

**Architect &
Structural
Consultants**

M/s. MP Developers construction Pvt. Ltd.

Project

**Proposed Residential Building at Nemilichery Village, Pallavaram
Taluk, Chengalpattu District**

Floors

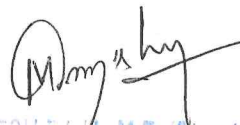
Stilt + 3 Floors

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1.INTRODUCTION

1.1 General

This document details the input data, principles, methods and performance criteria to be used in the structural engineering design of the project.

1.2 Scope

The proposed Residential building with 72 dwelling units at No: 6/3, Block: 25, Ward No: G, S No: 37, Nemilichery Village, Pallavaram Taluk, Chengalpattu District Within the Limit of Greater Chennai Corporation. This report presents details of structural analysis and design of the residential building. 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 analysis, material properties, loads and load combinations, design summary for beams, columns, footings and slabs.

2.DESCRPTIONS OF BUILDING

The proposed residential building consists of a stilt floor with three upper floors (Stilt + 3 storeys). The height of the stilt storey is 3 m, while the typical floor height for the upper storeys is 3 m each. The tot

al building height is 12 m, measured from the Finished Floor Level (F.F.L).

The foundation system comprises Isolated Shallow foundation, selected based on soil conditions and structural requirements. The Load carrying Capacity of bored cast in-situ piles has been adopted in accordance with the Geotechnical Investigation Report

3.LOADS & LOAD COMBINATIO

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.

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3.2 Description of types of loading & Load calculation

Dead load, Live Loads and Seismic Loads are 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 based on compatibility with architectural drawings.

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

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

Self-weight of the modeled elements is calculated by Staad.Pro 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 way slabs and as rectangular loads in one way slab by using FLOOR LOAD command in STAAD.

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

Dead Load considered on slab: Self Weight + 1.5 kN/m² for Floor Finish.

$$= 0.125 \times 25 = 3.125 \text{ kN/m}^2.$$

Red Brick Wall load	= 4.6 kN/m (from NGL to FFL=0.23X20X1)
ACC brick Wall load (9" Thk)	= 6kN/m (0.23 X 6.5 X (3-0.38))+ 1.3kN/m
ACC brick Wall load (4" Thk)	= 3kN/m (0.1X 6.5 X (3-0.38))+ 1.3kN/m
Red Brick Wall load (Parapet)	= 5kN/m (0.23x1.1x20)
Staircase load	= 9.4 kN/m (RCC staircase)
Water Tank	= 15kN/m ² (1200 mm height)
Lift	= 15kN/m ²
Floor finish	= 2kN/m ² (Terrace)

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

Live Load considered on slab = 2 kN/m² (Typical floor)

Live Load considered on slab = 1.5 kN/m² (Terrace floor)

Staircase load = 6 kN/m (RCC staircase)


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3.3 WIND LOAD

Wind loads are considered in the structural design in accordance with the applicable design code. The basic wind speed is 50m/sec, as per the code requirements for the project location. Wind pressure is calculated based on terrain category, building height, importance factor, and topography factor. The calculated wind loads are applied to the structural model in both principal directions and combined with other relevant load cases and load combinations as specified by the design code.

3.4 EARTHQUAKE LOAD

The loading due to earthquake is assessed based on the provisions of IS: 1893 (Part-1):2016

Seismic Zone	= III
Table-3 Zone factor (Z)	= 0.16
Table-8 Importance Factor (I)	= 1
Table-9 Response Reduction Factor (R)	= 5

Building frame system (OMRF) as per table 9 clause 7.3.1 of IS 1893 2016

Height of building (H) =13.7m

Base dimension of part of the building along the considered direction of Lateral force (D)

Fundamental Natural time period

$$T_s = 0.09H/\sqrt{d} \text{ from CL - 7.6.2 - IS 1893 (Part-I) 2016}$$

$$S_a/g = \text{from FIG-2 IS 1893 (part-I) 2016}$$

The respective natural time period can be referred from the respective model.

