Axis	=		1

Calculation Along Minor Axis Of Column

Joint	Column Stiffness	Beam Sizes		Beam Stiffness		Beta
		Beam 1 (Length x Width x Depth)	Beam 2 (Length x Width x Depth)	Beam 1	Beam 2	
	N-m x 10^6	mm	mm	N-m x 10^6	N-m x 10^6	
Bottom	16.387	No Beam	No Beam	-	-	1
Top	16.387	No Beam	No Beam	-	-	1

Sway Condition (as per Stability Index)	=	Sway	
Effective Length Factor along Minor axis	=		1

Minimum Eccentricity Check

Since Axial Force is compressive, Min. Eccentricity check to be performed
Most critical case is with Min. Eccentricity check in Y-direction
Minimum Eccentricity Along B :

Minimum Eccentricity	=	Unsupported Length / 500 + B / 30	
	=		13.77 mm
Mminy	=	Pu x Minimum Eccentricity	
	=		24.85 kNm

Slenderness Check

Max Slenderness Ratio(L/B)	=		13.26
	<		60 (Hence Ok)

Column Is Unbraced Along D
Slenderness Check Along D:

Effective Length Factor	=		1
Slenderness Ratio	=	Effective Length / D	
	=	5.44, Column not Slender Along D	

Column Is Unbraced Along B
Slenderness Check Along B:

Effective Length Factor	=		1
Slenderness Ratio	=	Effective Length / B	
	=	13.26, Column Slender Along B	
Slenderness moment along B	=	(Pu B/ 2000) (Ley/B)^2	
	=		25.12 kNm

Design slenderness moment along B

Puz	=		2964.11 kN
Pb	=		491.81 kN
Reduction factor 'k' for slenderness moment	=	(Puz - Pu) / (Puz - Pb) < = 1	
	=	0.7 < = 1, Hence k=0.7	
Mslndy	=	k x 25.12	
	=		17.5 kNm

Calculation of Design Moment

Direction	Manalysis	Mmin (Abs)	Mdesign	Mslndx (Abs)	Mdesign-final
	A	B	C	E	F
Major Axis - Mux	-142.71	---	-142.71	0	-142.71
Minor Axis - Muy	21.16	24.85	24.85	17.5	42.34

Where

A	=	Moments directly from analysis
B	=	Moments due to minimum eccentricity
C	=	Maximum of analysis moment and min. eccentricity = Max (A,B)
E	=	Moment due to slenderness effect
F	=	Final design Moment = Max(C- Top Bottom , D- Top Bottom) + E

Final Critical Design Forces

Pu	=		1242.35 kN
Mux	=		-142.71 kNm
Muy	=		42.34 kNm

Interaction Principle (Discrete Action)

Moment Capacity Check

Pt Calculated	=		3.79
Reinforcement Provided	=	8-T25	
Load Angle	=	Tan^{-1}(Muy/Mux)	
	=		16.53 deg
Corresponding NA angle (β)	=		52.08 deg
MRes	=		148.86 kNm
MCap	=		152.79 kNm

Capacity Ratio	=	MRes/ MCap
	=	0.97 <= 1

Shear Calculation	Along D	Along B
Critical Load Combination	[11] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) -1.5 (SPECXMax)	[12] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) +1.5 (SPECYMax)
Design shear force, Vu (kN)	-91.554	20.8562
Pu (kN)	1232.84	998.8
Deff , Beff (mm)	397.5	177.5
Design shear stress, Tv	Vu / (B x Deff)	Vu / (D x Beff)
Tv (N/sqmm)	1.0014	0.2611
Pt (%)	1.897	1.897
Design shear strength, Tc (N/sqmm)	0.828	0.828
Shear Strength Enhancement Factor (Compressive Force)	1 + 3 x Pu / (B x D x Fck)	
	2.1911	1.965
Shear Strength Enhancement Factor (Tensile Force)	-	-
Shear Strength Enhancement Factor (max)	1.5	1.5
Shear Strength Enhancement Factor	1.5	1.5
Enhanced shear strength, Tc-e (N/sqmm)	1.2421	1.2421
Design shear check	Tv < Tc x Enhancement factor	Tv < Tc x Enhancement factor
Shear Links Design	**Shear Links Not Required**	**Shear Links Not Required**

Design Of Links

Links in the zone where special confining links are not required

Normal Links

Diameter of link	=		8 mm
	>	Max. longitudinal bar dia / 4	
	=		6.25 mm

Table For Links

	Required			Provided	
	Normal Design	Shear Design	Ductile Design	Normal Zone	Ductile Zone
Link Dia.	8	8	8	8	8
Spacing	225	125	100	225	100

General Data

Column No.	:	C2,C5,C56,C69	
Level	:	3RD FLOOR LEVEL To 4TH FLOOR LEVEL	
Design Code	=	IS 456 : 2000 + IS 13920 : 2016	
Grade Of Concrete	=	M30	N/sqmm
Grade Of Steel (Main)	=	Fe550	N/sqmm
Grade Of Steel (Shear)	=	Fe415	N/sqmm
Grade Of Steel - Flexural Design	=	Fe550	N/sqmm
Grade Of Steel - Shear Design	=	Fe415	N/sqmm
Column B	=		230 mm
Column D	=		450 mm
Clear Cover	=		40 mm
Clear Floor Height @ B	=		3050 mm
Clear Floor Height @ D	=		2450 mm
No Of Floors	=		1
No Of Columns In Group	=		4
Code defined D/B ratio	:		4

D/B Ratio : 1.96 <= 4 Hence, Design as Column

Flexural Design (Analysis Forces)

