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15/01:1948
16th September, 2015

TO WHOME IT MAY CONCERN

Dear Sir/Madam,

Subject: Covering letter of structural consultant for Laxmi Sky City Housing and Commercial Development at Naroda, Ahmedabad.

We are the structural design consultants for Laxmi Sky City housing project at Naroda, Ahmedabad. The structure is more than 40mt. height.

With reference to your "Structural Safety Regularion – 2014", please find enclosed documents as per your requirement.

1. Check list for structural consultant as per GDCR clause 4.8
2. Structural consultant technical report
3. Structural consultant drawing set

Yours sincerely,

Himanshu Parikh

LAXMI SKY CITY, AHMEDABAD

RESIDENTIAL BLOCK OF 22 STOREYS

For

LAXMI DEVELOPERS

STRUCTURAL DESIGN BASIS REPORT

Dated: 16/09/2015

Structural Engineers:

Himanshu Parikh Consulting Engineers

43, JMC House, Opp. Parimal Garden, Ambawadi, Ahmedabad-380 006.

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1. Project Information

The site of the proposed Laxmi Sky City is located on Sardar Patel Ring Road of Ahmedabad. The present development comprises of 5 blocks of Basement+Ground+22 floors of flats, a 2 storey Commercial block and a multipurpose hall of a storey.

The proposed development consists of following buildings:

Sl. No	Description	No. of Blocks	No. of Floors	Total Built Up Area (in sqft)
1	**RESIDENTIAL APARTMENTS**	5	B+G+22	7,00,000
2	**COMMERCIAL BLOCK**	1	B+G+1	50,000
3	**MULTIPURPOSE HALL**	1	G	5,000

2. Structural Design Approach

All the residential towers are designed as principally reinforced concrete shear wall and flat slab structures. Care is taken to ensure that, in spite of shear walls, the columns have the minimum shear resistance to take at least 25% of the horizontal seismic load as prescribed in IS 1893 (Table 7).

The structural analysis is carried out to the relevant Indian Standards using in-house developed spreadsheets and propriety Etabs structural software. Although the high rise tower blocks are largely symmetrical in plan and less than 90m height, both static and dynamic analysis is undertaken and tallied as additional safety. For conservative design, in addition to the line loads of all the masonry walls taken at each floor, a blanket additional load provision of 0.5 Kn/m^2 is made at all levels over and above the code requirements. Care has been taken to avoid “soft storey” effects by ensuring infill masonry walls in both x and y directions at all levels including the ground floor. Special care has been taken for ductile detailing including additional links in the shear wall boundaries and the staggering of laps.

The raft foundations of all buildings are taken to the depth of minimum 2.6m into hard yellow morrum strata with lime kankar estimated at SBC of 250 Kn/m^2. The foundation are, however, designed for the conservative Soil Bearing Capacity of 200 Kn/m^2 as per the soil report.

The main emphasis of structural design has been to balance safety and serviceability with simplicity, conservation of natural resources and economy.

Elements of Design

Design for all frame members and shear walls will be directly extracted using analysis software's inbuilt design modules. Independent designs checks using in-house Excel sheets will be done to verify other members such as slabs, staircases, foundations etc. In addition to design reinforcement requirements to achieve ductility for effective seismic action will be provided according to IS 13920.

Durability Requirements

As per clause 8.2.2.1 and Table 3 of IS 456, "Mild" exposure condition is considered for slabs and "Moderate" exposure condition is considered for all other structural elements.

Fire resistance

Period of fire resistance is considered as 2hrs for all primary and secondary structural elements. The minimum concrete protective cover for reinforcement is largely depends upon exposure conditions and fire rating requirements. Values of nominal cover for different elements are summarized as shown in table below from table 16 and table 16A of IS 456:2000.

Sr. No.	Element	Cover (mm)
1	Continuous slabs	25
2	Continuous beams	30
3	Columns and shear/retaining walls	40

Reinforcement Requirements:

Minimum reinforcement and spacing requirements as defined in IS 456:2000 would be adopted to control shrinkage and temperature stresses. These ratios are reproduced below:

Structural Member	Minimum reinforcement ratio (as % of Ag)	Governing Clause	Remarks
Beams	(0.85/fy)%	26.5.1.1	-
Slabs	0.12%	26.5.2.1	-
Columns	0.80%	26.5.3.1	-
Walls - Horizontal Reinforcement	0.25%	32.5	0.20% for bars not > than 16mm diameter
Walls - Vertical Reinforcement	0.15%	32.5	0.12% for bars not > than 16mm diameter

