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DIGITALLY VERIFIED RECORD

PROPOSED CONSTRUCTION OF COMMERCIAL BUILDING (STILT +5 FLOORS) AT INDIRA NAGAR, ADYAR CHENNAI-600 020.

STRUCTURAL DESIGN CALCULATIONS

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08-08-2025

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1. INTRODUCTION:

The structure is a "Proposed Construction of Commercial Building" consisting of (Stilt + 5 Floors) at Plot No: 316-A, New Door No: 27, Old Door No: 10, 1st Avenue and 2nd Main Road, Indira Nagar, Adyar, Chennai-600 020. Comprising Document T.S.No: 47 To 49(PT), As Per Patta R.S.No – 39, 40/1, 40/2, 40/3 & 41/2, Block No: 13 of Kalikundram Village within the limit of Greater Chennai Corporation, Division: 175, Zone: 13. It is designed as a Reinforced Concrete Framed Structure which is supported on Pile foundation.

Building size

Length (X-direction)	–	24.16m
Width (Y-direction)	–	5.87m
Height		
Stilt floor	–	3.0m
First floor	–	3.0m
Second floor	–	3.0m
Third floor	–	3.0m
Fourth floor	–	3.0m
Fifth floor	–	3.0m

2. MATERIALS USED:

Following materials are generally used in the design of the various components of the structure.

1. M25 for all Reinforced concrete part of the structure.
2. Fe 500 grade reinforcement steel for all diameters.

The self-weight of the various elements are computed based on the unit weight of materials as given below:

Materials	Unit weight kN/m^3
Steel	78.50
Plain Cement Concrete	24.00
Reinforced Cement Concrete	25.00
Soil Fill (Landscape)	20.00 (Saturated)
Water	10.00
Cement Concrete screed	24.00
CLSM (Controlled low strength material)	20.00
Light weight Block (AAC)	8.00
Solid block wall (Concrete)	22.00

Normal weight aggregates shall be considered for arriving at self-weight of all Concrete works.

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3. DESIGN STANDARDS

The relevant Indian Standard Codes, as given below, shall be followed for structural design:

Sl.No.	Code	Description
1.	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.
2.	IS-875 (Part 2) – 1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Imposed loads.
3.	IS-875 (Part 3) – 2015	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Wind loads.
4.	IS-875 (Part 4) – 1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Snow loads.
5.	IS-875 (Part 5) – 1987	Code of Practice for Design Loads (other than earthquake) for buildings and structures – Special loads and load combinations.
6.	IS: 456 – 2000	Code of Practice for Plain and Reinforced Concrete.
7.	IS: 1786 – 2008	High Strength Deformed Steel Bars and Wires for Concrete Reinforcement - Specification.
8.	IS: 13920 – 2016	Ductile detailing of reinforced concrete structures subjected to seismic forces - Code of practice
9	IS: 800 – 1984/2007	Code of Practice for General Construction in Steel.
10.	IS: 1893 – 2016	Criteria for Earthquake resistant design of structures.
11.	IS3370-(PART I & II)-2009	Code of Practice for Concrete structures for the storage of liquids – Reinforced concrete structures
12.	IS 2950 (Part I) -1981	Code of Practice for Design and construction of Raft foundation
13.	IS 1343-1980	Code of Practice for Prestressed Concrete
14.	BS8110	The Structural use of Concrete
15.	TR43	Post tensioned concrete floors-Design Handbook

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4. DESIGN DATA:

1.	No. Of floors	= Stilt + 5 upper floors
2.	Height of floors	= 3.0m+3.0m+3.0m+3.0m+3.0m+3.0m
3.	Safe Bearing Capacity Capacity of 500mm dia Pile	= Low (Pile Foundation) = 540 kN = 54 Tonne
4.	Density of Concrete	=25kN/m^3
5.	D.L. due to partitions (Light Partition as per IS 875)	=1.25 kN/m^2
6.	D.L. due to flooring	=1.20 kN/m^2
7.	Live Load in lobby & corridors	=3.00 kN/m^2
8.	Live Load in Floor	=3.00 kN/m^2
9.	Live Load in stairs	=3.00 kN/m^2
10.	Live Load in Toilets & Bathrooms	=3.00 kN/m^2
11.	Basic wind speed	=50 m/sec
12.	Seismic Zone	= III
13.	Design mix	= M25 for all

5. ANALYSIS OF STRUCTURE:

The structure is analyzed using STAAD PRO V8i software. All beams & slabs are designed as conventional beam & slabs.

