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STRUCTURAL DESIGN CALCULATION REPORT OF THE PROPOSED CONSTRUCTION OF A STILT+5 STOREYS RESIDENTIAL BUIDING (TOWER A & B) IN THE FLATTED DEVELOPMENT PLOT NO: 169 IN CMDA PPD L.O.NO. 14/2022 AND IN VENGAIVASAL PANCHAYAT PRESIDENT PROC. NO.245/2021-22 DT. 24.2.22 COMPRISED IN S.NO. 177/2 (PT), 202/6, 202/7, 203, 204/1A (PT), 204/2 (PT), 204/3 (PT), 205/1 (PT) & 205/2 (PT)IN VENGAIVASAL VILLAGE, ST. THOMAS MOUNT PANCHAYAT UNION. TAMBARAM TALUK CHENGALPATTU DISTRICT

FOR

M/S. EMERALD HAVEN REALTY LIMITED, CHENNAI

R0	26-04-2025	DESIGN BASIS REPORT	OK	GOWTHAM	KALEEM	PERAM
REV NO.	**DATE**	**DESCRIPTION**	**STATUS**	**PREPARED BY**	**REVIEWED BY**	**APPRVD. BY**

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1. FORWARD

The intent of this document is to identify and record all the pertinent input requirements, analysis & design criteria for the structural design of the building structural elements on both completed and yet to be constructed ares of Block-B & Block-A. It is aimed at formulating the basis of the structural analysis, design & detailing work that the Structural Engineer is planning in delivering the structural scheme of the building. The scheme will be compatible with the architectural theme, satisfy the functional needs, at the same time conforming to the Indian Standards and other applicable building norms to achieve safe, stable, strong and yet optimally economical structures.

The parameters adopted in this report are going to be the basis of the structural design calculations. This report covers the minimum design requirement to establish the unified design basis that will form the overall design philosophy to be adopted in the structural design of the proposed building.

The design will aim to achieve

- Structural & functional integrity.
- Desirable Structural performance under characteristic service design loads.
- Resistance to loads due to natural phenomena i.e. wind and earthquakes.
- Structural durability & maintainability.

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2. PROJECT DESCRIPTION

PROJECT : PROPOSED STILT+5 STOREYS RESIDENTIAL APPARTMENT BUILDING – PLOT 169 – TOWER A & B

LOCATION : VENGAIVASAL VILLAGE, TAMBARAM TALUK, KANCHIPURAM DISTRICT.

2.1 AGENCIES

Client :	M/s. Emerald Haven Realty Limited, Chennai.
Architect :	M/s. Kembhavi Aechitects, Bangiore.
Structural Design Consultant :	M/s. A P Engineers, Chennai.
Peer Review Consultant :	
MEP Consultant :	M/s. Sanvir Associates, Chennai.

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2.2 THE BUILDING

The proposed construction of a Plot 169 Residential development comprises two towers (Tower-'A' & Tower-'B'). Tower-'A' has Stilt floor +5 upper stories whereas the Tower-'B' building also consists of Stilt+5 upper stories structure. In both Tower-'A' & Tower-'B' the stilt are designed to accommodate car parks whereas the 1st to 5 floors facilitate residential units.

a) Tower – 'A' :

Architecturally, it is configured as '**L**'shaped building with the plan size of 56.30m x 36.93m. It has been designed with two lifts and two staircases which serve the vertical transportation to all the floors. Lifts & Staircase are positioned at middle of the bulidng to enable the acces to both the building smoothly. Toilets and balconies are designed with the structural drop of 100mm and 150mm respectively with the ceiling suspended trap with false ceiling concept. Terrace is designed as RCC roof with the loadings to cater the 150mm thickness of weathering

course and equipment like A/C outdoor units, VRV, Solar panel etc. Above Terrace, staircase head room is provided and the Over Head Tank base slab located 0.7m above from staircase headroom slab is designed as for about 10,000 litre Capacity for fire. Structurally, the building is essentially a R.C.C. framed structures. The columns are connected to each other with a network of R.C.C beams and RC slabs with the slabs acting as in-plane rigid diaphragms for each of the floors.

Tower-'A' is designed with 300/200mm **wide** Shear wall are connected with conventional Beam-Slab systems with beam sizes of width 200mm and depth varies from 375mm, 450mm & 600mm etc. The slab thickness varies from 125mm to 200mm depends upon its span.

b) Tower – 'B' :

Architecturally, it is configured as '**L**'shaped building with the plan size of 90.38m x 34.00m. It has been designed with two lifts and two staircases which serve the vertical transportation to all the floors. Lifts & Staircase are positioned at middle of the bulidng to enable the acces to both the building smoothly. Toilets and bolcanies are designed with the structural drop of 100mm and 150mm respectively with the ceiling suspended trap with false ceiling concept. Terrace is designed as RCC roof with the loadings to cater the 150mm thickness of weathering course and equipment like A/C outdoor units, VRV, Solar panel etc. Above Terrace, staircase head room is provided and the Over Head Tank base slab located 0.7m above from staircase headroom slab is designed as for about 10,000 litre Capacity for fire. Structurally, the building is essentially a R.C.C. framed structures. The columns are connected to each other with a network of R.C.C beams and RC slabs with the slabs acting as in-plane rigid diaphragms for each of the floors.

