DUCON
CONSULTANTS PRIVATE LIMITED

PROJECT NO : 6214

PROJECT NAME : SEVENTY

(RESIDENTIAL STRUCTURE)

(3 BASEMENT + GROUND FLOOR + 22 UPPER FLOORS)

STRUCTURAL DESIGN BASIS REPORT FOR PROPOSED SEVENTY AT BOPAL ROAD, AHMEDABAD

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Date: 10th DECEMBER, 2015

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TABLE OF CONTENTS

1. INTRODUCTION

bSafal has appointed **DUCON CONSULTANTS PRIVATE LIMITED** to develop structural schemes and design for proposed construction of **SEVENTY at AHMEDABAD.**

The objectives of these reports are stated as follows:

- Identify and record all input requirements, Analysis and design criteria.
- Develop safe and stable structural scheme pertaining to Indian Standards compatible with Architectural vision, services requirements and client's needs.
- Prepare structural design that will aim to actual structural durability and integrity.
- Desirable structural performance under characteristic services load.

2. PROJECT DESCRIPTION

Project	:	SEVENTY
Location	:	AHMEDABAD,GUJARAT

2.1 AGENCIES

Client	:	bSafal
Design Architects	:	SCDA Design Pvt Ltd. & VITAN Architects
Structural Consultants	:	DUCON Consultants Private Limited A3-A4, 3rd floor, Safal Profitaire, Corporate Road, Near prahladnagar garden, S. G. Road, Ahmedabad-51 E-mail: utsav@duconconsultants.in contact@duconconsultants.in Ph: 40073196, 65410630, 65410631.

2.2 PROJECT

The project consists of **3 Basement + Ground Floor + 22 Upper Floors.**

Basement floors will be primarily used for parking purpose & Water body for architectural aesthetics.

Ground floor will be used for plantation , water body, floating pavilion, community greens and specifically for parking & fire fighting movement. While Typical floors(1st to 20th floor) will be used for only Residential purpose.

21st floor will be used for residential Penthouse type-A, M.E.P Service floor & specially for transfer floor having Wide PT Beams used, Where RCC pardi and steel truss to be supported for the provision of swimming pool (connecting between two towers) at 22nd floor level. While 22nd floor will be used for residential Penthouse-A, swimming pool, clubhouse & gym.

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Terrace level (23rd floor) will be used for Private Lap pool, landscaping, pavilion structure for type-A.while 24th level (Upper terrace)will be used for lift machine room, fire water tank & staircase covering slab.In this project we have considered framing system for the most of part of the structure is PT Flat Slab without drop at 2nd & 1st basement &typical floor while on ground floor PT Flat slab with drop and beams are provided at some place as per requirement.

The following are the PT Flat slab specifications considered for the design:

Material Specification for Monostrand Unbonded Standard PT system

(PTI Specs., ACI 423.6-01, IS : 14268:1995)

Prestressing Steel:

- Low-Relaxation 7 wire Strand of Class II (Grade 1860) with 12.7mm nominal diameter used in mono-strand unbonded post tensioning tendons shall conform to the requirements of IS-14268:1995
- Sectional steel area of Strand: 98.7mm2
- Yield Load: Not less than 180 KN
- Ultimate Strength: Not less than 1860 N/mm2
- Minimum Breaking Strength: Not less than 183.7 KN
- Modulus of Elasticity: At least 196,500 N/mm2
- Minimum elongation: 3.5% for gauge length of 600mm
- Relaxation at 1000 hours: Less than 2.5% at 70% Minimum Ultimate Tensile Strength
- Weight of Bare Strand: More than 0.775kg/m

Anchorage:

- Mono-strand anchorages of un-bonded tendons shall be designed to develop at least 95% of the actual strength of Prestressing steel with following Mechanical Properties:
- Material of Anchorage: SG Iron
- Hardness: 170 to 230 BHN
- Bearing Area: 7239mm2

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Structural form should contribute to the building character and identity, while being efficient, cost effective and simple to construct.

No future floor provision is accounted in analysis & design.

Provision will be done in design such a way that services can be laid without any major obstructions and maximum head room is achieved along with the basic criterion of cost effectiveness.

2.3 BUILDING DIMENSION

Plan dimension	:	(Refer Arch. Plans)
Floor heights (Finish floor to finish floor)		
Total Height of building	:	**78.5 m** (From Ground Level)
Basement – 3 height	:	**4.8 m**
Basement – 2 height	:	**3.45 m**
Basement – 1 height	:	**4.5 m**
Ground Floor	:	**5.9 m**
1st to 22nd Floor	:	**3.3 m**

3. STRUCTURAL DESIGN STANDARDS AND CODES

Following Indian codes shall here to be used for detailed design.

3.1 INDIAN CODES

3.1.1 LOADS

IS 875(Part 1): 1987 - Dead Loads - Unit Weight of Building Material and Stored Material

IS 875(Part 2): 1987 - Imposed Loads

IS 875(Part 3): 1987 - Wind Loads

IS 875(Part 5): 1987 - Special loads and load combinations

IS 1893(Part 1):2002 - Criteria for earthquake resistance design of structures.

3.1.2 CONCRETE DESIGN

IS 456: 2000 - Plain and Reinforced Concrete - Code of practice.

SP 16 - Structural use of concrete. Design charts for singly reinforced beams, doubly reinforced beams and columns.

SP 34 - Handbook on Concrete Reinforcement & Detailing.

IS 1904 - Indian Standard Code of practice for design & construction foundations in Soil: General Requirements.

IS 3370 (part I to IV) Code of practice for concrete structure for storage of liquid.

IS 4326: 1993 - Earthquake Resistant Design and Construction of Buildings.

IS 13920: .1993 - Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces.

3.1.3 STEEL DESIGN

IS 800:1984 - Code of Practice for General Construction in Steel

SP 6:1964 - Hand Book for Structural Engineers Part1-Structural Steel Sections

IS 4000:1992 - High strength bolts in steel structures -Code of practice

IS 816:1969 - Code of practice for use of Metal Arc welding for general construction in Mild steel

Tata Hollow Section Manual

4. DESIGN PARAMETERS

4.1 Material of Construction

4.1.1 RCC WORKS

The building will be primarily R.C.C framed structure with columns,Shear walls and lift walls and floor slabs being used as diaphragms in distribution of lateral forces.

- Density of reinforced concrete shall be 25 KN/m3.
- Concrete mix for columns and shear wall up to 5th floor : **M:50**
- Concrete mix for columns and shear wall from 6th to 10th floor : **M:40**
- Concrete mix for columns and shear wall above 10th floor : **M:35**
- Concrete mix for footings : **M:30**
- Concrete mix (minimum) for all PT slabs : **M:35**
- Concrete mix for all conventional slabs and beams : **M:35**
- Concrete mix for Retaining Wall : **M:35**
- Grade of Concrete M:10 will be used in filling, plum concrete, leveling courses and other nonstructural items. Density of reinforced concrete is assumed as 25 KN/m3.
- Minimum cement content, water cement ratio etc. will conform to IS 456:2000 provisions for durability and strength criteria.
- Ordinary Portland cement of grade 43 or higher confirming to IS 8112 and IS 12269 are specified for concrete grades ranging from M: 20 to M: 55.

- The sizes of aggregates conform to IS 383. Nominal maximum size of coarse aggregate is 20 mm, suitably graded as per the requirement of mix design.
- Mixing Water will conform to IS 456: 2000.
- High yield strength deformed bars conforming to IS 1786 with Fy = 500 N/mm2 TMT bars will be used.
- All mix design of concrete should be got approved prior to execution of work.
- Take out 6 cubes from every batch of concrete and report of the same of 7 days and 28 days must be submitted to us. However frequency of sampling of Concrete shall not be less than as specified in Clause 15.2.2 of IS:456:2000 Specified below.

Quantity of Concrete in the Work, m^3	*Number of Samples*
1 - 5	1
6 - 15	2
16 - 30	3
31 - 50	4
51 and above	4 plus one additional sample for each additional 50 m^3 or part thereof

NOTE—At least one sample shall be taken from each shift. Where concrete is produced at continuous production unit, such as ready-mixed concrete plant, frequency of sampling may be agreed upon mutually by suppliers and purchasers.

- For reinforcement report should be carried out at every 30 ton for each category.

4.2 LOADING PARAMETERS

4.2.1 SELF WEIGHTS

Self-weight of the structural members shall here to be considered on the basis of the following properties.

• Density of Reinforced Concrete	:	25.0	KN/m^3
• Density of Plain Concrete	:	24.0	KN/m^3
• Density of Steel	:	78.5	KN/m^3
• Density of Floor Finishes / Plasters	:	20.0	KN/m^3
• Density of Soil (Unsaturated)	:	18.0	KN/m^3
• Density of Soil (Saturated)	:	21.0	KN/m^3
• Density of Light Weight Cinder Filling Material	:	12.0	KN/m^3
• Density of Light weight Aerated Block	:	8.0	KN/m^3

4.2.2 IMPOSED GRAVITY LOADS

The following imposed gravity loads shall here to be adopted in addition to the self-weight of the structure. (Self-weight of slab / beam / columns will be as per the dimensions adopted in the respective drawings.