Structural Member	Maximum Allowable Spacing	Governing Clause	Remarks
Beams	As per Table 15 of IS 456	26.3.3	For main reinforcement
	300 mm	26.5.1.1	For shear Reinforcement
Slabs	2 x slab thickness	31.7.1	For flat slabs maximum 300mm
	3 x effective slab depth OR 300 mm whichever is least	26.3.3	For main reinforcement
	5 x effective slab depth OR 450 mm Whichever is least	26.3.3	For distribution reinforcement
Columns	**Links**: Least column dimension OR 16 x smallest vertical bar OR 300 mm, whichever is least	26.5.3.1	**Main Bars:** Maximum spacing < 300mm.
Walls - Horizontal Reinforcement	450 mm or 3 x wall thickness, whichever is least	31.5	Restricted to 300mm for all buildings
Walls - Vertical Reinforcement	450 mm or 3 x wall thickness, whichever is least	32.5	Restricted to 300mm for all buildings

In any case, continuous top and bottom mats of reinforcement are intentionally provided in all slabs to minimise both the initial shrinkage and the subsequent thermal cracking in buildings.

Serviceability Checks:

Vertical Deflection:

The clause 23.2 of IS 456: 2000 states that, 'the deflection of the structure or part there of shall not adversely affect the appearance or efficiency of the structure or finishes or partitions.

The deflection shall generally be limited to the following,

Type of Member	Deflection to be considered	Deflection Limitation
Supports of floors, roofs and all other horizontal members	The final deflection due to all loads including the effects of temperature, creep and shrinkage	L/250
Supports of floors, roofs and all other horizontal members	The deflection including the effects of temperature creep and shrinkage occurring after erection of partitions and the application of finishes.	L/350 or 20mm (whichever is less)

Lateral Sway:

As per clause 20.5 of IS 456:2000, permissible lateral sway at top of the structure due to transient wind load is to be limited to H/500, where H is height of the structure.

Storey drift in any storey under seismic load is to be limited to $H_s/250$, where H_s is height of the storey, as per clause 7.11 of IS 1893.

3. Design Framework and Code Provisions

The structural analysis and design is carried out to the relevant Indian Standards as follows:

Design Loads (other than Earthquake)

IS 875(Pt.1)	Dead Loads - Unit Weight of Building Material and Stored Material
IS 875(Pt.2)	Imposed Loads
IS 875(Pt.3)	Wind Loads

Earthquake Design

IS 1893	Criteria for Earthquake Resistance Design of Structures.
IS 4326	Earthquake Resistant Design and Construction of Buildings.
IS 13920	Ductile Detailing of Reinforced Concrete Structures.

Design of Reinforced Concrete

IS 456	Plain and Reinforced Concrete.
SP 16	Structural Use of Concrete - Design Charts.
SP 34	Handbook on Concrete Reinforcement & Detailing.
IS 1786	Specification for High Strength Deformed Bars & Wires Reinforcement.
IS 3370 (Pt.1)	Code of Practice for Concrete Structure for the Storage of Liquids.
SP 22	Explanatory Handbook on codes for earthquake engineering IS 1893: 1975 & IS 4326: 1976

Masonry Design

IS 1905	Code of Practice for Structural Use of Un-reinforced Masonry.
SP 20	Handbook on Masonry Design and Construction

Design of Structural Steel

IS 800	Code of Practice for General Construction in Steel.
IS 2062	Steel for General Structural Purposes

Foundation Design

IS 1904	Design and Construction of Foundations in Soil: General Requirements.
IS 2950	Code of Practice for Design and Construction of Raft Foundation (Pt.1).
IS 8009 (Pt.1)	Calculation of Settlements of Shallow Foundations.
IS 6403	Determination of Bearing Capacity of Shallow Foundations.

4. Loadings

Dead Loads:

Low grade Plain Cement Concrete	:	22.0 Kn/m^3 (M10 with over 50% flyash)
Reinforced Concrete (with 1% steel)	:	24.0 Kn/m^3 (As per item 22 of Table 1, IS 875 (Pt.1))
Lightweight Blockwork	:	6.5 Kn/m^3
Partitions	:	Calculated according to layout.
Plaster & Floor Finishes	:	21.0 Kn/m^3
Waterproofing	:	20.0 Kn/m^3
Earth filling	:	18.0 Kn/m^3
Lightweight False Ceiling	:	0.25 Kn/m^2
Water	:	10.0 Kn/m^3

Live Loads:

Residential Blocks:

All Rooms	:	2.0 Kn/m^2
Toilets	:	2.0 Kn/m^2
Balcony	:	3.0 Kn/m^2
Stairs and Corridors	:	3.0 Kn/m^2
Terrace with Access	:	1.5 Kn/m^2
Terrace Waterproofing	:	2.0 Kn/m^2
Roofs/Chajjas without Access	:	0.75 Kn/m^2
Lift Machine Room	:	5.75 Kn/m^2

Earthquake Loads:

Inertial loads due to earthquake will be applied at the mass centres of each level. These forces will be calculated using the Auto Seismic Loads function of the software used for analysis and cross checked manually. For all structures, the seismic base will be considered at plinth/podium level. All buildings will have special moment resisting frames with or without shear walls to resist lateral force due to earthquake. Either Seismic Coefficient Method or Response Spectrum Method will be used depending on the building height and geometric configuration as specified in clause 7.8.1 of IS 1893. For irregular structures in plan, dynamic and P-δ analysis will be performed as recommended by code and tallied with the base shear of static analysis. Imposed load reductions will be considered in seismic weight calculations as per table 8 of IS 1893.

