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PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (STILT +5 FLOORS) AT MOTILAL STREET, THYAGARAYA NAGAR, CHENNAI

STRUCTURAL DESIGN CALCULATIONS

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1. INTRODUCTION:

The structure is a "Proposed Construction of Residential Building consisting of (Stilt + 5 Floors) at "Aaniruth's Narmada" Comprised in Paimash No:138, 139, bearing Town Planning Old Survey No:144/1 and 144/2, New R.S. No: 143/1 and 3 Parts. T.S. No:5998, Block No:133, Situated at No:23/13, Motilal Street, Thyagaraya Nagar, Chennai-600 017. It is designed as a Reinforced Concrete Framed Structure which is supported on Pile foundation.

Building size

Length (X-direction)	–	38m
Width (Y-direction)	–	19m
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:

3.
4.
5.

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 – 1993	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

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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	= Low (Pile Foundation)
	Capacity of 500mm dia Pile	= 911 kN = 91 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	=2.00 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 456:2000 (Table 18) is considered in the staad Analysis

Refer Table 18 of IS 456:2000, Partial Safety factor for loads (DL, LL & EL).

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LIMIT STATE OF STRENGTH

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

8. SEISMIC ZONE:

The Proposed Residential 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'	=1.0
Type of Structure	=1.00
Type of Soil	= III (Soft)

SEISMIC ANALYSIS:

8.1. STATIC ANALYSIS:

As per IS 1893:2002, 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/√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 1893:2002 clause 6.4.2, Design horizontal seismic coefficient

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

Where, Z for Zone III	= 0.16
I for Residential Building	= 1.0
R for SMRF	= 5.0

8.2. DYNAMIC ANALYSIS:

As per IS 1893 : 2002 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. Footing = 50mm
2. Columns = 40mm
3. Beams = 30mm
4. Slabs = 25mm

10. FLOOR LOADS ON RESIDENTIAL 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 125mm. The load considered on the floor slab is 8.0 kN/m^2 .

Self-Weight of 125 thk. Slab	= 3.125 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	= 2.00 kN/m^2
Total load taken	= **7.825 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 Ayyan Associates by the Client.

Dia of pile in mm	Assumed Length of pile (m)	Axial capacity under compression kN	Tensile capacity kN	Lateral load capacity kN Fixed Head
500	24.5	911	398	31
600	24.5	1312	497	51
750	24.5	2142	641	91
900	24.5	3259	788	146

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.

C1 - Columns: (for maximum axial load case)

Total load on column = 4260 kN
Moment in Y-Direction = 88 kNm
Moment in Z-Direction = 131 kNm

Column Size = 450X750mm
A_{st} = 7830 mm^2
pt = 2.32 %
p/f_{ck} = 0.09
$P_u / f_{ck}\, bd$ = 0.50
$M_u / f_{ck}\, b^2d$ = 0.112
$M_u / f_{ck}\, bd^2$ = 0.112
Muy_1 = 425 KN.m
Muz_1 = 709 KN.m
Puz/Ag = 21 N/mm^2
Muy/Muy_1 = 0.208
Muz/Muz_1 = 0.184
$\propto n$ = 1.68
$(Muy/Muy_1)^{\propto n} + (Muz/Muz_1)^{\propto n} = 0.130$ Hence safe.

Provide 450X750columns with 16 Nos 25mm (2.32%) upto Stilt floor Roof.

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C1 - Columns: (for maximum bending moment case)

Total load on column	**= 4033 kN**
Moment in Y-Direction	**= 246 kNm**
Moment in Z-Direction	**= 131 kNm**
Column Size	= 450X750mm
A_{st}	= 7830 mm^2
pt	= 2.32 %
p/f_{ck}	= 0.09
$P_u / f_{ck}\, bd$	= 0.48
$M_u / f_{ck}\, b^2d$	= 0.116
$M_u / f_{ck}\, bd^2$	= 0.116
Muy_1	= 440 KN.m
Muz_1	= 736 KN.m
Puz/Ag	= 21 N/mm^2
Muy/Muy_1	= 0.558
Muz/Muz_1	= 0.170
∞n	= 1.64

$(Muy/Muy_1)^{\infty n} + (Muz/Muz_1)^{\infty n} = 0.440$ Hence safe.