4.2.2.1 LIVE LOAD

Basement Floors

- Live load on 2nd & 1st basement floor for Non-stack parking = 5.0 kN/m²

Ground Floor

- Live load on G. F. Slab for Non-stack parking = 5.0 kN/m²
- Fire fighter load = 12 kN/m²

Typical Floors (1st to 20th floor)

- Live load on Typical Floor = 2.0 kN/m²
- Live Load on Typical Floor (Balcony, Passage, Foyer, Staircase etc) = 3.0 kN/m²

21st Floor

- Live load for residence area = 2.0 kN/m²
- MEP Service load = 5.0 kN/m²
- Load from Sky walk Connecting two towers is applied on PT beams in terms of Point loads derived from a separate sky walk Model.

22nd Floor

- Live load for residence area = 2.0 kN/m²
- Live load for club house & Gym = 4.0 kN/m²

23rd Floor (Terrace Floor)

- Live Load on Landscape and pavilion structure = 4.0 kN/m²

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4.2.2.2 DEAD LOAD

Basement Floor

- Floor finish load on Basement Floor = 2.0 kN/m²
- Water-body load (0.3 x 10) = 3.0 kN/m²

- Suspended Services load =1.5 kN/m²

Ground Floor

- Floor finish load on Ground Floor = 2.0 kN/m²
- Water proofing load on Ground Floor = 2.25 kN/m²
- Water-body load (0.3 x 10) = 3.0 kN/m²
- 600mm Thick Soil filling on Ground Floor (=0.600x21) = 12.6 kN/m²
- 225mm thick light weight cinder filling + 150thk slab load
  = 0.225 x 12 + 0.150 x 25 = 2.7 + 3.75 = 6.45 kN/m²
- 300mm thick light weight cinder filling + 150thk slab load
  = 0.300 x 12 + 0.150 x 25 = 3.6 + 3.75 = 7.35 kN/m²
- 100mm thick slab = 0.100 x 25 = 2.5 kN/m²
- 875mm soil filling = 0.875 x 21 = 18.37kN/m²

Typical Floor (1st to 20th floors)

- Floor finish load on typical floor = 1.8 kn/m²
- Floor finish load on stair (in plan) [=1.8x(0.300+0.150)/0.300] = 2.7 kn/m²
- D.L. Of steps considering 150mm riser (0.5 x 0.150 x 25) = 1.875 kn/m²
- Services & false ceiling load = 0.5 kn/m²
- 40mm deep sunk – toilet area (=0.040x12) = 0.48 kn/m²
- 200mm deep sunk for kitchen (=0.2x12) = 2.4 kn/m²

21st Floor

- Floor finish load = 1.8 kn/m²
- Water load for balancing tank = 20 kn/m²

22nd Floor

- Floor finish load = 1.8 kn/m²
- Water-body (Swimming Pool) load on 20th Floor (=1.3x10) = 13.0 kN/m²

23rd Floor (Terrace floor)

- Floor finish load = 2.25 kn/m²
- Water-body (Lap Swimming Pool) load (=1.3x10) = 13.0 kN/m²
- Overhead Water-tank Load (=2.2x10) = 17.0 kN/m²

24th Floor (above Terrace Floor)

- Floor finish load on Terrace Floor (including Waterproofing) = 2.25 kN/m²
- Specific loads given by vendors sbe adopted wherever applicable.

4.2.2.3 SELF - WEIGHT OF DIFFERENT WALLS

At Typical Slab level

For 225 thick Light Weight Aerated Concrete Block (on Beams – 700mm deep)

(Typical height : 3.3 m) = (3.3-0.7) x 0.225 x 8.0+ (3.3-0.7) x 0.04 x20
= 6.76 KN/m

For 225 thick Light Weight Aerated Concrete Block (on Flat Slabs)

(Typical height : 3.3 m) = (3.3-0.175) x 0.225 x 8.0+ (3.3-0.175) x 0.04 x20
= 8.13 KN/m

For 150 thick Light Weight Aerated Concrete Block (on Beams – 700mm deep)

(Typical height : 3.3 m) = (3.3-0.7) x 0.15 x 8.0 +(3.3-0.7) x .04 x20
= 5.2 KN/m

For 150 thick Light Weight Aerated Concrete Block (on Flat Slabs)

(Typical height : 3.3 m) = (3.3-0.175) x 0.150 x 8.0 +(3.3-0.175) x .04 x20
= 6.25 KN/m

At Terrace Slab level

For 150 thick R.C.C. Parapet wall of Height 1.2m = 1.2 x 0.15 x 25 = 4.5 kN/m

Facade load at considered on peripheral beams at every floors = 5.0 kn/m

4.2.3 SEISMIC LOADS

The seismic load calculations will be carried out in accordance with IS 1893(Part 1): 2002.As per this code, AHMEDABAD lies in Zone III, zone factor Z = 0.16.The Design Base Shear is given by Vb = (Z/2) x (I/R) x (Sa/g) x W. Where, **Importance factor I will be taken as '1' and response reduction factor R will be taken as '5'** as the structure would be Ductile RCC Shear wall structure designed using ductile detailing conforming to Indian standards IS-

13920. Sa / g is the normalized Response Spectrum value for the structure which is the function of the fundamental time period of vibration of the structure and the type of the founding soil.W is the Seismic Weight of the building, which will be calculated in accordance with the relevant clause in, IS 1893(Part 1): 2002.Since the structure is a R.C.C. structure, an approximate damping value of 5% will be considered. Space frame analysis of the structure will be carried out using response spectrum method.

The seismic Analysis will be carried out in accordance with IS 1893(Part 1): 2002.Based on the type of external action and behavior of structure, the analysis can be classified as below.

- Linear Static Analysis (Equivalent Static Analysis)
- Linear Dynamic Analysis (Response Spectrum Method)

Height of Building : 78.05m

Time period calculation for A & D block

Time period in X direction $= 0.055 \times h^{0.75}$ $= 0.055 \times 78.5^{0.75}$

$= 1.444$ sec

Time period in Y direction $= 0.055 \times h^{0.75}$ $= 0.055 \times 78.5^{0.75}$

$= 1.444$ sec

Considering Medium Soil sites for foundation,

Sa/g for X direction for time period $0.55 \leq T \leq 4 = 1.36 / T = 0.942$

Sa/g for Y direction for time period $0.55 \leq T \leq 4 = 1.36 / T = 0.942$

Design Horizontal seismic co-efficient A_h for A & D block:

Design Horizontal seismic co-efficient A_h in X direction $= (0.16/2) \times (1/5) \times 0.942$
$= 0.015$

Design Horizontal seismic co-efficient A_h in Y direction $= (0.16/2) \times (1/5) \times 0.942$
$= 0.015$

Since the structure is a R.C.C. structure an approximate damping value of 5% will be considered.

The 3D analysis of the structure gives the results of various parameters to be checked for the stability & serviceability of the structure like drift, deflection, torsion effects, soft storey effects etc.

SDD Method :

S : Static

D : Dynamic Analysis (With Basic scale factor)

D : Scaled Dynamic Analysis

Step 1 (S):

In this method ,first of all Static Analysis is carried out with considering without infill Time Period.

Step 2 (D)

Then, 1st Dynamic Analysis is carried out with Response spectrum functions and cases for Spectrum are taken as SpecX & SpecY with basic scale factor. Scale factor is taken as 1.226 as Sa/g value is taken from response spectrum function, and as I=1, R=4, from Equation for scale factor (I*g)/(2R) = 1.226

Step 3 (D)

Now, 2nd Dynamic Analysis is carried out by multiplying Basic Scale factor by ratio of Static base shear & 1st Dynamic base shear.

5. WIND LOADS

The wind calculation is carried out as per IS 875:1987 (Part-3).

HEIGHT OF BUILDING (h)	=	78.5 m
LENGTH OF BUILDING (l)	=	37.41 m
WIDTH OF BUILDING (w)	=	28.02 m
CO-EFFICIENT	=	1.30 (Ref. IS-875_Part_3,Table-4, pg-14)
RATIO (h/w)	=	2.79
RATIO (l/w)	=	2.09

As the height of the building to width of the building ratio is less than 5,Hence Building will not be slender for Gust analysis however Normal Wind load will be applied on building.

IS 875-1987 is used for finding out the wind pressure.

Basic wind speed – 39 m/sec

Design wind speed $V_z = V_b \times k_1 \times k_2 \times k_3$

Where k_1 = risk factor; k2 = Terrain, Height & Structure size factor ; k_3 = Topography factor.

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Hence, for the present structure,

$k_1 = 1$; Refer Table 1 IS 875-1987-Part – 3

$k_2 = 1.065$ Refer Table 2 IS 875-1987-Part – 3(Category 3, Class C structure)

$k_3 = 1$; Refer Clause 5.3.3.1 IS 875-1987-Part – 3

Design Pressure (Pz) = $0.6\ Vz^2$

$= 0.6\ (39x1x1.065x1)^2$

$= 1035.09\ N/m^2$

Now Wind Forces are carried out as per IS:875:III-1987-Fig No-4 as per Clause: 6.3.2.

6. STRUCTURAL ANALYSIS

The structural form should contribute to the building character and identity while being efficient, cost effective and simple to construct. Structure will be for earthquake analysis using minimum column section at floors. Structure will be analyzed using ETABS 9.7.4. The analysis generated by software will be cross verified by hand calculations of critical members.