Analysis Reference No.	=	C59
Load Combination	=	[11] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) -1.5 (SPECXMax)
Critical Location	=	Bottom Joint
Pu	=	713.02 kN
Mux	=	-143.32 kNm
Muy	=	-19.87 kNm
Vux	=	-13.14 kN
Vuy	=	-94.33 kN

Effective Length Calculation

Calculation Along Major Axis Of Column

Joint	Column Stiffness	Beam Sizes		Beam Stiffness		Beta
		Beam 1 (Length x Width x Depth)	Beam 2 (Length x Width x Depth)	Beam 1	Beam 2	
	N-m x 10^6	mm	mm	N-m x 10^6	N-m x 10^6	
Bottom	62.73	6300 x 230 x 600	2850 x 230 x 600	71.986	159.128	0.352
Top	62.73	6300 x 230 x 600	2850 x 230 x 600	71.986	159.128	0.352

Sway Condition (as per Stability Index) = Non Sway

Effective Length Factor along Major Axis = 1

Calculation Along Minor Axis Of Column

Joint	Column Stiffness	Beam Sizes		Beam Stiffness		Beta
		Beam 1 (Length x Width x Depth)	Beam 2 (Length x Width x Depth)	Beam 1	Beam 2	
	N-m x 10^6	mm	mm	N-m x 10^6	N-m x 10^6	
Bottom	16.387	No Beam	No Beam	-	-	1
Top	16.387	No Beam	No Beam	-	-	1

Sway Condition (as per Stability Index) = Sway

Effective Length Factor along Minor axis = 1

Minimum Eccentricity Check

Since Axial Force is compressive, Min. Eccentricity check to be performed

Most critical case is with Min. Eccentricity check in X-direction

Minimum Eccentricity Along D:

Minimum Eccentricity = Unsupported Length / 500 + D / 30

= 19.9 mm

Mminx = Pu x Minimum Eccentricity

= 14.26 kNm

Slenderness Check

Max Slenderness Ratio(L/B) = 13.26

< 60 (Hence Ok)

Column Is Unbraced Along D

Slenderness Check Along D:

Effective Length Factor = 1

Slenderness Ratio = Effective Length / D

= 5.44, Column not Slender Along D

Column Is Unbraced Along B
Slenderness Check Along B:

Effective Length Factor	=		1
Slenderness Ratio	=	Effective Length / B	
	=	13.26, Column Slender Along B	
Slenderness moment along B	=	(Pu B/ 2000) (Ley/B)^2	
	=		14.42 kNm

Design slenderness moment along B

Puz	=		2682.08 kN
Pb	=		504.63 kN
Reduction factor 'k' for slenderness moment	=	(Puz - Pu) / (Puz - Pb) < = 1	
	=	0.9 > = 1, Hence k=1	
Mslndy	=	k x 14.42	
	=		13.04 kNm

Calculation of Design Moment

Direction	Manalysis	Mmin (Abs)	Mdesign	Mslndx (Abs)	Mdesign-final
	A	B	C	E	F
Major Axis - Mux	-143.32	14.26	-143.32	0	-143.32
Minor Axis - Muy	-19.87	---	-19.87	13.04	-32.91

Where

A	=	Moments directly from analysis
B	=	Moments due to minimum eccentricity
C	=	Maximum of analysis moment and min. eccentricity = Max (A,B)
E	=	Moment due to slenderness effect
F	=	Final design Moment = Max(C- Top Bottom , D- Top Bottom) + E

Final Critical Design Forces

Pu	=		713.02 kN
Mux	=		-143.32 kNm
Muy	=		-32.91 kNm

Interaction Principle (Discrete Action)

Moment Capacity Check

Pt Calculated	=		3.11
Reinforcement Provided	=	4-T25 + 4-T20	
Load Angle	=	Tan^{-1}(Muy/Mux)	
	=		12.93 deg
Corresponding NA angle (β)	=		48.06 deg
MRes	=		147.05 kNm
MCap	=		172.86 kNm
Capacity Ratio	=	MRes/ MCap	
	=	0.85 <= 1	

Shear Calculation	Along D	Along B
Critical Load Combination	[11] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) -1.5 (SPECXMax)	[20] : 0.9 (Dead) +0.9 (SDL) +0.9 (WALL) +1.5 (SPECYMax)
Design shear force, Vu (kN)	-94.3317	13.4812
Pu (kN)	703.51	337.94
Deff , Beff (mm)	397.5	177.5
Design shear stress, Tv	Vu / (B x Deff)	Vu / (D x Beff)
Tv (N/sqmm)	1.0318	0.1688
Pt (%)	1.556	1.556
Design shear strength, Tc (N/sqmm)	0.7725	0.7725
Shear Strength Enhancement Factor (Compressive Force)	1 + 3 x Pu / (B x D x Fck)	
	1.6797	1.3265
Shear Strength Enhancement Factor (Tensile Force)	-	-
Shear Strength Enhancement Factor (max)	1.5	1.5
Shear Strength Enhancement Factor	1.5	1.3265
Enhanced shear strength, Tc-e (N/sqmm)	1.1587	1.0247
Design shear check	Tv < Tc x Enhancement factor	Tv < Tc x Enhancement factor
Shear Links Design	**Shear Links Not Required**	**Shear Links Not Required**

Design Of Links

Links in the zone where special confining links are not required

Normal Links

Diameter of link	=		8 mm
	>	Max. longitudinal bar dia / 4	
	=		6.25 mm

Table For Links

	Required			Provided	
	Normal Design	Shear Design	Ductile Design	Normal Zone	Ductile Zone
Link Dia.	8	8	8	8	8
Spacing	225	125	100	225	100