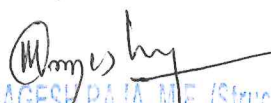
Horizontal Seismic Co-efficient

$$A_h = (Z/2) \times (I/R) \times (S_a/g)$$

Seismic Base Shear

$$V_b = A_h \times W$$

As per IS: 1893 – 2016, (Table 10), percentage of imposed loads to be considered


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for seismic weight calculation is mentioned below:

Imposed Uniformity Distributed Floor Load Loads (kN/ m2)	Percentage of Imposed
Up to & including 3.0	25
Above 3.0	50

3.4 LOAD COMBINATIONS

Strength combinations:

- 1.5DL + 1.5 LL
- 1.5DL (+/-)1.5 WL/EQ Load
- 1.2DL +1.2LL (+/-) 1.5 WL/EQ Load
- 0.9DL (+/-) 1.5 WL/EQ Load

Serviceability combinations:

- DL + LL
- DL +0.8 LL(+/-) 0.8 WL/EQ Load
- DL (+/-) WL/EQ Load.

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.


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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 reinforced concrete (M25 Grade)	density 25 x 10 ³ calculated using 5000√fck	0.2

4.3 Grade of Reinforcement

Reinforcement of Grade Fe-550 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/m³

AAC Brick masonry = 6.5 kN/m³

5. DESIGN METHODOLOGY

All structures have been designed according to the Limit State Method as specified in IS: 456-2000 & IS 1893 - 2016. Appropriate loads and its combinations, as per relevant clauses in IS 456:2000 code, for the most unfavorable effects are chosen for design.

6. COVER TO REINFORCEMENT

The clear cover to main reinforcement shall be as follows.

Foundation (pile cap) = Top/Bottom: 50mm, Sides: 50mm

Footing = 50mm

Slab = 20mm

Columns = 40mm

Beams = 25mm


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7. FOUNDATION SYSTEM

Foundation systems are based on recommendations given as per soil investigation report by Mars Synergy Geo tech private limited.

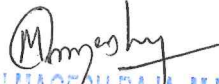
8. CODES & STANDARDS

All the design are conforming to the relevant Indian Standards. Some of the relevant Indian Standard Codes, which have been followed for the structural design are given below.

	Description
IS:875 (Part-1)- 1987	Code of Practice for Design Loads (Other than Earthquake) for Building 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 Building and Structures-Imposed loads
IS:875 (Part-3)- 2015	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures –Wind Load.
IS:456 (Part-1)- 2000	Code of Practice for Plain and Reinforced Concrete
IS:1893 (Part-1)- 2016	Indian Standard Criteria for Earthquake Resistant Design of Structures.
IS:432 (Part-2)- 1982	Specification of Mild Steel and Medium Tensile Steel bars and Hard drawn Steel Wire for concrete reinforcement – Hard drawn Steel Wire.
IS:1904	Indian Standard Code of practice for Design & Construction foundations in Soil: General Requirements.

9. STRUCTURAL ANALYSIS

The Building structures are analyzed using STAAD PRO for various load combination as per Indian Codes.


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FOOTING

DATA

Longer dimension of column L	450	mm
Shorter dimension of column B	230	mm
Unfactored axial load P	323	kN
Unfactored moment in longer direction M1	1.3	kN-m
Unfactored moment in shorter direction M2	1.08	kN-m
Net soil bearing capacity	300	kN/m ²
Gross safe bearing capacity	336	kN/m ²
Height of footing below NGL	2	m
Unit weight of soil	18	kN/m ³
Total load on footing	413	kN

Gross pressures and
check for tension

P1	174	ok	} No tension
P2	178	ok	
P3	182	ok	
P4	177	ok	

Required area	1.2	m ²
Provided area	2.322576	m ²
Longer dimension of footing L1	1.52	m
Shorter dimension of footing B1	1.52	m
Overall depth of footing D	381	mm
Effective depth of footing d	331	mm
Edge depth of footing ed	381	mm
Cover to the main reinforcement	50	mm
Grade of concrete fck	25	N/mm ²
Grade of steel fy	550	N/mm ²


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Diameter of bars 12 mm

LONGER MOMENTS

Maximum pressure Pmax	143	kN/m2
Minimum pressure Pmin	139	kN/m2
Cantilever length	0.54	m
Average pressure	142	kN/m2
Moment M11	31	kNm
Effective width for moment	0.39	m
Mu/bd ²	1.09	
Required percentage of steel	0.24	%
Minimum steel area	696.7728	mm2
Provided steel area Ast	313	mm2
Spacing of reinforcement	240	mm