6. DESIGN CONCEPT

Limit State concept of design will be used as per IS: 456-2000 & SP - 16. The detailing of reinforcement shall be done satisfying the requirements of IS: 456, SP-16, IS: 13920, IS: 4326 and SP-34.

The Slabs and beams are checked for deflection as per IS 456. Cover for Reinforcement is considered as per Table 16A of NBC, for a Fire resistance of **2 hrs.**

7. LOAD CASES:

7.1. Primary Load:

1. Dead Load (DL)
2. Live Load (LL)
3. Earthquake Load (EL)

7.2. Load Combinations:

The following combinations of Loads as per IS 1893-2016 is considered in the staad Analysis

LIMIT STATE OF STRENGTH

1. 1.5DL+1.5LL
2. 1.2DL+1.2LL+1.2EX
3. 1.2DL+1.2LL-1.2EX

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4. 1.2DL+1.2LL+1.2EZ
5. 1.2DL+1.2LL-1.2EZ
6. 1.5DL+1.5EX
7. 1.5DL-1.5EX
8. 1.5DL+1.5EZ
9. 1.5DL-1.5EZ
10. 0.9DL+1.5EX
11. 0.9DL-1.5EX
12. 0.9DL+1.5EZ
13. 0.9DL-1.5EZ

LIMIT STATE OF SERVICEABILITY

14. 1.0DL+1.0LL
15. 1.0DL+1.0EX
16. 1.0DL–1.0EX
17. 1.0DL+1.0EZ
18. 1.0DL–1.0EZ
19. 1.0DL+1.0LL+0.8EX
20. 1.0DL+1.0LL-0.8EX
21. 1.0DL+1.0LL+0.8EZ
22. 1.0DL+1.0LL-0.8EZ
23. 0.9DL+0.9EX
24. 0.9DL –0.9EX
25. 0.9DL+0.9EZ
26. 0.9DL-0.9EZ

8. SEISMIC ZONE:

The Proposed Commercial building is at Chennai & it is falls in Seismic Zone III as per the IS Code. Response spectrum method shall be used for seismic analysis of R.C.C. Frames as recommended by **IS: 1893**.

Seismic Zone	=III
Zone Factor 'Z'	=0.16
Response Reduction Factor 'R' (for SMRF)	=5.00
Importance Factor 'I'	=1.5
Type of Structure	=1.00
Type of Soil	= III (Soft)

SEISMIC ANALYSIS:

8.1. STATIC ANALYSIS:

As per IS 1893:2016, the total design lateral force or seismic design base shear (Vb) is determined by the following expression.

$$V_b = A_h W$$

Where A_h is Design acceleration spectrum value using fundamental natural period and W is seismic weight of the building.

The seismic weight is estimated based on full dead load + % of live load
(live load up to 3 kN/m^2 75% reduction, above 3 kN/m^2 50% reduction)

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The fundamental natural period of vibration (Ta) in seconds of a RC building is estimated by using the following formula

$Ta = 0.075\ h^{0.75}$ (moment resisting building without brick infill panel)

$Ta = 0.09\ h/\sqrt{d}$ (moment resisting building with brick infill panel)

Where h is the height of building in meters.

"d" is the base dimension of the building at the plinth level in m.

From is 1893:2016 clause 6.4.2, Design horizontal seismic coefficient

$$Ah = \frac{Z\ I\ S_a}{2\ R\ g}$$

Where, Z for Zone II	= 0.16
I for Commercial Building	= 1.5
R for SMRF	= 5.0

8.2. DYNAMIC ANALYSIS:

As per IS 1893 : 2016 clause 7.8.1, dynamic analysis shall be carried out to study the structural behavior of the building and to design the structural elements like columns and RC walls including floor elements etc .