Zone III (Zone Factor, Z = 0.16)
Importance Factor, I = 1
Soil Type = II (Medium soil – Yellowish brown, fine to very fine grained clayey sand)
Response Reduction Factor, R = 4 for Ductile Shear Walls.
Time Period, T as per clause 7.6.2 of IS 1893 for infill walls.
Damping value = 5% for concrete
Accidental eccentricities = 5%

Wind Loads:

Wind lateral loads shall be calculated floor by floor in spreadsheets and then applied at the mass centres of each level in the software used for analysis.

Wind Velocity (V_b) = 39 m/sec	(IS:875-Part 3 : 1987, Fig. 1)
Terrain Category = 3	(As specified)
Class of structure = C	(IS:875-Part 3 : 1987, Cl. 5.3.2.2)
Risk co-efficient (k_1) = 1	(IS:875-Part 3 : 1987, Table 1)
Terrain, height and structure size (k_2)	(IS:875-Part 3 : 1987, Cl. 5.3.2)
Topography factor (k_3) = 1	(IS:875-Part 3 : 1987, Cl. 5.3.3.1)

Design wind speed (V_z) = $V_b * k_1 * k_2 * k_3$ (m/sec)

Design wind pressure at base (P_z) = $0.6 * V_z^2$ (N/m^2)

Temperature load (TL):

By providing movement joints at approximately 45m as per the code and also between building blocks, thermal effects will not generally be critical. However, for special public buildings when the dimensions exceed reasonable limits, especially where additional insulation is not provided in the roofs, thermal effects would be considered in design.

Load Combinations

Combo	Type	Case	Factor	Case Type
DCON2	ADD	DEAD	1.5	Static
		LIVE	1.5	Static
DCON3	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		WINDX	1.2	Static
DCON4	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		WINDX	-1.2	Static
DCON5	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		WINDY	1.2	Static
DCON6	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		WINDY	-1.2	Static
DCON7	ADD	DEAD	1.5	Static
		WINDX	1.5	Static
DCON8	ADD	DEAD	1.5	Static
		WINDX	-1.5	Static
DCON9	ADD	DEAD	1.5	Static
		WINDY	1.5	Static
DCON10	ADD	DEAD	1.5	Static
		WINDY	-1.5	Static
DCON11	ADD	DEAD	0.9	Static
		WINDX	1.5	Static
DCON12	ADD	DEAD	0.9	Static
		WINDX	-1.5	Static
DCON13	ADD	DEAD	0.9	Static
		WINDY	1.5	Static
DCON14	ADD	DEAD	0.9	Static
		WINDY	-1.5	Static
DCON15	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		EQX	1.2	Static
DCON16	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		EQX	-1.2	Static
DCON17	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		EQY	1.2	Static
DCON18	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		EQY	-1.2	Static
DCON19	ADD	DEAD	1.5	Static
		EQX	1.5	Static

Combo	Type	Case	Factor	Case Type
DCON20	ADD	DEAD	1.5	Static
		EQX	-1.5	Static
DCON21	ADD	DEAD	1.5	Static
		EQY	1.5	Static
DCON22	ADD	DEAD	1.5	Static
		EQY	-1.5	Static
DCON23	ADD	DEAD	0.9	Static
		EQX	1.5	Static
DCON24	ADD	DEAD	0.9	Static
		EQX	-1.5	Static
DCON25	ADD	DEAD	0.9	Static
		EQY	1.5	Static
DCON26	ADD	DEAD	0.9	Static
		EQY	-1.5	Static
DCON27	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		SPECX	1.2	Static
DCON28	ADD	DEAD	1.2	Static
		LIVE	1.2	Static
		SPECY	1.2	Static
DCON29	ADD	DEAD	1.5	Static
		SPECX	1.5	Static
DCON30	ADD	DEAD	1.5	Static
		SPECY	1.5	Static
DCON31	ADD	DEAD	0.9	Static
		SPECX	1.5	Static
DCON32	ADD	DEAD	0.9	Static
		SPECY	1.5	Static

5. Material Strengths and Properties

Concrete:

Plain Cement Concrete M5	:	5.0 N/mm^2
Reinforced Concrete M30 Slabs & Beams	:	30.0 N/mm^2
Reinforced Concrete M35 Columns & Walls	:	35.0 N/mm^2

Steel:

TMT 500-D Reinforcement Yield Stress	:	500.0 N/mm^2
Elongation of 500-D	:	>14.5%
Mild Steel Yield Stress	:	250.0 N/mm^2
Structural Hollow Sections	:	310.0 N/mm^2

Masonry:

Lightweight AAC Block Compressive	:	3.0 N/mm^2

Soil:

Safe Bearing Capacity	:	200 kN/m^2 as per soil investigation report.

