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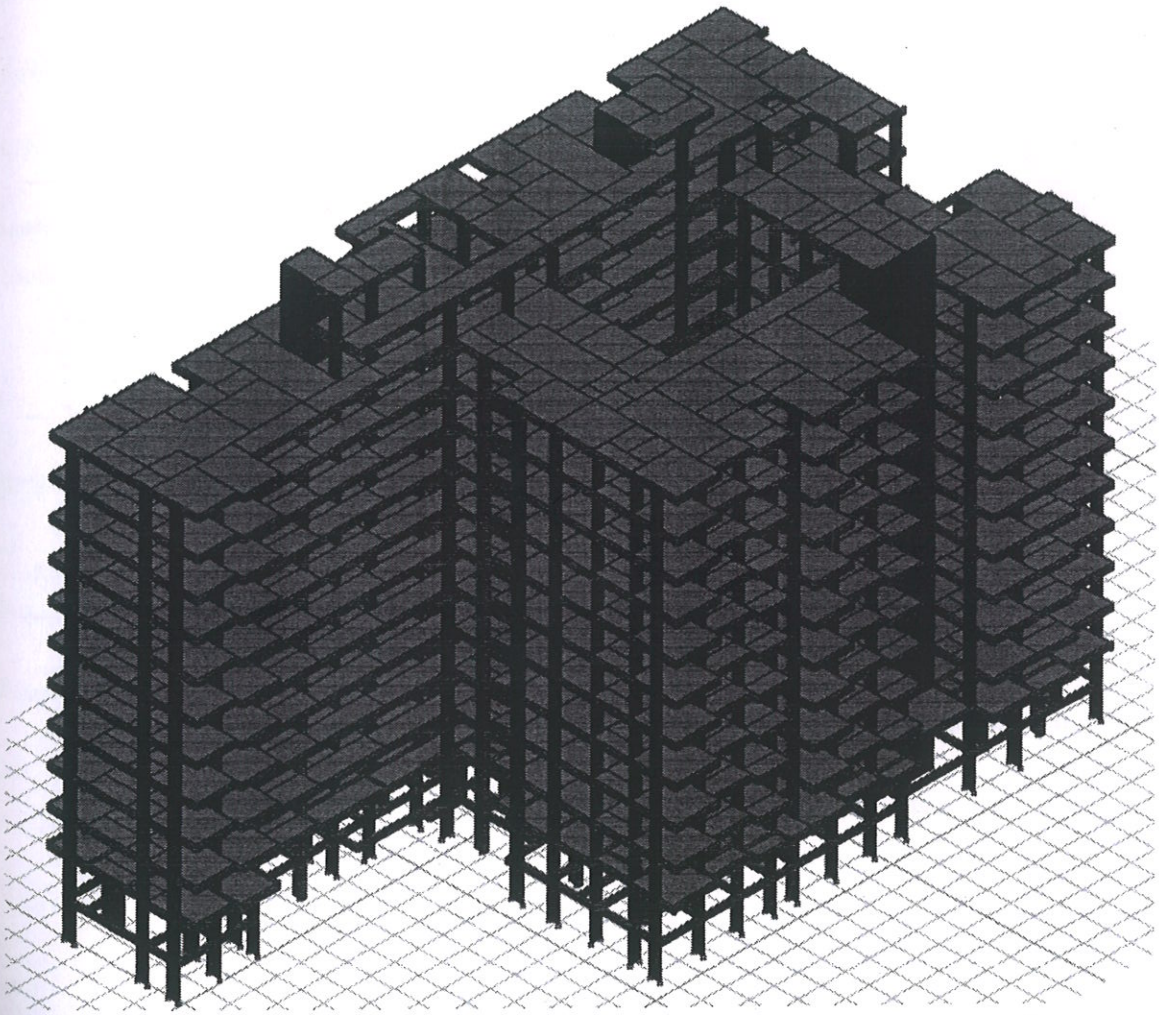


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PROPOSED RESIDENTIAL BUILDING AT GANDHI NAGAR, 3rd CROSS STREET, PERUMBAKKAM, and CHENNAI-100. COMPRISED IN OLD S.NO: 310/2A3, 310/2B, 310/3, 311/1 & 311/1B, AS PER PATTA NO: 5076, 3753, 20114 & 20082, NEW S.NO:310/2A3A, 310/2B1, 310/3B, 311/1A, 311/1B1 & 311/1B2 OF PERUMBAKKAM VILLAGE, TAMBARAM TALUK, CHENGALPATTU DISTRICT WITHIN THE LIMIT OF ST.THOMAS MOUNT PANCHAYAT UNION.

RESIDENTIAL BUILDING - Structural Design Report

AUGUST -2024



STRUCTURAL CONSULTANT

C.KANNAN B.E., M.E (STRUCTURE)
INDIRA NAGAR, CHENNAI-20.

C. KANNAN, B.E., M.E, (Structure)
Structural Engineer,
CMDA Reg. No: SE/I/2024/2/0047
Door No: 21, 4th Main Road,
Indira Nagar, Chennai-600 020.

1.1 FOREWORD

1.1.1 - Description of Project

M/s.Urbando Housing LLP, Chennai is developing a High rise residential building (Stilt + 10 upper floors) at Perubakkam , Chennai. This project is designed to provide a generous and comfortable habitat, complete with facilities that cater to a relaxed and convenient lifestyle. The project construction is carried out as RCC framed structure with Shear wall and RCC Slab system. The building is designed with accessibility in mind as well as earthquake-resistant construction to ensure the well-being of occupants.

1.1.2 – Objective of the Report

The objective of this report is to provide and furnish complete details related to Project and structural analysis and design considerations.

1.1.2 – Scope of the Report

The Structural Report covers the complete Structural Elements design considerations for analysis of lateralloads & gravity loads.

1.2 CODES, STANDARDS AND REFERENCES

Statutory Requirements:

The design of structural and other building services will comply with the following requirements:

- National Building Code The Building Regulations
- The Environmental Protection Act in liaison with the Environmental Agency.
- Fire prevention and detection in compliance with the local Fire Regulation.

DESIGN STANDARDS:

Specific applicable codes and standards will be identified and adopted in the design philosophies as appropriate to the structural elements. The latest editions of the Codes and Standards will be used indesigns. All design work shall be based on Indian Standards and Codes with latest revision, with amendments if any, as on date.

Loads:

IS: 875 -2015	-	Code of Practice for design loads (other than earthquake) for Buildings & structure (All parts)
IS: 1893-2016	-	Criteria for earthquake resistant design of structure

Foundations:

IS: 1080-1985(2016)	-	Code of Practice for design and construction of shallow foundations on soils(other than raft, ring and shell)
IS: 1904-1986(2015)	-	Code of Practice for design and construction of foundations in soils general requirement
IS: 2911-1980(2013)	-	Code of Practice for design and construction of pile foundations (All parts)
IS: 2950-1981(2013)	-	Code of Practice for design and construction of raft foundations
IS: 2974-1998(2013/2015)	-	Code of Practice for design and construction of machine Foundations(All parts)
IS: 8009-1976/1980(2013/2015)	-	Code of Practice for calculation of settlement of foundations (All parts)

RCC:

IS: 456 -2000(2016)	-	Code of Practice for plain and reinforced concrete
IS: 458 -1988	-	Specification for precast concrete pipes
IS: 3370-2009	-	Code of Practice for concrete structures for the storage of liquids:(All parts)
IS: 4326-2013	-	Code of Practice for earthquake resistant design and construction of building
IS: 5525-1969(2013)	-	Recommendation for detailing of reinforced concrete works
IS: 1786-2008	-	Code of Practice for design and construction of machine Foundations(All parts)
IS: 5525-1969(2013)	-	Specification for high strength deformed steel bars and wires for concrete reinforcement
IS: 1786-2008	-	Recommended guidelines for concrete mix design
IS: 10262-2009	-	Criteria for earthquake resistant design of structures (General provisions and building).
IS: 1893 (Part-1)-2016	-	Criteria for structural safety of Tall Concrete buildings
IS: 16700 – 2017	-	Ductile design and Detailing of Reinforced concrete structures subjected to Seismic forces – Code of practice
IS: 13920 – 2016	-	Ductile design and Detailing of Reinforced concrete structures subjected to Seismic forces – Code of practice
IS: 1343 – 1980	-	Code of practice for Prestressed concrete

Miscellaneous:

IS: 432(part 2)-1995	-	Specification for mild steel and medium tensile steel bars and hard-drawnsteel wire for concrete reinforcement
IS: 6313(part II)-2001	-	Standards for anti-termite treatment
IS: 1905-1998	-	Code of Practice for structural use of unreinforced masonry
IS: 3067-1995	-	Code of Practice for general design details and preparatory works for damp proofing and water proofing of buildings
SP: 6 -1998	-	Handbook for structural engineers (all parts)
SP: 7 -2005	-	National Building Code of India
SP: 16-1999	-	Design Aids for reinforced concrete to IS:456-1978
SP: 22-1982	-	Explanatory handbook on codes for earthquake engineering (IS:1982-1975and IS:4326-1976)
SP: 24-1983	-	Explanatory handbook on Indian Standard code of Practice for plain andreinforced concrete
SP: 34-1987	-	Handbook of concrete reinforcement and detailing (SCIP)

Material:

IS: 269 -2015	-	Specification for Ordinary, rapid hardening and low heat Portland cement'
.IS: 455 -1995	-	Specification for Portland blast furnace slag cement.
IS: 1489-1991	-	Specification for Portland pozzolana cement
IS: 4031-1991	-	Method of physical tests for Portland cement.
IS: 383 - 2016	-	Specification for coarse and fine aggregates from natural sources for concrete.
IS: 516 – 1999	-	Method of test for strength of concrete
IS: 1199-1999	-	Method of sampling and analysis of concrete.
IS: 1566-2000	-	Specification for plain hard drawn steel wire fabric for concrete reinforcement
IS: 4990-1998	-	Specification for plywood for concrete shuttering works.
IS: 2645-1999	-	Specification for integral cement water proofing compounds.