Tower-'B' is designed with 300/200mm **wide** Shear wall are connected with conventional Beam-Slab systems with beam sizes of width 200mm and depth varies from 375mm, 450mm & 600mm etc. The slab thickness varies from 125mm to 200mm depends upon its span.

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2.3 ARCHITECTURAL/STRUCTURAL CONFIGURATION

The structural configuration what is proposed originally by the Architect and as constructed/intended to construct has been decribed in this section for the better understanding of the configuration.

Table : Architectural Floor heights/Structural & Details

BUILDING CONFIGURATION – PLOT-169-TOWER 'A'	
Building Dimension in Plan	**56.30mx36.93m**
No. Of Floors	**Stilt+5 Storey+Roof**
Stilt floor height	3.20m
1st floor height to 5th floor height	2.925m
Head room Slab	2.50m
OHT Slab	2.50m
Foundation System	**Isolated/Combined Footing**
Grade of concrete for Footings	M30
Grade of concrete for RC Columns	M30
Grade of concrete for RC Beams/RC slabs	M30
Grade of Steel	Fe500

BUILDING CONFIGURATION – PLOT-169-TOWER 'B'	
Building Dimension in Plan	**90.38mx34.00m**
No. Of Floors	**Stilt+5 Storey+Roof**
Stilt floor height	3.20m
1st floor height to 5th floor height	2.925m
Head room Slab	2.50m
OHT Slab	2.50m

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Foundation System	Isolated/Combined Footing
Grade of concrete for Footings	M30
Grade of concrete for RC Columns	M30
Grade of concrete for RC Beams/RC slabs	M30
Grade of Steel	Fe500

3. LIST OF CODES

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

3.1 DESIGN LOADS (OTHER THAN EARTHQUAKE LOADS)

IS CODE	DESCRIPTION
IS 875 (Part 1): 1987	Dead Loads (Unit Weight of Building Material and Stored Material)
IS 875 (Part 2): 1987	Imposed Load
IS 875 (Part 3): 2015	Wind Load

3.2 DESIGN FOR EARTHQUAKE RESISTANCE

IS CODE	DESCRIPTION
IS 1893: 2016	Criteria for Earthquake Resistance design of structures.
IS 4326: 2013	Earthquake Resistant Design and Construction of Buildings – Code of Practice
IS 13920: 2016	Ductile Detailing of Reinforced Concrete Structures subject to Seismic Forces - Code of Practice.

3.3 DESIGN OF STEEL STRUCTURAL ELEMENTS

IS CODE	DESCRIPTION
IS 800: 2007	Code of Practice for General Construction in Steel

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IS 2062: 2011	Steel for General structural purposes

3.4 DESIGN OF CONCRETE ELEMENTS

IS CODE	DESCRIPTION
IS 456: 2000	Plain and Reinforced Concrete - Code of practice
IS 2974-Part-4	Design and Construction of Pile Foundation - Code of practice -Load Tests on Pile
IS 2911-(Part1-Sec2)	Indian Standard Code of Practice for Design and Construction of Pile Foundation-Bored Cast In situ Piles
IS 1904 : 2005	Indian Standard Code of practice for design & construction foundations in Soil : General Requirements
IS 2974 : 1982	Code of practice for design & construction of machine foundation
SP 16	Structural use of concrete. Design charts for singly reinforced beams, doubly reinforced beams and columns.
SP 34	Handbook on Concrete Reinforcement & Detailing
SP 7(Part IV)	National Building code of India
IS 1786-2008	Specification for high strength deformed bars and wires for concrete Reinforcement.
IS 3370 (part I)	Code of practice for concrete structure for the storage of liquids

4. DESIGN PARAMETERS

4.1 MATERIALS OF CONSTRUCTION

The building is conceived as RCC framed structure which involves lot of raw material especially for concrete. Hence the selection of suitable grade and quality material is important to esure durability and strength of structural elements or as a whole structure. The following primary material with its desired/recommended quality as per code are listed below.

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4.1.1 Concrete Grade

For both Tower-'A' & Tower-'B' the grade of Concrete used for the construction is M30 with minimum 28 day strength of 30 Mpa for all structural works. Hence the same grade has been retained as it found to be very much suitable for all the structural element designs which includes Footings, Columns, RC Beams & Slabs etc.