Prof. Himanshu Parikh

ME (Cantab), MICE, FIASE, FRSA

16th September, 2015

Annexure A: Checking of Analysis and Design

Annex. A.1. Earth Quake Loading

Zone factor	:	0.16 (Zone III)
Importance factor	:	1
Response reduction factor	:	4 (Ductile shear walls)
Soil type	:	II (Medium soil)
% Live load considered in seismic	:	0.25
Time period in the horizontal X-Dir. (from formula in code)	:	1.301
Time period in the horizontal Y-Dir. (from formula in code)	:	1.339
Total seismic weight (SW) of building	:	1,16,380.00 Kn
Static Base-shear in X-Dir.	:	2.09% of SW
Static Base-shear in Y-Dir.	:	1.61% of SW
Maximum deflection at roof level	:	77 mm
Maximum inter storey drift/height	:	0.00870

Annex. A.2. Wind Loading

Category of building	:	3
Class of building	:	C
Basic wind speed	:	39 m/sec
Maximum wind pressure	:	91.94 Kn
Force coefficient	:	1.300
Wind Base-shear in X-Dir.	:	1740.62 Kn
Wind Base-shear in Y-Dir.	:	1904.13 Kn
Maximum deflection at roof level	:	52.3 mm
Maximum inter storey drift/height	:	0.00094

Annex. A.3. Result of Dynamic Analysis

Modes	Frequency in Hz	Time Period in sec	X-Participation	Y-Participation
Mode 1	0.336	2.974	0.1184	0.1366
Mode 2	0.376	2.657	0.0993	0.4887
Mode 3	0.407	2.460	0.4273	0.0203
Mode 4	1.222	0.819	0.0159	0.0349
Mode 5	1.357	0.737	0.0110	0.0823
Mode 6	1.612	0.620	0.0991	0.0004
Mode 7	2.500	0.400	0.0056	0.0135
Mode 8	2.797	0.358	0.0042	0.0296
Mode 9	3.510	0.285	0.0404	0.0002
Mode 10	4.095	0.244	0.0024	0.0081
Mode 11	4.637	0.216	0.0023	0.0173
Mode 12	5.835	0.171	0.0230	0.0005
Mode 13	6.062	0.165	0.0002	0.0048
Mode 14	6.917	0.145	0.0015	0.0118
Mode 15	8.301	0.120	0.0069	0.0034
Mode 16	8.508	0.118	0.0072	0.0003
Mode 17	9.572	0.104	0.0013	0.0089
Mode 18	10.877	0.092	0.0034	0.0027
Mode 19	11.329	0.088	0.0057	0.0000
Mode 20	12.527	0.080	0.0013	0.0069
Mode 21	13.664	0.073	0.0023	0.0023
Mode 22	14.352	0.070	0.0036	0.0001
Mode 23	15.669	0.064	0.0016	0.0052
Mode 24	16.612	0.060	0.0016	0.0020
Mode 25	17.600	0.057	0.0022	0.0004
		Summation	**0.8877**	**0.8812**

Annex. A.4. Lateral Deflection at Terrace Level

Load Case	Dx (Max.)	H/Dx	Drift-X	Dy (Max.)	H/Dy	Drift-Y
DL	6.7	432.86	0.000418	1.5	1933.33	0.000180
DL+LL	9.2	315.22	0.000531	2.1	1380.95	0.000234
EQX	77.7	32.32	0.003148	7.1	408.45	0.001119
EQY	5.1	568.63	0.000710	68.7	42.21	0.000174
WINDX	42.6	68.08	0.000387	7.3	397.26	0.000939
WINDY	6.3	460.32	0.000659	52.3	55.45	0.001318

Annex. A.5. Corner Displacement for Torsional Irregularity

Load Case	Corner 1	Corner 2	Corner 3	Corner 4	Average	% (Max./Avg.)
EQX	77.7	77.7	67.0	67.0	72.35	1.07%
WINDX	32.3	32.3	42.6	42.6	37.45	1.14%
EQY	68.7	57.5	57.5	68.7	63.10	1.09%
WINDY	40.5	52.3	52.3	40.5	46.40	1.13%