7. LOAD COMBINATIONS

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

For Foundation sizing

- DL + LL
- DL + LL ± EQ/WL in X
- DL + LL ± EQ/WL in Y
- DL ± EQ/WL in X
- DL ± EQ/WL in Y

For Structural Design

- 0.9 DL ± 1.5 EQ/WL in X
- 0.9 DL ± 1.5 EQ/WL in Y
- 0.9 DL + 1.5 SPEC in X
- 0.9 DL + 1.5 SPEC in Y

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- 1.5 (DL + LL)
- 1.2 (DL + LL ± EQ/WL in X)
- 1.2 (DL + LL ± EQ/WL in Y)
- 1.2 (DL+ LL + SPEC in X)
- 1.2 (DL + LL + SPEC in Y)
- 1.5 (DL ± EQ/WL in X)
- 1.5 (DL ± EQ/WL in Y)
- 1.5 (DL+ LL + SPEC in X)
- 1.5 (DL + LL + SPEC in Y)
- 1.5 DL ± 1.5 EQ/WL in X ± 0.45 EQ/WL in Y
- 1.5 DL ± 1.5 EQ/WL in Y ± 0.45 EQ/WL in X
- 1.2 DL + 1.2LL ± EQ/WL in X ± 0.36 EQ/WL in Y
- 1.2 DL + 1.2LL ± EQ/WL in Y ± 0.36 EQ/WL in X

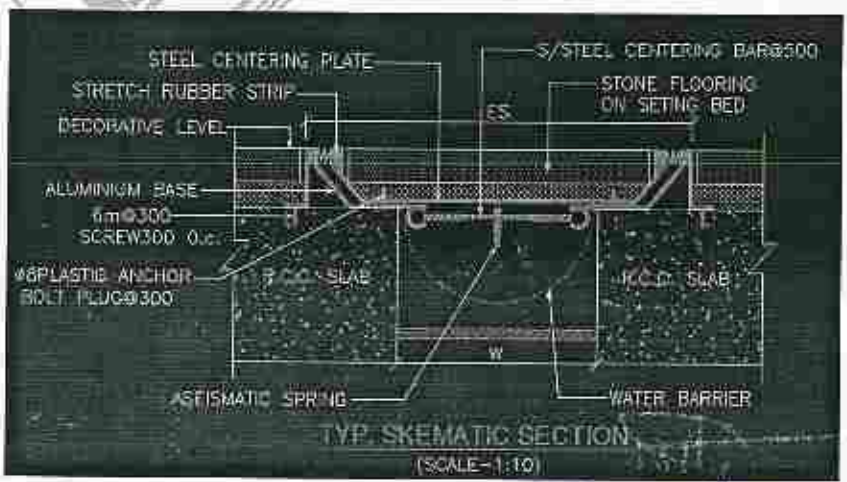
8. SEPARATION / EXPANSION JOINTS

The Expansion joint will be provided in between two towers at Sky Walk (21st Floor) level Where Two towers will be connected by Bridge (Box-Truss System).

The separation and expansion joints will be carried out in accordance with IS 456: 2000.

Maximum Storey Displacement = 36mm; Response Reduction Factor R = 4

Thus Seismic gap required as IS 1893 (part 1) : 2002; cl.7.11.3 = R/2*(sum of calculated Storey displacement) = 5/2*(65+115) =450 mm. Thus **450mm wide expansion joint is proposed to allow.**



9. STRUCTURAL DESIGN

9.1 DESIGN METHOD

For the design of R.C.C. elements, the Limit State Method will be used as per ***IS: 456:2000***. Materials of construction will be predominantly concrete with consideration for strength and durability.High Yield Strength Deformed bars conforming to **IS:1786** with **fy=500 N/mm2** will be used as reinforcement.

9.2 COVERS TO REINFORCEMENT

Clear cover for all Exposed RCC members shall be in accordance with IS: 456:2000 corresponding to moderate exposure conditions for the super-structure as well as the substructure and to satisfy a fire rating of 2 hrs.

Minimum clear cover is to be provided,

For footing	: Side Cover 50 mm
	: Bottom Cover 50mm
For Column	: 40mm (From extreme face of column ring/link.)
For Beam	: 30 mm for side face (From extreme face of beam stirrups.)
	: 30 mm for bottom (From extreme face of beam stirrups.)
For Slab	: 25 mm
For Retaining wall	: 40 mm
For RCC shear wall	: 40 mm

10. SOIL INVESTIGATION & BEARING CAPACITY

Soil bearing capacity considered as **25.5 T/M²** for Isolated foundation at 1.3 m depth below from 3rd basement floor leveland **50 T/M²** for Raft foundation at 2.1 m depth

Below from 3rd basement floor level as per soil report of M.K.Soil Testing Laboratory.

With reference to Report no (project reference) MK/50/12-13,
Date: DECEMBER, 2013, Pg no 11,

Thickness of P.C.C. is considered 150mm.

Foundation is designed for fixed condition only.

11. SERVICES DETAILS & ELEVATIONS TREATMENT & ROOFING SYSTEM

Lift floor slabs will be designed for loads as mentioned in manufacturers data + impact loads.

Necessary cut outs in floors, walls and beams will be provided as per service consultant's

drawings. Sunken Slab requirements for toilets are to be clarified by architect. Elevation treatment such as glass facades or precast/prefabricated insulate panels may be considered for exterior and the loads for the same shall be confirmed to us by the architects and clients.

12. VALUE ENGINEERING

The parameters adopted in this report are going to be the basis of the structural design.Hence it is requested that all team members give their feedback and approval to the parameters, suggestions, recommendations mentioned in this report. Certain additional parametric changes may be adopted due to some conditional changes in plans or requirements. Structural consultant shall have full freedom to add value to any aspect of design parameters mentioned here in this DBR to maintain the sound integrity of the structure.

13. CONCLUSIONS & RECOMMENDATIONS

This brief concept has been formulated based on the architectural scheme provided by **SCDA Design PVT LTD. & VITAN Architects** . The report suggests a concept level structural design of **SEVENTY at Bopal, Ahmedabad** and must be read keeping in mind these limitations.

It focuses only on the overall structural design and durability of the building and does not aim to address the structural details of building. As the next logical step towards scheme design, following is recommended:

1. Concept design of superstructure to be finalized by Client and Architects followed by final architectural drawings (Plans, Elevations & Sections) to be sent across for Structural Consultants to re-initiate the drawing process.

2. Approvals/Comments and sign-off of the structural system and structural framing plans.

3. Development of Construction Drawings.

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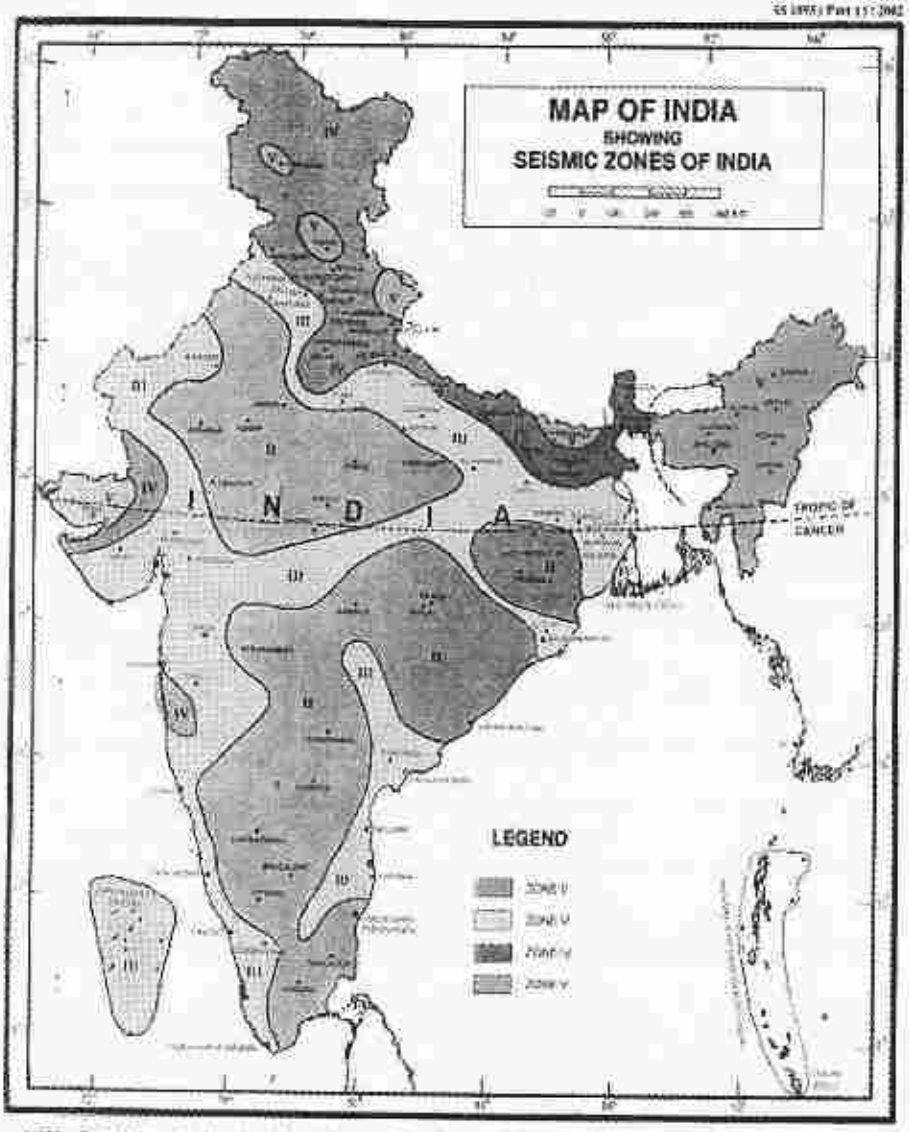
14. REFERENCE FOR SIESMIC ZONE



NOTE. Towns falling at the boundary of zones demarcation line between two zones shall be considered in High Zone.