Provide 450X750columns with 16 Nos 25mm (2.32%) upto Stilt floor Roof.

12.2 DESIGN OF PILE & PILE CAP:

Pile cap is analyzed using Truss Analogy theory.

DESIGN OF PILE:

Un factored load on column	= 1200kN
Carrying capacity of 500 mm dia Pile	= 911 kN
Number of piles	= 2
Length of Pile	= 25m
2 no's of 500Dia Pile provided	= 1200/ 2
	= 600kN < 911 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 PC2-1 WITH 2 PILES:

Grade of Concrete	= M25
Grade of Steel Fy	= Fe 500
Pile cap depth,	= 750 mm
Cover	= 75 mm
Carrying capacity of 500 mm dia Pile	= 911 kN
Un factored load on column	= 1200 kN
Number of piles	= 2

Centre to centre of piles, L = 1350 mm

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

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Column size
Length along X axis, A = 300 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 = $1200(3x1.350^2 - 0.30^2)/ (12x1.350x0.675) = 590$ kN
Area of steel = Tensile Force = $590 \times 10^3 \times 1.5/0.87 \times 500 = 1356$ mm^2
0.87 Fy
Provide 7 nos 20mm dia at Bottom
Provide 7 nos 16mm dia at Top
Hence Pile cap size – 1000 x 2400 x 750mm depth

12.3 TYPICAL DESIGN OF ROOF SLAB:

Typical Floor Slab, S11:

Size of the Slab	=	4.12m X 4.42m
Thickness of Slab	=	125mm
Dead load on the Slab		
Due to Self Weight (0.125x25)	=	3.125 kN/m^2
Due to Partitions	=	1.5 kN/m^2
Due to Floor Finish	=	1.2 kN/m^2
Live load on Slab	=	2.0 kN/m^2
TOTAL LOAD ON THE SLAB	=	**8.00 kN/m^2**

l_y / l_x = 1.07

Short span B.M =8.0 kN/m^2 x 4.120^2 / 12 = 11.32 kN.m
Provide 150 mm thick slab.
$M_u / bd^2 = 1.68$, $p_t = 0..56\%$, $A_{st} = 560$ mm^2

Y10 @ 160mm c/c required

PROVIDE:
Y10 @ 150mm c/c
Y10 @ 150mm c/c

12.4 DESIGN OF STILT FLOOR ROOF BEAM:

Design of beam "B1-7": 300 x 600 mm

Results from STAAD

Mu (+)	= 237 kN.m
Mu (-)	= 194 kN.m
Shear	= 257 kN
Beam size	= 300 X 600mm
bf	= 1000 mm
Effective depth	= 550 mm

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Grade of Concrete = M25
Grade of Steel = Fe500

Tension Reinforcement Details:

Mu (+) / (bf * d^2) = (237 x 10^6) / (1000 * 550 * 550)
= 0.74N/mm^2
For 0.74N/mm^2; p_t = 0.18%
Then Ast = 0.18* 1000 *550/100
= 1000 mm^2
No of bars = 100/ ((π * 20^2) / 4)
= 3 Nos.

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

Mu (-) / (B * d^2) = (194 * 10^6) / (300 * 550 * 550)
= 2.66 N/mm^2

For 2.66 N/mm^2; From SP16, p_t = 0.71 %
Then Ast = 0.71* 300 * 550/100
= 925 mm^2
Provide 3-Y16 (throughout) + 3-Y20 (Extra) @ support in top.

Shear Reinforcement Details:

τv = Vu / (B*d)
τv = 257*10^3 / (300 * 550)
= 1.98
τc = 0.43

Hence $\tau v > \tau c$
Provide 10mm dia stirrup- 4legged
Vus = ($\tau v - \tau c$) * B *d
Sv = (0.93 *fy* d * Asv) / (Vus)
Sv = 142 mm