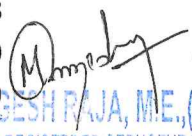
SHORTER MOMENTS

Maximum pressure Pmax	143	kN/m2
Minimum pressure Pmin	139	kN/m2
Cantilever length	0.65	m
Average pressure	142	kN/m2
Moment M22	45	kN-m
Effective width for moment	0.58	m
Required percentage of steel	0.25	%
Minimum steel area	696.7728	mm2
Provided steel area Ast	473	mm2
Spacing of reinforcement	240	mm

CHECK FOR ONE-WAY SHEAR

Longitudinal Direction

Effective width at the section	892	mm
Effective depth at the section	331	mm
Shear Area at the section	504444	mm2
Pressure at distance d from the face	142.5	kN/m2
Shear force at the section	45	kN
Shear stress at the section Tv	0.133	N/mm2
pt for shear stress	0.138	%
Allowable shear stress Tc	0.280	ok
Revised pt from shear requirement	0.120	%
Revised area of steel Ast	605	mm2
Spacing of reinforcement	280.000	mm


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Transverse Direction

Effective width at the section	1088	mm
Effective depth at the section	319	mm
Shear Area at the section	486156	mm ²
Pressure at distance d from the face	142	kN/m ²
Shear force at the section	66	kN
Shear stress at the section T_v	0.204	N/mm ²
pt for shear stress	0.143	%
Allowable shear stress T_c	0.285	ok
Revised pt from shear requirement	0.120	%
Revised area of steel A_{st}	583	mm ²
Spacing of reinforcement	290.000	mm

CHECK FOR PUNCHING SHEAR

Average pressure	139	kN/m ²
Punching shear force	262	kN
Perimeter at distance d/2	2660	mm
Effective depth at distance d/2	325	mm
Shear area	864500	mm ²
Shear stress at the section T_v	0.30	N/mm ²
Allowable shear stress T_c	1.25	ok

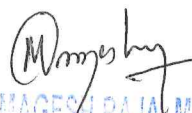
TRANSFER OF LOAD AT BASE

Supporting area for bearing (A1)	2756796	mm ²
Loaded area at column base (A2)	103500	mm ²
$\sqrt{A1/A2}$	2	
Actual bearing stress	4.68	N/mm ²
Allowable bearing stress	22.5	ok

COLUMN DESIGN

General Data

Column No.	:	C17
Level	:	4.5 m To 6 m
Frame Type	=	Non-Ductile
Response Reduction Factor	=	3
Design Code	=	IS 456 : 2000 + IS 13920 : 2016
Grade Of Concrete	=	M25 N/sqmm
Grade Of Steel (Main)	=	Fe550 N/sqmm
Grade Of Steel (Shear)	=	Fe550 N/sqmm
Grade Of Steel - Flexural Design	=	Fe550 N/sqmm
Grade Of Steel - Shear Design	=	Fe550 N/sqmm


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Column B	=	230	mm
Column D	=	450	mm
Clear Cover	=	40	mm
Clear Floor Height @ B	=	3550	mm
Clear Floor Height @ D	=	3550	mm
No Of Floors	=	1	
No Of Columns In Group	=	1	
Column Type	:	UnBraced	
Minimum eccentricity check	:	Simultaneously (Both Axis)	
Code defined D/B ratio	:	4	
D/B Ratio	:	1.96 <= 4 Hence, Design as Column	

Flexural Design (Analysis Forces)

Analysis Reference No.	=	37	
Critical Analysis Load Combination	:	4	
Load Combination	=	[2] : 1.5 (LOAD 1: DL) +1.5 (LOAD 2: LL)	
Critical Location	=	Top Joint	
Pu	=	396.83	kN
Mux	=	11.6	kNm
Muy	=	12.43	kNm
Vux	=	5.06	kN
Vuy	=	-4.98	kN

Minimum Eccentricity Check

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

Minimum Eccentricity Along D:

Minimum Eccentricity	=	Unsupported Length / 500 + D / 30	
	=	22.1	mm
Minimum Eccentricity	>	20	mm
Mminx	=	Pu x Minimum Eccentricity	
	=	8.77	kNm

Minimum Eccentricity Along B :

Minimum Eccentricity	=	Unsupported Length / 500 + B / 30	
	=	14.77	mm
Mminy	=	Pu x Minimum Eccentricity	


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$$= 7.94 \quad \text{kNm}$$

Slenderness Check

$$\begin{aligned} \text{Max Slenderness Ratio}(L/B) &= 15.43 \\ &< 60 \quad (\text{Hence Ok}) \end{aligned}$$