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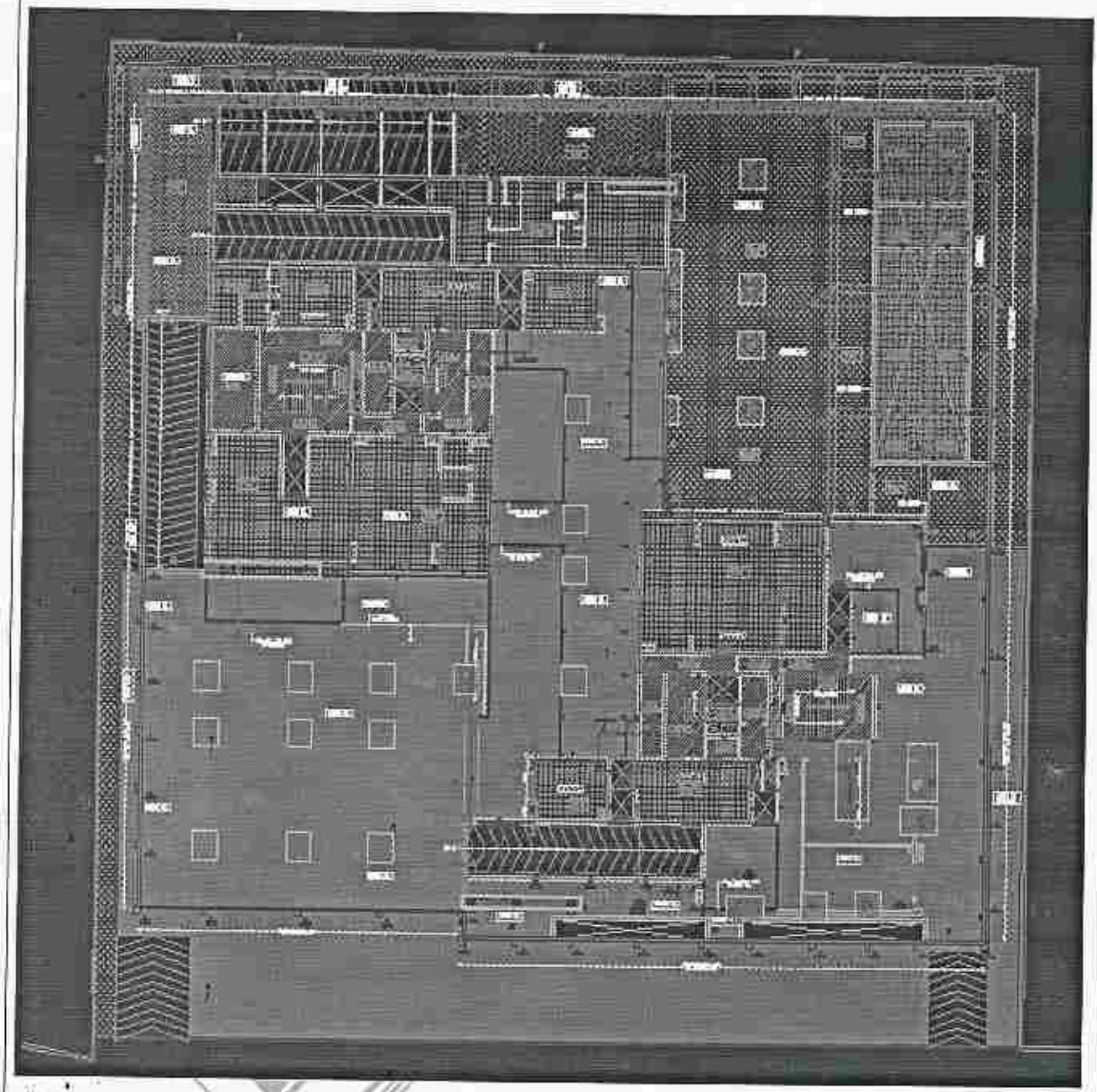

Structural layout at ground Floor level

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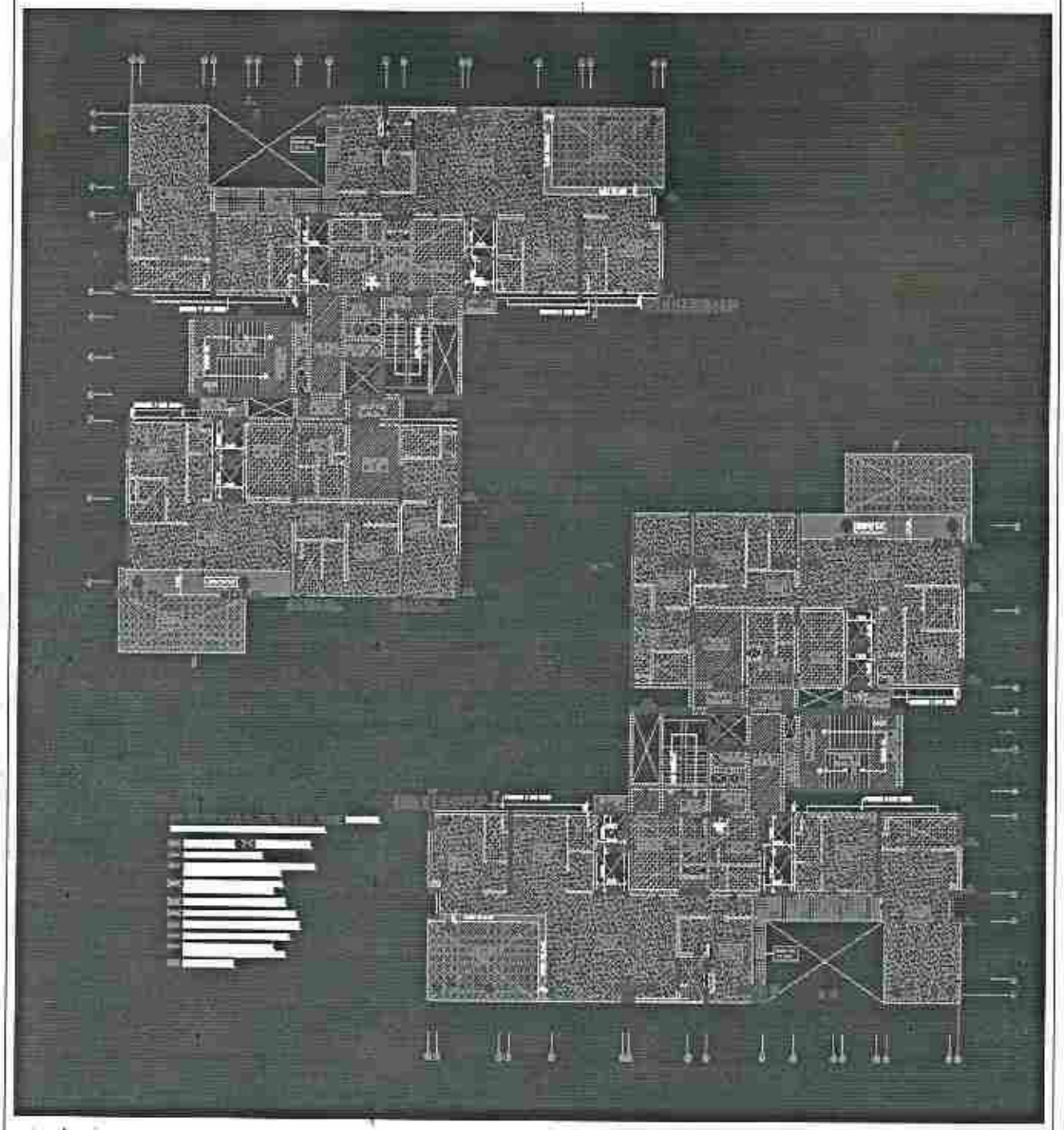