Dynamic analysis shall be carried out using response spectrum method. The design base shear **(V_b)** from the analysis shall be compared with a base shear **($V_{b'}$)** calculated manually using a fundamental period Table as per 10.1 or same as static analysis.

9. COVER FOR REINFORCEMENT:

Cover for Reinforcement is considered as per Table 16A of NBC, for a Fire resistance of **2 hrs.**

1. Pile	= 50mm (Circular Cover)
2. Pile cap	= 75mm
3. Columns	= 40mm
4. Beams	= 30mm
5. Slabs	= 25mm

10. FLOOR LOADS ON COMMERCIAL BUILDING:

The Typical floor slab and beams are designed as a conventional R.C.C beam & slab for floor loads as mentioned below. Thickness of slab is 150mm. The load considered on the floor slab is 10 kN/m^2.

Self-Weight of 150 thk. Slab	= 3.75 kN/m^2
Load due to Floor Finish	= 1.20 kN/m^2
Load due to Partition	= 1.5 kN/m^2(Light weight)
Live load	= 3.00 kN/m^2
Total load taken	= **10 kN/m^2**

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11. FOUNDATION SYSTEM:

The support condition for columns in STAAD model is considered as Fixed support. The soil investigation work was entrusted to YUBE Prime Infra by the Client.

Type of Foundation

After critical review of the results, DEEP FOUNDATION in the form of PILE FOUNDATION may be designed for this project.

Depth of Pile & Safe Pile Capacity

The safe Pile capacities (Q) and depth of pile are shown in the table may be used for design.

Diameter Ø ,mm / Depth, m	Safe pile capacity in kN				
	450 Ø	500 Ø	600 Ø	750 Ø	900 Ø
10	150	190	260	360	470
11	160	200	280	410	540
12	320	420	660	1180	1630
13	330	440	690	1270	1870
14	390	520	820	1530	2480
15	410	540	860	1600	2680

12.1 Typical Design of Column:

Results from the STAAD analysis are taken out and using Excel work sheet format, three worst forces from all load combinations are considered for the design of the Columns. Percentage of steel required for the most required case is considered as the final reinforcement. A typical Design calculation is furnished below for Stilt +5 floors Column C1.

K. R. [illegible]

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C1 - Columns: (for maximum axial load case)

Total load on column = 2104 kN
Moment in Y-Direction = 34 kNm
Moment in Z-Direction = 142 kNm

Column Size = 300X525mm
A_{st} = 4830 mm^2
pt = 3.10 %
p/f_{ck} = 0.12
$P_u / f_{ck}\, bd$ = 0.53
$M_u / f_{ck}\, b^2d$ = 0.112
$M_u / f_{ck}\, bd^2$ = 0.130
Muy_1 = 132 kNm
Muz_1 = 405 kNm
Puz/Ag = 23 N/mm^2
Muy/Muy_1 = 0.254
Muz/Muz_1 = 0.35
∞n = 1.65
$(Muy/Muy_1)^{\infty n} + (Muz/Muz_1)^{\infty n} = 0.08$ Hence safe.
Provide 300X525columns with 6 No's 25mm + 6 No's 20mm (3.1%) up to Second floor roof.

C1 - Columns: (for maximum bending moment case)

Total load on column = 880 kN
Moment in Y-Direction = 140 kNm
Moment in Z-Direction = 101 kNm

Column Size = 300X525mm
A_{st} = 4830 mm^2
pt = 3.10 %
p/f_{ck} = 0.12
$P_u / f_{ck}\, bd$ = 0.22
$M_u / f_{ck}\, b^2d$ = 0.164
$M_u / f_{ck}\, bd^2$ = 0.184
Muy_1 = 194 kNm
Muz_1 = 389 kNm
Puz/Ag = 23 N/mm^2
Muy/Muy_1 = 0.721
Muz/Muz_1 = 0.265
∞n = 1.08
$(Muy/Muy_1)^{\infty n} + (Muz/Muz_1)^{\infty n} = 0.90$ Hence safe.
Provide 300X525columns with 6 No's 25mm + 6 No's 20mm (3.1%) up to Second floor roof.

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12.2 DESIGN OF PILE & PILE CAP:

Pile cap is analyzed using Truss Analogy theory.