1.3 DESCRIPTION OF STRUCTURE

1.3.1 Building Description

The Development consists of the following:

a. Residential building floor covered with RCC roofing.

The usages of individual floors are as given below:

Floors	Details
Main Residential Building	Space for living Purpose

1.3.2 Structural Arrangement:

The Structural System for the residential buildings comprises of RCC column and beam and slab.

S.No.	Description	Details
1.	Column Grids	3.60 m x 2.10 m (Varies for some grids)
2.	Structural System	RCC Shear Wall & Column
3.	Slab Thickness RCC Slab	Min. 120mm (Varies on span)
4.	Foundation	Pile Foundation
5.	Column	As per design
6.	Beams	As per design

1.4 DESIGN APPROACH

1.4.1 – Design Life.

The design life of the building is assumed as 50 years. This requirement is applicable only for concrete works and not applicable to replaceable finishing materials, water proofing membrane and thermal insulations (if any). Hence periodic maintenance / refurbishment are required for all replaceable material for longer life.

1.4.2 – Material Properties.

Materials specified will conform to the latest edition of the relevant Indian Standard or other accepted standard. Specifications for materials will include sampling and testing as stipulated in the design standards. Detailed material specifications will be included in the Technical Specification.

Concrete:

All structural concrete shall have cube crushing strength of 40 N/sq.mm (M35) at 28 days.Plain cement concrete shall have cube crushing strength of 10 N/sq.mm (M10) at 28 days.

Concrete Mix:

Concrete Item	Grade
Pile Foundation	M30
Columns	M40
Slabs & Beams	M30

Reinforcement steel:

- All reinforcement shall confirm to IS: 1786 – 1985 having minimum yield strength of 500 N/sq.mm.Corrosion resistant steel is not required.

1.4.3 – Design loads

Dead loads:

Dead load shall include weight of all structural and Architectural components. Self-weight of the materials shall be calculated on the basis of unit weights given in IS: 875.

- Floor finish of 75 mm thickness : 75 kg/sqm
- Self-weight of Plain concrete : 2400 kg/cum (24 kN/cum)
- Self-weight of RCC : 2500 kg/cum (25 kN/cum)
- Aerocon block masonry : 700 kg/cum (7 kN/cum) [For walls]
  (With additional 15mm thick plastering on external surface and 12mm plastering on internal wallsurfaces)
- Soil (Dry) : 1800 kg/cum (18 kN/cum)
- Soil (Wet : 2000 kg/cum (20 kN/cum)
- Water : 1000 kg/cum (10 kN/cum)
- Masonry with plastering : 2200 kg/cum (22 kN/cum)
- Wall loads : As per actuals

Live loads:

The superimposed loads shall be calculated in accordance with IS: 875(Part-2) based on Occupancy Classification. For multiple occupancies of use in the building shall be referred with the other appropriate comparable occupancy classification as per Table.1 of IS 875(Part-2)-1987.

Following live loads are considered while designing the structural elements apart from the dead loads asper codes.

Floor Live loads:

- Living Area : 200 kg/sqm (2.0 kN/sqm)
- Stairs : 300 kg/sqm (3.0 kN/sqm)
- Corridors / Balcony : 300 kg/sqm (3.0 kN/sqm)
- Toilets : 200 kg/sqm (2.0 kN/sqm)
- Terrace with Access : 200 kg/sqm (2.0 kN/sqm)
- Electrical rooms : 400 kg/sqm (4.0 kN/sqm)

Sunken Details:

- Toilet : 250mm

Wind Loads

The Wind pressure shall be calculated in accordance with IS: 875 (Part-3):2015.Chennai has a high wind speed of 50m/s.

Basic Wind Speed V_b : 50 m/s

Risk Coefficient k_1 : 1.00 (k_1 corresponds to 50 years Mean Probable Design Life of Structure)

Terrain, height, structure size factor k_2 : To suit the height of the structure for terrain category 2

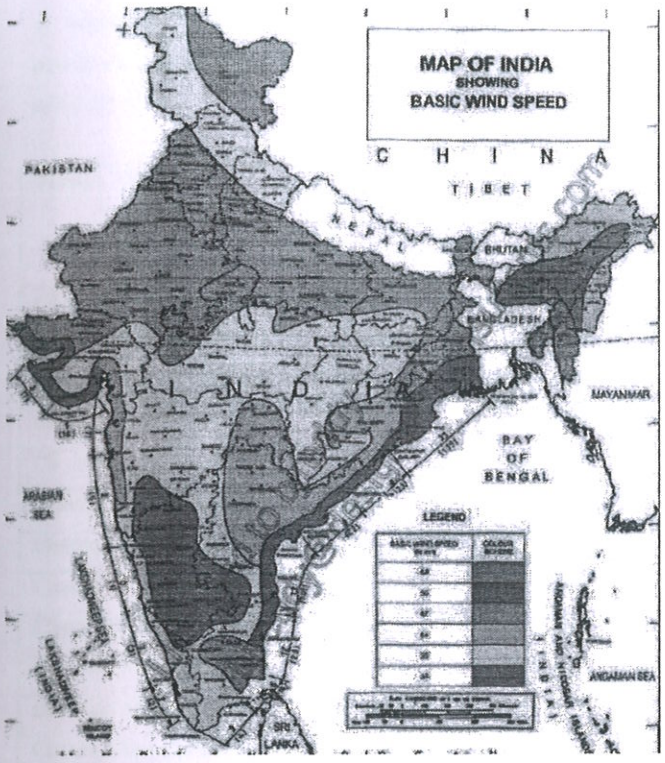
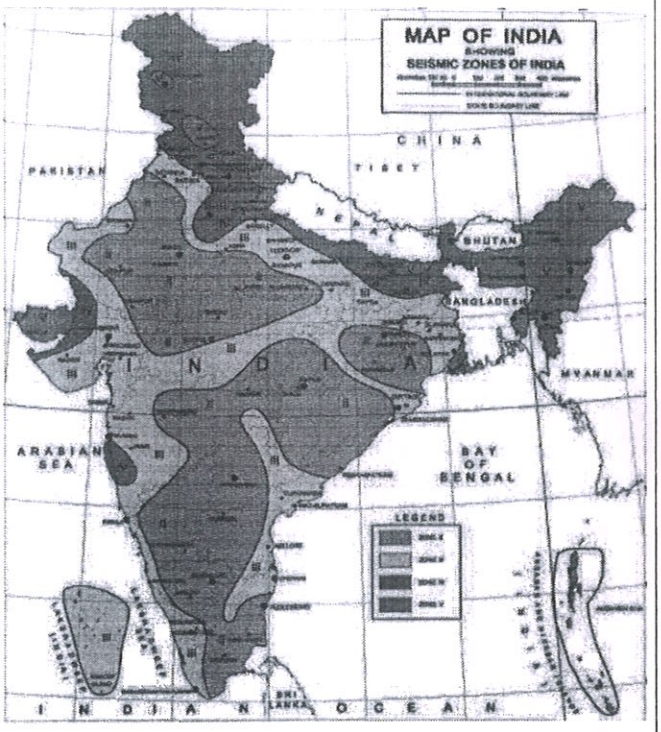
Topography factor k_3 : 1.0

Importance factor for cyclonic region k_4 : 1.00

The external and internal pressure co-efficient shall be as per respective clauses of IS: 875 (Part 3):2015 Design

Wind speed V_z : $V_b \times k_1 \times k_2 \times k_3 \times k_4$

Design Wind Pressure, P_z : $0.6V_z^2$

Map showing basic wind speed	Map showing seismic zones
	
Basic wind speed in m/s (based on 50-year return period)	Seismic zones of India

Seismic Forces:

Chennai falls under seismic zone III as per IS 1893-2016 (Part 1) (Sixth Revision) and has the following factors to be considered for designs. Ductile detailing is required. (Please refer attached map above)

Seismic Zone	: III
Seismic Zone factor, Z	: 0.16 (As per Table 3; IS: 1893-2016)
Design horizontal seismic coefficient (Ah)	: $(Z/2)*(S_a/g)*(I/R)$
I -Importance factor	: 1.2 (Ref Table 8; IS: 1893-2016)
Response reduction Factor	: 4
Soil type	: Type -1
Damping Ratio for RCC	: 5 %

Sa/g – Average response acceleration coefficient for soil sites as per Fig.2 of IS: 1893-2016 and it is arrivedbased on appropriate fundamental natural period of structure as per Cl 7.6.2 (b)

Design horizontal seismic coefficient (A_h)	: $(Z/2)*(S_a/g)*(I/R)$
	: $(0.16/2)*(1.2/4) * (S_a/g)$
A_h	: $0.024 * (S_a/g)$
Design seismic base shear, V_b	: $A_h * w$ where, w - seismic weight of building
Effect of infill panels	: Not considered in the analysis

Table No : 03

Seismic Zone Factor Z

(Clause 6.4.2)

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

Temperature Loads:

The effect of temperature will be considered wherever applicable in accordance with relevant Indian Codes. Minimum & maximum temperatures considered are as shown in the table below. Same will be used for the analysis & design. The coefficient for thermal expansion and contraction will be in accordance with IS: 456 and IS: 800 for concrete and steel respectively.