Structural layout at Typical Floor level

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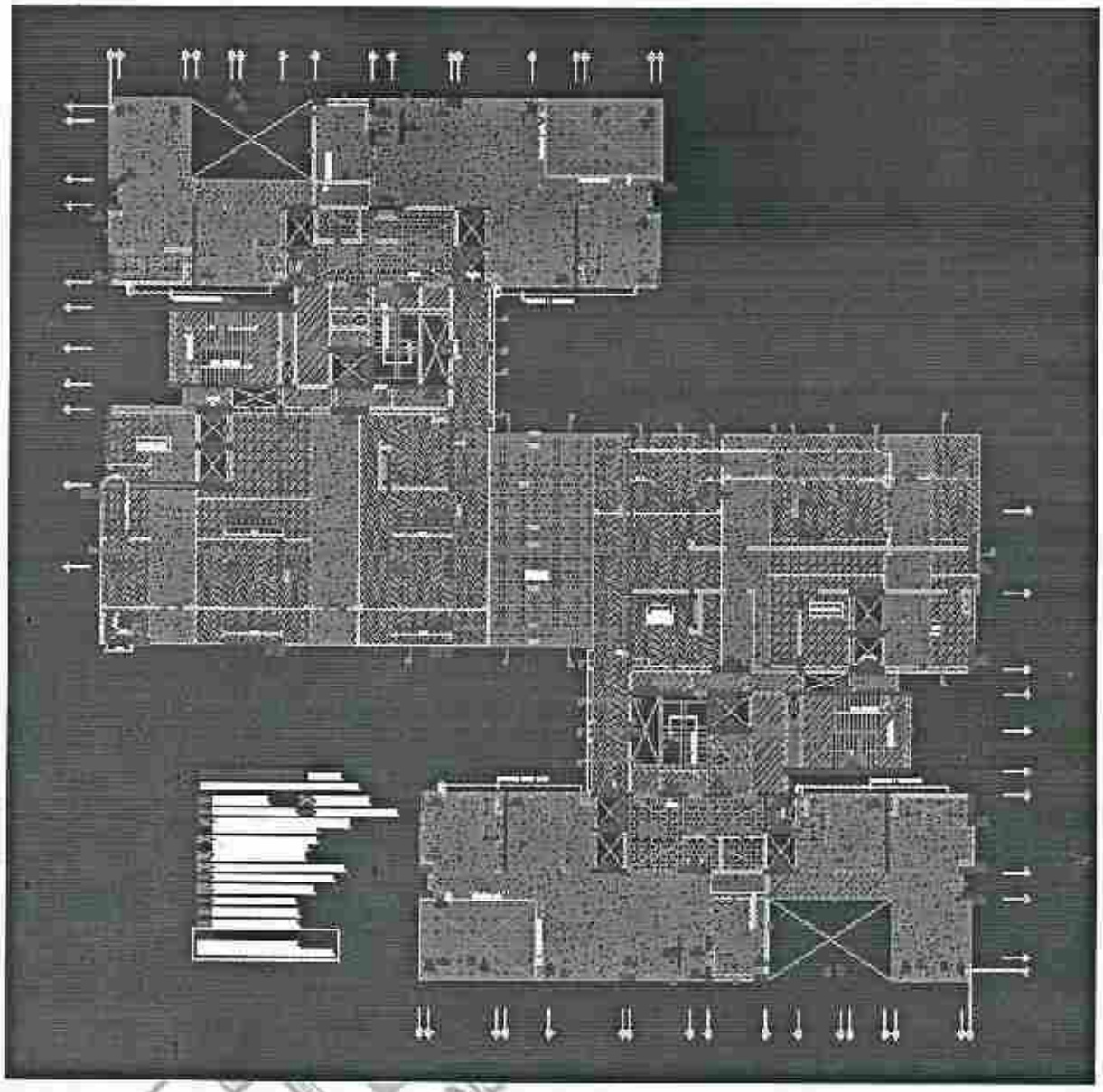

Structural layout at 21st Floor level

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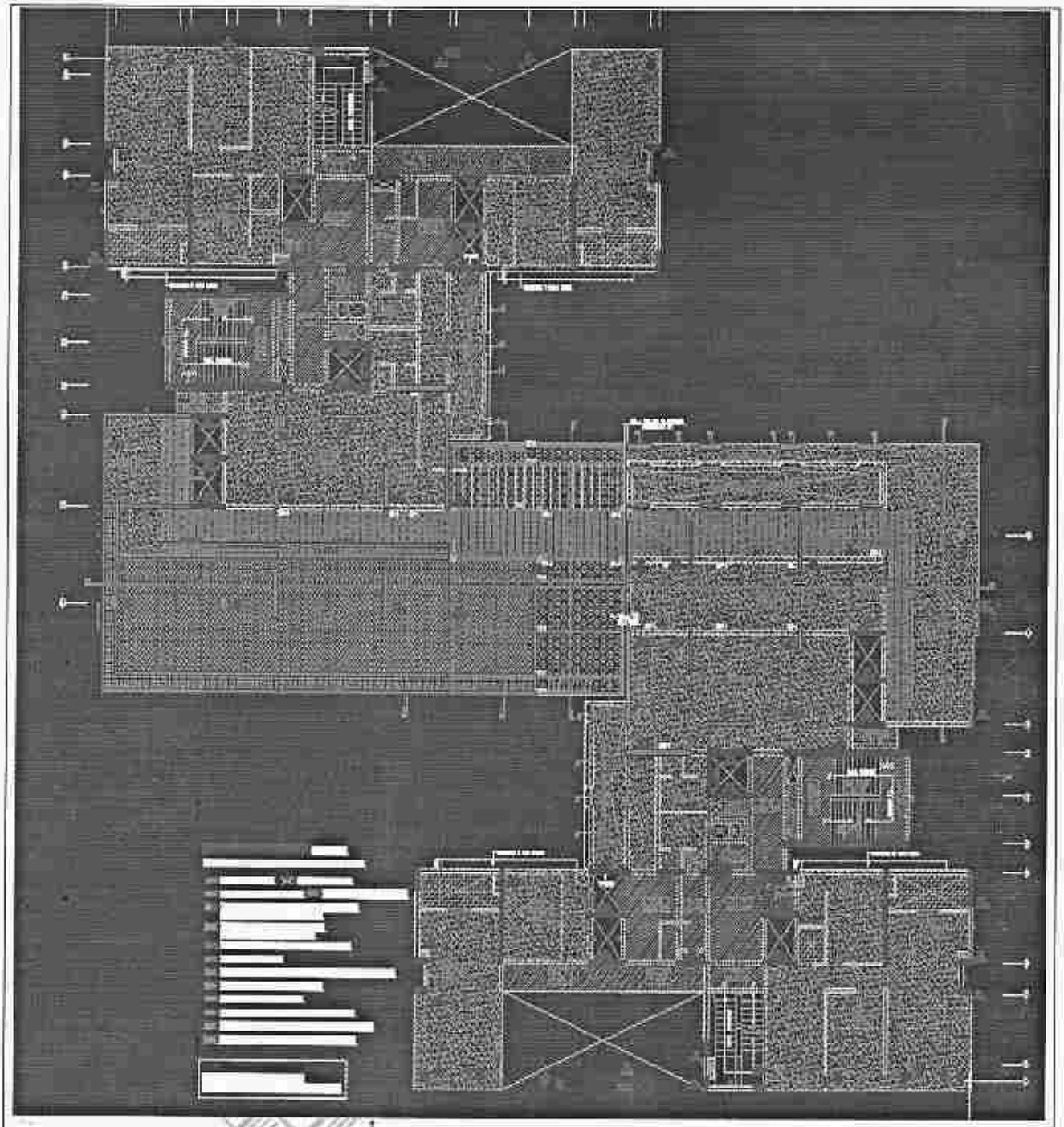

Structural layout at 22nd Floor level

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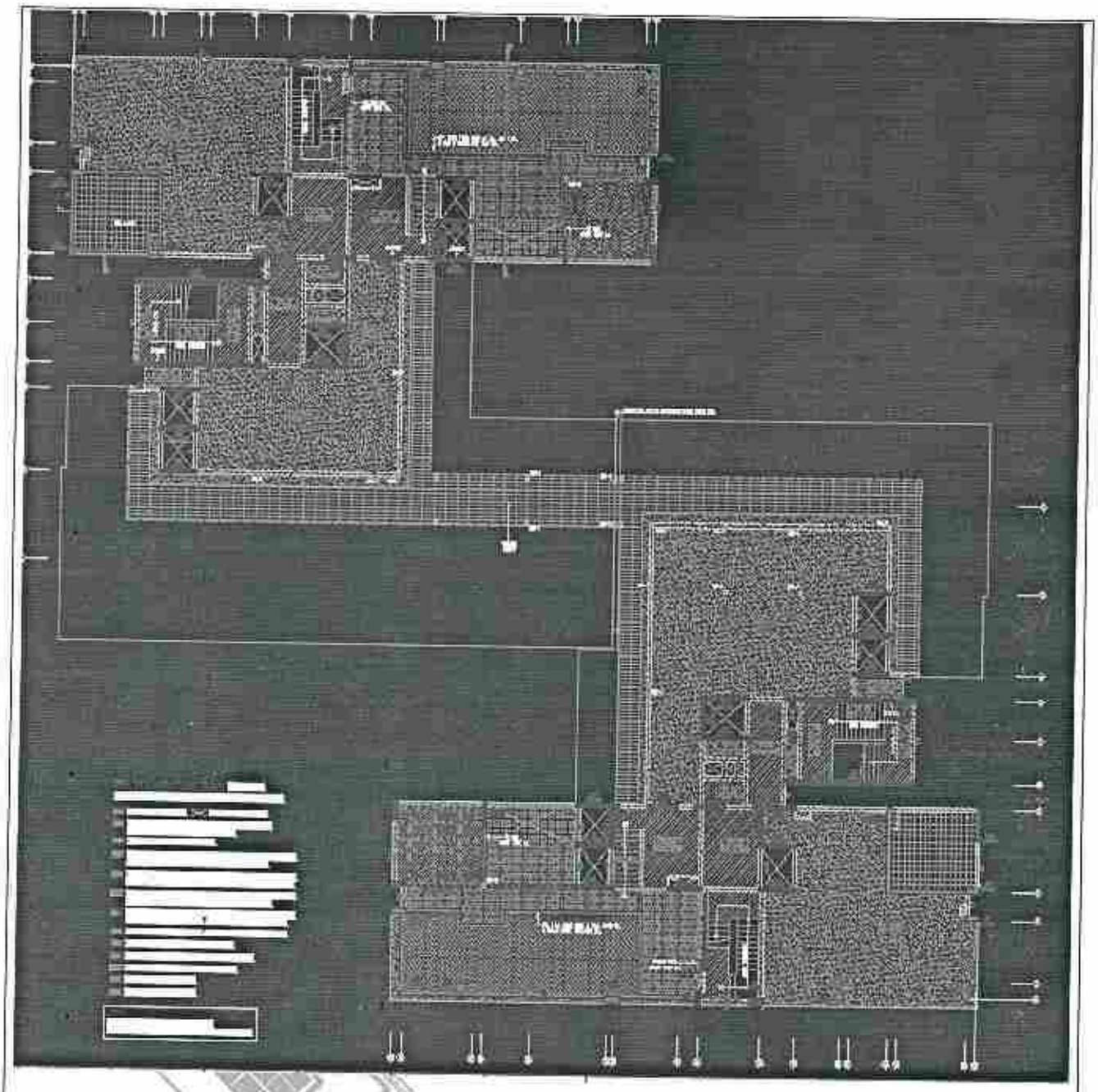