General Data

Column No.	:	C2,C5,C56,C59	
Level	:	4TH FLOOR LEVEL To ROOF	
Design Code	=	IS 456 : 2000 + IS 13920 : 2016	
Grade Of Concrete	=	M30	N/sqmm
Grade Of Steel (Main)	=	Fe550	N/sqmm
Grade Of Steel (Shear)	=	Fe415	N/sqmm
Grade Of Steel - Flexural Design	=	Fe550	N/sqmm
Grade Of Steel - Shear Design	=	Fe415	N/sqmm
Column B	=		230 mm
Column D	=		450 mm
Clear Cover	=		40 mm
Clear Floor Height @ B	=		3050 mm
Clear Floor Height @ D	=		2450 mm
No Of Floors	=		1
No Of Columns In Group	=		4
Code defined D/B ratio	:		4
D/B Ratio	:	1.96 <= 4 Hence, Design as Column	

Flexural Design (Analysis Forces)

Analysis Reference No.	=	C59
Load Combination	=	[11] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) -1.5 (SPECXMax)
Critical Location	=	Bottom Joint
Pu	=	466.96 kN
Mux	=	-137.48 kNm
Muy	=	-18.64 kNm
Vux	=	-11.61 kN
Vuy	=	-89.79 kN

Effective Length Calculation

Calculation Along Major Axis Of Column

Joint	Column Stiffness	Beam Sizes		Beam Stiffness		Beta
		Beam 1 (Length x Width x Depth)	Beam 2 (Length x Width x Depth)	Beam 1	Beam 2	
	N-m x 10^6	mm	mm	N-m x 10^6	N-m x 10^6	
Bottom	62.73	6300 x 230 x 600	2850 x 230 x 600	71.986	159.128	0.352
Top	62.73	6300 x 230 x 600	2850 x 230 x 600	71.986	159.128	0.352

Sway Condition (as per Stability Index)	=	Non Sway
Effective Length Factor along Major Axis	=	1

Calculation Along Minor Axis Of Column

Joint	Column Stiffness	Beam Sizes		Beam Stiffness		Beta
		Beam 1 (Length x Width x Depth)	Beam 2 (Length x Width x Depth)	Beam 1	Beam 2	
	N-m x 10^6	mm	mm	N-m x 10^6	N-m x 10^6	
Bottom	16.387	No Beam	No Beam	-	-	1
Top	16.387	No Beam	No Beam	-	-	1

Sway Condition (as per Stability Index)	=	Sway
Effective Length Factor along Minor axis	=	1

Minimum Eccentricity Check

Since Axial Force is compressive, Min. Eccentricity check to be performed
Most critical case is with Min. Eccentricity check in X-direction
Minimum Eccentricity Along D:

Minimum Eccentricity	=	Unsupported Length / 500 + D / 30
	=	19.9 mm
Mminx	=	Pu x Minimum Eccentricity
	=	9.34 kNm

Slenderness Check

Max Slenderness Ratio(L/B)	=	13.26
	<	60 (Hence Ok)

Column Is Unbraced Along D
Slenderness Check Along D:

Effective Length Factor	=	1
Slenderness Ratio	=	Effective Length / D
	=	5.44, Column not Slender Along D

Column Is Unbraced Along B

Slenderness Check Along B:

Effective Length Factor	=		1
Slenderness Ratio	=	Effective Length / B	
	=	13.26, Column Slender Along B	
Slenderness moment along B	=	(Pu B/ 2000) (Ley/B)^2	
	=		9.44 kNm

Design slenderness moment along B

Puz	=		2400.05 kN
Pb	=		538.03 kN
Reduction factor 'k' for slenderness moment	=	(Puz - Pu) / (Puz - Pb) < = 1	
	=	1.04 > = 1, Hence k=1	
Mslndy	=	k x 9.44	
	=		9.44 kNm

Calculation of Design Moment

Direction	Manalysis	Mmin (Abs)	Mdesign	Mslndx (Abs)	Mdesign-final
	A	B	C	E	F
Major Axis - Mux	-137.48	9.34	-137.48	0	-137.48
Minor Axis - Muy	-18.64	---	-18.64	9.44	-28.09

Where

A	=	Moments directly from analysis
B	=	Moments due to minimum eccentricity
C	=	Maximum of analysis moment and min. eccentricity = Max (A,B)
E	=	Moment due to slenderness effect
F	=	Final design Moment = Max(C- Top Bottom , D- Top Bottom) + E

Final Critical Design Forces

Pu	=		466.96 kN
Mux	=		-137.48 kNm
Muy	=		-28.09 kNm

Interaction Principle (Discrete Action)

Moment Capacity Check

Pt Calculated	=		2.43
Reinforcement Provided	=	8-T20	
Load Angle	=	Tan^{-1}(Muy/Mux)	
	=		11.55 deg
Corresponding NA angle (β)	=		42.14 deg
MRes	=		140.32 kNm
MCap	=		148.66 kNm
Capacity Ratio	=	MRes/ MCap	
	=	0.94 <= 1	