Concrete Mix M10 has been used in filling, plum concrete, leveling courses (PCC). Density of reinforced concrete is assumed as 25.00 kN/cu.m.

Minimum cement content. water cement ratio etc shall conform to IS 456 :2000 code provisions for durability and strength criteria. The cementitious content shall be in the range of 350 to 360 kg/m^3 for M30 grade concrete. However recommends to carry out trial mixes and the cube tests are to be conducted in order to establish its design compressive strength achievable. The design mix shall be approved by the Structural Engineer based on the trial mix cube compressive test results before adopt in to the construction. The slump shall not be less than 100 in any case and it shall be min. of 120 for pumbable concrete.

4.1.2 Cement

Ordinary Portland Cement of grade 43 or higher confirming to IS 8112 and IS 12269 is specified for concrete M30 with cement content appropriate to the grade.

4.1.3 Aggregates

The sizes of coarse aggregates confirm to IS 383. Nominal maximum size of coarse aggregate to be 20 mm, suitably graded as per the requirement of mix design. The fine aggregates confirm to the specifications of IS 383.

4.1.4 Water

Water used for construction shall comply with stipulations given in IS 456: 2000

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4.1.5 Reinforcement

High yield strength deformed bars conforming to IS 1786-2008 with fy = 500 N/sq.mm has been used.

4.1.6 Structural Steel

MS steel with yield strength fy = 250 N/sq.mm has been used for Structural steel work shall conform to IS 226 and IS 2062 for Indian steel sections.

4.1.7 Concrete Cover

Following clear cover to all reinforcement is used in the design.

a.	Footings	= 50mm
b.	Column/Shear Wall	= 40mm
c.	Beam	= 30mm (Bottom and sides)
d.	Slab	= 25mm (Top and Bottom)
e.	UG Sump/Septic Tank	
	On water face	= 40mm (Top and Bottom)
	On other face	= 30mm (Top and Bottom)

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4.1.8 Development Length

Unless otherwise specified in the good for construction drawing, the Development length of 50 times diameter of bar is to be considered in the BBS & Facbrication.

4.1.9 Soil Parameters

The Soil Investigation Report No. 204/GI/18-19 dated 12th December, 2018, carried out by M/s. Prasad Armstrong Yen Gec Pvt Ltd, Chennai. Based on the soil report made

available to us, there are (27) bore holes are drilled for field investigation and to collect the soil samples for lab testing. Standard penetration tests were conducted at change of layers and at specified intervals, commencing the test at the top of existing ground level. The relative density of different soil layers obtained from the N-Values. Disturbed and un-disturbed soil samples were collected from all the layers for visual observation, classification tests and strength characteristics of the soil layers. Found that the sub-soil stratigraphy is relatively uniform i.e. difference between depth of occurrence and thickness of different layers are within normal range. The bore holes are drilled from the said EGL for soil investigation.

From the bore log data the top 1m is a brown fine to medium sand with silt. Below it is a brown weathered rock presents with «N» value around 20 to 25. The brown weathered rock continues up to 7m depth, it exists from 2m to 7m where the bore holes are terminated. The «N» of these layers ranging from 25 to above 100. As per the bore log data, the Ground Water Table (GWT) met at a depth of 2.1m measuring from NGL.

The soil report recommends to design a Isolated/Combined footings with a Safe Bearing Capacity (SBC) of 25t/m^2 at depth about 2m measuring from EGL.

4.2 LOADING STANDARDS

Table : Unit Weight of Materials

Material	Density
Reinforced Cement Concrete	25.00 kN/m3
Plain Cement/Screed Concrete	24.00 kN/m3
Cement Mortar	20.00 kN/m3
AAC Block (Infill walls) (Internal & External)	08.00 kN/m3
Structural Steel	78.50 kN/m3
Cinder Concrete (Filling material)	08.00 kN/m3
Dry soil	18.00 kN/m3
Wet Soil	20.00 kN/m3

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Landscape soil	16.00 kN/m3
Saturated soil	10.00 kN/m3
Glass	28.00 kN/m3
Water	10.00 kN/m3

Table : Gravity Load Calculation :

Floor Slab :	
Self weight of 125 mm thick Slab	0.125x25 = 3.125 kN/m2
Self weight of 150 mm thick Slab	0.150x25 = 3.750 kN/m2
Self weight of 175 mm thick Slab	0.175x25 = 4.375 kN/m2
Self weight of 200 mm thick Slab	0.200x25 = 5.000 kN/m2
External Wall Line Load :	
For 200mm Thick. Wall	
Stilt Floor	= (0.20x2.75x8)+(0.04x2.75x8) = 5.30 kN/m
1st Floor to 5th Floor	= (0.20x2.50x8)+(0.04x2.50x8) = 4.80 kN/m
Head Room	= (0.20x2.05x8)+(0.04x2.05x8) = 4.00 kN/m
Internal Wall Line Load :	
For 100mm Thick. Wall	
Stilt Floor	= (0.10x2.75x8)+(0.04x2.75x8) = 3.10 kN/m
1st Floor to 5th Floor	= (0.10x2.50x8)+(0.04x2.50x8) = 2.80 kN/m

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4.2 Imposed Loads on Slab

The following are the imposed loads in the structural slabs, in addition to the self-weight and the floor finishes. (Self-weight of slab will be as per the thickness mentioned in the respective drawings and the Floor finishes of 50 mm thickness have been considered on all floors).