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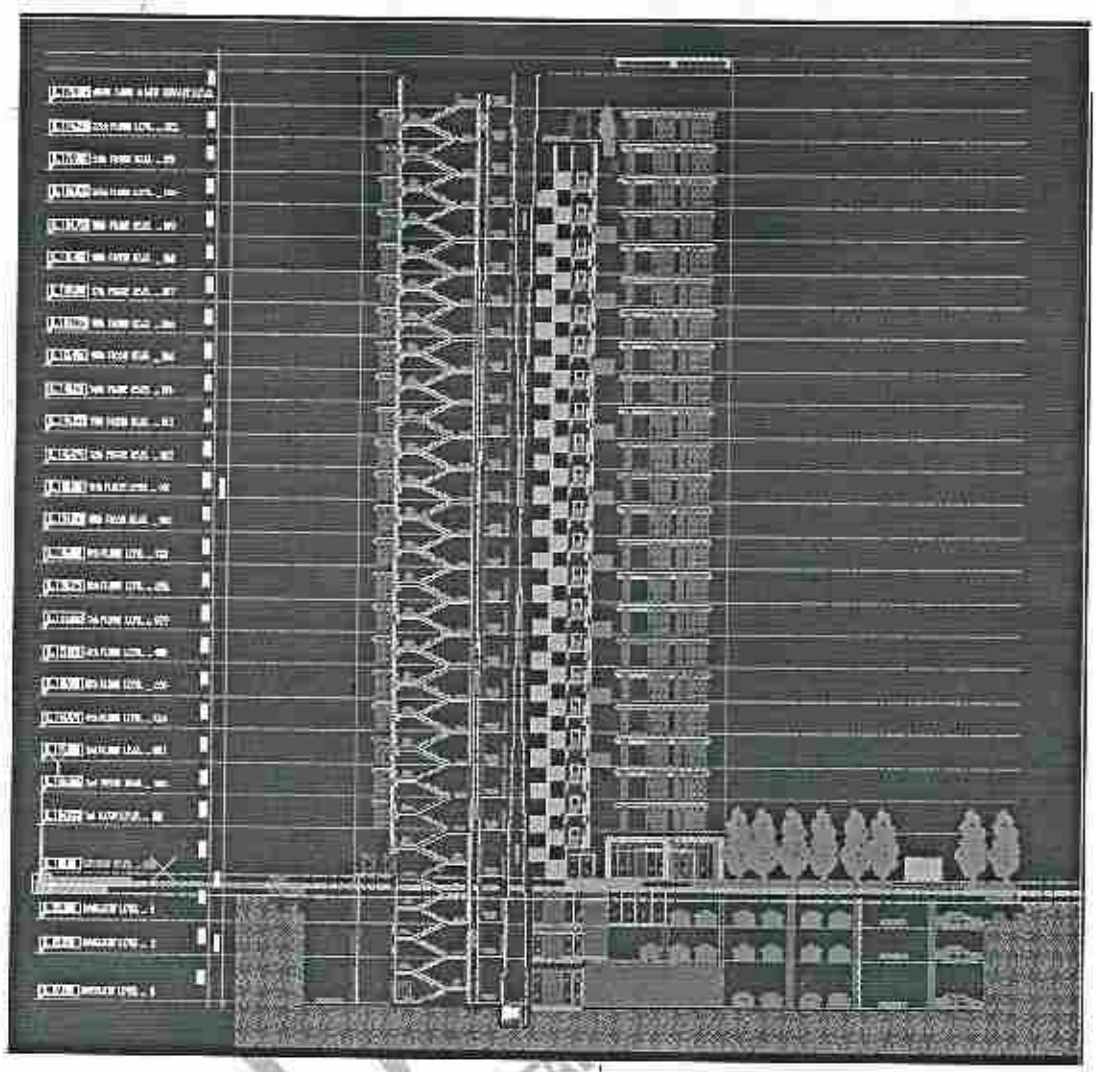

Building Section

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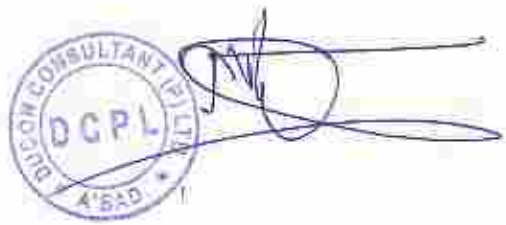

15. E-TABS Model

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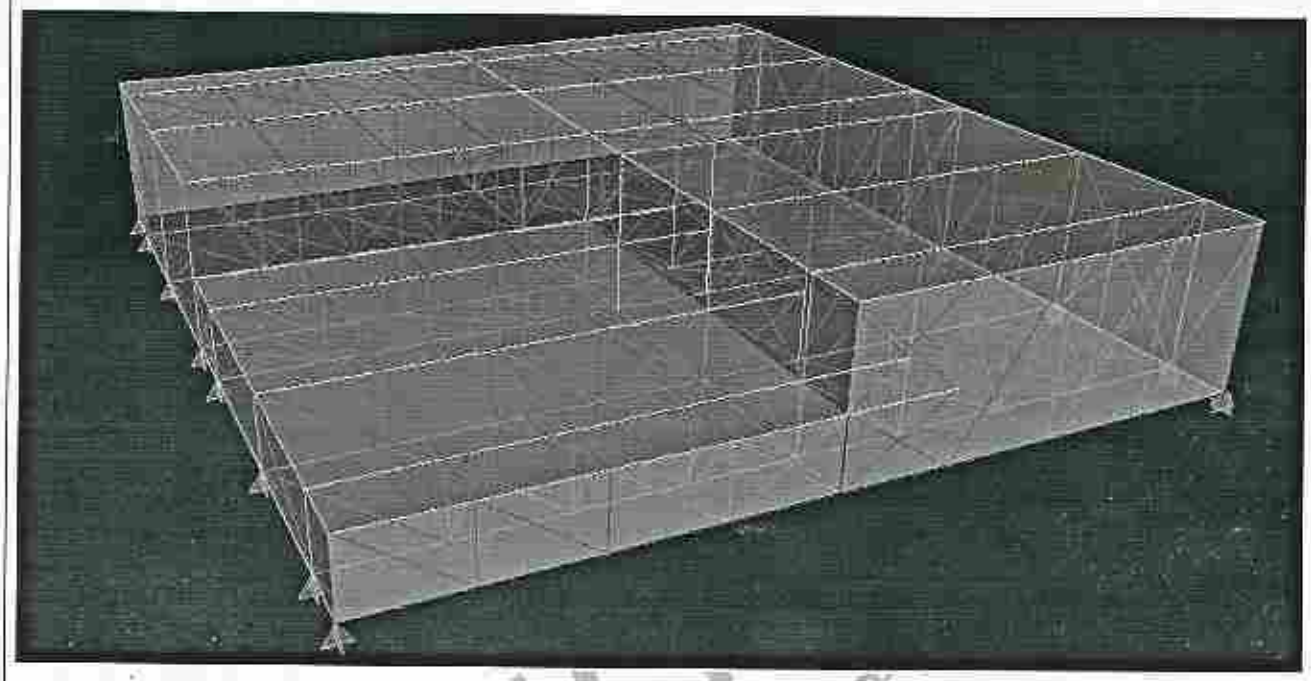
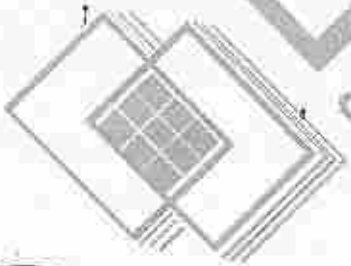
16.1 SKY WALK CONNECTING TWO TOWERS @ 21st & 22nd FLOOR LEVEL.