Shear Calculation	Along D	Along B
Critical Load Combination	[10] : 1.5 (Dead) +1.5 (SDL) +1.5 (WALL) +1.5 (SPECXMax)	[20] : 0.9 (Dead) +0.9 (SDL) +0.9 (WALL) +1.5 (SPECYMax)
Design shear force, Vu (kN)	87.9226	11.6821
Pu (kN)	363.69	225
Deff , Beff (mm)	400	180
Design shear stress, Tv	Vu / (B x Deff)	Vu / (D x Beff)
Tv (N/sqmm)	0.9557	0.1442
Pt (%)	1.214	1.214
Design shear strength, Tc (N/sqmm)	0.7057	0.7057
Shear Strength Enhancement Factor (Compressive Force)	1 + 3 x Pu / (B x D x Fck)	
	1.3514	1.2174
Shear Strength Enhancement Factor (Tensile Force)	-	-
Shear Strength Enhancement Factor (max)	1.5	1.5
Shear Strength Enhancement Factor	1.3514	1.2174
Enhanced shear strength, Tc-e (N/sqmm)	0.9537	0.8591
Design shear check	Tv > Tc x Enhancement factor	Tv < Tc x Enhancement factor
Shear Links Design	**Shear Links Required**	**Shear Links Not Required**
Pt %	1.214	-
Shear resisted by concrete Vc (kN)	(Tc-e) x (B x Deff)	-
	87.74	-
Shear to be resisted by shear reinforcement = Vus (kN)	Vu - Vc	
	0.18	-
Area of shear reinforcement required, Asv (sqmm)	(Vus x 1000) / (Deff x 0.87 x Fy)	(Vus x 1000) / (Beff x 0.87 x Fy)
	1.27	-
Master Link Rebar (mm)	8	-
Number of legs provided	2	-
Spacing of links reqd (mm)	79067	-
Spacing of links prvd, Sv (mm)	225	-
Asv Provided (sqmm)	446.8	-

Design Of Links

Links in the zone where special confining links are not required

Normal Links

Diameter of link = 8 mm

> Max. longitudinal bar dia / 4

= 5 mm

Table For Links

	Required			Provided	
	Normal Design	**Shear Design**	**Ductile Design**	**Normal Zone**	**Ductile Zone**
Link Dia.	8	8	8	8	8
Spacing	225	125	100	225	100

BEAM DESIGN CALCULATION

Beam No	: **THB3**	
Analysis Reference (Member)	2ND : B87	
Beam Length	: 2400	mm
Breadth (B)	: 230	mm
Depth (D)	: 600	mm
Effective Depth (d)	: 535	mm
Design Code	: IS 456	
Beam Type	: Regular Beam	
Grade Of Concrete (Fck)	: M30	N/sqmm
Grade Of Steel (Main)	: Fe550	N/sqmm
Grade Of Steel (Shear)	: Fe415	N/sqmm
Clear Cover (Cmin)	: 35	mm
Es	: 2x10^5	N/sqmm

Flexure Design

	Beam Bottom			Beam Top		
	Left	**Mid**	**Right**	**Left**	**Mid**	**Right**
Critical L/C - RCDC	18	18	18	11	11	11
Mu (kNm)	53.46	31.6	53.06	94.14	45.16	63.81
Tu (kNm)	0	0	0	0	0	0
M_{Tu} (kNm)	0	0	0	0	0	0
Mud (kNm)	53.46	31.6	53.06	94.14	45.16	63.81
MuLim (kNm)	257	257	257	257	257	257
R	0.812	0.48	0.806	1.43	0.686	0.969
Ptmin (%)	0.2	0.2	0.2	0.2	0.2	0.2
Ptclc (%)	0.2	0.2	0.2	0.317	0.2	0.211
Pcclc (%)	0	0	0	0	0	0
PtPrv (%)	0.327	0.327	0.327	0.327	0.327	0.654
AstCalc (sqmm)	246.1	246.1	246.1	390.58	246.1	259.32
AstPrv (sqmm)	402.12	402.12	402.12	402.12	402.12	804.24
Reinforcement Provided	2-T16	2-T16	2-T16	2-T16	2-T16	2-T16 2-T16

Shear Design

	Left	**Mid**	**Right**
Critical L/C - RCDC	11	11	10
PtPrv (%)	0.327	0.327	0.327
Vu (kN)	85.89	77.38	65.25
Tu (kNm)	0	0	0
V_{Tu} (kN)	0	0	0

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Vut (kN)	85.89	77.38	65.25
Tv (N/sqmm)	0.7	0.63	0.53
Tc (N/sqmm)	0.41	0.41	0.41
Vc (kN)	51.02	51.02	51.02
Vus=Vut-Vc (kN)	34.87	26.36	14.23
Legs	2	2	2
Stirrup Rebar	8	8	8
Asv Torsion (sqmm)	-	-	-
Asv Torsion Prv (sqmm)	-	-	-
Asv Reqd (sqmm/m)	254.81	254.81	254.81
SvCalc (mm)	250	250	250
SvPrv (mm)	200	200	200
Asv Total Prv (sqmm)	502.7	502.7	502.7

Maximum Spacing Criteria

Basic

Spc1 =0.75d	=401	mm
Spc2	=300	mm

SFR Design

Beam Width	=230	mm
Beam Depth	=600	mm
Web Depth	=600 <= 750	mm

Side Face Reinforcement not required.

Beam No	: **THB4**	
Analysis Reference (Member)	2ND : B86	
Beam Length	: 5850	mm
Breadth (B)	: 230	mm
Depth (D)	: 600	mm
Effective Depth (d)	: 535	mm
Design Code	: IS 456	
Beam Type	: Regular Beam	
Grade Of Concrete (Fck)	: M30	N/sqmm
Grade Of Steel (Main)	: Fe550	N/sqmm

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Grade Of Steel (Shear)	: Fe415	N/sqmm
Clear Cover (Cmin)	: 35	mm
Es	: 2x10^5	N/sqmm

