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BAASHYAAM - WEST MAMBALAM

RESIDENTIAL BUILDING

STRUCTURAL DESIGN BASIS REPORT

TITLE : STRUCTURAL DESIGN BRIEF REPORT

DOCUMENT NO : STR - DBR/Rev-R0

DATE	ISSUE	PREPARED	CHECKED	REVISION
24/09/2023	Final Report	N.S	P.J	R0

1.0 INTRODUCTION

The proposed Development of Residential building for M/s Baashyaam (Pvt) Ltd at West Mambalam, Chennai, India.The development comprises of 2 Basements + Ground + 18 Floors + Terrace.

1.1 Scope of the Report

This report provides the information on Codes of Practice, Design loads, Material Strength considered for the Design and Analysis of the building. In addition, this report summaries the main design criteria, Structural system, Foundation system, structural analysis which will be adopted for design of the building.

1.2 Project Overview

The proposed towers are named as Residential building for M/s Baashyaam (Pvt) Ltd at West Mambalam, Chennai, India. The development comprises of 2 Basements +Ground + 18 Floors + Terrace.

1.2.1. Facilities covered in Building:

Basement-2 Floor: Parking (Car), Fireman's staircase, Fireman's Lift, Lumber room, Fire tower lobby, Ramp, STP.

Basement-1 Floor: Parking (Car), Fireman staircase, Fire tower lobby, Ramp.

Ground Floor: Fire Driveway, Fireman staircase, Electrical Room, Caretaker room, Association room, Mail Room, Ramp, BMS room, Parking,DG area,Transformer Yard, Entrance Lobby, Toilet.

Extended podium Area: Landscape area, Fire Driveway.

First Floor: Master Bedroom, Toilet, Bedroom, Living & Dining, Pooja room, Kitchen, Fireman's lift, Utility, Balcony, Sky garden, Terrace, Lobby, Staircase, Lift lobby.

Typical Floors: Master Bedroom, Toilet, Bedroom, Living & Dining, Pooja room, Kitchen, Fireman's lift, Utility, Balcony, Lobby, Staircase, Lift lobby.

Eighteenth Floor: Gym space, Yoga hall, Pantry, Party hall, Staircase, Ramp, Swimming pool, Landscape, Lift lobby, Toilet.

Terrace: OpenTerrace, OHT, LMR.

1.2.3 The basement and typical floor heights are refer below sketch



SECTION–AA

Proposed residential building Floor to Floor height details:

Basement-02 Floor height - 3.3m
Basement-01 Floor height - 4.15m
Typical Floor to Floor height - 3.15m

2.0 CODES OF PRACTICE

2.1 CODES, STANDARDS & REFERENCES

All design of structures shall comply with the requirements specified in the following.

a. Relevant Indian Standard Codes of Practice
b. National Building Code.
c. Local Building regulations.
d. Other relevant International codes where required.

All applicable latest edition of codes and standards will be referred and adopted in the analysis of structures and the design and detailing of structural members. All structural elements design shall be carried out primarily based on. Indian Standards and Codes with latest revision, with amendments if any, as on date.In addition, other international codes and standards shall also be referred when required and relevant.

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

CODE	DESCRIPTION
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
IS 875 (Part 2) 1987	Code of practice for Design Loads (other than earthquake) for buildings and structures – Imposed Loads
IS 875 (Part 3) 2015	Code of practice for Design Loads (other than earthquake) for buildings and structures – Wind Loads
IS 875 (Part 5) 1987	Code of practice for Design Loads (other than earthquake) for buildings and structures – Special Loads and load combinations
IS 16700 – 2017	Criteria for Structural Safety of Tall Concrete Buildings
IS 456 – 2000	Code of Practice for Plain and Reinforced Concrete
IS 1786 – 2008	Specification for High Strength Deformed bars and Wires for concrete reinforcement
IS 432 (Part 2) 1982	Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete reinforcement – Hard Drawn Steel Wire
IS 1343 – 2012	Code of Practice for Prestressed Concrete
IS 1893 – 2016 (Amendment-2)	Criteria for earthquake resistant design of structures
IS 4326 –1993	Code of practice for Earthquake Resistant Design and Construction of Buildings
IS 3370 – 2009	Code of Practice for Concrete structures for the storage of liquids
IS 1904-1995	Code of Practice for design and construction of Foundation
IS 1080 – 1997	Code of Practice for design and construction of shallow Foundation