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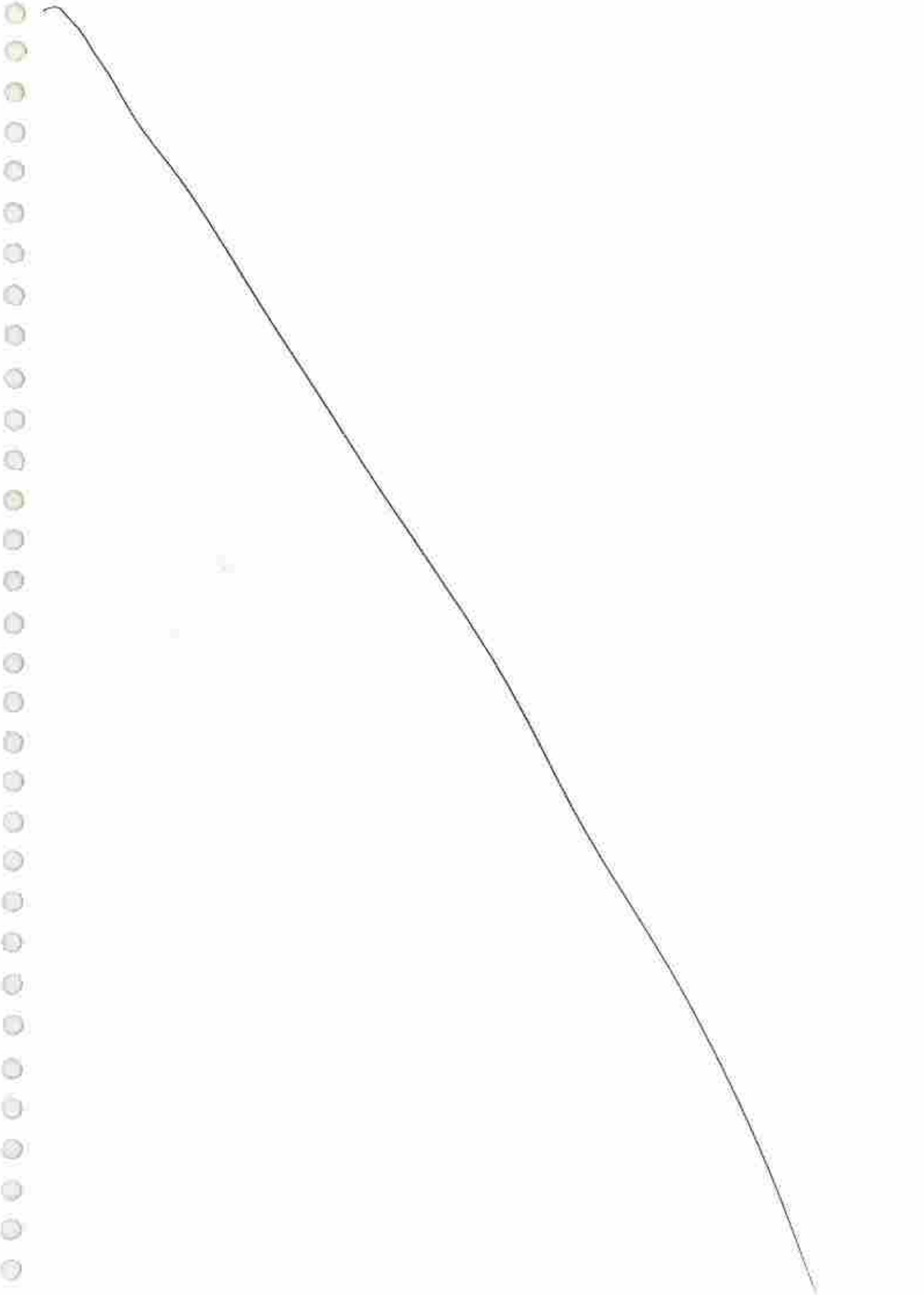

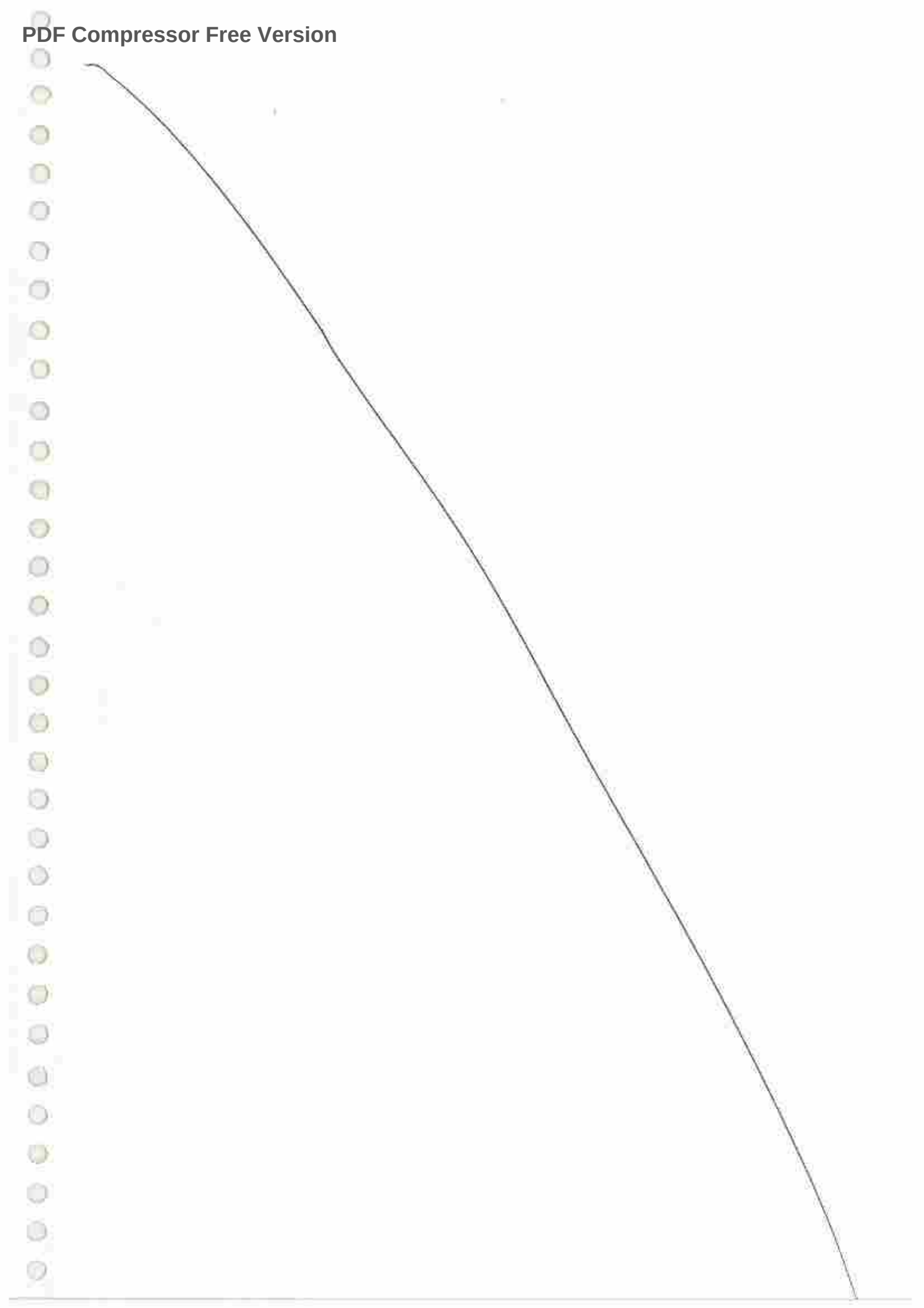

STRUCTURAL CONCEPT REPORT

For

SEVENTY

(3 Basement+ Ground Floor + 22 Upper floor)

Proposed Residential Building On f.p. no : 70 s.r.

N.O : 1061 , T.P.S. NO. : 51 (Vejalpur)

MOJE : Vejalpur, Taluka : City-West, Dist : Ahmedabad.

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DCPL

List of Indian Standards

Loads other than From Earthquake

IS 875		Code of practice for design loads for buildings and structures
	Part I	Dead Loads
	Part II	Imposed Loads
	Part III	Wind Loads
	Part V	Special Loads and Combinations
ISO 10137: 2007		Bases for design of structures - Serviceability of buildings and walkways against vibrations

Design for Earthquake Resistance

IS 1893:2002	Criteria for earthquake resistance design of structures
IS 4326:1993	Code of practice for earthquake resistant design and construction of buildings
IS 13920:1993	Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
SP 22	Explanatory handbook on codes for earthquake engineering, IS 1893 & IS 4326

Concrete: Structural Element Design, Materials and Mixes

IS 456:2000	Plain and reinforced concrete - Code of practice
IS 13920:1993	Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces
SP 16	Design aids for reinforced concrete to IS 456
SP 24	Explanatory handbook on Indian Standard Code for plain and reinforced concrete , IS 456
SP 34	Handbook on concrete reinforcement and detailing
IS 2502	Code of practice for bending and fixing of bars for concrete reinforcement
IS 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement

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IS 269	Specification for 33 grade ordinary Portland cement
IS 8112	Specification for 43 grade ordinary Portland cement
IS 12269	Specification for 53 grade ordinary Portland cement
IS 1489 (Part 1)	Portland-Pozzolona Cement – Specification
IS 383	Specification for coarse and fine aggregates from natural sources for concrete
IS 9103	Specification for admixtures for concrete
IS 10262	Recommended guidelines for concrete mix design

SOIL ENGINEERING AND FOUNDATION DESIGN

IS 1904 : 1986	Code of practice for design and construction of foundations in soils – General Requirements
IS 2911:1979	Code of Practice for Design and Construction of Pile Foundations, Part 1 – Concrete Piles, Section 2 – Bored Cast in-Situ Piles
IS 14593:1998	Design and Construction of Bored Cast-in-Situ Piles founded on Rock – Guidelines
IS 6403:1981	Code of Practice for Determination of Bearing Capacity of Shallow Foundations
IS 12070:1987	Code of Practice of Design and Construction of Shallow Foundations on Rocks

Description of the Structure

INTRODUCTION

The building has 3 Basement + Ground Floor + 22 Upper Floor. A brief architectural and structural description of the building is given in this chapter.