Station Name	Month	Period	No. of Years	Mean Temperature in Degree C		Mean rainfall in mm
				Maximum	Minimum	
Chennai (Minambakkam)	January	1901-2000	100	28.8	20.4	35.3
Chennai (Minambakkam)	February	1901-2000	100	30.5	21.1	13.0
Chennai (Minambakkam)	March	1901-2000	100	32.6	23.0	14.5
Chennai (Minambakkam)	April	1901-2000	100	34.7	25.8	15.9
Chennai (Minambakkam)	May	1901-2000	100	37.4	27.6	42.4
Chennai (Minambakkam)	June	1901-2000	100	37.3	27.4	53.9
Chennai (Minambakkam)	July	1901-2000	100	35.3	26.1	99.6
Chennai (Minambakkam)	August	1901-2000	100	34.5	25.5	129.9
Chennai (Minambakkam)	September	1901-2000	100	33.9	25.2	123.5
Chennai (Minambakkam)	October	1901-2000	100	31.8	24.2	284.6
Chennai (Minambakkam)	November	1901-2000	100	29.4	22.6	353.0
Chennai (Minambakkam)	December	1901-2000	100	28.4	21.2	146.3

[Source: National Data Centre: ndc@imdpune.gov.inDGM (Sectt.): dgm.hq@imd.gov.in]

Considering the average **daily** maximum temperature as 34 degrees and minimum as 24 degrees, the variation in temperature for analysis is considered as **10 degrees.** [Source https://www.wunderground.com/history/airport/VOMM/2016/1/4/CustomHistory.html?dayend=5&monthend=2&yearend=2017&req_city=&req_state=&req_statename=&reqdb.zip=&reqdb.magic=&reqdb.wmo=]

Temperature and shrinkage effect:

Horizontal floor displacement due to differential temperatures and shrinkage is of importance in long concrete buildings. It can be taken care of by either providing expansion joints at an appropriate spacing or designing structural members for the additional moments caused by the temperature and shrinkage effects. Pour strips at suitable locations shall also be considered where required.

Exceptional Loads:

Loads due to the following catastrophe scenarios are not considered in the design:

- Exceptional loads due to terrorist attacks (Explosions)
- Accidental loads (Falling of aircraft on the building)
- Accidental collision of vehicles on the façade of the building

On behalf of CMDA MSB Panel the Structural design Calculations are Generally reviewed.

Superintending Engineer, P.W.D.,
Planning and Designs Circle,
Chepauk, Chennai-5.

1.4.4 Durability Considerations:

Environmental conditions, Corrosion and Fire protection for concrete and structural steel

- Environment : Moderate
- Exposure conditions : Concrete surfaces exposed to moderate environment
- Minimum grade of Concrete : Moderate Exposure – M25

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(Clauses 6.1.2, 8.2.4.1 *and* 9.1.2*)*

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
ii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

1.4.5 Fire Rating

Thickness of the structural elements as per table 15, 16 & 16A clause 26.4 of IS 456-2000.

Fire Resistance h	*Minimum Beam Width b*	*Rib Width of Slabs b_w*	*Minimum Thickness of Floors D*	*Column Dimension (b or D)*			*Minimum Wall Thickness*		
				Fully Exposed	50% Exposed	One Face Exposed	$p<0.4\%$	$0.4\% \le p \le 1\%$	$p>1\%$
	mm	mm	mm	mm	mm	mm	mm	mm	mm
0.5	200	125	75	150	125	100	150	100	100
1	200	125	95	200	160	120	150	120	100
1.5	200	125	110	250	200	140	175	140	100
2	200	125	125	300	200	160	–	160	100
3	240	150	150	400	300	200	–	200	150
4	280	175	170	450	350	240	–	240	180

NOTES

1 These minimum dimensions relate specifically to the covers given in Table 16A.

2 p is the percentage of steel reinforcement.

FIG. 1 MINIMUM DIMENSIONS OF REINFORCED CONCRETE MEMBERS FOR FIRE RESISTANCE

Nominal covers for 2 hr. fire resistance:

Nominal Cover						
Beams		Slabs		Ribs		Columns
Simply supported	Continuous	Simply supported	Continuous	Simply supported	Continuous	
mm	mm	mm	mm	mm	mm	mm
40	30	35	25	45	35	40

1.5 ANALYSIS METHODOLOGY:

This structure has a physical interface with almost all the disciplines like geotechnical works, MEP services,etc. The structure proposed is of cast in-situ concrete construction with columns suitably placed. The vertical loads including the dead and super imposed loads are transferred to the soil through columns and foundation. Foundations are sized with consideration to the safe bearing capacity of soil at the level of transfer of load recommended by specialist soil investigation consultants.

1.5.1 Assumptions:

- The structure is idealized as 3D space frame and analyzed using ETABS software package for both vertical and lateral loads.
- The structure is analyzed for specific loads likc dcad load, livc load, wind, and seismic loads and forthc load combinations as given in the relevant codes.
- The foundation is represented in analysis model using fixed end conditions.

1.5.2 Mathematical model

Mass Modelling:

Mass Source as per IS: 1893_2016 is considered as follows.

Mass source = DL+SDL+ 0. 5LLWhere DL - Dead Load;

SDL – Super Imposed Dead Load;LL - Live Load

1.5.3 Static Analysis:

The following Static loads cases are considered in the analysis.

DL - Dead Load which includes self-weight of the structure.

SDL – Super Imposed Dead Load, including load due to finishes, wall Loads, Soil filling loads etc.

LL - Live Load

1.6 LOAD COMBINATIONS:

Load combinations Used for Strength, Serviceability are tabulated below:

Load Combination	Limit State of Collapse			Limit State of Serviceability		
	DL+SDL	*LL*	*WL/EL/TL*	*DL+SDL*	*LL*	*WL/EL/TL*
DL + LL	1.5	1.5	—	1	1	—
DL + WL	1.5 or 0.9*	—	1.5	1	—	1
DL + EL	1.5 or 0.9*	—	1.5	1	—	1
DL + TL	1.5	—	1.5	1	—	1
DL+LL+WL	1.2	1.2	1.2	1	0.8	0.8
DL+LL+EL	1.2	1.2	1.2	1	0.8	0.8
DL+LL+TL	1.2	1.2	1.2	1	1	1
DL+WL+TL	1.2	—	1.2	1	—	1
DL+EL+TL	1.2	—	1.2	1	—	1
DL+LL+EL+TL	1.2	1.2	1.2	1	1	1

Response spectrum combinations:

- 1.2[DL+LL+(SPECX+0.3 SPECY+0.3 SPECZ)]
- 1.2[DL+LL+(SPECY+0.3 SPECX+0.3 SPECZ)]
- 1.5[DL+(SPECX+0.3 SPECY+0.3 SPECZ)]
- 1.5[DL+(SPECY+0.3 SPECX+0.3 SPECZ)]
- 0.9DL+1.5(SPECX+0.3 SPECY+0.3 SPECZ)]
- 0.9DL+1.5(SPECY+0.3 SPECX+0.3 SPECZ)]

The various loads are combined in accordance with the stipulations in IS: 875 (Part 5)-1987; whichever combination produces the most unfavorable effect in the building foundation or structural member concerned may be adopted.

*This value is to be considered when stability against overturning and stress reversal is critical where DL/LL/WL/EL denotes,DL - Dead Load; LL - Live Load; TL - Temperature Load; WL - Wind Load;EL - Earthquake Load , SPEC- Response spectrum Wind load and earthquake loads are considered for both x & y directions. Whenever imposed load is combined with earthquake load, the appropriate part of imposed load as specified in IS: 1893-2016 / Clause 7.3.3 of seismic code will be used both for evaluating earthquake effect and for combined load effects usedin such combination. Serviceability loads combinations with suitable live load reduction factor as per IS: 875(Part-2) will be used for foundation design.

1.7 DESIGN METHODOLOGY:

- All R.C.C structures shall be designed according to the Limit State Method as specified in IS: 456 – 2000.
- Forces and moments from the 3D analysis output for the worst combinations are used for the design of the structure.
- The foundations are designed for critical load combination.
- The structure is analyzed for specific loads like dead load, live load, wind and seismic loads and for the load combinations as given in the relevant codes.
- The slab is analyzed as two-way and one way slabs.
- Design of special members like retaining wall, water tanks will be done in accordance with the relevant IS Codes.