IS 2950 - 1998	Code of Practice for design and construction of Raft Foundation
IS 800 – 2007	Code of practice for General Construction in steel
BS 8110 : 1997	Plain and reinforced concrete-code of practice(British standard)
ACI 318	Plain and reinforced concrete-code of practice (American standard)
IS 13920: 2016	Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
IS:16700-2016	Criteria for Structural safety of Tall Concrete Buildings
IS 3414	Code of practice for joints in the buildings
IS 1956	Glossary of terms relating to iron and steel
IS 2062	Steel for general structural purpose (Grade-A)
IS 814	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel (part-1 & part-3)
IS 815	Classification coding of covered electrodes for metal arc welding of structural steel.
IS818	Code of practice for safety and health requirements in electric and gas welding.
IS 816	Code of practice for use of metal arc welding for general construction in mild steel
IS 1363	Hexagonal head bolts, screws and nuts of product Grade-C, part 1,2,3
IS 1364	Hexagonal head bolts, screws and nuts of product A&B
EN 1992-4 2013	Eurocode-2: Design of concrete structures. Part-4 Design of fastenings for use in concrete.

EN 1992-1 2004	Eurocode-2:Design of concrete structures.Part1:General rules and rules of building
AISC	Design Guide-1:Base plate and Anchor Rod
IS 1161	Steel tubes for structural purposes
IS 4923	Hollow steel section for structural use
IS 2062	Steel for General structural purpose specification
IS 6639	Specification for Hexagon Bolts for steel structures
IS 7205	Safety code for erection of structural steel work
IS 7215	Tolerances for fabrication of steel structures
IS 12843	Tolerances for erection of steel structures
SP 6(1)	Hand Book on structural steel sections
SP24	Explanatory Hand book on Indian standard code of practice For plain Reinforced concrete
SP34	Handbook on concrete reinforcement and detailing

3.0 DESIGN OF LOADINGS

SUPER IMPOSED DEAD LOADS AND LIVE LOADS

The following are the imposed loads such as SDL and LL to be considered for the design of floor system depending usage floor. In addition to these loads, self-weight of structural elements will be considered depending member sizes shown in the floor plans.

a) BASEMENT FLOORS

LOADINGS	DEAD LOAD (KN/m2)				LIVELOAD (kN/m2
	FINISHES	SERVICES	Non Reduce LL	PARTITION	
LOBBY	1.20	0.00	0.00	0.00	3.00
STAIRCASE	1.20	0.00	0.00	1.80 (step load)	3.00
RAMP	2.40	0.00	0.00	0.00	4.00
PARKING(car)	2.40	0.00	0.00	0.00	4.00
STP	1.80	0.50	Actual water load	0.00	7.50(pump room area)
LUMBER ROOM	2.40	0.00	0.00	0.00	3.00

b) GROUND FLOOR

LOADINGS	DEAD LOAD (KN/m2)				LIVE LOAD (KN/m2
	FINISHES	SERVICES	Non Reduce LL	PARTITION	
STAIRCASE	3.00	0.00	0.00	0.00	3.00
RAMP	2.40	0.00	0.00	0.00	4.00
PARKING (car)	2.40	0.00	0.00	0.00	4.00
LOBBY	1.20	0.00	0.00	0.00	3.00
ASSOCIATION ROOM	2.40	0.00	0.00	0.00	3.00
FIRE DRIVEWAY+ FILLING	9.00(0.45(Filling)*20+0.150*24)=12.6kN/m2				12.00
DG ROOM	2.40	0.50	10.00	0.00	0.00
TRANSFORMER YARD	2.40	0.50	10.00	0.00	0.00
ELECTRICAL ROOM	2.40	0.50	6.90	0.00	0.00
TOILET	3.60	0.00	0.00	0.00	2.00
BMS ROOM	2.40	0.00	0.00	0.00	3.00
MAIL ROOM	2.40	0.00	0.00	0.00	3.00

c) 1ST FLOOR

LOADINGS	DEAD LOAD (KN/m2)				LIVE LOAD (kN/m2
	FINISHES	SERVICES	Non Reduce LL	PARTITION	
STAIRCASE	3.00	0.00	0.00	0.00	3.00
POOJA ROOM	1.20	0.00	0.00	0.00	2.00
MASTER BEDROOM	1.20	0.00	0.00	0.00	2.00
LOBBY	1.20	0.00	0.00	0.00	3.00
LIVING & DINING	1.20	0.00	0.00	0.00	2.00
TOILET	3.60	0.00	0.00	0.00	2.00

LOADINGS	DEAD LOAD (KN/m2)				LIVE LOAD (kN/m2
	FINISHES	SERVICES	Non Reduce LL	PARTITION	
KITCHEN	1.20	0.00	0.00	0.00	2.00
UTILITY	5.00	0.00	0.00	0.00	2.00
BALCONY	2.40	0.00	0.00	0.00	3.00
SKY GARDEN	7.20	0.00	0.00	0.00	2.00
TERRACE	3.60	0.00	0.00	0.00	3.00

d) TYPICAL FLOORS (2ND TO 17TH FLOOR)