DESIGN OF PILE:

Un factored load on column	= 1025kN
Carrying capacity of 500 mm dia Pile	= 540 kN
Number of piles	= 2
Length of Pile	= 15m
2 no's of 500Dia Pile provided	= 1025/ 2
	= 512.5kN < 540 kN

Hence Safe

Provide 500 dia pile with 6 No's Y16 with Y8 rings @ 200 c/c as outer stirrups & Y12 rings @ 900 c/c as Inner stirrups.

DESIGN OF PILE CAP PC2 WITH 2 PILES:

Grade of Concrete	= M30
Grade of Steel Fy	= Fe 500
Pile cap depth,	= 750 mm
Cover	= 75 mm
Carrying capacity of 500 mm dia Pile	= 800 kN
Un factored load on column	= 1025 kN
Number of piles	= 2

Centre to centre of piles, L = 1350 mm

a = 230 mm b = 600 mm c = 450 mm

Column size

Length along X axis, A = 230 mm

Length along Y axis, B = 600 mm

Tensile force to be resisted by reinforcement

Tension along Y-Y $= \frac{P\,(3L^2-A^2)}{12LD}$

Tension along Y-Y = $1025(3\text{x}1.350^2 - 0.0.23^2)/\,(12\text{x}1.350\text{x}0.675) = 507.54$ kN

Area of steel = $\frac{\text{Tensile Force}}{0.87\,Fy} = 507.54 \text{ x } 10^3 \text{x } 1.5/0.87 \text{ x } 500 = 1166 \text{ mm}^2$

Provide 7 nos 20mm dia at Bottom

Provide 7 nos 16mm dia at Top

Hence Pile cap size – 900 x 2400 x 750mm depth

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12.3 DESIGN OF STILT FLOOR ROOF BEAM:

Design of beam "B1-1": 300 x 450 mm

Results from STAAD

Mu (+)	= 105 kN.m
Mu (-)	= 148 kN.m
Shear	= 217 kN
Beam size	= 300 X 450mm
bf	= 1000 mm
Effective depth	= 550 mm
Grade of Concrete	= M25
Grade of Steel	= Fe500

Tension Reinforcement Details:

Mu (+) / (bf * d^2) = (205 x 10^6) / (1000 * 400 * 400)
= 0.64N/mm^2

For 0.64N/mm^2; p_t = 0.15%

Then Ast = 0.15* 1000 *400/100
= 861 mm^2

No of bars = 861/ ((π * 20^2) / 4)
= 3 Nos.

Provide 3-Y20 (throughout) +2-Y16 (Extra) @ middle in bottom

Mu (-) / (B * d^2) = (248 * 10^6) / (300 * 400 * 400)
= 2.6 N/mm^2

For 2.6 N/mm^2; From SP16, p_t = 0.7 %

Then Ast = 0.7* 300 * 400/100
= 1172 mm^2

Provide 3-Y16 (throughout) + 3-Y16 (Extra) @ support in top.

Shear Reinforcement Details:

τv = Vu / (B*d)
τv = 217*10^3 / (300 * 400)
= 1.29
τc = 0.33

Hence $\tau v > \tau c$

Provide 8mm dia stirrup- 2legged

Vus = ($\tau v - \tau c$) * B *d
Sv = (0.96 *fy* d * Asv) / (Vus)
Sv = 136 mm

Reinforcement Details:

Provide 3-Y16 (throughout) + 2-Y16 (Extra) @ middle in bottom
Provide 3-Y16 (throughout) + 3-Y16 (Extra) @ support in top.

Provide 8mm dia rod 2 legged with 100C/C @ supports & 150 C/C in mid span

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12.3.2 DESIGN OF GROUND FLOOR ROOF SLAB:

Slab marked : **S1**

Design data

Length of shorter span	L_x	=	**3280**	mm
Length of longer span	L_Y	=	**6480**	mm
Thickness of Slab	D	=	**150**	mm
Concrete grade	f_{ck}	=	**25**	N/mm²
Reinforcement grade	f_y	=	**500**	N/mm²
Nominal cover to reinf.		=	**20**	mm
Finishes Load		=	**2.7**	kN/m²
Unit weight of concrete		=	**25**	kN/m³
Live load on the slab		=	**3.0**	kN/m²
Dia of reinforcement bar		=	**10**	mm
Ratio	l_y / l_x	=	1.9	< 2, Hence Two way slab design procedure is followed