Column Is Unbraced Along D

Slenderness Check Along D:

$$\begin{aligned} \text{Effective Length Factor} &= 1 \\ \text{Slenderness Ratio} &= \text{Effective Length} / D \\ &= 7.89, \text{ Column not Slender Along D} \end{aligned}$$

Column Is Unbraced Along B

Slenderness Check Along B:

$$\begin{aligned} \text{Effective Length Factor} &= 1 \\ \text{Slenderness Ratio} &= \text{Effective Length} / B \\ &= 15.43, \text{ Column Slender Along B} \end{aligned}$$

$$\begin{aligned} \text{Slenderness moment along B} &= (P_u B / 2000) (L_e / B)^2 \\ &= 10.87 \quad \text{kNm} \end{aligned}$$

Design slenderness moment along B

$$P_{uz} = 1527.43 \quad \text{kN}$$

$$P_b = 477.67 \quad \text{kN}$$

$$\text{Reduction factor 'k' for slenderness moment} = (P_{uz} - P_u) / (P_{uz} - P_b) \leq 1$$

$$= 1.08 \geq 1, \text{ Hence } k=1$$

$$\begin{aligned} M_{sldy} &= k \times 10.87 \\ &= 10.87 \quad \text{kNm} \end{aligned}$$

Calculation of Design Moment

Direction	M _{analysis}	M _{min (Abs)}	M _{design}	M _{sldx (Abs)}	M _{design-final}
	A	B	C	E	F
Major Axis - M _{ux}	11.6	8.77	11.6	0	11.6
Minor Axis - M _{uy}	12.43	7.94	12.43	10.87	23.3

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


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F = Final design Moment = Max(C- Top Bottom , D- Top Bottom) + E

Final Critical Design Forces

Pu	=	396.83	kN
Mux	=	11.6	kNm
Muy	=	23.3	kNm

Resultant Moment (Combined Action)

Moment Capacity Check

Pt Calculated	=	0.87
Reinforcement Provided	=	8-T12

Load Angle	=	$\tan^{-1}(Muy/Mux)$	
	=	63.53	deg
MRes	=	26.03	kNm
MCap	=	55.13	kNm
Capacity Ratio	=	MRes/ MCap	
	=	0.47 <= 1	

Shear Calculation	Along D	Along B
Critical Analysis Load Combination	4	4
Critical Load Combination	[2] : 1.5 (LOAD 1: DL) +1.5 (LOAD 2: LL)	[2] : 1.5 (LOAD 1: DL) +1.5 (LOAD 2: LL)
Design shear force, Vu (kN)	-4.9849	5.0557
Pu (kN)	396.83	396.83
Deff , Beff (mm)	404	184
Aeff (sqmm)	92920	82800
Design shear stress, Tv	$Vu / (B \times Deff)$	$Vu / (D \times Beff)$
Tv (N/sqmm)	0.0536	0.0611
Pt (%)	0.437	0.437
Design shear strength, Tc (N/sqmm)	0.4626	0.4626


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Shear Strength Enhancement Factor (Compressive Force)	$1 + 3 \times P_u / (B \times D \times F_{ck})$	
	1.5125	1.5751
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, T_{c-e} (N/sqmm)	0.6938	0.6938
Design shear check	$T_v < T_c \times \text{Enhancement factor}$	$T_v < T_c \times \text{Enhancement factor}$
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

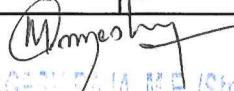
Diameter of link = 8 mm
 > Max. longitudinal bar dia / 4
 = 3 mm

Criterion for spacing of normal links

Min. Longitudinal Bar dia X 16 = 192 mm
 Min. dimension of column = 230 mm
 Max. 300 mm = 300 mm
 Provided spacing = 175 mm

Table For Links

	Required			Provided	
	Normal Design	Shear Design	Ductile Design	Normal Zone	Ductile Zone
Link Dia.	8	---	---	8	---
Spacing	175	---	---	175	---