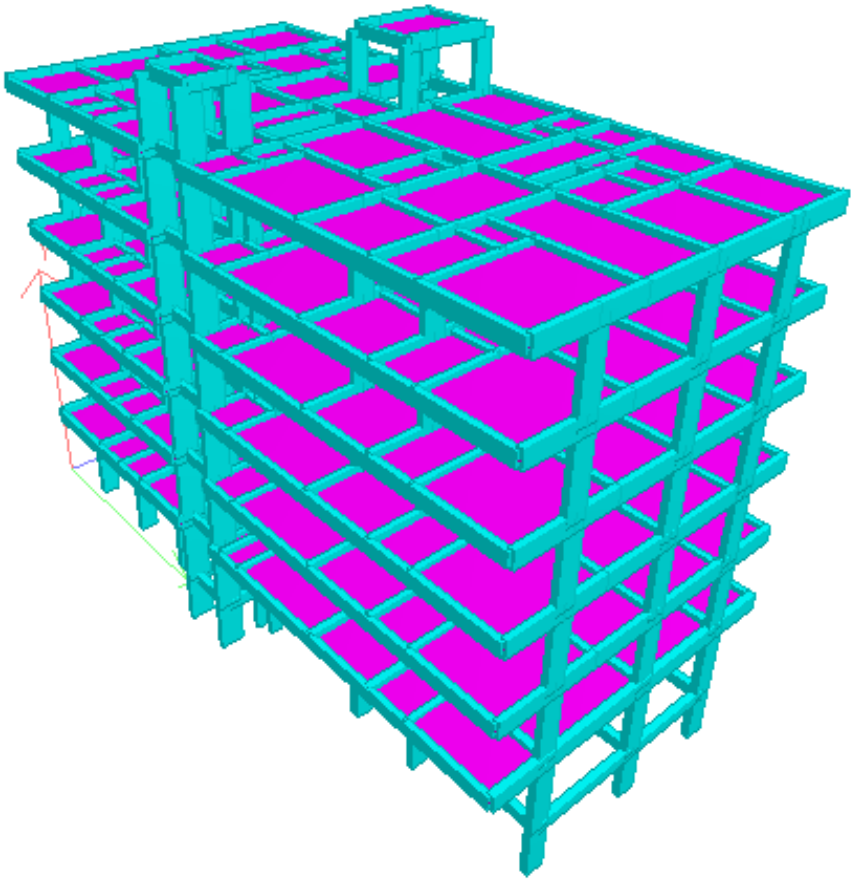
Reinforcement Details:

Provide 3-Y20 (throughout) + 3-Y16 (Extra) @ middle in bottom
Provide 3-Y16 (throughout) + 3-Y20 (Extra) @ support in top.

Provide 10mm dia rod 2 legged with 100C/C @ supports & 150 C/C in mid span

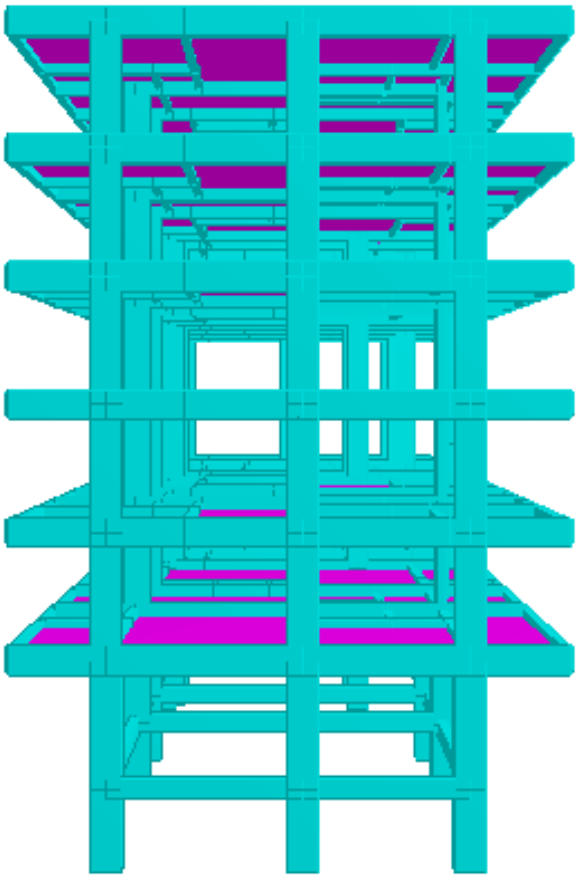
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ISOMETRIC VIEW OF STAAD MODEL