Annex. A.6. Acceleration (Mg)

EQX	EQY	WINDX	WINDY
100%	100%	100%	100%

Annex. A.7. Data Regarding Vertical Element

		Columns	Walls
Size of maximum loaded column	:	250 x 600	225 x 2000
Gravity load on max. loaded column	:	1573.41 kN	3917.64 kN
Axial stress in max. loaded column (gravity loads)	:	2.6 Mpa	2.5 Mpa
Grade of max. loaded column	:	35 N/sqmm	35 N/sqmm
Axial settlement in max. loaded column	:	2.2 mm	1.6 mm
% base shear resisted by all columns along X-Dir. (static)	:	3.17% (25%)	99.87%
% base shear resisted by all columns along Y-Dir. (static)	:	2.63% (25%)	97.37%

Columns are designed to take25% of earthquake shear load as per IS:1893-2002.

Annex. A.8. Data Regarding Floating Columns

No floating columns in these towers.

Total gravity load on floating column	:	NA
(Provide table if there are multiple floating columns)		
Size and span of girders supporting floating columns	:	NA
No. Of floors supported by floating columns	:	NA
Deflection of girder under column (from model)	:	NA
Deflection of girder under column (from s/s action)	:	NA
Specific details about floating columns on cantilever girders	:	NA

Columns	Supporting Girder		Deflection Value		Floors above	Total load in column
	Size	Span	Model	S/S Action		

Annex. A.9. Stability Calculation for Uplift and Overturning of Raft

c.g. of raft in x-direction=	12097.5	mm
c.g. of raft in y-direction=	11190	mm

SBC at 2.5m depth	200	kN/m^2
Max SBC Overturning (+50%)	300	kN/m^2
Min SBC Overturning	0	kN/m^2

Area of raft=	680691600	mm^2
Z in x-dir=	2.72468E+12	mm^3
Z in y-dir=	3.21529E+12	mm^3

1. LOAD CASE-1: (DEAD+FF+EXTRAPART.+0.5LIVE)

eccentricity in x-direction=	73.4	mm
eccentricity in y-direction=	0.4	mm

c.g. of load in x-direction=	12024.1	mm
c.g. of load in y-direction=	11189.6	mm

P/A=	0.198516471	Mpa
M/Z in x=	0.003641228	Mpa
M/Z in y=	1.76360E-05	Mpa

	AT RAFT BTM	
P/A+M/Z in x-dir=	202.2	kN/m²
P/A-M/Z in x-dir=	194.9	kN/m²
P/A+M/Z in y-dir=	198.5	kN/m²
P/A-M/Z in y-dir=	198.5	kN/m²

2. LOAD CASE-2: (DEAD+FF+EXTRAPART.+EQX)

eccentricity in x-direction=	680.0	mm
eccentricity in y-direction=	5.5	mm

c.g. of load in x-direction=	12777.5	mm
c.g. of load in y-direction=	11195.5	mm

P/A=	0.180010675	Mpa
M/Z in x=	0.030582385	Mpa
M/Z in y=	0.000209746	Mpa

	AT RAFT BTM			
P/A+M/Z in x-dir=	210.6	kN/m²	Overturning FOS	3.9
P/A-M/Z in x-dir=	149.4	kN/m²		
P/A+M/Z in y-dir=	180.2	kN/m²		
P/A-M/Z in y-dir=	179.8	kN/m²		

3. LOAD CASE-3: (DEAD+FF+EXTRAPART.-EQX)

eccentricity in x-direction=	872.9	mm
eccentricity in y-direction=	2.1	mm

c.g. of load in x-direction=	11224.6	mm
c.g. of load in y-direction=	11192.1	mm

P/A=	0.180012015	Mpa
M/Z in x=	0.039256904	Mpa
M/Z in y=	8.16094E-05	Mpa

	AT RAFT BTM			
P/A+M/Z in x-dir=	219.3	kN/m²	Overturning FOS	3.1
P/A-M/Z in x-dir=	140.8	kN/m²		
P/A+M/Z in y-dir=	180.1	kN/m²		
P/A-M/Z in y-dir=	179.9	kN/m²		

4. LOAD CASE-4: (DEAD+FF+EXTRAPART.+EQY)

eccentricity in x-direction=	99.4	mm
eccentricity in y-direction=	749.1	mm

c.g. of load in x-direction=	11998.1	mm
c.g. of load in y-direction=	11939.1	mm

P/A=	0.180010512	Mpa
M/Z in x=	0.004468	Mpa
M/Z in y=	0.028548382	Mpa

	AT RAFT BTM			
P/A+M/Z in x-dir=	184.5	kN/m²	Overturning FOS	4.2
P/A-M/Z in x-dir=	175.5	kN/m²		
P/A+M/Z in y-dir=	208.6	kN/m²		
P/A-M/Z in y-dir=	151.5	kN/m²		