Flexure Design						
	Beam Bottom			Beam Top		
	Left	Mid	Right	Left	Mid	Right
Critical L/C - RCDC	10	1	18	11	19	11
Mu (kNm)	41.32	107.63	32.55	135.02	13.82	145.88
Tu (kNm)	0	0	0	0	0	0
M_{Tu} (kNm)	0	0	0	0	0	0
Mud (kNm)	41.32	107.63	32.55	135.02	13.82	145.88
MuLim (kNm)	257	257	257	257	257	257
R	0.628	1.635	0.494	2.051	0.21	2.216
Ptmin (%)	0.2	0.2	0.2	0.2	0.2	0.2
Ptclc (%)	0.2	0.366	0.2	0.469	0.2	0.511
Pcclc (%)	0	0	0	0	0	0
PtPrv (%)	0.327	0.654	0.327	0.654	0.327	0.654
AstCalc (sqmm)	246.1	450.86	246.1	577.33	246.1	629.09
AstPrv (sqmm)	402.12	804.24	402.12	804.24	402.12	804.24
Reinforcement Provided	2-T16	2-T16 2-T16	2-T16	2-T16 2-T16	2-T16	2-T16 2-T16

Shear Design			
	Left	Mid	Right
Critical L/C - RCDC	1	11	10
PtPrv (%)	0.654	0.654	0.654
Vu (kN)	131.74	69.35	111.85
Tu (kNm)	0	0	0
V_{Tu} (kN)	0	0	0
Vut (kN)	131.74	69.35	111.85
Tv (N/sqmm)	1.07	0.56	0.91
Tc (N/sqmm)	0.55	0.55	0.55
Vc (kN)	68.23	68.23	68.23
Vus=Vut-Vc (kN)	63.51	1.12	43.62
Legs	2	2	2
Stirrup Rebar	8	8	8
Asv Torsion (sqmm)	-	-	-
Asv Torsion Prv (sqmm)	-	-	-
Asv Reqd (sqmm/m)	328.78	254.81	254.81
SvCalc (mm)	250	250	250
SvPrv (mm)	200	200	200
Asv Total Prv (sqmm)	502.7	502.7	502.7

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Maximum Spacing Criteria

Basic

Spc1 =0.75d	=401	mm
Spc2	=300	mm

SFR Design

Beam Width	=230	mm
Beam Depth	=600	mm
Web Depth	=600 <= 750	mm

Side Face Reinforcement not required.

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DESIGN OF SLAB : TS2

Panel Name : Four edges discontinuous Code : 18

Clear Longer span, ly = 3300 mm

Clear Shorter span, lx = 3150 mm

ly / lx = 1.05 < 2, Hence, Twoway slab.

Effective Longer span = 3396.00 mm

Effective Shorter span = 3246.00 mm

Assume thickness of slab = 125.00 mm

Effective depth available = 96.00 mm

Loads :

Dead Load and Imposed Load (fixed) :

Floor finish = 1.200 kN/m^2

Self weight = 3.000 kN/m^2

w_{DL} = 4.200 kN/m^2

Imposed Load (Not fixed) :

Occupancy classification as per IS: 875(Part 2) - 1987 :

Live load = 2.000 kN/m^2

w_{LL} = 2.000 kN/m^2

Total load, $w = w_{DL} + w_{LL}$ = 6.200 kN/m^2

Span Moments:

Along Shorter span: BM = $\alpha_x w l_x^2$ = 0.059 x 6.20 x 3.246^2 = 3.87 kNm M_{ux1} = 5.80 kNm

Along Longer span: BM = $\alpha_y w l_x^2$ = 0.056 x 6.20 x 3.246^2 = 3.66 kNm M_{uy1} = 5.49 kNm

Support Moments:

Along Shorter span: BM = $\alpha_x w l_x^2$ = 0.000 x 6.20 x 3.246^2 = 0.00 kNm M_{ux2} = 0.00 kNm

Along Longer span: BM = $\alpha_y w l_x^2$ = 0 x 6.20 x 3.246^2 = 0.00 kNm M_{uy2} = 0.00 kNm

Check for section :

Factored Max. BM, Mu = 5.80 kNm / m

For M25 grade concrete & Fe500 grade steel , Mu, lim / bd^2 = 3.449

Effective depth required = 41.01 mm < Effective depth available, OK

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Along the Shorter span

A_{st} reqd at midspan :

$A_{st} = [\ 0.5f_{ck}/f_y\ ]\ \{1 - \sqrt{(\ 1 - [4.6\ M_{ux1}/(f_{ck}\ bd^2)]\ )}\}\ b\ d =$ 143.26 mm^2 / m

Provide 8 mm dia bars @ 200 mm c/c As = 251.33 mm^2 / m OK

A_{st} reqd at support :

$A_{st} = [\ 0.5f_{ck}/f_y\ ]\ \{\ 1 - \sqrt{(\ 1 - [4.6\ M_{ux2}/(f_{ck}\ bd^2)])}\}\ b\ d =$ 0.00 mm^2 / m

Provide 8 mm dia bars @ 200 mm c/c As = 251.33 mm^2 / m OK

Along the Longer span

A_{st} reqd at midspan :

$A_{st} = [\ 0.5f_{ck}/f_y\ ]\ \{1 - \sqrt{(\ 1 - [4.6\ M_{uy1}/(f_{ck}\ bd^2)]\ )}\}\ b\ d =$ 135.28 mm^2 / m

Provide 8 mm dia bars @ 200 mm c/c As = 251.33 mm^2 / m OK

A_{st} reqd at support :

$A_{st} = [\ 0.5f_{ck}/f_y\ ]\ \{\ 1 - \sqrt{(\ 1 - [4.6\ M_{uy2}/(f_{ck}\ bd^2)])}\}\ b\ d =$ 0.00 mm^2 / m