Structural steel work shall conform to IS 226 and IS 2062 for Indian steel sections.

Table 4.2.1 Car Parks

Load Component	Thickness (mm)	Load	Units
Floor Finishes+service		2.4	kN/m2

Live Load		3.0	kN/m2

Table 4.2.2 Rooms

Load Component	Thickness (mm)	Load	Units
Floor Finishes+service		1.2	kN/m2
Partition Loads		-	kN/m2
Live Load		2.0	kN/m2

Table 4. 2.3 Balcony

Load Component	Thickness (mm)	Load	Units
Floor Finishes+service		2.4	kN/m2
Live Load.		3.0	kN/m2

Table 4. 2.4 Toilets

Load Component	Thickness (mm)	Load	Units
Finishes		1.20	kN/m2
Sunk & Filled	100 mm	1.00	kN/m2
Live Load		2.00	kN/m2

Table 4. 2.5 Terraces

Load Component	Thickness (mm)	Load	Units
Weathering course with Water-Proofing		3.0	kN/m2
Live Load		2.0	kN/m2

Table 4. 2.6 Corridors, Passage

Load Component	Thickness (mm)	Load	Units
Finishes		1.2	kN/m2
Live Load		3.0	kN/m2

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Table 4. 2.7 Staircases

Load Component	Thickness (mm)	Load	Units
Steps	150 (Riser) Assuming 75mm Avg thickness	1.8	kN/m2
Finishes	-	1.2	kN/m2
Live Load	-	4.0	kN/m2

Table 4. 2.8 Lift Machine Rooms

Load Component	Thickness (mm)	Load	Units
Finishes		1.8	kN/m2
Live Load		10.0	kN/m2

4.3 THERMAL EFFECTS

Temperature variation produces stresses in the structure, as it tends to expand and contract. In the structures, with large geometrical dimensions. the effect of temperature is important in the behavior and final design. Due to deformation of expansion & contraction - between Day time and nights, and between winter and summer - the effect on the durability of structure and on the supported finishes is significant to produce considerable results.

4.3.a. TOWER 'A'

In this case, expansion joint has been avoided considering the fact that the building length is only 56.30m in Tower-'A' which falls close to the limit prescribed in IS 456-2000, Clause. 27.2.

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4.3.b. TOWER 'B'

Expansion joint has been provoided considering the fact that the building length is 90.38m in Tower-'B' which is reached the limit prescribed in IS 456-2000, Clause. 27.2 and there is no exposed slab in the building except terrace. Hence the stresses developed due to expansive forces has been taken care by providing additional re-bars on the terrace slab appropriately.

4.3.1 Shrinkage Effects

4.3.1.a. Tower 'A'

The Building length is only 56.30m in Tower-'A' which falls close to the limitation laid down in IS 456: 2000, clause.27.2. Hence it is not required to perform detailed thermal analysis.

4.3.1.b. Tower 'B'

The Building length is 90.38m in Tower-'B' which is reached the limitation laid down in IS 456: 2000, clause.27.2. Hence it is required to perform detailed thermal analysis.

However the shrinkage crack control shall be taken care by adopting the construction sequences with pour joints. In addition to it, also care is to be taken to control Shrinkage by way of early sprinking just after the initial setting is over and put the floor under proper immersed curing subsequently other than the care shall be taken in terms of cement properties and content, weather of concreting etc.

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4.3.2 Expansion Joints

4.3.2.a. Tower 'A'

Expansion joints are normally provided when the structure is more than 45m length as per IS-456-2000, clause 27.2, The width of expansion joint shall be calculated as per IS-

1893-2002, clause 7.11.3. In this case, no expansion joint has been provided considering the fact that the building length is only 56.30m in Tower-'A' which falls close to the limit prescribed in the said clause and there is no exposed slab in the building except Terrace.

4.3.2.b. Tower 'B'

Expansion joint has been provided considering the fact that the building length is 90.38m in Tower-'B' which reached the limit prescribed in the said clause and there is no exposed slab in the building except Terrace. The stresses developed by expansive forces caused due to temperature variation has been taken care by providing additional re-bars on the slabs at re-entrant corners and on the exposed Terrace appropriately.