5. LOAD CASE-5: (DEAD+FF+EXTRAPART.-EQY)

eccentricity in x-direction=	93.5	mm
eccentricity in y-direction=	741.5	mm

c.g. of load in x-direction=	12004.0	mm
c.g. of load in y-direction=	10448.5	mm

P/A=	0.180012178	Mpa
M/Z in x=	0.004206518	Mpa
M/Z in y=	0.028257027	Mpa

	AT RAFT BTM			
P/A+M/Z in x-dir=	184.2	kN/m²	Overturning FOS	4.2
P/A-M/Z in x-dir=	175.8	kN/m²		
P/A+M/Z in y-dir=	208.3	kN/m²		
P/A-M/Z in y-dir=	151.8	kN/m²		

Annex. A.10.Soft Storey Effect

No soft storeys in these towers. All floors from ground to terrace built-up on.

Stiffness of lower floor (in deflection/Kn) : NA
Stiffness of upper floor (in deflection/Kn) : NA
Relative stiffness ratio (upper/lower) : NA
Level of soft storey : NA
Number of floors above soft storey : NA

Annex. A.11.Cantilever

Cantilever span : 1050mm
Structural system : Cantilever flat slab at slab level
Nature of usage : Balcony
Maximum elastic deflection under DL+LL : 12.5mm

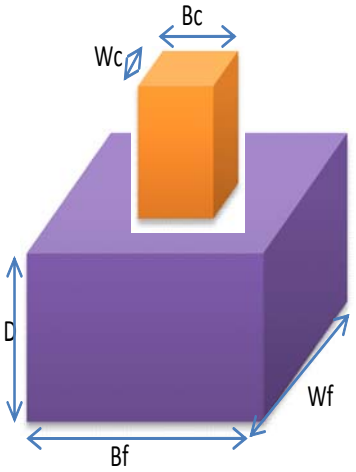
Annex. A.12.Typical Design Calculation for Footing

FOOTING DESIGN

LOADING			
Load	P	2302	kN
Moment	M	46.0	kN.m
COLUMN SIZE			
Col	B_c	0.225	m
column	Wc	1.5	m
Footing	Area	11.74	Actual 10.90
Footing	Breq	1.33	m
Footing	Wreq	8.85	m
	Depth req	591	mm

BENDING MOMENT

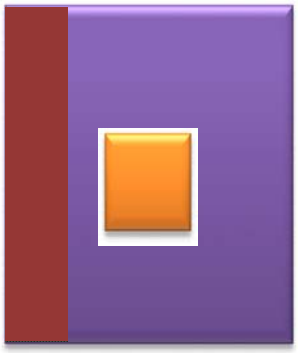
	X-B	Y-W
Mu	255	255
dreq-f	126	153
Mu/bd2	0.520	0.520
Pt	0.122	0.122
Ast	855	855
diameter	12	12
spacing req	132	132
spacing prov	100	100
As, prov	1131	1131



FOUNDATION SIZE			
SBC		200	kN/sqm
Footing	B_f	2.725	1.25 m cantilever
Footing	Wf	4	1.25 m cantilever
	D-prov	750	mm
	d'	50	mm
	d=	700	mm

ONE WAY SHEAR @ d away

Vu	718	489
Tv=Vu/bd	0.256	0.256
pt	0.162	0.162
Γc, IS456	0.304	0.304
	ok	ok
	591.21	591.21

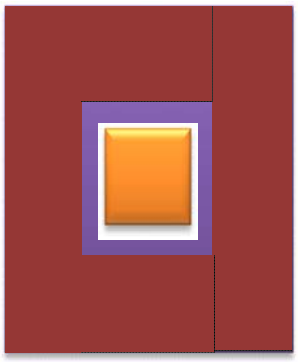


	Fck	30 N/mm2
	Fy	500 N/mm2
STRESS		
	P/A	211 kN/sqm
	M/Z	6 kN/sqm
Stress		218 kN/sqm