LOADINGS	DEAD LOAD (KN/m2)				LIVE LOAD (kN/m2
	FINISHES	SERVICES	Non Reduce LL	PARTITION	
STAIRCASE	3.00	0.00	0.00	0.00	3.00
POOJA ROOM	1.20	0.00	0.00	0.00	2.00
MASTER BEDROOM	1.20	0.00	0.00	0.00	2.00
LOBBY	1.20	0.00	0.00	0.00	3.00
LIVING & DINING	1.20	0.00	0.00	0.00	2.00
TOILET	3.60	0.00	0.00	0.00	2.00
KITCHEN	1.20	0.00	0.00	0.00	2.00
UTILITY	5.00	0.00	0.00	0.00	2.00
BALCONY	2.40	0.00	0.00	0.00	3.00

e) 18TH FLOOR

LOADINGS	DEAD LOAD (KN/m2)				LIVE LOAD (kN/m2
	FINISHES	SERVICES	Non Reduce LL	PARTITION	
GYM	7.50	0.00	0.00	0.00	3.00
STAIRCASE	3.00	0.00	0.00	0.00	3.00
RAMP	2.40	0.00	0.00	0.00	4.00
PARTY HALL	5.00	0.00	0.00	0.00	4.00
SWIMMING POOL	20.00	0.00	5.00	0.00	3.00
LANDSCAPE	0.00	0.00	12.80	0.00	0.00
LOBBY	1.20	0.00	0.00	0.00	3.00
TOILET	3.36	0.00	0.00	0.00	2.00
YOGA HALL	2.40	0.50	0.00	0.00	3.00
PANTRY	2.40	0.50	0.00	0.00	3.00

f) ROOF

OPEN TERRACE	3.60	0.00	0.00	0.00	5.00
OVER HEAD TANK	1.20	0.00	Actual water load=18.5	0.00	0.00
LMR	2.40	0.00	7.50	0.00	0.00

Permissible reduction in imposed load on each floor is considered for design of columns and footings as per IS 875 Part (2).

Super Imposed Dead Load (kN/m2)

(i) Floor finishes of 50mm thickness have been considered on all the floor (Basement-2 to 18thfloor). – 0.050x24 = 1.20kN/m^2.
(ii) Ramp finishes of 100mm thickness have been considered – 0.10x24 = 2.4kN/m^2
(iii) Toilet sunken 150mm- 0.15x24=3.60kN/m2.
(iv) Terrace water proofing thickness – Average 150mm screed, minimum 75mm and maximum 150mm is considered for design. The total SDL on terrace – 0.15 x 24= 3.60kN/m^2.

Note:

f) The Block Masonry wall loads in different thickness is mentioned below.

200mm thick light weight wall load per meter height	2.40kN/m (including plastering)
100mm thick light weight wall load per meter height	1.40kN/m (including plastering)

g) SEISMIC LATERAL FORCE

Design of lateral force under seismic condition shall be as per IS1893 – 2016. Total lateral force (base shear) of the building shall be estimated as per clause 7.2.1 of IS1893 – 2016 which provides by

Base shear $V_b = A_h W$

Ah is horizontal seismic coefficient and W is seismic weight of the building, Horizontal seismic coefficient depends on location of the building (Zone factor Z), usage of the building (Importance factor, I), building lateral resisting system (Response reduction factor, R) and design acceleration coefficient (S_a /g) which is based on subsoil condition and fundamental natural period (Ta).

For the proposed development is for residential use. Considering it, the seismic weight is summation of total dead load and 25% of live load where live load is lesser than 3.0kN/m^2 and 50% of live load where live load is greater than 3.0 kN/m^2.
The fundamental natural period (Ta) for building with shear walls

b) Buildings with RC structural walls:

$$T_a = \frac{0.075h^{0.75}}{\sqrt{A_w}} \geq \frac{0.09h}{\sqrt{d}}$$

where A_w is total effective area (m^2) of walls in the first storey of the building given by:

$$A_w = \sum_{i=1}^{N_w}\left[A_{wi}\left\{0.2+\left(\frac{L_{wi}}{h}\right)^2\right\}\right]$$

where

h = height of building as defined in **7.6.2**(a), in m;

A_{wi} = effective cross-sectional area of wall i in first storey of building, in m^2;

L_{wi} = length of structural wall i in first storey in the considered direction of lateral forces, in m;

d = base dimension of the building at the plinth level along the considered direction of earthquake shaking, in m; and

N_w = number of walls in the considered direction of earthquake shaking.

The value of L_{wi}/h to be used in this equation shall not exceed 0.9.

► The lateral load resisting system of the building with structural shear wall system.The structural shear walls are designed for 100% of lateral load.