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SLAB DESIGN

Along Grid : (A-D/2-4)		Level: FF LVL		slab Ref. S4						
INPUT DATA										
Slab			Loads							
Shorter Span	$L_x =$	4.400 m	Dead Load	$DL =$	3.75 kN/m ²					
Longer Span	$L_y =$	6.200 m	Live load	$LL =$	2.00 kN/m ²					
Thickness of Slab	$D =$	150 mm	Floor Finishes	$FF =$	1.50 kN/m ²					
Clear Cover	$d' =$	25 mm	False Ceiling Load	$=$	0.25 kN/m ²					
L_y/L_x ratio	$k =$	1.41 Two-Way Slab	Total Load	$w =$	7.50 kN/m ²					
Panel Type			Materials							
Basic L/d ratio = 26			Grade of Concrete = 25 N/mm ²							
Edge Condition: = 9			Grade of Reinf. Steel = 550 N/mm ²							
Four Edges Discontinuous			Young's Modulus E = 2.50E+04 N/mm ²							
DESIGN										
Direction	BM Coefficients (IS:456-2000)	Flexural Design			dia & Required Spacing				Provided Reinforcement	
		M_u kNm	$A_{st_{req}}$ mm ²	$A_{st_{pro}}$ mm ²	8 mm	10 mm	12 mm	16 mm		
Shorter Span	$\alpha X (-) = 0.0000$	0.000	144	707	300	300	300	300	10 @ 125 Safe	
	$\alpha X (+) = 0.0854$	18.592	346	707	145	227	300	300	10 @ 125 Safe	
Longer Span	$\alpha Y (-) = 0.0000$	0.000	144	550	300	300	300	300	10 @ 150 Safe	
	$\alpha Y (+) = 0.0560$	12.197	222	550	227	300	300	300	10 @ 150 Safe	
CHECK FOR DEFLECTION										
Area of Steel required = 346 mm ²		Area of Steel Provided = 707 mm ²		Steel stress of service load = 156.08 N/mm ²		Provided reinforcement (%) = 0.59%		Modification ratio MF = 1.712		
Effective depth required for deflection point of view $d_{req} = 98.82183$ mm		Eff. depth provided $d = 120$ mm		Safe						
SLAB SUMMARY										
Shorter Span: Provide T 10 @ 125 mm c/c + 1 T 10 Extra between the two cranked bars										
Longer Span: Provide T 10 @ 150 mm c/c + 1 T 10 Extra between the two cranked bars										
CHECK FOR SHEAR										
Max Shear Force = 25 kN		Actual Shear stress $\tau_v = 0.206$ N/mm ²		P_c of $A_{st} = 0.59\%$		Design Shear Stress $\tau_c = 0.52$ N/mm ²		Shear is less than Design Shear Stress, Hence Safe against shear		
NOTES										
1. Crank alternate bars at 0.3 times the respective span. 2. Provide 12mm dia chairs at 1000mm c/c in both directions. 3. Provide 6 mm thick cover blocks at 600mm c/c in both directions.										
Reinforcement Summary: Along Shorter Span Provided T10@ 125mm c/c Along Longer Span Provided T10@ 150mm c/c										


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IS-456 LIMIT STATE DESIGN
BEAM NO. B216 DESIGN RESULTS

M25 Fe550 (Main) Fe550 (Sec.)

Length: 3300.0 mm Size: 230.0 mm X 530.0 mm Cover: 25.0 mm

Summary of Reinforcement Area (Sq.mm)

Section	0.0 mm	825.0 mm	1650.0 mm	2475.0 mm	3300.0 mm
Top Reinforcement. (Sq. mm)	1712.30	826.69	174.88	0.00	489.56
Bottom Reinforcement. (Sq. mm)	843.51	0.00	175.16	857.81	1378.73

Summary of provided Reinforcement Area

Section	0.0 mm	825.0 mm	1650.0 mm	2475.0 mm	3300.0 mm
Top Reinforcement.	6-20d 2 layer(s)	3-20d 1 layer(s)	3-20d 1 layer(s)	3-20d 1 layer(s)	3-20d 1 layer(s)
Bottom Reinforcement.	5-20d 2 layer(s)	3-20d 1 layer(s)	3-20d 1 layer(s)	5-20d 2 layer(s)	5-20d 2 layer(s)
Shear Reinforcement.	2 legged 8d @ 160 mm c/c				
	2 legged 8d @ 110 mm c/c				
	2 legged 8d @ 110 mm c/c				
	2 legged 8d @ 155 mm c/c				
	2 legged 8d @ 160 mm c/c				

Shear Design Results at distance d (Effective Depth) From Face of the Support

Shear Design Results at 776.7 mm AWAY From StartT Support

VY = 200.77 MX = -12.82 LD= 4

Provide 2 Legged 8d @ 105 mm c/c


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