Accept

TWO WAY SHEAR @ 0.5d away

Vu	1960
Γv	0.448
Γ'c	1.369
229	ok



RAFT DESIGN FOR RESIDENTIAL BLOCKS

PROPERTIES	fcu	30	n/sqmm			fy	500	n/sqmm	
		col btm	slab btm	col top	slab top	col btm	slab btm	col top	slab top
BENDING	Panel Mu	443.03	443.03	443.03	443.03	223.42	223.42	223.42	223.42
	factor strip	0.75	0.25	0.6	0.4	0.75	0.25	0.6	0.4
	factor T/B	0.65	0.65	0.35	0.35	0.65	0.65	0.35	0.35
	%redist	5.0%	0.0%	-11.6%	0.0%	0.0%	0.0%	0.0%	0.0%
	Design bm	332.20	188.29	168.12	162.22	199.69	79.87	86.02	68.81
	b=	1000	1000	1000	1000	1000	1000	1000	1000
	D=	750	750	750	750	750	750	750	750
	cover=	40	40	40	40	50	50	50	50
	d=	710	710	710	710	700	700	700	700
	d T-flange	40.12	22.45	20.01	19.30	24.19	9.57	10.32	8.24
	m/bd2	0.659	0.374	0.333	0.322	0.408	0.163	0.176	0.140
	%ast needed	0.156	0.087	0.078	0.075	0.095	0.038	0.041	0.032
	ast needed	1107	619	552	532	667	264	285	227
		12/100	12/100	12/200	12/200	12/100	12/100	12/200	12/200
	Ast prov	1130	1130	565	565	1130	1130	565	565
	%Ast provided	0.16	0.16	0.08	0.08	0.16	0.16	0.08	0.08
	fy	284.0626	158.9715	283.3828	273.3036	171.2568	67.7826	146.0713	116.6828
DEFLECTION	factor			2.00	2.00			2.00	2.00
	ss			28400	28400			28000	28000
	cont.			36920	36920			36400	36400
	cantilever								

PUNCHING		SQUARE		UNIT LOADS			
	ult col load	4454.709618			SBC	**198.516**	kn/sqm
	less over col	1787.4					
	punch load	2667.3					
	Min Column	950					
	slab D	750					
	av. Cover	45		PANELS			
	av slab d	705		span m	4.40	span m	3.40
	shear stress	0.572		col strip	2.40	col strip	2.10
	permissible	1.369		slab strip	2.00	slab strip	1.30

CHECK CANTILEVER RAFT EDGES

PROPERTIES	fcu	30	n/sqmm	fy	500	n/sqmm
BENDING	Design BM	242.1135189	Kn-M/m	Projection	1.2	m
	b=	1000		Col width	0.225	m
	D=	750		span	1.0875	m
	cover=	50		BM Factor	2	
	d=	700				
	Total T-flange	29.442				
	m/bd2	0.494	OK			
	%ast	0.116				
	ast	812				

DEFLECTION	Ast prov	1130
	fy	208.44044
	factor	2
	cantilever	9800

SHEAR	total ult shear	100.50	Kn/m
	%Ast	0.1614	
	Tv N/mm2	0.1436	
	Tc N/mm2	0.3035	OK

Annex. A.13.Typical Design Calculation for RCC Column

ETABS 2013 Concrete Frame Design

IS 456:2000 Column Section Design

Column Element Details Type: Ductile Frame (Summary)

Level	Element	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
GF	C2	COL250X600M35	DCon2	0	3750	0.5

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
250	600	56	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
29580.4	35	1	500	500

Design Code Parameters

ɣc	ɣs
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 % %
2382.9843	77.8721	4.3722	47.6597	65.5321	3015	2.01

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)	1	3750	-3.6035	0	65.5321
Minor Bend(M2)	1	3750	-1.6354	30.2124	47.6597

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}	0	0	0	0	0
Minor, V_{u3}	1.6593	129.0397	46.5596	0	665.06

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}	N/A	N/A	N/A	N/A	N/A	N/A
Minor Shear, V_{u3}	N/A	N/A	N/A	N/A	N/A	N/A

(1.1) Beam/Column Capacity Ratio

Major Ratio	Minor Ratio
N/A	N/A

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
1500	30.1	3490.9333	1033.1267	2382.9843	0.450788

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	1	600	6.25	12	No	0
Minor Bending (M_2)	Yes	1	250	15	12	Yes	67.0214

Annex. A.14.Typical Design Calculation for RCC Wall

ETABS 2013 Shear Wall Design

IS 456:2000 Pier Design

Pier Details

Story	Pier ID	Centroid X (mm)	Centroid Y (mm)	Length (mm)	Thickness (mm)	LLRF
GF	P14	24195	6070	3280	225	0.5

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
29580.4	35	1	500	500

Design Code Parameters

Γ_S	Γ_C	IP_{MAX}	IP_{MIN}	P_{MAX}	MinEcc Major	MinEcc Minor
1.15	1.5	0.02	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	24195	4430	24195	7710	3280	225
Bottom	Leg 1	24195	4430	24195	7710	3280	225

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	3483	0.0047	0.003	DWal30	6562.6908	-193.9199	-2702.6307	738000
Bottom	1845	0.0025	0.003	DWal32	4472.707	126.8958	-300.1182	738000