1.8 ACCEPTANCE CRITERIA:

1.8.1 Deflection Limits:

For Reinforced concrete works:

- Limiting values of deflection (Short and Long term) as per clause 35.3 of IS: 456-2000 is followed in the design.
- Limiting value for long term deflection is considered as span/250 and for the long term deflection after erection of partitions & finishes is considered as span/350 or 20mm whichever less as per IS 456 – 2000.

1.8.2 Cracking Limits:

- 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 water retaining structures, crack width is limited to 0.2mm.

1.8.3 Soil data:

Foundations are designed based on Geo Technical investigation report and will dissipate all the vertical and horizontal loads safely to the soil below. The soil investigation report recommends pile foundation system.

1.9 DETAILING REQUIREMENTS:

RC walls, which are considered as lateral load resisting elements are detailed as ductile RC walls along with perimeter SMRFs (both columns and beams). Rest of the columns and beams are detailed as per normal detailing requirement. Detailing for all structural members shall be in accordance with IS: 456 & SP: 34.

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQ +X according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = X + Eccentricity Y

Eccentricity Ratio = 5% for all diaphragms

Structural Period

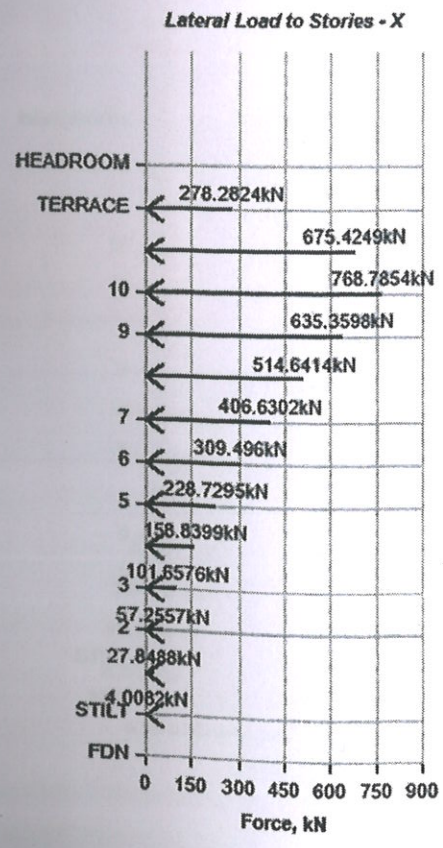
Period Calculation Method = User Specified

User Period		T=1.231 sec
Factors and Coefficients		
Seismic Zone Factor, Z [IS Table 3]		Z = 0.16
Response Reduction Factor, R [IS Table 9]		R = 4
Importance Factor, I [IS Table 8]		I = 1.2
Site Type [IS Table 1] = II		
Seismic Response		
Spectral Acceleration Coefficient, S_a/g [IS 6.4.2]	$\frac{S_a}{g} = \frac{1.36}{T}$	$\frac{S_a}{g} = 1.104793$
Equivalent Lateral Forces		
Seismic Coefficient, A_h [IS 6.4.2]	$A_h = \frac{ZI\frac{S_a}{g}}{2R}$	

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X + Ecc. Y	1.231	157154.6443	4166.9599

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
HEADROOM	42	0	0
TERRACE	39	278.2824	0
11	36	675.4249	0
10	33	768.7854	0
9	30	635.3598	0
8	27	514.6414	0
7	24	406.6302	0
6	21	309.496	0
5	18	228.7295	0
4	15	158.8399	0
3	12	101.6576	0
2	9	57.2557	0
1	6	27.8488	0
STILT	3	4.0082	0
FDN	0	0	0

IS 1893:2016 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQ +Y according to IS 1893:2016, as calculated by ETABS.

Direction and Eccentricity

Direction = Y + Eccentricity X

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = User Specified

User Period — T=0.568 sec

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 3] — Z = 0.16

Response Reduction Factor, R [IS Table 9] — R = 4

Importance Factor, I [IS Table 8] — I = 1.2

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, S_a/g [IS 6.4.2] — $\frac{S_a}{g} = \frac{1.36}{T}$ — $\frac{S_a}{g} = 2.394366$

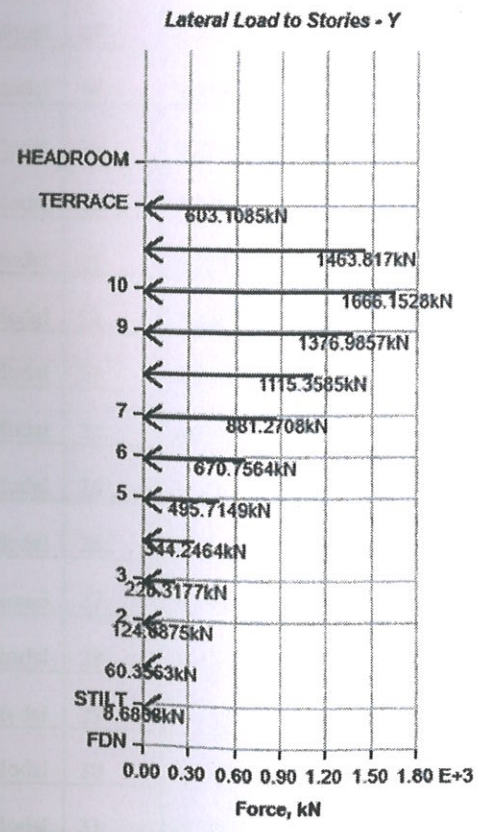
Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2] — $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y + Ecc. X	0.568	157154.6443	9030.8584

Applied Story Forces



Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
HEADROOM	42	0	0
TERRACE	39	0	603.1085
11	36	0	1463.817
10	33	0	1666.1528
9	30	0	1376.9857
8	27	0	1115.3585
7	24	0	881.2708
6	21	0	670.7564
5	18	0	495.7149
4	15	0	344.2464
3	12	0	220.3177
2	9	0	124.0875
1	6	0	60.3553
STILT	3	0	8.6868
FDN	0	0	0

MODAL PARTICIPATING MASS RATIOS

Case	Mode	Period	UX	UY	UZ	Sum UX	Sum UY	Sum UZ	RX	RY	RZ	Sum RX	Sum RY	Sum RZ
		sec												
Modal	1	2.340	0.520	0.000	0.000	0.522	0.000	0.000	0.000	0.060	0.225	0.000	0.060	0.225
Modal	2	1.678	0.029	0.633	0.000	0.551	0.633	0.000	0.144	0.003	0.057	0.144	0.064	0.283
Modal	3	1.634	0.173	0.092	0.000	0.724	0.725	0.000	0.018	0.022	0.449	0.161	0.086	0.732
Modal	4	0.669	0.100	0.000	0.000	0.823	0.725	0.000	0.000	0.086	0.038	0.161	0.172	0.770
Modal	5	0.455	0.000	0.145	0.000	0.823	0.869	0.000	0.223	0.000	0.001	0.385	0.172	0.770
Modal	6	0.414	0.057	0.000	0.000	0.880	0.870	0.000	0.001	0.036	0.106	0.385	0.208	0.877
Modal	7	0.368	0.023	0.000	0.000	0.903	0.870	0.000	0.000	0.014	0.013	0.385	0.221	0.889
Modal	8	0.353	0.010	0.001	0.000	0.913	0.870	0.000	0.001	0.005	0.000	0.386	0.227	0.890
Modal	9	0.344	0.000	0.000	0.000	0.914	0.871	0.000	0.000	0.000	0.000	0.386	0.227	0.890
Modal	10	0.286	0.004	0.000	0.000	0.918	0.871	0.000	0.000	0.001	0.002	0.386	0.228	0.892
Modal	11	0.265	0.000	0.000	0.007	0.918	0.871	0.007	0.007	0.011	0.000	0.393	0.239	0.892
Modal	12	0.262	0.001	0.000	0.000	0.918	0.871	0.007	0.000	0.000	0.000	0.393	0.240	0.892
Modal	13	0.262	0.006	0.000	0.000	0.925	0.871	0.007	0.000	0.006	0.003	0.393	0.245	0.895
Modal	14	0.262	0.000	0.000	0.000	0.925	0.871	0.007	0.000	0.000	0.000	0.393	0.246	0.895
Modal	15	0.261	0.001	0.000	0.000	0.925	0.871	0.008	0.000	0.001	0.000	0.393	0.247	0.895
Modal	16	0.261	0.000	0.000	0.000	0.925	0.871	0.008	0.000	0.000	0.000	0.393	0.247	0.895
Modal	17	0.260	0.000	0.000	0.000	0.926	0.871	0.008	0.000	0.001	0.000	0.394	0.247	0.895
Modal	18	0.260	0.000	0.000	0.000	0.926	0.871	0.008	0.000	0.000	0.000	0.394	0.247	0.895
Modal	19	0.259	0.000	0.000	0.000	0.926	0.871	0.008	0.001	0.000	0.000	0.395	0.247	0.895
Modal	20	0.259	0.000	0.000	0.000	0.926	0.871	0.008	0.000	0.001	0.000	0.395	0.248	0.895
Modal	21	0.257	0.007	0.000	0.000	0.933	0.871	0.008	0.000	0.006	0.002	0.395	0.254	0.897
Modal	22	0.220	0.002	0.042	0.000	0.935	0.913	0.008	0.041	0.002	0.003	0.436	0.256	0.901
Modal	23	0.216	0.005	0.003	0.000	0.940	0.916	0.008	0.003	0.003	0.010	0.439	0.259	0.911
Modal	24	0.215	0.001	0.004	0.000	0.941	0.920	0.008	0.003	0.001	0.007	0.442	0.260	0.918
Modal	25	0.201	0.000	0.000	0.001	0.941	0.920	0.009	0.001	0.000	0.000	0.443	0.260	0.918
Modal	26	0.201	0.010	0.000	0.000	0.951	0.920	0.009	0.000	0.009	0.005	0.443	0.270	0.923
Modal	27	0.194	0.000	0.000	0.000	0.951	0.920	0.009	0.000	0.000	0.000	0.443	0.270	0.923
Modal	28	0.189	0.000	0.000	0.000	0.951	0.920	0.009	0.000	0.000	0.000	0.444	0.270	0.923
Modal	29	0.186	0.006	0.001	0.001	0.957	0.921	0.009	0.001	0.005	0.013	0.444	0.275	0.936
Modal	30	0.182	0.000	0.000	0.013	0.957	0.921	0.022	0.001	0.000	0.000	0.445	0.275	0.936
Modal	31	0.175	0.000	0.000	0.003	0.957	0.921	0.025	0.000	0.000	0.000	0.445	0.275	0.936
Modal	32	0.172	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.445	0.275	0.936