Type of slab Panel = One short edge continuous

Bending moment coefficient For the above ratio as per *IS456:2000, Annexure-D, Table 26*

Bending Moment coefficient		+ ve moment	- ve moment
Short span coefficient	α_x	0.088	0.000
Long span coefficient	α_y	0.043	0.057

Loadings

Self weight of slab	=	0.15	x	25	=	3.75	kN/m²
Finishes load on slab	=					2.70	kN/m²
Live Load	=					3.00	kN/m²
	Total Load				=	9.45	kN/m²
Factored Load on slab	w =	9.45	x	1.5	=	**14.18**	kN/m²

Moment and reinforcement Moments per unit width are given by the following equation:

Bending Moment	M_x	=	$\alpha_x w L_x^2$	=	α_x	x	14.18	x	3.89	=	214	α_x
Bending Moment	M_y	=	$\alpha_y w L_x^2$	=	α_y	x	14.18	x	3.89	=	214	α_y

Depth Required = $\sqrt{M / (0.1338 f_{ck} b)}$

Ast Required = $((f_{ck}/(2 f_y))x(1-(\sqrt{(1-((4.6xR)/f_{ck})))))xbxd$

where, $R = M/(bd^2)$

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	Moment kN.m/m	Depth Reqd mm	Eff. Depth mm	Reinf Reqd A_{st} mm^2	Provided Reinf. Bar dia	Spacing	Summary A_{st} mm^2	check
M_x(-ve)	0.00	0.00	125	180	T **10**	**150 mm**	628	**OK**
M_x(+ve)	18.97	75.31	125	371	T **10**	**150 mm**	628	**OK**
M_y(-ve)	12.23	60.46	115	256	T **8**	**175 mm**	449	**OK**
M_y(+ve)	9.22	52.51	115	191	T **8**	**175 mm**	449	**OK**

Check for deflection

IS456:2000, 23.2.1

Span to depth ratio (L / d) should not exceed the values as calculated below.

Actual Span to depth ratio, L/d = 3280 / 125
= 26.2

Allowable span to depth ratio = $\alpha\ \beta\ \gamma\ \delta$

where α = **26** *20 for simply supported, 26 for continuous span*

β = 1.00 *For Span < 10m, β = 1 & for span > 10m, β = 10 / span*

Short span reinf. % = 0.50 % *at mid span*

Steel stress at service load f_s = 0.58 x f_y x area of steel required / area of steel provided
= 0.58 x 500 x 371 / 628
f_s = 171 N/mm²

Modification factor for tension reinforcement *as per IS456:2000, Fig. 4, page-38*

γ = 1.69 *For the above caculated steel stress*

Modification factor for compression reinforcement *as per IS456:2000, Fig. 5, Page no 39*

δ = **1.0** *No compression reinf. is provided*

Allowable L / d ratio = **44**

Actual L/d ratio < Allowable L/d ratio, Hence OK



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Check for Crack Width

Permissible Compressive stress, σ_{cbc}	=	8.5	N/mm²
Modular ratio, m	=	10.98	
Modulus of Elasiticity of steel, Es	=	200000	N/mm²
Area of steel provided, Ast	=	628.00	mm²/m
Tension Steel percentage provided, Pt	=	0.502	%

Neutral axis depth factor, k

= $\sqrt{((2x((Pt/100)xm))+(((Pt/100)xm)^2))} - ((Pt/100)xm)$

= 0.282

Neutral axis depth, x = 35.19 mm

Cracked Moment of Inertia, I_{cr}

= $((bx(x^3))/3)+((mxAst)x((d-x)^2))$

= $((1000x(35.19^3))/3)+((10.98x628.00)x((125-35.19)^2))$

= 70143171 mm^4

Service load Moment, M = 12.65 kNm/m

Tensile stress in steel, fst

= $((mxMx(d-x))/I_{cr}$

= (10.98x12.65x10^6x(125-35.19))/(70143171.04)