► The lateral load resisting system of the buildings is "Ductile RC structural wall system"

► As per IS 1893:2016 code, Chennai lies in Zone III with Zone factor Z = 0.16

► The Design Base Shear is given by $V_b = A_h$ x W, Where A_h = Z / 2 x I / R x S_a / gI = Importance Factor = 1.2

Soil Type 2 (Medium or stiff soil)

R (Response reduction factor) = 4.0- (Buildings with ductile RC structural wall system)

S_a/g = Average Response acceleration coefficient

i. T = 0.09 h / √d (Refer IS 1893 - 2016 clause 7.6.2c),

ii. T = (0.075 $h^{0.75}$) / (√Aw) (Refer IS 1893 - 2016 clause 7.6.2b) ,

The time period has been calculated for all above specified cases and it ensured that the case (ii) time period is not lesser than case-(i).

Where,

T is Fundamental natural period

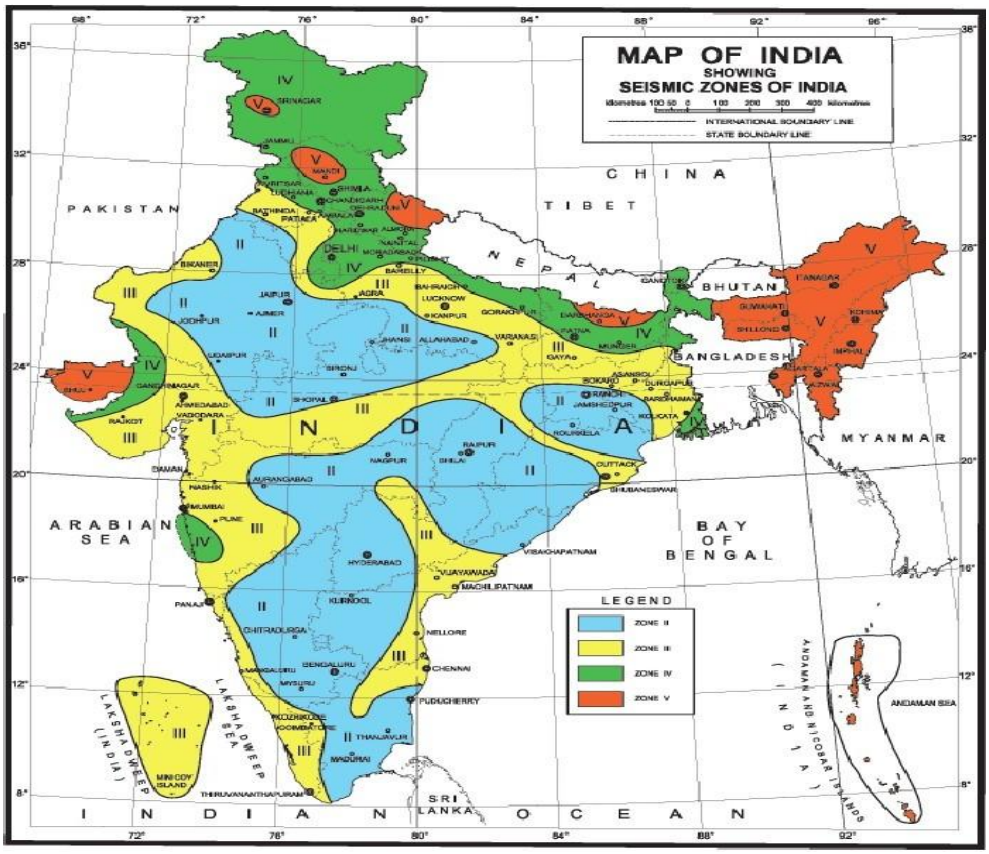
h = Height of the structure from Ground to roof for the building.

dx = Base dimension of the building in X-Direction

dy = Base dimension of the building in Y-Direction

Aw = Total effective area in square meter

Sl.No	Building description	Length (m)	Width (m)	Height (m)	Time period (sec)	
					Tax	Tay
1	TOWER	52.575	30.75	59.85	1.045	1.041



Dynamic Analysis

Response spectrum method of Dynamic Analysis carried out with following parameters pertaining to dynamic analysis.

Number of modes Considered : 15 Numbers (Min)

Modal Combination Method Used : Complete Quadratic combination (CQC).

Directional Combination Method used : Square root of the sum of Square (SRSS).