Modal	33	0.172	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.445	0.275	0.936
Modal	34	0.172	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.445	0.275	0.936
Modal	35	0.171	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.445	0.275	0.936
Modal	36	0.171	0.000	0.000	0.000	0.957	0.921	0.026	0.000	0.000	0.000	0.446	0.275	0.936

STORY DRIFT

Story	Output Case	Direction	Drift	X	Y	Z
				m	m	m
TERRACE	EQ +X	X	0.00167	43.6352	11.525	39
11	EQ +X	X	0.001783	0	31.225	36
10	EQ +X	X	0.002171	0	31.225	33
9	EQ +X	X	0.002421	0	31.225	30
8	EQ +X	X	0.002587	0	31.225	27
7	EQ +X	X	0.002691	0	31.225	24
6	EQ +X	X	0.002745	56.7352	31.225	21
5	EQ +X	X	0.002721	56.7352	31.225	18
4	EQ +X	X	0.002628	56.7352	31.225	15
3	EQ +X	X	0.00246	56.7352	31.225	12
2	EQ +X	X	0.002174	56.7352	31.225	9
1	EQ +X	X	0.001596	55.9352	27.975	6
STILT	EQ +X	X	0.000886	19.6102	27.475	3
TERRACE	EQ +Y	Y	0.002602	48.6353	10.725	39
11	EQ +Y	Y	0.002759	56.7352	16.325	36
10	EQ +Y	Y	0.003083	59.3852	5.325	33
9	EQ +Y	Y	0.00339	59.3853	2.7749	30
8	EQ +Y	Y	0.003618	59.3853	2.7749	27
7	EQ +Y	Y	0.003772	59.3853	2.7749	24
6	EQ +Y	Y	0.003836	59.3853	2.7749	21
5	EQ +Y	Y	0.003791	59.3852	9.925	18
4	EQ +Y	Y	0.00361	59.3852	6.875	15
3	EQ +Y	Y	0.003269	59.3852	9.925	12
2	EQ +Y	Y	0.002729	59.3852	6.875	9
1	EQ +Y	Y	0.001953	59.3853	2.7749	6
STILT	EQ +Y	Y	0.000798	55.5352	24.775	3
TERRACE	RSA-X	X	0.000574	56.7352	31.225	39
11	RSA-X	X	0.000689	56.7352	31.225	36
10	RSA-X	X	0.000819	0	31.225	33
9	RSA-X	X	0.000903	56.7352	31.225	30
8	RSA-X	X	0.000957	56.7352	31.225	27
7	RSA-X	X	0.000985	56.7352	31.225	24
6	RSA-X	X	0.000997	56.7352	31.225	21
5	RSA-X	X	0.000997	56.7352	31.225	18
4	RSA-X	X	0.000989	56.7352	31.225	15
3	RSA-X	X	0.000967	56.7352	31.225	12
2	RSA-X	X	0.000902	56.7352	31.225	9
1	RSA-X	X	0.000675	55.9352	27.975	6
STILT	RSA-X	X	0.000387	19.6102	27.475	3
TERRACE	RSA-Y	Y	0.000614	49.7354	10.725	39
11	RSA-Y	Y	0.000702	0.000000612	20.425	36
10	RSA-Y	Y	0.000762	0	29.0571	33
9	RSA-Y	Y	0.000815	6.112E-07	21.225	30

8	RSA-Y	Y	0.000856	0	29.0571	27
7	RSA-Y	Y	0.000883	6.112E-07	21.225	24
6	RSA-Y	Y	0.000898	0	22.925	21
5	RSA-Y	Y	0.000899	6.112E-07	21.225	18
4	RSA-Y	Y	0.000883	0	22.925	15
3	RSA-Y	Y	0.000839	6.112E-07	21.225	12
2	RSA-Y	Y	0.000743	0	31.225	9
1	RSA-Y	Y	0.000564	6.112E-07	21.225	6
STILT	RSA-Y	Y	0.000354	23.1352	21.225	3

STORY MAX OVER AVG DISPLACEMENTS:

Story	Output Case	Case Type	Direction	Maximum	Average	Ratio
				mm	mm	
TERRACE	EQ +X	LinStatic	X	82.041	69.701	1.177
11	EQ +X	LinStatic	X	78.075	62.995	1.239
10	EQ +X	LinStatic	X	72.989	58.318	1.252
9	EQ +X	LinStatic	X	66.876	52.900	1.264
8	EQ +X	LinStatic	X	59.876	46.956	1.275
7	EQ +X	LinStatic	X	52.294	40.685	1.285
6	EQ +X	LinStatic	X	44.366	34.239	1.296
5	EQ +X	LinStatic	X	36.286	27.772	1.307
4	EQ +X	LinStatic	X	28.286	21.456	1.318
3	EQ +X	LinStatic	X	20.568	15.459	1.330
2	EQ +X	LinStatic	X	13.356	9.970	1.340
1	EQ +X	LinStatic	X	6.985	5.213	1.340
TERRACE	EQ +Y	LinStatic	Y	114.427	91.729	1.247
11	EQ +Y	LinStatic	Y	109.651	79.073	1.387
10	EQ +Y	LinStatic	Y	101.427	73.100	1.388
9	EQ +Y	LinStatic	Y	92.182	66.470	1.387
8	EQ +Y	LinStatic	Y	82.014	59.212	1.385
7	EQ +Y	LinStatic	Y	71.160	51.455	1.383
6	EQ +Y	LinStatic	Y	59.846	43.351	1.380
5	EQ +Y	LinStatic	Y	48.338	35.091	1.378
4	EQ +Y	LinStatic	Y	36.968	26.909	1.374
3	EQ +Y	LinStatic	Y	26.140	19.093	1.369
2	EQ +Y	LinStatic	Y	16.338	11.982	1.364
1	EQ +Y	LinStatic	Y	8.156	6.006	1.358
TERRACE	RSA-X	LinRespSpec	X	29.020	23.702	1.224
11	RSA-X	LinRespSpec	X	27.591	22.167	1.245
10	RSA-X	LinRespSpec	X	25.864	20.556	1.258
9	RSA-X	LinRespSpec	X	23.840	18.732	1.273
8	RSA-X	LinRespSpec	X	21.566	16.763	1.286
7	RSA-X	LinRespSpec	X	19.121	14.701	1.301
6	RSA-X	LinRespSpec	X	16.554	12.575	1.316
5	RSA-X	LinRespSpec	X	13.888	10.413	1.334
4	RSA-X	LinRespSpec	X	11.156	8.248	1.353
3	RSA-X	LinRespSpec	X	8.386	6.115	1.371
2	RSA-X	LinRespSpec	X	5.629	4.063	1.385
1	RSA-X	LinRespSpec	X	3.029	2.184	1.387
TERRACE	RSA-Y	LinRespSpec	Y	25.845	22.922	1.128
11	RSA-Y	LinRespSpec	Y	26.304	22.499	1.169
10	RSA-Y	LinRespSpec	Y	24.306	20.808	1.168
9	RSA-Y	LinRespSpec	Y	22.162	18.990	1.167
8	RSA-Y	LinRespSpec	Y	19.877	17.036	1.167
7	RSA-Y	LinRespSpec	Y	17.464	14.965	1.167
6	RSA-Y	LinRespSpec	Y	14.948	12.799	1.168

5	RSA-Y	LinRespSpec	Y	12.355	10.564	1.170
4	RSA-Y	LinRespSpec	Y	9.722	8.298	1.172
3	RSA-Y	LinRespSpec	Y	7.108	6.053	1.174
2	RSA-Y	LinRespSpec	Y	4.607	3.915	1.177
1	RSA-Y	LinRespSpec	Y	2.385	2.022	1.179

STORY STIFFNESS:

Story	Output Case	Case Type	Shear X	Drift X	Stiff X	Shear Y	Drift Y	Stiff Y
			kN	mm	kN/m	kN	mm	kN/m
HEADROOM	EQ +X	LinStatic	1.248	2.184	571.107	0.069	0.662	0.000
TERRACE	EQ +X	LinStatic	286.282	4.225	67759.713	0.368	0.522	0.000
11	EQ +X	LinStatic	979.823	4.740	206697.667	0.561	1.215	0.000
10	EQ +X	LinStatic	1773.080	5.560	318890.950	0.543	1.330	0.000
9	EQ +X	LinStatic	2432.876	6.042	402638.183	0.544	1.454	0.000
8	EQ +X	LinStatic	2971.642	6.321	470122.533	0.554	1.601	0.000
7	EQ +X	LinStatic	3401.812	6.467	526024.134	0.568	1.734	0.000
6	EQ +X	LinStatic	3733.814	6.471	576997.217	0.565	1.850	0.000
5	EQ +X	LinStatic	3984.015	6.318	630546.476	0.565	1.927	0.000
4	EQ +X	LinStatic	4162.784	6.000	693822.275	0.549	1.932	0.000
3	EQ +X	LinStatic	4282.408	5.493	779574.810	0.508	1.836	0.000
2	EQ +X	LinStatic	4355.140	4.756	915689.399	0.436	1.624	0.000
1	EQ +X	LinStatic	4396.296	3.509	1252751.777	0.420	1.254	0.000
STILT	EQ +X	LinStatic	4405.371	1.889	2331543.523	0.409	0.521	0.000
HEADROOM	EQ +Y	LinStatic	0.202	0.150	1343.180	1.439	5.402	266.466
TERRACE	EQ +Y	LinStatic	1.305	0.434	0.000	612.916	6.187	99066.187
11	EQ +Y	LinStatic	2.974	0.848	0.000	2099.759	6.013	349220.549
10	EQ +Y	LinStatic	5.058	0.798	0.000	3797.051	6.643	571563.033
9	EQ +Y	LinStatic	7.257	0.885	0.000	5205.182	7.276	715414.816
8	EQ +Y	LinStatic	9.532	0.979	0.000	6351.384	7.777	816641.985
7	EQ +Y	LinStatic	11.839	1.043	0.000	7262.827	8.123	894083.394
6	EQ +Y	LinStatic	14.102	1.080	0.000	7962.473	8.279	961711.419
5	EQ +Y	LinStatic	16.336	1.078	0.000	8485.659	8.200	1034853.824
4	EQ +Y	LinStatic	18.449	1.059	0.000	8855.203	7.833	1130433.572
3	EQ +Y	LinStatic	20.367	0.969	0.000	9097.974	7.125	1276829.204
2	EQ +Y	LinStatic	21.985	0.812	0.000	9240.884	5.993	1541903.911
1	EQ +Y	LinStatic	23.270	0.517	0.000	9316.832	4.307	2163264.851
STILT	EQ +Y	LinStatic	23.669	0.225	0.000	9330.748	1.743	5352919.197

STORY FORCES:

Story	Output Case	Case Type	P	VX	VY	T	MX	MY
TERRACE	RSA-X	LinRespSpec	3.920	197.425	32.837	6526.981	160.793	698.328
TERRACE	RSA-Y	LinRespSpec	1.798	15.042	266.342	10208.711	1039.820	174.759
TERRACE	EQ +X	LinStatic	0.000	-286.282	0.368	7262.138	-0.898	-862.588
TERRACE	EQ +Y	LinStatic	0.000	1.305	-612.916	-24771.633	1843.066	4.519
11	RSA-X	LinRespSpec	7.064	449.204	54.542	14662.771	374.761	1994.222
11	RSA-Y	LinRespSpec	5.658	37.934	700.758	26384.771	3380.566	380.188
11	EQ +X	LinStatic	0.000	-979.823	0.561	21090.159	-2.579	-3802.058
11	EQ +Y	LinStatic	0.000	2.974	-2099.759	-80563.934	8142.342	13.439
10	RSA-X	LinRespSpec	9.176	700.086	67.985	21618.973	579.209	4045.244
10	RSA-Y	LinRespSpec	9.593	65.637	1109.378	41152.700	6943.867	619.536
10	EQ +X	LinStatic	0.000	-1773.080	0.543	36243.795	-4.208	-9121.299
10	EQ +Y	LinStatic	0.000	5.058	-3797.051	-142931.08	19533.495	28.612
9	RSA-X	LinRespSpec	11.298	881.319	79.639	25853.756	793.884	6576.939
9	RSA-Y	LinRespSpec	12.909	84.806	1374.986	50590.515	11167.983	864.340
9	EQ +X	LinStatic	0.000	-2432.876	0.544	48871.236	-5.839	-16419.928
9	EQ +Y	LinStatic	0.000	7.257	-5205.182	-194688.38	35149.041	50.384
8	RSA-X	LinRespSpec	12.935	1004.563	93.034	28397.175	1019.234	9411.051
8	RSA-Y	LinRespSpec	14.633	98.171	1553.169	56827.360	15709.454	1092.806
8	EQ +X	LinStatic	0.000	-2971.642	0.554	59206.666	-7.502	-25334.854
8	EQ +Y	LinStatic	0.000	9.532	-6351.384	-236833.94	54203.192	78.979
7	RSA-X	LinRespSpec	14.272	1088.985	108.957	30314.827	1275.100	12413.539
7	RSA-Y	LinRespSpec	14.722	113.582	1695.848	61928.369	20399.655	1331.820
7	EQ +X	LinStatic	0.000	-3401.812	0.568	67479.788	-9.205	-35540.290
7	EQ +Y	LinStatic	0.000	11.839	-7262.827	-270345.10	75991.673	114.495
6	RSA-X	LinRespSpec	15.319	1158.209	124.298	32229.299	1578.782	15493.403
6	RSA-Y	LinRespSpec	13.903	130.930	1834.714	67077.597	25202.858	1616.924
6	EQ +X	LinStatic	0.000	-3733.814	0.565	73876.509	-10.901	-46741.731
6	EQ +Y	LinStatic	0.000	14.102	-7962.473	-296074.06	99879.092	156.801
5	RSA-X	LinRespSpec	16.271	1244.598	136.468	34730.728	1934.143	18625.363
5	RSA-Y	LinRespSpec	13.462	142.938	1990.946	72891.853	30166.802	1966.550
5	EQ +X	LinStatic	0.000	-3984.015	0.565	78738.149	-12.597	-58693.776
5	EQ +Y	LinStatic	0.000	16.336	-8485.659	-315348.91	125336.069	205.809
4	RSA-X	LinRespSpec	17.861	1365.358	145.201	38028.211	2332.809	21866.979
4	RSA-Y	LinRespSpec	13.824	148.684	2175.314	79624.435	35395.102	2371.851
4	EQ +X	LinStatic	0.000	-4162.784	0.549	82239.758	-14.243	-71182.128
4	EQ +Y	LinStatic	0.000	18.449	-8855.203	-328979.26	151901.679	261.157
3	RSA-X	LinRespSpec	19.833	1513.296	152.283	41706.627	2761.404	25330.338
3	RSA-Y	LinRespSpec	14.373	154.229	2378.467	86935.393	41025.638	2816.221
3	EQ +X	LinStatic	0.000	-4282.408	0.508	84610.736	-15.767	-84029.353
3	EQ +Y	LinStatic	0.000	20.367	-9097.974	-337948.76	179195.602	322.258
2	RSA-X	LinRespSpec	20.864	1671.154	158.631	45256.875	3209.146	29134.833
2	RSA-Y	LinRespSpec	14.825	161.849	2563.243	93510.751	47168.569	3287.507
2	EQ +X	LinStatic	0.000	-4355.140	0.436	86077.797	-17.076	-97094.772
2	EQ +Y	LinStatic	0.000	21.985	-9240.884	-343242.27	206918.253	388.213

1	RSA-X	LinRespSpec	21.133	1812.036	164.034	48152.493	3672.768	33350.983
1	RSA-Y	LinRespSpec	15.272	168.807	2696.901	98267.089	53843.327	3779.232
1	EQ +X	LinStatic	0.000	-4396.296	0.420	86924.051	-18.337	-110283.66
1	EQ +Y	LinStatic	0.000	23.270	-9316.832	-346095.64	234868.750	458.024
STILT	RSA-X	LinRespSpec	20.220	1850.666	165.157	48817.063	4141.004	37913.697
STILT	RSA-Y	LinRespSpec	16.175	170.763	2724.795	99157.541	60876.697	4269.868
STILT	EQ +X	LinStatic	0.000	-4405.371	0.409	87110.911	-19.564	-123499.77
STILT	EQ +Y	LinStatic	0.000	23.669	-9330.748	-346600.46	262860.993	529.030
TERRACE	RSA-X	LinRespSpec	3.920	197.425	32.837	6526.981	160.793	698.328
TERRACE	RSA-Y	LinRespSpec	1.798	15.042	266.342	10208.711	1039.820	174.759
TERRACE	EQ +X	LinStatic	0.000	-286.282	0.368	7262.138	-0.898	-862.588
TERRACE	EQ +Y	LinStatic	0.000	1.305	-612.916	-24771.633	1843.066	4.519
11	RSA-X	LinRespSpec	7.064	449.204	54.542	14662.771	374.761	1994.222
11	RSA-Y	LinRespSpec	5.658	37.934	700.758	26384.771	3380.566	380.188
11	EQ +X	LinStatic	0.000	-979.823	0.561	21090.159	-2.579	-3802.058
11	EQ +Y	LinStatic	0.000	2.974	-2099.759	-80563.934	8142.342	13.439
10	RSA-X	LinRespSpec	9.176	700.086	67.985	21618.973	579.209	4045.244
10	RSA-Y	LinRespSpec	9.593	65.637	1109.378	41152.700	6943.867	619.536
10	EQ +X	LinStatic	0.000	-1773.080	0.543	36243.795	-4.208	-9121.299
10	EQ +Y	LinStatic	0.000	5.058	-3797.051	-142931.08	19533.495	28.612