5. PROPOSED APPROACH OF STRUCTURAL ANALYSIS

The building is a R.C.C columns connected by beams as frame structure. Slabs acting as rigid in-plane diaphragms have been considered. After preliminary sizing of various structural members, a computer model of the structural frame of the building is generated for carrying out computer analysis for the effects of vertical and lateral loads that are likely to be imposed on the structure.

The building structure has been analyzed using the ETABS software for the following computer models of the building floor analysis of all floors - for vertical loads with the entire building space frame. ETABS have been thoroughly tested, validated and recognized internationally by several organizations and are well suited for the analysis of building systems.

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Geometrical dimensions, member properties and member-node connectivity, including eccentricities will be modeled in the analysis problem. Variation in material grades, if present, will also be considered.

The permissible values of the load factors and stresses will be utilized within the purview of the Indian Standards.

The computer analysis will produce accurate individual member forces, reactions at foundation level and deflection pattern of the entire structure as well as individual members. This data will then be used to confirm/review the member sizes and arrive at the most appropriate design of the structural members. Some re-runs of the analysis program might be required for arriving at the optimum structural space frame characteristics that satisfy the strength and stability criteria in all respects.

Design of different structural elements will be carried out using In-house developed spreadsheets and packages.

The following model assumptions used in E-TABS 3D modeling and the load applications are done as listed below,

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

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- Modulus of Elasticity of Concrete -5000$\sqrt{}$fck
- Consideration of Diaphragm - Rigid Diaphragm
- Slab element considered as Shell element

The structural model and its behavior has been checked for the following,

a) Storey Drift.

b) Storey Weight/Column Loading.

c) Soft Storey Effect.

d) Deformation.

e) Design Forces.

The following methods of modelling are adopted in creating ETABS 3D model,

- The 3D ETABS model generated based on the shuttering drawing prepared using preliminary sizes.
- Sectional properties are assigned to all the structural elements as per the preliminary shuttering drawing.
- Mesh size assigned in size of 1m x 1m approx.
- External & Internal filler wall loads are assigned as uniformly distributed line load on beams and as area load if the wall is intend to distribute on slab directly. These loads are assigned under SIDL type load case.
- Slabs are modelled as shell element in Flat slab area and the same has been modelled as membrane in Beam-slab system which 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/SIDL 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 875-2015.
- Temperature loads are applied on to the terraces which are directly exposed to sun includes podium, Roof etc.
- 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 0.01 to torsional constant "J". Hence no specific design for Torsion is required for these beams.

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- Chennai is zone-III. Hence ductile detailing is followed in the design and detailing of structural elements.
- Concrete cover to reinforcement complied accordance with IS 456-2000, Tabl.16 & 16A.
- UG Sump/STP base slab & wall is designed for 0.2mmcrack width.
- Secondary beams are not designed for ductile detailing.
- Long term deflections are checked by manual calculation using excel spread sheet wherever necessary. Crack width calculation will be done using spread sheet wherever necessary.

Area Load & Application: Applied as area load with intensity proportionate to its usage as mentioned in the Loading caluse in the DBR.

Line (Wall) Load & Application: In fill wall loads are calculated appropriately and Applied as uniformly distributed load.

Lateral Load Resisting Systems : The proposed structure is a RCC Columns with a network of Beams & floor Slabs connected. In this building the vertical structural system predominantly Columns which forms vertical components that are designed to transfers the lateral Shear in proportion to its stiffness in their loading direction of Wind & Seismic.

6. LATERAL LOADS

6.1 Wind Loads

The wind pressure shall be calculated based on the basic wind speed and other provisions laid in IS 875 (part 3) – 2015. The wind speed is considered in the analysis for Chennai is 50 m/sec. The design parameters for wind load calculation on Tower A & Tower B are as follows,

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6.1.1 Tower-'A'

Design Wind Pressure Vz = 0.6 Vz^2

But Vz = Vb*k1*k2*k3*k4

Where Vz - Design Wind Speed

k1 – 1.0, probability factor or risk coefficient

k2 – 0.993, Terrain height (17.93m), structure size factor

Terrain Category –3 and Structure Class-A

k3 – 1.0, Topography factor

K4 – 1.0, Importance factor for the cyclonic region, for all

Other Structure as per IS 875-2015 (Part3), clause 6.3.4.

Hence Design Wind Pressure = 0.6x (50x1.0*0.993 *1.0*1.0)^2

= 1497.07 N/m^2 ≈ 1.50 kN/m^2

Design wind pressure (P_d) = K_d*K_a*K_c*P_z

Where K_d - Wind Directionality factor = 1.0

Ka – Area averaging factor = 0.9

Kc – Combination factor = 0.9

Design Wind pressure = 1.50x1x0.9x0.9 = 1.21 kN/m^2

6.1.2 Tower-'B'

Design Wind Pressure Vz = 0.6 Vz^2

But Vz = Vb*k1*k2*k3*k4

Where Vz - Design Wind Speed

k1 – 1.0, probability factor or risk coefficient

k2 – 0.993, Terrain height (17.93m), structure size factor

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Terrain Category –3 and Structure Class-A

k3 – 1.0, Topography factor

K4 – 1.0, Importance factor for the cyclonic region, for all

Other Structure as per IS 875-2015 (Part3), clause 6.3.4.