Modal case type : Ritz vector Method

h) WIND LOADS

The wind pressure shall be calculated based on the basic wind speed and other provisions laid in IS 875 Part (3) - 2015

Design Wind speed $V_Z = V_b x k_1 x\ k_2 x\ k_3 x\ k_4$

V_b ⟶ Basic Wind velocity for Chennai = 50m/s

k_1 ⟶ Risk coefficient for all general buildings = 1.00

k_2 ⟶ Terrain category 2 = To suit the height of the structure for terrain

Roof level K2 (H (GF to Roof) =61.17m) = 1.1856

k_3 ⟶ Topography = 1.00

k_4 ⟶ Importance Factor = 1.00

Based on the above,

Max. design wind speed (V_Z) ($V_b x k_1 x\ k_2 x\ k_3 x\ k_4$) = 59.28m/s

Max. design wind pressure (Pz) = 0.6 x Vz^2 =2108.50N/m2

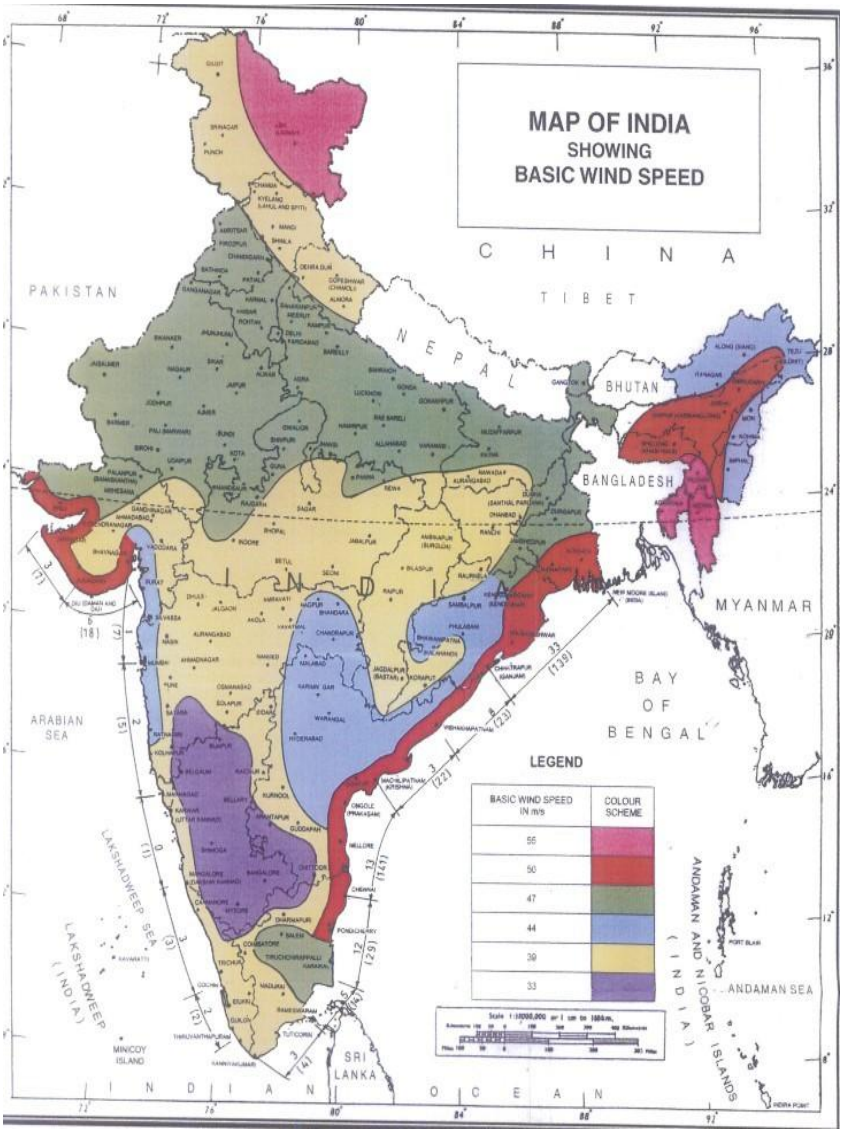
Design wind pressure: pd = Pz x Kax Kd x Kc =1452N/m2

But Pd shall not be less than 0.7*Pz, Hence Pd= 0.7*2108.50=1476 N/m2

Kd ⟶Wind directionality factor = 0.90

ka ⟶ Area averaging factor = 0.85

k_c ⟶ Combination factor = 0.90



SELF WEIGHTS

The Self-weights are calculated on the basis of unit weights of materials given in IS 875 (Part 1) the data provided by consultant and other service consultants will be used for the specific materials.

Material	Density
Reinforced Cement Concrete	25.00 kN/m^3
Plain Cement Concrete	24.00 kN/m^3
Screed Concrete	24.00 kN/m^3
Light weight blocks	10.00 KN/m^3
Structural Steel	78.50 kN/m^3
Cinder Concrete (Filling material)	08.00 kN/m^3
Dry soil	18.00 kN/m^3
Saturated soil	20.00 kN/m^3
Glass	27.20 kN/m^3
water	09.81 kN/m^3
Light weight concrete filling	08.00 kN/m^3
Solid block wall	22.00 kN/m^3

DEAD LOAD (DL)

These are permanent loads due to self-weight of RCC Slabs, Beam and Columns, RCC Walls and Infill walls.