Provide 8 mm dia bars @ 200 mm c/c As = 251.33 mm^2 / m OK

Min Ast = 0.12% Gross section area = 150 mm^2 / m

Distribution steel = 0.5 x (0.12/100) x 1000 x 125 = 75.00 mm^2 / m

Provide 8 mm dia bars @ 200 mm c/c As = 251.33 mm^2 / m OK

Max Spacing = 3d or 300 mm whichever is less = 288 mm or 300 mm

Check for deflection:

fs = 0.58 x fy x (Ast req/Ast pro) = 165.30 MPa

MF = $1/(0.225+0.00322\ fs - 0.625 \log 10\ (1/pt)) \leq 2$ = 2.000

Type of Slab = Simply Supported

Effective Shorter span = 3246.00 mm

Basic Value = 35

Allowable l/d = 70.00

Actual l/d = 33.81 Hence OK

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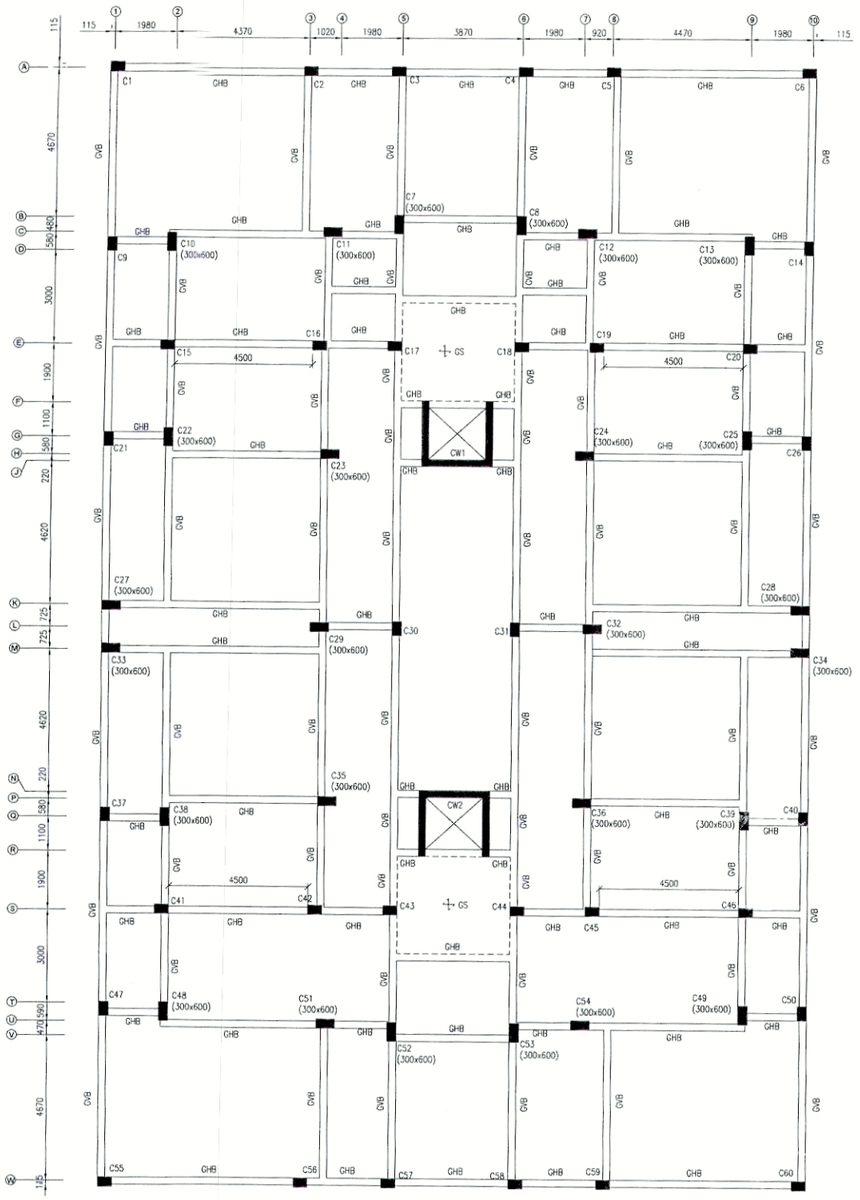


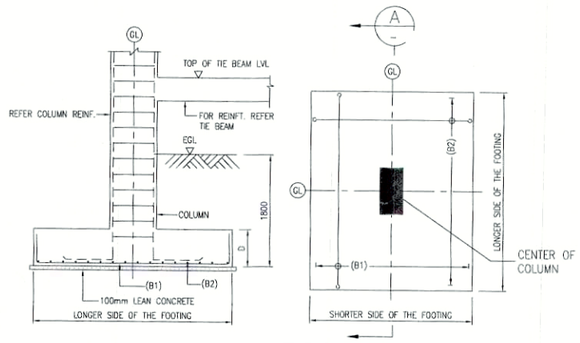
TIE BEAM LAYOUT PLAN

SCALE 1:100

NOTES

UNLESS OTHERWISE SPECIFIED

1. ALL COLUMNS ARE TO BE 300x450mm
2. ALL BEAMS ARE TO BE 230x450mm
3. ALL SLABS ARE TO BE 125mm
4. GRADE OF CONCRETE M30
5. GRADE OF STEEL Fe550D



SECTION A
SCALE :N.T.S

TYPICAL PLAN OF FOOTING
SCALE :N.T.S

NOTES :-

1. According to the soil investigation report, the proposed foundation located at about 1.8m from existing ground level and it should be rest on hard stratum. The bearing capacity of soil at the formation level of foundation is taken as 180kN/m² upon excavation to the formation level, if the soil is found to be hard stratum, further excavation is to be carried out to reach the above specified soil layer having safe bearing capacity of 180kN/m².
2. Upon reaching the specified formation level the bearing layer shall be immediately protected with lean concrete 100mm thick (P.C.C).
3. Where over excavation is carried out beyond the depth of formation level, over excavated area shall be filled with lean concrete, up to the required formation level.
4. All excavated area shall be kept dry until the foundation is completed.