Hence Design Wind Pressure = 0.6x (50x1.0*0.993 *1.0*1.0)^2

= 1497.07 N/m^2 ≈ 1.50 kN/m^2

Design wind pressure (P_d) = K_d*K_a*K_c*P_z

Where K_d - Wind Directionality factor = 1.0

Ka – Area averaging factor = 0.9

Kc – Combination factor = 0.9

Design Wind pressure = 1.50x1x0.9x0.9 = 1.21 kN/m^2

6.2 Earthquake Loads

Chennai is classified under Earthquake Zone III (Moderate) as per the latest classification. The loading due to earthquake shall be assessed based on the provisions of IS 1893 – 2016.

The design parameters adopted are as follows :

Seismic Zone III with seismic zone factor Z = 0.16 (Moderate) and Response reduction factor is to be 5 considering Special Moment resisting Frame system as per IS : 1893-2002, Table-7 and applied ductile detailing as per code IS 13920 : 1987. Soil considered as Type-II soil.

Base Shear Calculation for Static Analysis

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

$V_b = A_h W$

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Where Ah is Design horizontal 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 + 50 % of Live load for Office use i.e. for Live Load > 3 kN/Sq.mt. Hence in our case, the Live load percentage considered in the seismic calculation is 50% of Live load.

The Fundamental natural period of vibration (Ta) in seconds of a RC building is estimated by using the following formula, Ta = 0.09*h/(d)^0.5. All vertical elements like Columns & Shear walls are considered to be part of lateral load resisting system proportionate to its stiffness in the seismic considered direction and adopted ductile detailing.

Where h is the height of the building in meters. d is the base dimension of the building at the plinth level, in m along the considered direction of the lateral force.

6.2.1 Tower-'A'

Height of the building (measured from Ground Level) = 17.93m

d (along the length of the building) = 56.30 m

b (along the breadth of the building) = 36.93 m

Ta (along-x) = 0.09 x17.93/(56.30)^0.5

= 0.215 Sec.

Ta (along-y) = 0.09 x17.93/(36.93)^0.5

= 0.265 Sec.

From IS 1893: 2002, Clause 6.4.2, Design horizontal seismic coefficient

Ah = (Z/2)* (I/R)*(Sa/g)

Where

Z for Zone III = 0.16

I for Residential Building = 1.2

R for Special Moment resisting Frame = 5.0

As per IS-1893-2016 (Table 9)

Sa/g (x&y) = 2.5 (Refer to IS 1893-2016, page 9)

Design horizontal seismic coefficient Ah = 0.04

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Base Shear = 0.04

6.2.2 Tower-'B'

Height of the building (measured from Ground Level) = 17.93m

d (along the length of the building) = 90.38 m

b (along the breadth of the building) = 34.00 m

Ta (along-x) = 0.09 x17.93/(90.38)^0.5

= 0.169 Sec.

Ta (along-y) = 0.09 x17.93/(34.00)^0.5

= 0.276 Sec.

From IS 1893: 2002, Clause 6.4.2, Design horizontal seismic coefficient

Ah = (Z/2)* (I/R)*(Sa/g)

Where

Z for Zone III = 0.16

I for Residential Building = 1.2

R for Special Moment resisting Frame = 5.0

As per IS-1893-2016 (Table 9)

Sa/g (x&y) = 2.5 (Refer to IS 1893-2016, page 9)

Design horizontal seismic coefficient Ah = 0.04

Base Shear = 0.04

7. LOAD COMBINATION

The various loads shall be combined in accordance with the stipulations in IS 875 (Part 5) 1987 and IS 456 : 2000. The structural elements shall be designed for the combination that produces most unfavorable effect out of the following combinations.