LOADS ON M&E SERVICES AREA

Loads arising due to HVAC/ electrical, DG and other equipment's are considered as per the relevant integrated M&E consultant input.

TEMPERATURE LOAD

The building is completely covered with block work on the sides. So there will be no appreciable differential temperature during the service life of building. In addition to this, Temperature difference during construction stage is taken care by providing construction joints. The roof and podium slab of building is analysed for ± 20°C temperature is applied to Etabs model and necessary load combinations are considered in analysis & Design of the building.

Maximum mean Temperature	35°C
Minimum mean Temperature	20°C
Average ambient Temperature during construction	15°C

The maximum and minimum temperature for city of Chennai as recorded by Indian Metrological Department are as follows.

4.0 LOAD COMBINATIONS

The various loads shall be combined in accordance with the stipulations in IS 875 (Part 5) 1987 and IS 456: 2000. The structure will be checked for serviceability Limit State and Ultimate Limit State (Limit State of Collapse) conditions. The load factors to be used for the load combinations are shown in the Table below. The structural elements shall be designed and checked for the critical forces from the combinations.

The various loads combinations used for design in accordance with IS 1893-2016 are as follows

1. 1.5 (DL + LL) + 1 Temp
2. 1.2 (DL + LL + SPECX+30%SPECY+30%SPECZ)+1Temp
3. 1.2 (DL + LL + SPECY+30%SPECX+30%SPECZ)+1Temp
4. 1.2 (DL + LL + SPECZ+30%SPECX+30%SPECY)+1Temp
5. 1.2 (DL + LL ± WindX)+1Temp
6. 1.2 (DL + LL ± WindY)+1Temp
7. 1.5 (DL + SPECX+30%SPECY+30%SPECZ)+1Temp
8. 1.5 (DL + SPECY+30%SPECX+30%SPECZ)+1Temp

9. 1.5 (DL + SPECZ+30%SPECX+30%SPECY)+1Temp
10. 1.5 (DL ± WindX)+1Temp
11. 1.5 (DL ± WindY)+1Temp
12. 0.9DL + 1.5(SPECX+30%SPECY+30%SPECZ)+1Temp
13. 0.9DL + 1.5(SPECY+30%SPECX+30%SPECZ)+1Temp
14. 0.9DL + 1.5(SPECZ+30%SPECX+30%SPECY)+1Temp
15. 0.9DL ± 1.5WindX+1Temp
16. 0.9DL ± 1.5WindY+1Temp

Load Combination for foundation sizing

17. DL+LL+Temp
18. DL+0.8LL+0.8(SPECX+30%SPECY+30%SPECZ)+Temp
19. DL+0.8LL+0.8(SPECY+30%SPECX+30%SPECZ)+Temp
20. DL+0.8LL+0.8(SPECZ+30%SPECX+30%SPECY)+Temp
21. DL+1(SPECX+30%SPECY+30%SPECZ)+Temp
22. DL+1(SPECY+30%SPECX+30%SPECZ)+Temp
23. DL+1(SPECZ+30%SPECY+30%SPECX)+Temp
24. DL+0.8LL±0.8WX+Temp
25. DL+0.8LL±0.8WY+Temp
26. DL±WX+Temp
27. DL±WY+Temp

Where,

DL - Dead load,
LL - Live load
FTL - Fire Tendor load,
WindX - Wind load in x-direction
WindY - Wind load in y-direction
SPECX - Earthquake load in x-direction (Dynamic)
SPECY - Earthquake load in y-direction (Dynamic)

5.0 MATERIAL GRADES

i) Concrete

Characteristic concrete strength (concrete grade) for the project shall be based on exposure condition and forces to be supported by specified structural elements. The minimum cement content and maximum water–cement ratio shall be as per IS code 456:2000. The minimum 28-day compressive strength of concrete for specified structural elements shall be as follows

Table C. Grade of Concrete for Individual Structural elements of Tower/Non-Tower areas

Sl.No.	Structural Elements	Grade of Concrete

1.	Foundation and basement wall	M30
2.	Basement 2 Slab	M30
3.	RC Shear wall & Column	M50
4.	Slab & beam	M35 – Basement-1 to Roof
5.	Water Tank/STP	M30

Table D Concrete Properties

Young's Modulus of Elasticity of Concrete	$5000\sqrt{fck}$
Poisson Ratio's Ratio v =	0.2

ii) Reinforcement

On confirming to IS 1786-2008 for Fe550 and IS 432-1982 for Fe415, The characteristic tensile properties of steel in design shall be as follows.

Reinforcement Characteristic yield strength f_y (N/mm^2)	$550N/mm^2$
Young's Modulus E (kN/mm^2)	$200kN/mm^2$
Poisson's ratio	0.3
Coefficient of Thermal expansion, α ($^oC^{-1}$)	$12x10^{-6}$
Density	$78.5\ kN/m^3$
Diameters [in mm]: 8, 10, 12, 16, 20, 25, 32 & 40	

iii) Structural steel

All structural steel shall conform to Indian standard IS: 2062-2011.