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ETABS Shear Wall Design (C1)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW100	21685.2	1725	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	21685.2	1325	21685.2	2125	800	200
Bottom	Leg 1	21685.2	1325	21685.2	2125	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	400	0.0025	0.0614	119 0.9 DL+1.5 WL +Y	711.258	-14.5905	33.4853	160000
Bottom	438	0.0027	0.0614	109 -0.45 SL X+1.5 SL Z+1.5 DL	1856.3854	44.0241	-129.8465	160000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	1302.2763	43.8455	-45.4842	57.6	173.0783
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	1320.271	79.456	-45.4842	57.6	173.0783

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	0	112 0.45 SL X+1.5 SL Z+0.9 DL	1210.2573	-4.5768	7.78	8
Top–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1838.3907	43.8455	13.55	8
Bottom–Left	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1856.3854	-129.8465	17.69	8
Botttom–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1856.3854	79.456	15.33	8

ETABS Shear Wall Design (C2)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW18	56735.2	29457.4	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	56735.2	29057.4	56735.2	29857.4	800	200
Bottom	Leg 1	56735.2	29057.4	56735.2	29857.4	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	454	0.0028	0.0614	109 -0.45 SL X+1.5 SL Z+1.5 DL	1967.1242	49.3978	-64.2594	160000
Bottom	1152	0.0072	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	1915.3087	52.2024	145.5791	160000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1258.8436	12.7225	45.4554	57.6	173.0783
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1276.8383	145.5791	45.4554	83.9525	199.4307

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1967.1242	-29.5998	13.68	8
Top–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	1967.1242	7.3852	12.64	8
Bottom–Left	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	1985.1189	-103.7089	17.27	8
Botttom–Right	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	1985.1189	135.1314	18.74	8

ETABS Shear Wall Design (C3)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW20	33285.2	28224.9	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	33285.2	27824.9	33285.2	28624.9	800	200
Bottom	Leg 1	33285.2	27824.9	33285.2	28624.9	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	920	0.0058	0.0614	109 -0.45 SL X+1.5 SL Z+1.5 DL	2120.0371	-50.6068	69.6583	160000
Bottom	1573	0.0098	0.0614	109 -0.45 SL X+1.5 SL Z+1.5 DL	2138.0318	51.0117	-152.6054	160000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	1485.2443	69.6583	-73.7738	76.7091	192.1874
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	1503.239	75.41	-73.7738	97.07	212.5482

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	2120.0371	-0.5054	13.27	8
Top–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	2120.0371	69.6583	16.52	8
Bottom–Left	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	2138.0318	-152.6054	20.52	8
Botttom–Right	Leg 1	200	108 0.45 SL X+1.5 SL Z+1.5 DL	2138.0318	75.41	16.9	8

ETABS Shear Wall Design (C4)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW1	0	29457.1	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	0	29057.1	0	29857.1	800	200
Bottom	Leg 1	0	29057.1	0	29857.1	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	1851	0.0116	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2270.6495	59.1969	-95.4261	160000
Bottom	2669	0.0167	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2288.6442	59.6018	191.3202	160000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1964.1375	5.8589	62.0756	103.3415	218.8198
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1982.1321	191.3202	62.0756	120.3662	235.8445

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2270.6495	-95.4261	18.66	8
Top–Right	Leg 1	200	106 1.5 SL X+0.45 SL Z+1.5 DL	2270.6495	5.8589	14.47	8
Bottom–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2288.6442	-107.6208	19.35	8
Botttom–Right	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	2289.871	167.3897	22.16	8

ETABS Shear Wall Design (C5)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW49	6.116E-04	20825	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	6.12E-04	20425	6.112E-04	21225	800	200
Bottom	Leg 1	6.12E-04	20425	6.112E-04	21225	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	3050	0.0191	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2663.4602	-65.3441	87.0064	160000
Bottom	4129	0.0258	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2681.4549	65.749	-231.5503	160000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	955.5017	69.7069	-87.5965	121.4315	236.9097
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	973.4964	129.2975	-87.5965	121.4315	236.9097

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	0	101 1.5 DL+1.5 LL	0	0	0	0
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2663.4602	69.7069	19.91	8
Bottom–Left	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	2681.4549	-231.5503	27.61	8
Botttom–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2681.4549	129.2975	22.82	8

ETABS Shear Wall Design (C6)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW38	0	23325	800	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	0	22925	0	23725	800	200
Bottom	Leg 1	0	22925	0	23725	800	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	2987	0.0187	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2655.0219	-64.5794	86.7307	160000
Bottom	3742	0.0234	0.0614	107 1.5 SL X+-0.45 SL Z+1.5 DL	2673.0166	64.9843	190.854	160000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1565.6538	9.2503	63.1575	121.4315	236.9097
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1583.6485	190.854	63.1575	121.4315	236.9097

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2655.0219	-23.1231	17.68	8
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2655.0219	9.2503	17.03	8
Bottom–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2673.0166	-184.2601	25.34	8
Botttom–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2673.0166	190.854	25.65	8

ETABS Shear Wall Design (C7)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW24	8410	25975	1000	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	8410	25475	8410	26475	1000	200
Bottom	Leg 1	8410	25475	8410	26475	1000	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	4589	0.0229	0.0589	107 1.5 SL X+-0.45 SL Z+1.5 DL	3507.814	-87.4913	-137.974	200000
Bottom	5499	0.0275	0.0589	107 1.5 SL X+-0.45 SL Z+1.5 DL	3530.3074	87.9974	-287.5054	200000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	2744.5492	96.1776	-86.4159	151.7893	296.1372
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	2767.0425	199.0995	-86.4159	151.7893	296.1372

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	3507.814	-30.3786	18.45	8
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	3507.814	96.1776	20.42	8
Bottom–Left	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	3530.3074	-287.5054	26.28	8
Botttom–Right	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	3530.3074	199.0995	23.62	8

ETABS Shear Wall Design (C8)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW3	4000	23425	1000	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	4000	22925	4000	23925	1000	200
Bottom	Leg 1	4000	22925	4000	23925	1000	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	2845	0.0142	0.0025	107 1.5 SL X+-0.45 SL Z+1.5 DL	3094.8072	76.6892	121.7291	200000
Bottom	3623	0.0181	0.0025	107 1.5 SL X+-0.45 SL Z+1.5 DL	3117.3005	77.1953	-257.554	200000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1964.3929	115.3071	-52.8282	140.642	284.9899
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1986.8862	223.9887	-52.8282	151.7893	296.1372

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	3094.8072	-100.835	18.5	8
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	3094.8072	115.3071	18.93	8
Bottom–Left	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	3117.3005	-257.554	23.31	8
Botttom–Right	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	3117.3005	223.9887	22.31	8

ETABS Shear Wall Design (C9)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW66	49635.2	16675	1100	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	49635.2	16125	49635.2	17225	1100	200
Bottom	Leg 1	49635.2	16125	49635.2	17225	1100	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	3816	0.0173	0.058	101 1.5 DL+1.5 LL	3659.9792	-81.0407	156.1591	220000
Bottom	3903	0.0177	0.058	101 1.5 DL+1.5 LL	3684.7219	81.5974	-157.2148	220000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	2722.0673	108.4706	-63.997	166.9683	325.7509
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	2746.81	201.5939	-63.997	166.9683	325.7509

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	3469.0144	-48.7865	16.98	8
Top–Right	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	3469.0144	108.4706	18.46	8
Bottom–Left	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	3493.7571	-239.5419	21.82	8
Botttom–Right	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	3493.7571	201.5939	20.88	8

ETABS Shear Wall Design (C10)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW77	49185.3	10725	1100.1	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	48635.3	10725	49735.4	10725	1100.1	200
Bottom	Leg 1	48635.3	10725	49735.4	10725	1100.1	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	6944	0.0316	0.058	109 -0.45 SL X+1.5 SL Z+1.5 DL	4291.3195	112.9266	183.1117	220021
Bottom	7096	0.0323	0.058	107 1.5 SL X+-0.45 SL Z+1.5 DL	4264.8786	111.0868	-241.5244	220021

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	3335.1492	34.8212	69.9078	166.9846	325.7827
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	3359.8943	238.0447	69.9078	166.9846	325.7827

