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DIGITALLY VERIFIED RECORD

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.DESCRIPTIONS 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.

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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.

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/m^2 for Floor Finish.

= 0.125X25 = 3.125Kn/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/m^2 (Typical floor)
Live Load considered on slab	=1.5 kN/m^2 (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 = $0.09H/\sqrt{d}$ from CL - 7.6.2 - IS 1893 (Part-I) 2016

S_a/g = from FIG-2 IS 1893 (part-I) 2016

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

Horizontal Seismic Co-efficient

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

Seismic Base Shear

Vb = Ah x W

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

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.

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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.

4.2 Elastic & Physical Properties

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

Table.1 – Elastic properties of materials

S.No.	Material	Elastic Modulus (kPa)	Poisson's Ratio
1	Normal density reinforced concrete (M25 Grade)	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/m^3

AAC Brick masonry = 6.5 kN/m^3

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 = 25m

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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/mm2
Grade of steel fy	550	N/mm2

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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	mm2
Pressure at distance d from the face	142	kN/m2
Shear force at the section	66	kN
Shear stress at the section Tv	0.204	N/mm2
pt for shear stress	0.143	%
Allowable shear stress Tc	0.285	ok
Revised pt from shear requirement	0.120	%
Revised area of steel Ast	583	mm2
Spacing of reinforcement	290.000	mm

CHECK FOR PUNCHING SHEAR		
Average pressure	139	kN/m2
Punching shear force	262	kN
Perimeter at distance d/2	2660	mm
Effective depth at distance d/2	325	mm
Shear area	864500	mm2
Shear stress at the section Tv	0.30	N/mm2
Allowable shear stress Tc	1.25	ok

TRANSFER OF LOAD AT BASE		
Supporting area for bearing (A1)	2756796	mm2
Loaded area at column base (A2)	103500	mm2
sqrt(A1/A2)	2	
Actual bearing stress	4.68	N/mm2
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	kNm

Slenderness Check

Max Slenderness Ratio(L/B)	=	15.43	
	<	60	(Hence Ok)

Column Is Unbraced Along D

Slenderness Check Along D:

Effective Length Factor	=	1	
Slenderness Ratio	=	Effective Length / D	
	=	7.89, Column not Slender Along D	

Column Is Unbraced Along B

Slenderness Check Along B:

Effective Length Factor	=	1	
Slenderness Ratio	=	Effective Length / B	
	=	15.43, Column Slender Along B	
Slenderness moment along B	=	(Pu B/ 2000) (Ley/B)^2	
	=	10.87	kNm

Design slenderness moment along B

Puz	=	1527.43	kN
Pb	=	477.67	kN
Reduction factor 'k' for slenderness moment	=	(Puz - Pu) / (Puz - Pb) < = 1	
	=	1.08 > = 1, Hence k=1	
MsIndy	=	k x 10.87	
	=	10.87	kNm

Calculation of Design Moment

Direction	Manalysis	Mmin (Abs)	Mdesign	MsIndx (Abs)	Mdesign-final
	A	B	C	E	F
Major Axis - Mux	11.6	8.77	11.6	0	11.6
Minor Axis - Muy	12.43	7.94	12.43	10.87	23.3

Wher
e

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 x Deff)	Vu / (D x 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 x Pu / (B x D x Fck)	
	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, Tc-e (N/sqmm)	0.6938	0.6938
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	
	=	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

	Level	FF LVL	
Along Grid	:(A-D/2-4)	slab Reff.	S4

INPUT DATA

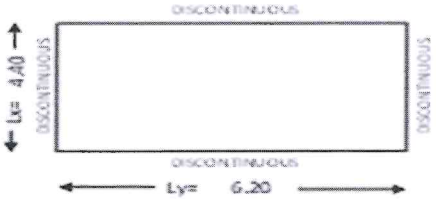
Slab					Loads				
Shorter Span	Lx	=	4.400	m	Dead Load	DL	=	3.75	kN/m²
Longer Span	Ly	=	6.200	m	Live load	LL	=	2.00	kN/m²
Thickness of Slab	D	=	150	mm	Floor Finishes	FF	=	1.50	kN/m²
Clear Cover	d'	=	25	mm	False Ceilling Load		=	0.25	kN/m²
Ly/Lx ratio	k	=	1.41	Two-Way Slab	Total Load	w	=	7.50	kN/m²
Panel Type					**Materials**				
Basic L/d ratio		=	26		Grade of Concrete		=	25	N/mm²
Edge Condition:		=	9		Grade of Reinf. Steel		=	550	N/mm²
Four Edges Discontinuous					Young's Modulus E			2.50E+04	N/mm²

DESIGN

Direction	BM Coefficients (IS:456-2000)			Flexural Design Mu	Ast_{req}	$Ast_{p.ro}$	dia & Required Spacing 8	10	12	16	Provided Reinforcement			
				kNm	mm²	mm²	mm	mm	mm	mm				
Shorter Span	αX (-)	=	0.0000	0.000	144	707	300	300	300	300	10	@	125	Safe
	αX (+)	=	0.0854	18.592	346	707	145	227	300	300	10	@	125	Safe
Longer Span	αY (-)	=	0.0000	0.000	144	550	300	300	300	300	10	@	150	Safe
	αY (+)	=	0.0560	12.197	222	550	227	300	300	300	10	@	150	Safe

CHECK FOR DEFLECTION

Area of Steel required = 346 mm²
Area of Steel Provided = 707 mm²
Steel stress of service load = 156.08 N/mm²
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 τv = 0.206 N/mm2
P_t of A_{st} = 0.59%
Design Shear Stress τc = 0.52 N/mm²
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

Sunnary of Reinforcement Area (Sq.mm)

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

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 (EffectiveE 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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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

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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.