Structural steel	Grade E=250	Grade E-350
Tensile strength	410 N/mm^2	490 N/mm^2
Yield stress t<20mm	250 N/mm^2	350 N/mm^2
Yield stress t = 20mm to 40mm	240 N/mm^2	330 N/mm^2
Yield stress t> 40mm	230 N/mm^2	320 N/mm^2
Young's Modulus (E)	200,000 N/mm^2	200,000 N/mm^2
Density	78.5 kN/m^3	78.5 kN/m^3

Self-Weight:

Self-weight is in accordance to the member size specified in the GA drawing considering the density of concrete as 25 kN/m^3.

Super Imposed Load:

Super Imposed Loads (Service Load, Floor Finish and Super imposed dead loads)considered as mentioned above Design load.

Live Load:

Live Loads are considered as mentioned in above design loads.

6.0 COVER AND FIRE RATING

Fire rating considered - 2hrs.

Cover to reinforcement considered for various elements

Pile Cap	75 mm (Very severe exposure condition)
Basement wall- Outer face (Soil side)	45 mm (Severe exposure condition)
Basement wall- Inner face	30 mm
Columns	40 mm (2 hours fire resistance)
Tank walls- Inner face (Water side)	45 mm (Severe exposure condition)
Tank walls- Outer face (If its soil side)	45 mm (Severe exposure condition)
Tank walls- Outer face (If its inside the building)	30 mm
Shear Walls	30 mm (2 hours fire resistance)
Beams (simply supported)	40 mm (2 hours fire resistance & Moderate)
Beams (continuous)	30 mm (2 hours fire resistance & Moderate)
Slabs (simply supported)	35 mm (2 hours fire resistance & Moderate)
Slabs (continuous)	25 mm (2 hours fire resistance & Moderate)

7.0 DEFLECTION CRITERIA

7.1 Lateral Deflection (Wind)

- Overall Deflection < Height/500
- Storey Deflection < Storey height/500

7.2 Lateral Deflection (Seismic)

- Overall Drift < H / 250
- Storey Drift < 0.004 times storey height

7.3 Vertical Deflection of Beams and Slabs due to Gravity Loads

- Total Deflection (DL + LL) < Span/250

- Deflection including the effects of Temperature, Creep and ShrinkageOccurring after erection of partitions and the application of finishes < Span/350 or 20mm whichever is less

7.4 Crack width Limits

The Limiting values of crack width as per clause 35.3 of IS: 456-2000 is followed in the design

- In general, for slabs and beams, the crack width is limited to 0.3mm.
- For STP and UG Sump water retaining structures crack width is limited to 0.2mm.

8.0 STRUCTURAL SYSTEM

a. Sub Structure

The Sub Structure is RCC slab and RCC Beam system.

For ground floor extended podium the structural system is RCC Beam and RCC Slab system.

b. Super Structure

The super structure is RCC slab and RCC Beam system.

9.0 STRUCTURAL ANALYSIS

Computer-aided analysis using finite element method (FEM) shall be carried out for the Analysis of structure.

Assumptions:

- The structure is idealized as 3D space frame and analysed using Etabs software package for both vertical and lateral loads.
- The structure is analysed for specific loads like dead load, live load, wind and seismic loads and for the load combinations as given in the relevant codes.

► Column: Frame Element

► RC Wall: Wall (Shell) Element

► Beam Element: Frame Element

► Slab: Shell Element

For 3D or 2D structural frame analysis ETABS or SAFE software shall be used, Prokon, RCDC and verified in-house spreadsheets will be used for the design of reinforced concrete (RC) and steel elements in consideration of flexure, shear and axial forces.

The following are general parameters adopted in the analysis and design,

Consideration of Diaphragm - Rigid Diaphragm.
Slab/Wall element considered as Shell element

Stiffness modification factors are adopted in the analysis as per IS -16700-2017, Table.6.

Table 6 Cracked RC Section Properties
(Clause 7.2)

Sl No.	Structural Element	Un-factored Loads		Factored Loads	
		Area	Moment of Inertia	Area	Moment of Inertia
(1)	(2)	(3)	(4)	(5)	(6)
i)	Slabs	1.0 A_g	0.35 I_g	1.00 A_g	0.25 I_g
ii)	Beams	1.0 A_g	0.7 I_g	1.00 A_g	0.35 I_g
iii)	Columns	1.0 A_g	0.9 I_g	1.00 A_g	0.70 I_g
iv)	Walls	1.0 A_g	0.9 I_g	1.00 A_g	0.70 I_g

The following parameters and methods are adopted in creating ETABS 3D model for the buildings and design of structural elements.