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	4291.3195	-36.3054	20.4	8
Top–Right	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	4291.3195	4.507	19.62	8
Bottom–Left	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4264.8786	-241.5244	25.37	8
Botttom–Right	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4264.8786	238.0447	25.28	8

ETABS Shear Wall Design (C11)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW57	49635.2	20675	1100	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	49635.2	20125	49635.2	21225	1100	200
Bottom	Leg 1	49635.2	20125	49635.2	21225	1100	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm^2)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm^2
Top	4182	0.019	0.058	101 1.5 DL+1.5 LL	3753.6496	-83.849	-160.1557	220000
Bottom	4280	0.0195	0.058	101 1.5 DL+1.5 LL	3778.3923	84.4057	161.2114	220000

Shear Design

Station Location	ID	Rebar mm^2/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	3122.9786	86.8678	47.7351	166.9683	325.7509
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	3147.7213	228.3675	47.7351	166.9683	325.7509

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	3451.0205	-81.0581	17.7	8
Top–Right	Leg 1	300	108 0.45 SL X+1.5 SL Z+1.5 DL	3451.0205	86.8678	17.84	8
Bottom–Left	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	3475.7632	-201.8097	20.8	8
Botttom–Right	Leg 1	400	108 0.45 SL X+1.5 SL Z+1.5 DL	3475.7632	228.3675	21.46	8

ETABS Shear Wall Design (C12)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW22	49635.2	28324.9	1200	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	49635.2	27724.9	49635.2	28924.9	1200	200
Bottom	Leg 1	49635.2	27724.9	49635.2	28924.9	1200	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	7359	0.0307	0.0573	101 1.5 DL+1.5 LL	4820.8568	110.1283	-221.7594	240000
Bottom	7451	0.031	0.0573	101 1.5 DL+1.5 LL	4847.8488	-110.7356	223.001	240000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	4119.9228	94.431	76.1013	182.1472	355.3646
Bottom	Leg 1	500	109 -0.45 SL X+1.5 SL Z+1.5 DL	4146.9148	321.0455	76.1013	182.1472	355.3646

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4243.3339	-160.814	21.03	8
Top–Right	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	4243.3339	83.9035	19.43	8
Bottom–Left	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4270.326	-171.1918	21.36	8
Botttom–Right	Leg 1	500	106 1.5 SL X+0.45 SL Z+1.5 DL	4270.326	305.3563	24.15	8

ETABS Concrete Frame Design (C13)

IS 456:2000 + IS 13920:2016 Column Section Design (Summary)

Column Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
STILT	C8	3562	C300*900	109 -0.45 SL X+1.5 SL Z+1.5 DL	0	3000	0.6

Column Element Details (Part 2 of 2)

Type

Ductile Frame

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
300	900	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
3197.4515	63.949	95.2454	63.949	111.9108	2160	0.8

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.688897	2500	38.0982	0	111.9108
Minor Bend(M2)	0.638117	2500	8.0916	0	63.949

Axial Compression Check for Seismic Design per IS 13920:2016 Section 7.1

Limit Compression Factor Unitless	Limit Compression Strength kN	Compression D/C Ratio Unitless	Status
0.4	4320	0.740151	OK

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	23.2084	178.7402	100.8002	20.0428	332.53
Minor, V_{u3}	40.0849	165.2406	86.4007	40.0849	997.59

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
2700	21.6	5670	2145.8291	3197.4515	0.701597

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.833	900	1.914	12	No	0
Minor Bending (M_2)	Yes	0.833	300	5.318	12	No	0

ETABS Shear Wall Design (C14)

IS 456:2000 Pier Design

Pier Details

Story ID	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
STILT	PW59	56135.2	21225	1200	200	0.6

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.04	0.0025	0.8	Yes	Yes

Pier Leg Location, Length and Thickness

Station Location	ID	Left X_1 mm	Left Y_1 mm	Right X_2 mm	Right Y_2 mm	Length mm	Thickness mm
Top	Leg 1	55535.2	21225	56735.2	21225	1200	200
Bottom	Leg 1	55535.2	21225	56735.2	21225	1200	200

Flexural Design for P_u, M_{u2} and M_{u3}

Station Location	Required Rebar Area (mm²)	Required Reinf Ratio	Current Reinf Ratio	Flexural Combo	P_u kN	M_{u2} kN-m	M_{u3} kN-m	Pier A_g mm²
Top	808	0.0034	0.0573	107 1.5 SL X+-0.45 SL Z+1.5 DL	2902.5528	73.7418	-165.0657	240000
Bottom	2932	0.0122	0.0573	107 1.5 SL X+-0.45 SL Z+1.5 DL	2929.5449	74.3491	483.1373	240000

Shear Design

Station Location	ID	Rebar mm²/m	Shear Combo	P_u kN	M_u kN-m	V_u kN	V_c kN	$V_c + V_s$ kN
Top	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1954.4745	34.4211	151.7937	90.6161	263.8335
Bottom	Leg 1	500	107 1.5 SL X+-0.45 SL Z+1.5 DL	1981.4666	483.1373	151.7937	158.3608	331.5782

Boundary Element Check

Station Location	ID	Edge Length (mm)	Governing Combo	P_u kN	M_u kN-m	Stress Comp MPa	Stress Limit MPa
Top–Left	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2902.5528	-165.0657	15.53	8
Top–Right	Leg 1	300	106 1.5 SL X+0.45 SL Z+1.5 DL	2902.5528	34.4211	12.81	8
Bottom–Left	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	2929.5449	-358.5376	19.68	8
Botttom–Right	Leg 1	400	106 1.5 SL X+0.45 SL Z+1.5 DL	2929.5449	483.1373	22.27	8

ETABS Concrete Frame Design (C15)

IS 456:2000 + IS 13920:2016 Column Section Design (Summary)

Column Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
1	C5	529	C300X450	111 1.5 SL X+-0.45 SL Z+0.9 DL	2400	3000	1

Column Element Details (Part 2 of 2)

Type
Ductile Frame

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
300	450	60	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
31622.78	40	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
152.2991	-15.8048	239.852	3.046	3.046	3729	2.76

Axial Force and Biaxial Moment Factors

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.910446	2400	34.4937	0	3.046
Minor Bend(M2)	1	2400	7.7733	0	3.046

Axial Compression Check for Seismic Design per IS 13920:2016 Section 7.1

Limit Compression Factor Unitless	Limit Compression Strength kN	Compression D/C Ratio Unitless	Status
0.4	2160	0.074871	OK

Shear Design for V_{u2} , V_{u3}

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	159.9013	102.6295	57.2719	159.9013	406.93
Minor, V_{u3}	59.8116	97.8465	43.2003	59.8116	498.8

Joint Shear Check/Design

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	0	0	335.2523	853.815	1350	0.393
Minor Shear, V_{u3}	0	0	149.326	664.0783	1050	0.225

(1.4) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
0.934	0.542

Additional Moment Reduction Factor k (IS 39.7.1.1)

A_g cm^2	A_{sc} cm^2	P_{uz} kN	P_b kN	P_u kN	k Unitless
1350	37.3	3828.4899	978.1761	152.2991	1

Additional Moment (IS 39.7.1)

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.8	450	4.856	12	No	0
Minor Bending (M_2)	Yes	0.8	300	8	12	No	0

ETABS Concrete Frame Design (FB5)

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)

Beam Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
7	B379	2112	B200X500	109 -0.45 SL X+1.5 SL Z+1.5 DL	0	4817.6	1

Beam Element Details (Part 2 of 2)

Type
Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
200	500	200	0	60	60

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-143.3329	2.1176	122.5612	8.3608

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-143.3329	4.3597	0	-147.6926

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-147.6926		943	0	943	236
Bottom (-2 Axis)		0	471	0	0	471

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
170.4505	0	187.3912	58.7922	1180.17

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
2.1176	122.5612	100	400	498.25

ETABS Concrete Frame Design (FB11)

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)

Beam Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
7	B312	1028	B200X500	109 -0.45 SL X+1.5 SL Z+1.5 DL	5400	5400	1

Beam Element Details (Part 2 of 2)

Type
Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
200	500	200	0	60	60

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	500	500

Design Code Parameters

ɣc	ɣs
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-168.429	2.7517	135.2455	11.3376

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-168.429	5.6652	0	-174.0942

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-174.0942		1117	0	1117	279
Bottom (-2 Axis)		0	559	0	124	559

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
184.3251	0	206.3383	60.8494	1299.5

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
2.7517	135.2455	100	400	585.7

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ETABS Concrete Frame Design (FB11)

IS 456:2000 + IS 13920:2016 Beam Section Design (Summary)

Beam Element Details (Part 1 of 2)

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
7	B312	1028	B200X500	109 -0.45 SL X+1.5 SL Z+1.5 DL	5400	5400	1

Beam Element Details (Part 2 of 2)

Type
Ductile Frame

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
200	500	200	0	60	60

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	500	500

Design Code Parameters

γ_c	γ_s
1.5	1.15

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-168.429	2.7517	135.2455	11.3376

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-168.429	5.6652	0	-174.0942

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-174.0942		1117	0	1117	279
Bottom (-2 Axis)		0	559	0	124	559

Shear Force and Reinforcement for Shear, V_{u2} & T_u

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
184.3251	0	206.3383	60.8494	1299.5

Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
2.7517	135.2455	100	400	585.7

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