= 177.83 N/mm²

Strain in concrete, $\varepsilon 1$

= $(f_{st} \times (D - x)) / (E_s \times (d - x))$

= 0.0011366

Mean tensile Strain in concrete, εm

= $\varepsilon 1 - ((b \times ((D - x)^2)) / (3 \times E_s \times Ast \times (d - x)))$

= 0.0007471 **OK**

Status of Section = CRACKED

Spacing of reinforcement, S = 125 mm

Distance of point from surface of reinforcing bar, a_{cr}

= $\sqrt{(((S/2)^2) + (d_c^2))} - (d_b/2)$

= 62.31 mm

[d_c = Effective cover
d_b = Bar diameter]

Crack width, Wcr

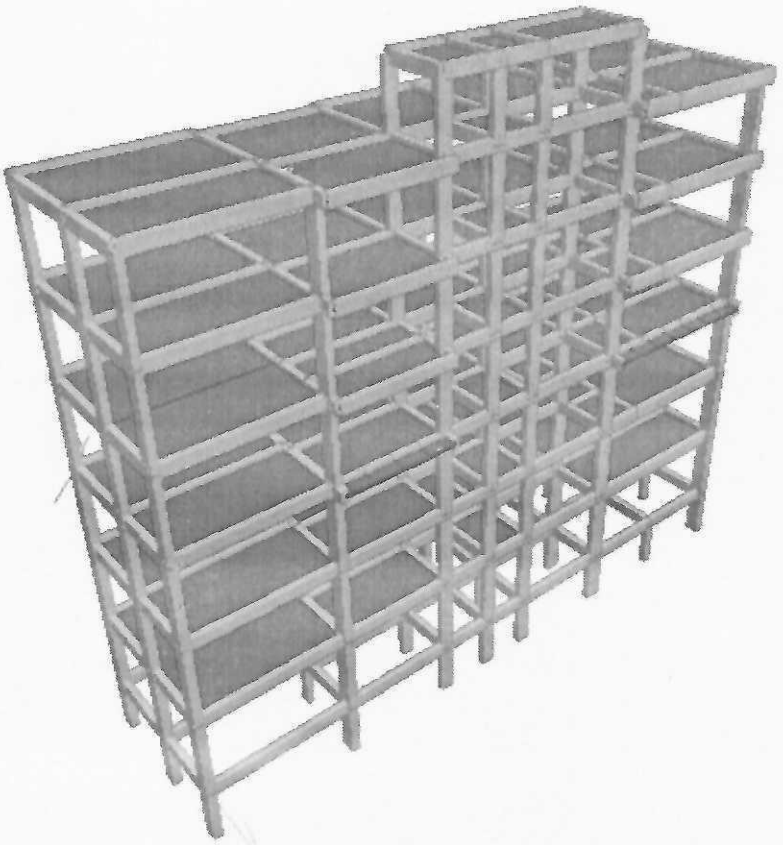
= $(3 \times a_{cr} \times \varepsilon m) / [1 + 2(a_{cr} - c) / (D - x)]$

= 0.08 mm

< 0.2mm, Crack width is with in the Limit, Hence OK

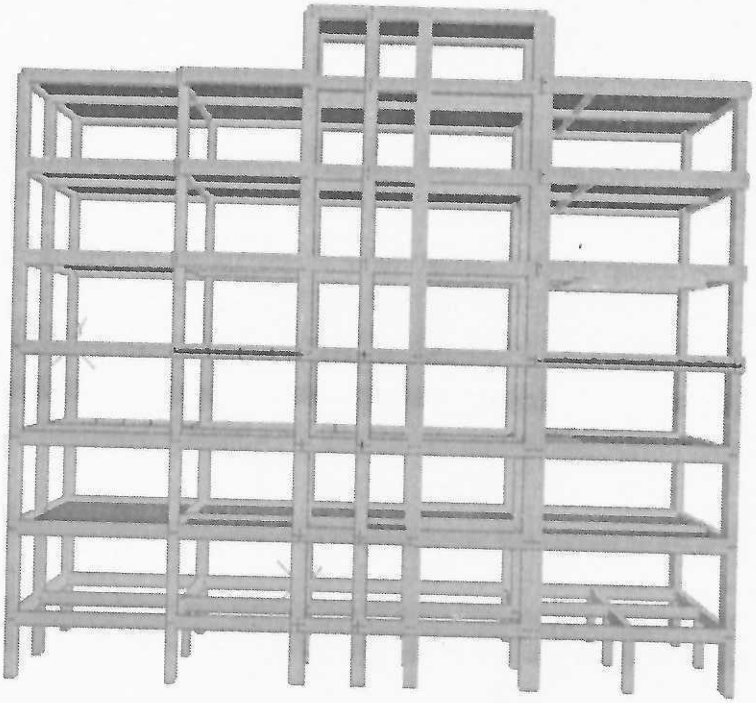
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STAAD MODEL:

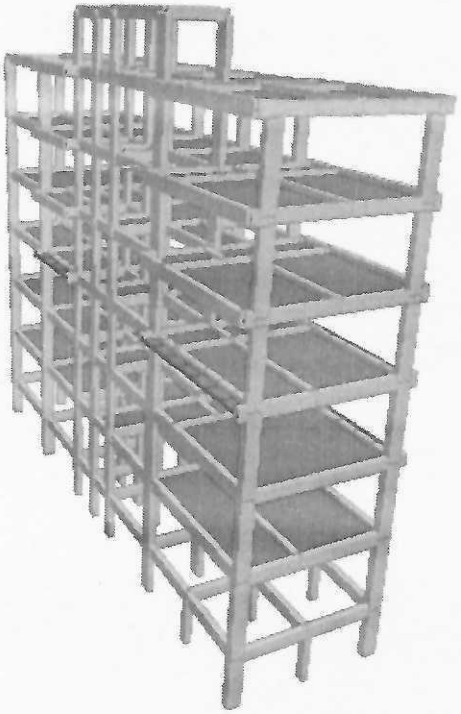


3D VIEW

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FRONT VIEW

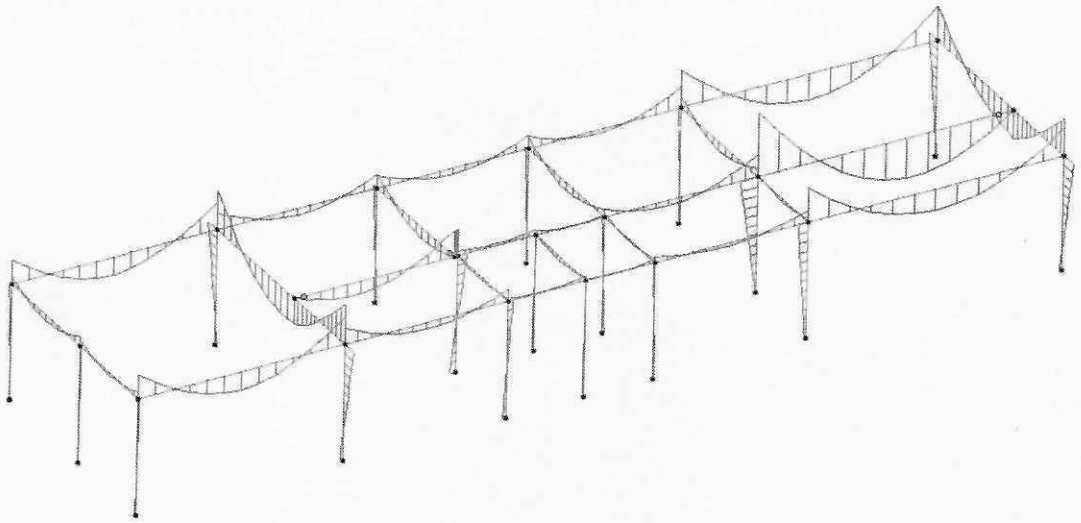


SIDE VIEW

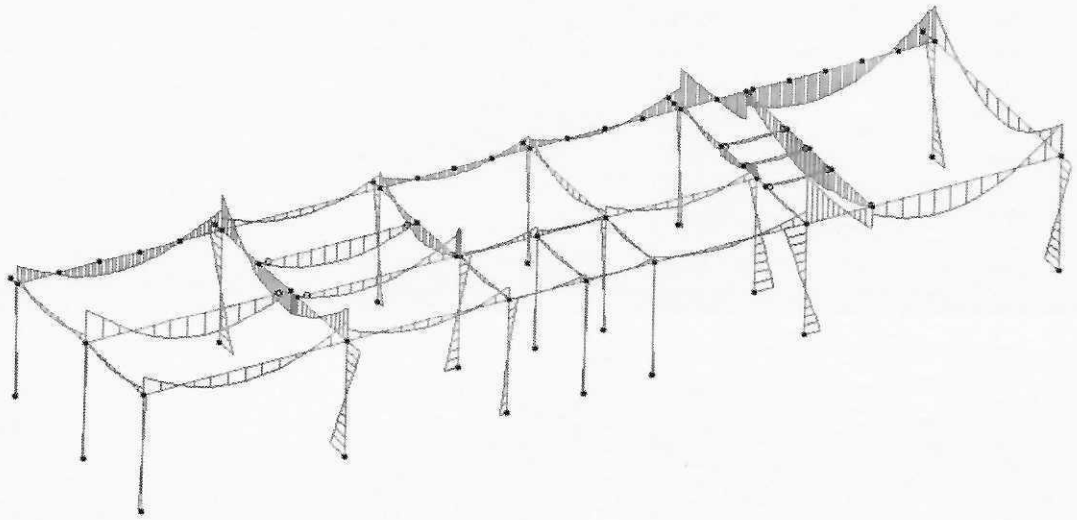
GENUINE CONSULTANTS
CHENNAI
600 100
Structural Engineering

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08-08-2025

BENDING MOMENT DIAGRAM:



STILT FLOOR ROOF SLAB & BEAM



FIRST FLOOR ROOF SLAB & BEAM

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THE LANDLENS SUITE

Eight ways to know a piece of land before you pay for it.

This report covers one part of the picture. These cover the rest, drawn from the same government records, for any property in Tamil Nadu.

LandLens One
Ask anything about a property and get an answer grounded in live government records, with the sources shown.
/landlens/one

Verify My Land
Every record check run on one property and returned as a single report.
/landlens/verify-my-land

Legal Opinion
An advocate's written opinion on the title, built on the records we pull for it.
/landlens

One Map
Every layer on one map: the parcel, its boundary, zoning, water bodies and what sits around it.
/landlens/one/map

PriceMap
What land actually changed hands for around this plot, taken from the registered deeds.
/landlens/pricemap

Build Scope
What you are allowed to build here: floor space, height, coverage and setbacks.
/landlens/build-scope

Property Tracker
Watch a property and hear about it when something new is registered against it.
/landlens/property-tracker

Deal Room
Run the transaction in one place: documents, stamping, signatures and the parties.
/landlens/deal-room