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REGISTRATION No. CGLRGN/SE/Gr-I/2019/07/020
NEW No. 31 (OLD No.14), BESANT AVENUE ROAD,
ADYAR, CHENNAI – 600 020.
E-Mail: jegatheesan@buroengineers.in
Mobile: +91 9962545631

ALL SETTING OUT DIMENSION SHOWN IN THE STRUCTURAL DRAWINGS, SHALL BE VERIFIED WITH THE LATEST ARCHITECTURAL DRAWINGS BEFORE COMMENCEMENT OF CONSTRUCTION. IF THERE IS ANY DISCREPANCY, IT SHOULD BE IMMEDIATELY BROUGHT TO THE ATTENTION OF THE ARCHITECT/ENGINEER. THE CONSTRUCTION CAN ONLY PROCEED UPON RECEIVING THE CONFIRMATION FROM THE ARCHITECT ON THE DIMENSIONS.

DATE OF ISSUE
20 DEC 2022
BURO ENGINEERS (I) PRIVATE LTD

NO.	AMENDMENTS	BY	DATE
-	ISSUED AS A APPROVAL DRAWING	GUNA	20-12-2022

APPROVAL DRAWING

STRUCTURAL

Client
M/S., RAMANIYAM REAL ESTATES (P) LTD.,
NO : 17/35, 2ND MAIN ROAD,
GANDHINAGAR, ADYAR,
CHENNAI - 600 020.
PH : 044 - 43447500 (100 LINES)

Civil & Structural Engineer :

Buro Engineers (I) Private Ltd.,
CIVIL & STRUCTURAL CONSULTANTS
NEW #31, OLD #14, BESANT AVENUE ROAD,
ADAYAR, CHENNAI-600020.
TEL: 42658573 / 74, FAX: 24662755

project title

PROPOSED RESIDENTIAL DEVELOPMENT AT MADURAI

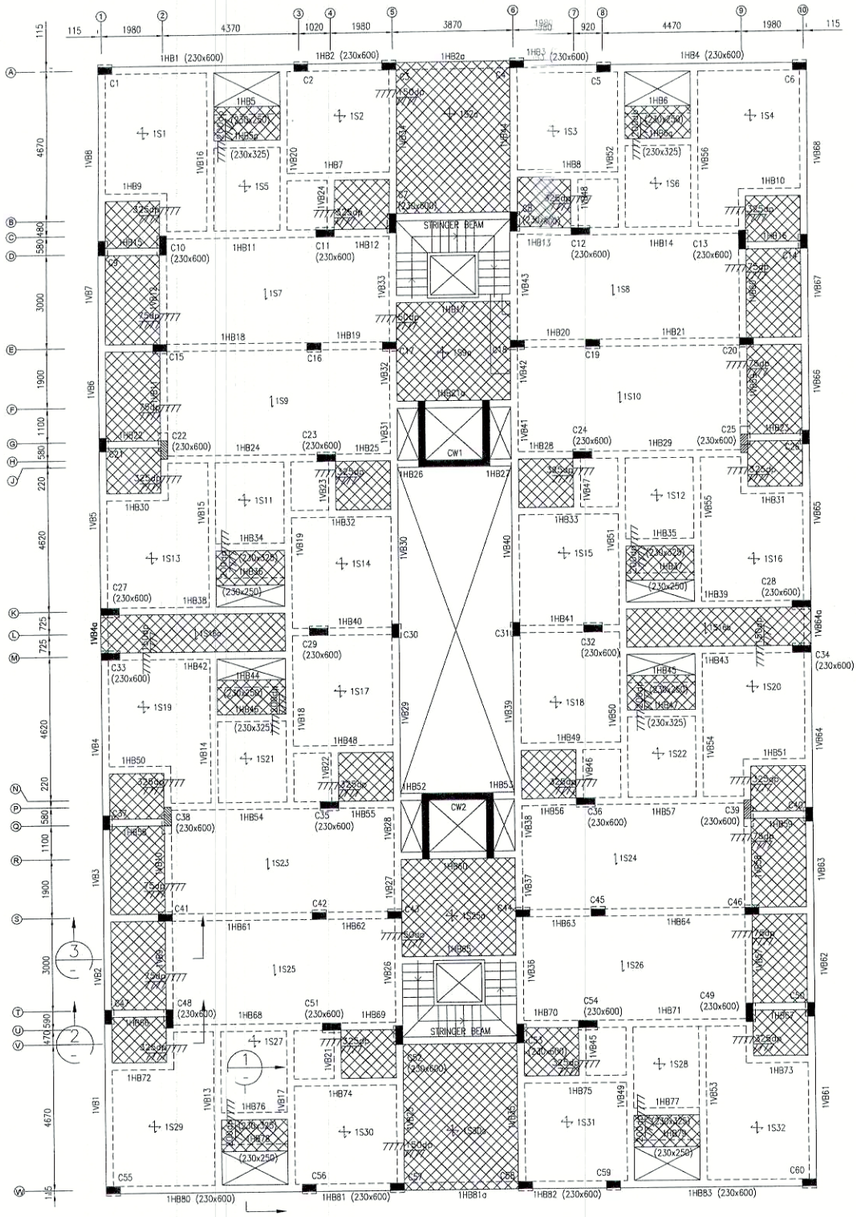
G + 5 + ROOF

drawing title

TIE BEAM LAYOUT PLAN

scale	1:100	design by	YOGA
drawn by	GUNA	checked by	SIVA
date	DEC 2022	approved by	PJ
drawing no.	BEI---_S-/FP/G-/--/01		revision
			-