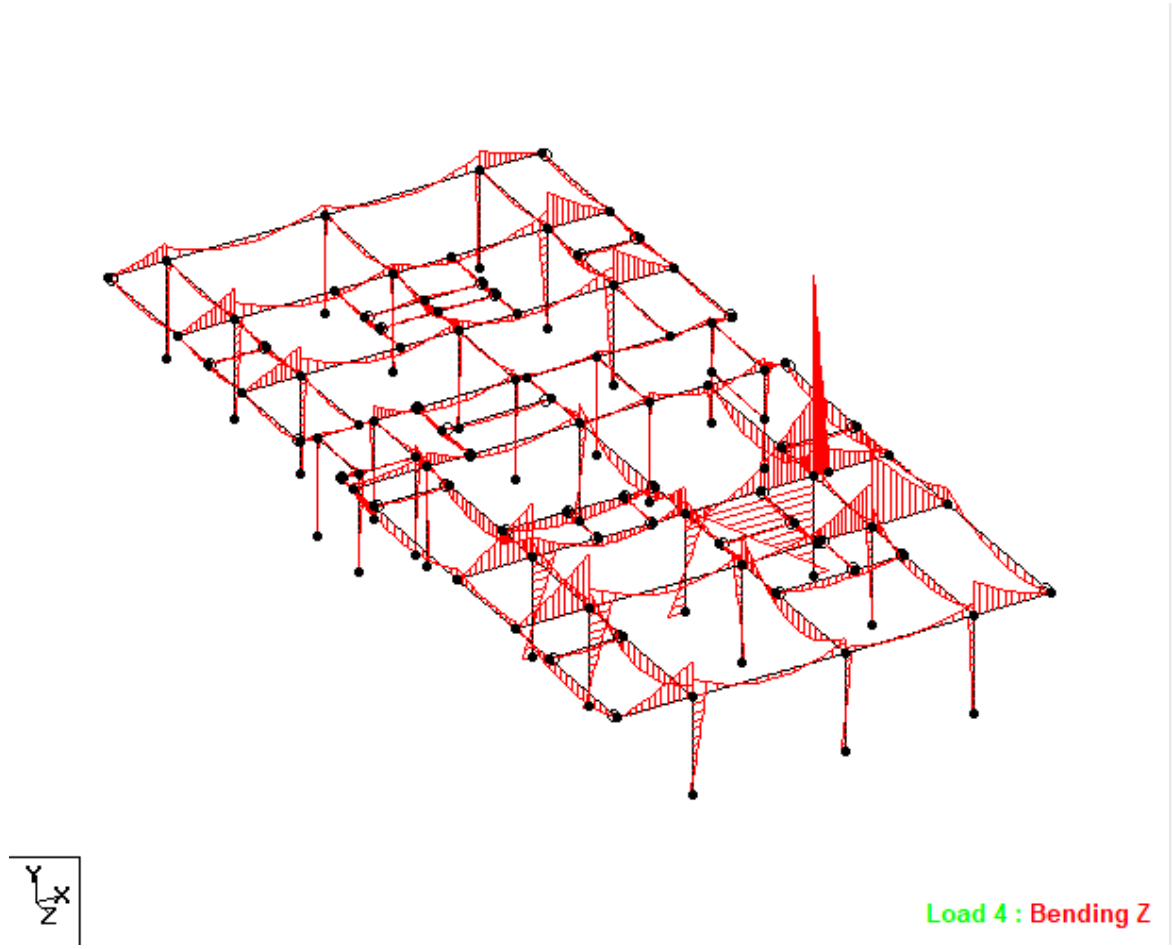
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FRONT VIEW OF STAAD MODEL



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BENDING MOMENT VIEW OF STAAD MODEL



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An advocate's written opinion on the title, built on the records we pull for it.
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One Map
Every layer on one map: the parcel, its boundary, zoning, water bodies and what sits around it.
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PriceMap
What land actually changed hands for around this plot, taken from the registered deeds.
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Build Scope
What you are allowed to build here: floor space, height, coverage and setbacks.
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Property Tracker
Watch a property and hear about it when something new is registered against it.
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Deal Room
Run the transaction in one place: documents, stamping, signatures and the parties.
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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
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- 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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