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	562.5	DWal30	4186.1184	2408.7207	641.4535	314.8173	847.4608
Bottom	Leg 1	562.5	DWal30	4285.7485	300.1969	641.4535	256.4412	789.0847

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	787.5	DWal29	6683.1294	-2209.5184	14.53	7
Top–Right	Leg 1	787.5	DWal29	6562.6908	2408.7207	14.86	7
Bottom–Left	Leg 1	562.5	DWal19	6805.6375	-36.2688	9.31	7
Botttom–Right	Leg 1	562.5	DWal19	6782.7594	233.2075	9.77	7

Annex. A.15.Typical Design Calculation for RCC Beam

ETABS 2013 Concrete Frame Design

IS 456:2000 Beam Section Design

Beam Element Details Type: Ordinary Frame (Summary)

Level	Element	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
GF	B7	BEAM225X500M30	DCon28	0	4150	1

Section Properties

b (mm)	h (mm)	b_f (mm)	d_s (mm)	d_{ct} (mm)	d_{cb} (mm)
225	500	225	0	30	30

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
-36.261	6.3589	11.4854	-12.883

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-36.261	12.0527	0	-48.3137

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)	-48.3137		246	0	246	191
Bottom (-2 Axis)		0	0	0	0	0

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
11.4854	38.5032	42.3	29.4365	249.4

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
6.3589	11.4854	185	460	234.74

Annex. A.16.Typical Design Calculation for RCC Girder

Not required, as transfer girder is not provided.

Annex. A.17.Typical Design Calculation for Steel Bracings

Not required, as steel bracing is not provided.

Annex. A.18.Wind Tunnel Study

Not required, as height is not more than 250m.

Annex. A.19.Note on Specific Provisions

No specific provision is provided.

Annexure B: Description of Sub-Structure

Descriptions		Remarks
No. Of basements		One
Minimum clearance between outermost basement retaining wall and compound wall		3500 mm
Has a shoring system been installed? Submit section detail of the shoring system		No
Give details of methodology used to resist uplift pressure due to ground water for tower portion as well as the portion outside the tower.	Bottom level of raft w.r.t. ground level in mts. Total downward load of self weight of raft + counter weight over raft + rock anchors if any (for raft spanning between columns) Whether pressure release pipes have been used? Water level assumed for uplift calculation.	Raft bottom 2.6m below ground. No groundwater encountered in any of the boreholes upto 6m below ground Self weight of 0.75m raft = 18 kN/sqm + Avg 200mm PCC fill on raft = 5.5 kN/sqm No ground water encountered.
Description of the foundation for the tower block		750mm deep raft below tower block
Nature of foundation	Piles, Spread footings, Combined raft, Piled raft, etc.	Raft
SBC assumed (T/Sq.mt.)		20
Sub-grade elastic modulus		4000 kN/m
Flooring system of the basement		Raft+200mm thk. PCC
Retaining wall types & sequence of back filling	Whether propped cantilever, Cantilever, Supported between buttresses/counter forts, etc.	Propped cantilever (Backfilling will be done after casting of basement slab or wall should be propped until casting of the basement slab)
Intended use of basement		Parking
If rock anchors are used, are they grouted after installation and stressing?		Not Applicable

Descriptions		Remarks
Is structural steel used in the construction of the sub-structure?		No
If yes, what are the measures taken for its fire proofing and corrosion resistance?		Not applicable
Whether expansion/separation joint provided? **Whether expansion joint/separation joint continues through basement?** **If yes, detail basement level & retaining wall junction.**		No

Annexure C: Description of Super-Structure

Descriptions	Remarks
No. Of floors & height of building in Mt.	B+G+25 Storeys (71.370 Mt.)
Shape of building, Plan, Elevation, Whether symmetric in elevation	Symmetric in Plan and Elevation
Maximum plan dimension in either direction in Mt.	24.195 in X-Dir. 22.830 in Y-Dir.
Ratio of plan dimension	1.059
Typical floor to floor height in Mt. **Maximum floor to floor height in entire height of building in Mt.**	2.90 Mt.
Aspect ratio (height of building till terrace/max. dimension of building)	2.938
Type of floor slab	Flat slab
Average thickness of floor slab in mm	170mm
Whether columns are RCC, composite or in structural steel	RCC
<u>Lateral System</u> **Whether the geometry of building is symmetric** **Whether the lateral load resisting system is symmetrically placed in geometry**	 Symmetric Yes
Use of floor at different levels (residential/commercial/industrial)	Residential
Is there any transfer level? **If yes, depth of transfer girder.**	No
Whether expansion joint is provided? **If yes, what is the maximum plan dimension in Mt.**	Not required
Whether separation gap at the joint is sufficiently provided?	Not required
Maximum cantilever projection in Mt.	1.05 Mt.