FREE TOOLS · NO ACCOUNT NEEDED

Twenty-four checks you can run yourself, at no cost.

Records and verification

The registers themselves, read for you.

- Encumbrance Certificate
- Patta and Chitta
- Field Measurement Sketch
- EC Analyzer
- Bank charge check
- Court case search
- Seller background check
- Approval check by survey

Value and duty

What it is worth and what it costs to register.

- Guideline value by street
- Guideline value by survey
- Stamp duty and registration fees
- Capital gains
- Floor space index
- Area unit converter

Zoning and land use

What the plan says can happen on this land.

- Land use zone finder
- CMDA land use check
- Coastal regulation zone
- Master plan check
- Water bodies finder
- Airport height clearance

Registers and directories

Who holds it, and which office keeps the record.

- Find your registering office
- Temple property check
- Waqf property check
- RERA register

Every free tool
/tools

Services we run for you
/services

The LandLens suite
/landlens/one

Verified RealEstate™

Every claim in this document traces back to a government record.

- Legal opinions, due diligence and title verification
- Building plan, layout and sub-division approvals
- Completion and occupancy certificates, regularisation
- Escrow, negotiation and NRI property management
- Land survey, soil testing, architecture and construction

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Prepared from the registers named on the page each finding sits on. Where a register could not be read, this document says so in its place rather than leaving the gap to be read as a clean result.