The results obtained from the computer analysis in the form of member forces and reactions will be used for design the structural members. Following load combinations of the member forces will be considered for arriving at the design forces. The analysis considered load factor is as follows,

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Load Combination	LOAD FACTORS							
	D.L.	I.L.	EQX	EQY	SPECX	SPECY	WX	WY
	Limit State Of Serviceability (LSS) Combinations							
LC1	1.0	-	-	-	-	-	-	-
LC2	1.0	1.0	-	-	-	-	-	-
LC3	1.0	-	1.0	-	-	-	-	-
LC4	1.0	-	-1.0	-	-	-	-	-
LC5	1.0	-	-	1.0	-	-	-	-
LC6	1.0	-	-	-1.0	-	-	-	-
LC7	1.0	-	-	-	-	-	1.0	-
LC8	1.0	-	-	-	-	-	-1.0	-
LC9	1.0	-	-	-	-	-	-	1.0
LC10	1.0	-	-	-	-	-	-	-1.0
LC11	1.0	-	-	-	1.0	-	-	-
LC12	1.0	-	-	-	-1.0	-	-	-
LC13	1.0	-	-	-	-	1.0	-	-
LC14	1.0	-	-	-	-	-1.0	-	-
LC15	1.0	0.8	0.8	-	-	-	-	-
LC16	1.0	0.8	-0.8	-	-	-	-	-
LC17	1.0	0.8	-	0.8	-	-	-	-
LC18	1.0	0.8	-	-0.8	-	-	-	-
LC19	1.0	0.8	-	-	-	-	0.8	-
LC20	1.0	0.8	-	-	-	-	-0.8	-
LC21	1.0	0.8	-	-	-	-	-	0.8
LC22	1.0	0.8	-	-	-	-	-	-0.8
LC23	1.0	0.8	-	-	0.8	-	-	-
LC24	1.0	0.8	-	-	-0.8	-	-	-
LC25	1.0	0.8	-	-	-	0.8	-	-
LC26	1.0	0.8	-	-	-	-0.8	-	-
	Limit State Of Collapse (LSC) Combinations							
COMB1	1.5	-	-	-	-	-	-	-
COMB2	1.5	1.5	-	-	-	-	-	-
COMB3	1.2	1.2	1.2	-	-	-	-	-
COMB4	1.2	1.2	-1.2	-	-	-	-	-
COMB5	1.2	1.2	-	1.2	-	-	-	-
COMB6	1.2	1.2	-	-1.2	-	-	-	-
COMB7	1.2	1.2	-	-	-	-	-	-

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COMB8	1.2	1.2	-	-	-	-	-1.2	-
COMB9	1.2	1.2	-	-	-	-	-	1.2
COMB10	1.2	1.2	-	-	-	-	-	-1.2
COMB11	1.2	1.2	-	-	1.2	-	-	-
COMB12	1.2	1.2	-	-	-1.2	-	-	-
COMB13	1.2	1.2	-	-	-	1.2	-	-
COMB14	1.2	1.2	-	-	-	-1.2	-	-
COMB15	1.5	-	1.5	-	-	-	-	-
COMB16	1.5	-	-1.5	-	-	-	-	-
COMB17	1.5	-	-	1.5	-	-	-	-
COMB18	1.5	-	-	-1.5	-	-	-	-
COMB19	1.5	-	-	-	-	-	1.5	-
COMB20	1.5	-	-	-	-	-	-1.5	-
COMB21	1.5	-	-	-	-	-	-	1.5
COMB22	1.5	-	-	-	-	-	-	-1.5
COMB23	1.5	-	-	-	1.5	-	-	-
COMB24	1.5	-	-	-	-1.5	-	-	-
COMB25	1.5	-	-	-	-	1.5	-	-
COMB26	1.5	-	-	-	-	-1.5	-	-
COMB27	0.9	-	1.5	-	-	-	-	-
COMB28	0.9	-	-1.5	-	-	-	-	-
COMB29	0.9	-	-	1.5	-	-	-	-
COMB30	0.9	-	-	-1.5	-	-	-	-
COMB31	0.9	-	-	-	-	-	1.5	-
COMB32	0.9	-	-	-	-	-	-1.5	-
COMB33	0.9	-	-	-	-	-	-	1.5
COMB34	0.9	-	-	-	-	-	-	-1.5
COMB35	0.9	-	-	-	1.5	-	-	-
COMB36	0.9	-	-	-	-1.5	-	-	-
COMB37	0.9	-	-	-	-	1.5	-	-
COMB38	0.9	-	-	-	-	-1.5	-	-

DL: Dead Load EQX : Earthquake Load in X-dir. WX: Wind Load in X-dir.
IL: Imposed Load EQY : Earthquake Load in Y-dir. WY: Wind Load in Y-dir.

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8. DESIGN OF STRUCTURAL ELEMENTS

For the design of R.C.C. elements, the Limit State Method will be used as per IS 456-2000.

Materials of construction will be predominantly concrete with consideration for strength and durability. The grade of concrete is suggested as M30 for Foundation, Columns, Shear walls, RC Beam/Slab and for other structural elements considering the level of stresses to be borne by the members both in compression as well as flexural.

High Yield Strength Deformed bars conforming to IS: 1786 with F_y = 500 MPa will be used as reinforcement. Structural steel, if any with Fy = 250 Grade shall be used. Covers to reinforcement shall be in accordance with IS: 456:2000 corresponding to **moderate exposure conditions** for the super-structure or severe exposure conditions for the sub-structure and to satisfy a fire rating of 2 hrs as per National building code of India- SP7 (part IV).