- The 3D ETABS model generated based on the floor plans (shuttering drawings).
- Sectional properties are assigned to all the structural elements as per the framing plans (shuttering drawings).
- External & Internal in fill wall loads are assigned as uniformly distributed line load on beams and as line load if the wall is intending to distribute on slab directly.
- Slabs are modelled as shell element except the staircase. The slabs are assigned as rigid 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/SDL 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.
- 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 0.000001 to torsional constant "J".
- Concrete cover to reinforcement complied accordance with IS 456-2000, Table.16 & 16A.
- All vertical wall elements are assigned with auto meshing/manual messing appropriately in order to achieve accuracy in results.

Design approach of structural elements

Shear wall/Column

RC Structural Walls & Columns which are supporting both vertical loads and lateral forces are designed for the most adverse load conditions and envelope of the forces which will be the maximum for that structural element from the load combinations considered in the 3D Etabs Model.

RCDC a design software will be used to design the element for the maximum forces obtained from the Etabs model analysis results.

Beams

Each Beam will be designed for maximum forces from the 3D analysis. The RCC beams are designed using RCDC Software and the PT beams are design using Adopt /RAPT Prestress concrete design software shall be used to design of RC or PT members.

Slabs

Flat Slabs which are Post Tension slab will be designed using software Adopt /RAPT. Basement-2 slab has to be checked for flotation against uplift pressure. Suitable preventing system has to be designed to balance uplift force.

Basement wall: (Retaining wall)

Lateral pressures on the basement walls will be related to the properties of the natural soils and/or the backfill material that surround it and the load applied by compaction plant. Unless otherwise noted, the following values will be used for design of retaining elements

Natural Soils

Fill density

Material	Unit weight kN/m3
Silty clay	20.50
Clayey Silty sand	21
Completely Weathered Rock	21

Characteristic Effective Shear Resistance Angle

Material	Phi (degrees)
Silty clay	30
Clayey Silty sand	42.5
Completely Weathered Rock	42.5

Granular back

Fill density

Material	Unit weight kN/m3
Course granular backfill	20

Characteristic Effective Shear Resistance Angle

Material	Phi (degrees)
Course granular backfill	30

Hydrostatic pressure

With reference to the soil investigation recommendation in the design of basement wall the water level is considered 5.0m From the EGL.

Support condition:

The basement 2 level support considered as fixed support and the other floor level supports are considered as prop support.

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

Line (Wall) Load & Application: Non load bearing or infill wall loads are calculated Appropriately and Applied as uniformly distributed line load.

11.0 FOUNDATION

With reference to the soil investigation report No-G© 2069 from Dr. C.V. Prasad , Geo Marine Consultants Pvt. Ltd, recommended as follows,

4.3 FOUNDATION SYSTEM:

In the present project, adopt pile foundation as no shallow foundation system is feasible from both soil shear and compressibility characteristics of the underlying sub soil formation.

5.1 RECOMMENDATION FOR PILE FOUNDATION SYSTEM:

- For the kind of proposed structure Bored Cast in situ piles are recommended as the suitable foundation system.
- The allowable safe load carrying capacities of different diameters of piles as given in Table-4.1 can be adopted as provisional design loads, as the load carrying capacity of piles is not only depends upon the sub soil properties, but also depends on the care and experience of installation piles.

TABLE:- 4.1 RECOMMENDED SAFE LOAD CARRYING CAPACITIES OF BORED CAST-IN SITU PILES

Sl.No	Reference Bore hole No.	Length of Pile below E.G.L	Assumed Length of Cut-Off Below E.G.L	Length of Pile below Cut-off	Dia.of Pile in (mm)	SAFE LOAD CARRYING CAPACITY (kN)		
						Vertical Load Carrying Capacity	Pull Out Capacity	Lateral Load Carrying Capacity
1.0	BH-01	23.0	9.0	14.00	500	1400	700	25
2.0					600	1900	800	30
3.0					750	2500	1000	35
4.0					900	3500	1200	45
5.0					1000	4000	1400	50

Basement 2 slab design for uplift pressure of 5T/m2 and for Basement wall 5.0m from the existing ground level considered for the design.

12.0 COMPUTER PROGRAMS

The following Software / spreadsheet to be used to carry out Structural analysis and design.

1. PROKON Ver 2.3 - Wall & Beam design
2. ETABS Ver 19.1.0 - Three Dimensional Program
3. SAFE Ver 20.3.0 - Raft Analysis / Strip Analysis
4. In-House Spreadsheet - one way/ two way slab design
5. Rapt-6 - Post Tensioning Analysis & Design
6. RCDC - Beam Design, Foundation design, Column design and Wall design
7. STAAD PRO & ETABS - Structural Steel Design.



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