CAD FILE NAME: BEI---_S-FPG---01_.dwg



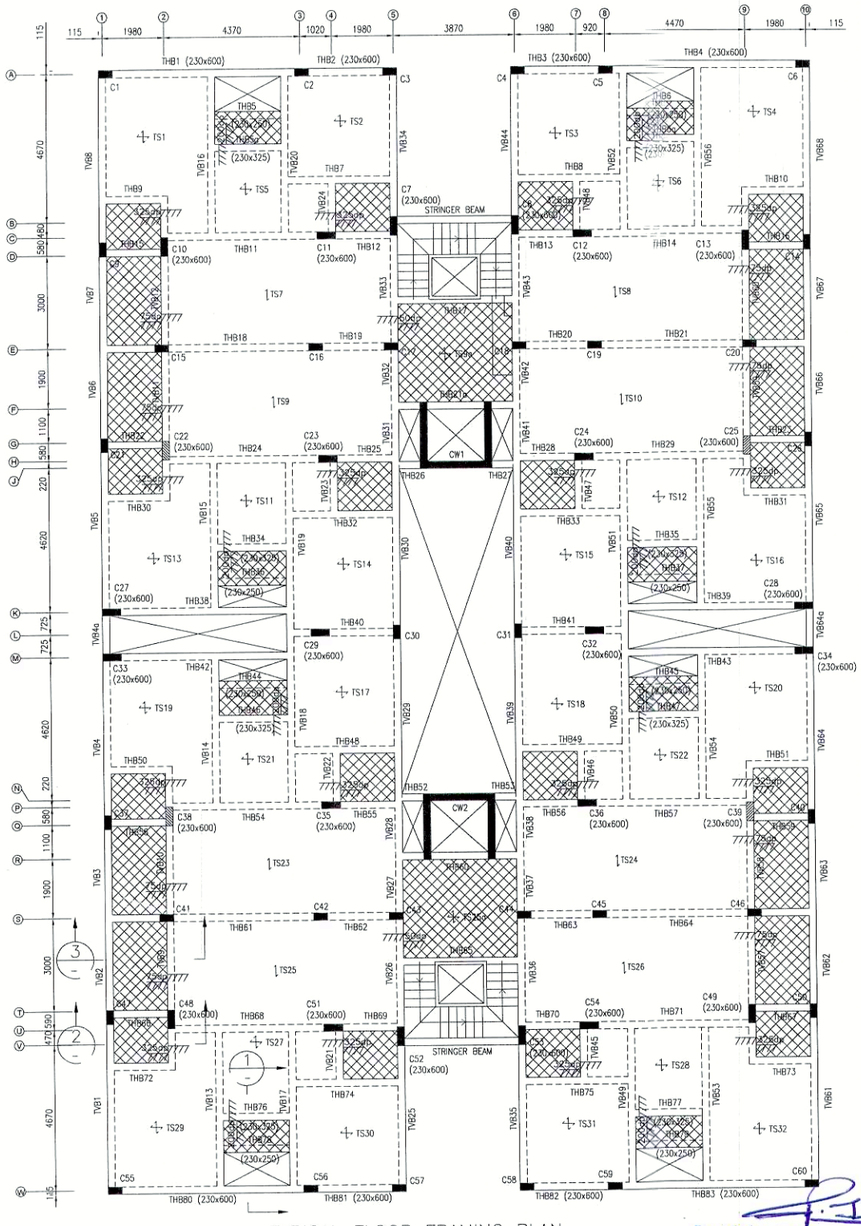
1st FLOOR FRAMING PLAN

SCALE 1:100

NOTES

UNLESS OTHERWISE SPECIFIED

1. ALL COLUMNS ARE TO BE 230x450mm
2. ALL BEAMS ARE TO BE 230x450mm
3. ALL SLABS ARE TO BE 125mm
4. GRADE OF CONCRETE M30
5. GRADE OF STEEL Fe550D



TYPICAL FLOOR FRAMING PLAN

2nd,3rd & 4th FLOOR

SCALE 1:100

NOTES

UNLESS OTHERWISE SPECIFIED

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2. ALL BEAMS ARE TO BE 230x450mm
3. ALL SLABS ARE TO BE 125mm
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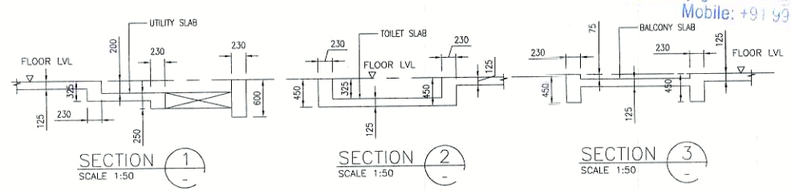

SECTION 1 SCALE 1:50

SECTION 2 SCALE 1:50

SECTION 3 SCALE 1:50

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NO.	AMENDMENTS	BY	DATE
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APPROVAL DRAWING

STRUCTURAL

Client

M/S., RAMANIYAM REAL ESTATES (P) LTD.,
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project title

PROPOSED RESIDENTIAL DEVELOPMENT AT MADURAI

G + 5 + ROOF

drawing title

TYPICAL FLOOR PLAN
(1st, 2nd, 3rd, 4th & 5th FLOOR)

scale	1:100	design by	YOGA
drawn by	GUNA	checked by	SIVA
date	DEC 2022	approved by	PJ
drawing no.	BEI---_S-/FP/T-/--/01	revision	_

CAD FILE NAME: BEI---_S-FPT---01_.dwg