9. FOUNDATION FOR THE BUILDING

The proposed Residential Apartment Building comprises Sitlt + 5 Storey+Roof structure. Some of the vertical elements like Columns/Shear Walls are considerably loaded. The structure is provided with columns/shear walls are adequately spreaded across, in order to satisfy the structural requirements for both gravity and lateral loads.

Based on the sub soil condition presented in the Soil Investigation Report No. 204/GI/18-19 dated 12th December, 2018, adopted Isolated/Combined footing to the building. As per the recommandation, the foundation is designed as Isolated/Combined Footings as suggested with the recommended SBC of 25t/m^2. The Footings are rest at the depth of 2.0m from EGL.

10. STABILITY OF STRUCTURES

1. For the purpose of stability of the structure as a whole against overturning, the restoring moment shall not be less than 1.2 times the maximum overturning moments due to dead load plus 1.4 times the maximum overturning moments due to imposed loads. In case

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where dead load provides the restoring moments only 0.9 times in dead load shall be considered. The restoring moments due to imposed loads shall be ignored.

2. The factor of safety against sliding shall not be less than 1.40.

3. Factor of safety against buoyancy shall be not less than 1.20 ignoring the superimposed loading.

11. OTHER DATA

Specific requirements of floor and wall cutouts for services, sinking (extent & depth) of floors in services, kitchen, utility and toilet areas, external architectural features, and entrance canopies are provided as required by Architects and Service Consultants. The relevant information is obtained from them in the form of drawings.

Lift loads and lift machine room equipment and cut out layouts will be obtained from the lift manufacturers. An impact factor of 100% will be considered in the lift supporting structures.

11.1 R C STRUCTURAL ELEMENT DESIGNS

The structures are analyzed for the various load combinations as per IS: 456-2000. In house spread sheet is being used for the design of footings and slabs. Rest of the structural elements like beam, columns etc shall be designed using ETABS design platform. For the design of the R.C.C structures the recommandations of IS: 456-2000 is followed. Limit State design is adopted with appropriate load factors with the various load combinations for the different structural elements as follows.

11.1.1 ISOLATED/COMBINED FOOTINGS

As per the recommendation laid down in the Geo-technical Report No. 204/GI/18-19 dated 12th December, 2018, designed Isolated/Combined Footing as foundation system. The size of the footing arrived considering the vertical elements load intensity using the Safe Bearing Capacity of the soil is 25t/m^2. The design of the Footings are designed as per IS-456 : 2000 guidelines and the footings are designing using Limit State method of designs.

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11.1.2 DESIGN OF COLUMNS

R.C Columns will be designed for uni-axial/bi-axial bending for the forces of critical load combination depends upon the nature of behavior. The designs are made using ETABS/in-house spread sheet as per the guide lines of IS : 456-2000 adopting limit state method.

11.1.3 DESIGN OF BEAMS

Beams will be designed for the results of critical load combination as per IS: 456-2000 using ETABS. The ETABS designs takes in to account all the member forces like axial, shear, torsional wherever applicable and bending while desigining the structural memebrs & it will lists out the area of the reinforcement required for all the members shall be transformed in to drawings manually.

11.1.4 DESIGN OF SUSPENDED FLOOR / ROOF SLABS

Slab elements will be designed for the forces obtained from the coefficients given in Annex -D in IS code 456:2000 by using the limit state design method. Wall load on slab is taken as uniformly distributed over entire area wherever applicable. Based on yield line theory, slab loads are transferred on to supporting beams.

12. COMPUTER PROGRAMS USED

The following Software/Spreadsheet are used to carry out structural element design,

12.1	ETABS	-Three Dimensional analysis and Design Programs
12.2	SAFE	- Mat/Raft Analysis & Design
12.3	In-House Spreadsheet	- One way/ Two way slab design
12.4	STAAD.Pro/ETABS	- Structural Steel Design

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Guideline Value, Apartment Composite Value, Stamp Duty & Registration Fees Calculator, Building Value Calculator, Capital Gains Calculator, Area Unit Converter, Length Unit Converter

Ownership, Compliance & Legal Verification

Encumbrance Certificate (EC) Search, Find Your SRO, Temple Property Check, WAQF Property Check, View Patta/Chitta, View FMB, Patta Analyzer, EC Analyzer

Zoning & Land Use Analysis

Land Use Zone Finder, CRZ Zone Check, Aquifer Zone Check, CBA Check, EWS Check, Road Width Check, Proposed Road Widening Check, FSI Calculator

Property Documentation & Workflow Tools

Forms & Templates, Document Generator, Document Translation, Dictionary

Vastu & Property Management Tools

Home Vastu Shastra, Plot Vastu Shastra, Property Management

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