ARCHITECTURAL DESCRIPTION

Primary building components include:

- 78.5 m tall (up to terrace) residential tower.
- Ground Floor Level: Parking Floor
- 1st Basement : Parking floor and floor to floor Ht of 4.5 m
- 2nd Basement : Parking floor and floor to floor Ht of 3.45 m
- 3rd Basement : Parking floor and floor to floor Ht of 4.8 m

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- 22 upper floor: Residential tower with floor to floor height of 3.3 m.
- Plan Dimension

  : 37.4 m (X direction) (H/W Ratio 2.1:1)

  : 31.4 m (Y direction) (H/W Ratio 2.5:1)

Structural System

This section covers the super-structure and sub-structure system selected for the building.

Super-structure

The tower lateral system consists of concrete shear walls (shear core) surrounding the lobby, service corridor, stairs. Openings through the core shall be provided in the form of coupling beams at every level to make the core function as a composite tube. Certain columns & Beams are also part of the lateral system.
Most of the lateral load from earthquake and wind is resisted by the concrete shear walls i.e. the core. The response reduction factor for seismic walls is taken as R = 5.

Sub-structure (Foundations)

Soil Profile

Considering all five boreholes the governing borehole is BH-3 & BH-4 having average N value at 10.5m depth is 34 & 38 shows hard silty clay layer. This layer is followed by very dense clayey sand underlain by very dense silty sand up to termination depth below EGL. Considering three basements of height 3.0m = 3.0 x 3 = 9.0m total height of basement below EGL with @ 18 stories higher rise building footing and raft bearing capacity is calculated and reported.

Type of Foundations

Proposed buildings should be supported on Spread foundation.Can be designed for maximum net allowable bearing capacity of 50 t/m^2.

Permissible settlement is consider as 100 mm. A modulus of sub -grade reaction of 500 t/m^3 can be used for design of foundations.

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Loads on the Structure

Dead Loads and Live Loads

Dead and live loads were calculated different types of levels. The parameters used for obtaining the loads are given in this section.

Dead Load Parameters

For calculating the dead loads such as floor loads, walls loads, self weight etc. the parameters given in Table 4.1 were used.

Dead load parameters

Parameter	*Value*
Density of Reinforced Concrete	25 kN/cu.m
Density of Plain Concrete	20 kN/cu.m
Density of Steel	78.5 kN/cu.m
Density of Plasters/Floor Finishes	20 kN/cu.m
Design Density of Sephorex/Light Weight Blocks	8 kN/cu.m
Density of Bricks	19 kN/cu.m

Live Load Parameters and Values

Live loads were assigned on the three different types of levels based on the type of usage. The values were obtained from IS 875: Part II.

In general, the live load used for residential areas is 2 kN/m2. For basement levels and recreation level it is taken as 5 kN/m2. For staircases and passages on residential floors, live load is taken as 3 kN/m2.

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LIVE LOAD

Basement Floors

- Live load on 2nd & 1st basement floor for Non-stack parking = 5.0 kN/m²

Ground Floor

- Live load on G. F. Slab for Non-stack parking =5.0 kN/m²
- Fire fighter load = 12 kN/m²

Typical Floors (1st to 20th floor)

- Live load on Typical Floor = 2.0 kN/m²
- Live Load on Typical Floor (Balcony, Passage, Foyer, Staircase etc) = 3.0 kN/m²

21st Floor

- Live load for residence area = 2.0 kN/m²
- MEP Service load = 5.0 kN/m²
- Load from Sky walk Connecting two towers is applied on PT beams in terms of Point loads derived from a separate sky walk Model.

22nd Floor

- Live load for residence area = 2.0 kN/m²
- Live load for club house & Gym = 4.0 kN/m²

23rd Floor (Terrace Floor)

- Live Load on Landscape and pavilion structure = 4.0 kN/m²

DEAD LOAD

Basement Floor

- Floor finish load on Basement Floor = 2.0 kN/m²
- Water-body load (0.3 x 10) = 3.0 kN/m²
- Suspended Services load = 1.5 kN/m²

Ground Floor

- Floor finish load on Ground Floor = 2.0 kN/m²
- Water proofing load on Ground Floor = 2.25kN/m²
- Water-body load (0.3 x 10) = 3.0 kN/m²
- 600mm Thick Soil filling on Ground Floor =12.6 kN/m²
  (=0.600x21)
- 225mm thick light weight cinder filling + 150thk slab load
  = 0.225 x 12 + 0.150 x 25 = 2.7 + 3.75 =6.45 kN/m²

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- 300mm thick light weight cinder filling + 150thk slab load
  = 0.300 x 12 + 0.150 x 25 = 3.6 + 3.75 = 7.35kN/m²
- 100mm thick slab (= 0.100 x 25) = 2.5 kN/m²
- 875mm soil filling(= 0.875 x 21) =18.37kN/m²

Typical Floor (1st to 20th floors)

- Floor finish load on typical floor =1.8 kN/m²
- Floor finish load on stair (in plan) = 2.7 kN/m²
  (=1.8x(0.300+0.150)/0.300)
- D.L. Of steps considering 150mm riser =1.875 kN/m²
  (0.5 x 0.150 x 25)
- Services & false ceiling load = 0.5 kN/m²
- 40mm deep sunk – toilet area (=0.040x12) =0.48 kN/m²
- 200mm deep sunk for kitchen (=0.2x12) = 2.4 kN/m²

21st Floor

- Floor finish load = 1.8 kN/m²
- Water load for balancing tank = 20 kN/m²

22nd Floor

- Floor finish load = 1.8 kN/m²
- Water-body (Swimming Pool) load on 20th Floor = 13.0 kN/m²
  (=1.3x10)

23rd Floor (Terrace floor)

- Floor finish load =2.25 kN/m²
- Water-body (Lap Swimming Pool) load =13.0kN/m²
  (=1.3x10)
- Overhead Water-tank Load (=2.2x10) =17.0 kN/m²

24th Floor (above Terrace Floor)

- Floor finish load on Terrace Floor =2.25 kN/m²

Specific loads given by vendors should be adopted wherever applicable.

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EARTHQUAKE LOADS

First, the parameters used for calculating earthquake loads are given. Then hand calculations for earthquake forces based on IS 1893:2002 provisions are given.

Loading Parameters for Earthquake Forces

Parameters for calculating earthquake forces of building

Parameter	*Value*
Z i.e. Zone Factor	0.16
I i.e. Importance Factor	1
R i.e. Response Reduction Factor	5
% of Live Load Considered in Seismic	0.25
h i.e. Height of Building	78.5 m
dx i.e. Length of Building (along X dirn) (in this case only shear wall extents)	69.35 m
dy i.e. Breadth of Building (along Y dirn) (in this case only shear wall extents)	58.44 m
W i.e. Seismic Weight of Building	761426 kN
Soil Type	Medium Clay(Type-II)
Vbx	7626.98 kN
Vby	4234.65 kN

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WIND LOADS

The following are the parameters used.

Parameters for calculating earthquake forces of building

Parameter	*Value*
Category	3
Class	C
Basic Wind Speed	39 m/sec
Force Coefficient	0.8 (windward) 0.5 (Leeward)
Wind Base Shear in X direction	3050 KN
Wind Base Shear in Y direction	2256 KN
Wind Tunnel	NA

LOAD COMBINATIONS

The following basic load combinations for the structural design of members were considered:

0.9 DL ± 1.5 EQ/WL in X

0.9 DL ± 1.5 EQ/WL in Y

0.9 DL + 1.5 SPEC in X

0.9 DL + 1.5 SPEC in Y

1.5 (DL + LL)

1.2 (DL + LL ± EQ/WL in X)

1.2 (DL + LL ± EQ/WL in Y)

1.2 (DL+ LL + SPEC in X)

1.2 (DL + LL + SPEC in Y)

1.5 (DL ± EQ/WL in X)

1.5 (DL ± EQ/WL in Y)

1.5 (DL+ LL + SPEC in X)

1.5 (DL + LL + SPEC in Y)

1.5 DL ± 1.5 EQ/WL in X ± 0.45 EQ/WL in Y

1.5 DL ± 1.5 EQ/WL in Y ± 0.45 EQ/WL in X

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1.5 (DL + LL + SPEC in Y)

1.5 DL ± 1.5 EQ/WL in X ± 0.45 EQ/WL in Y

1.5 DL ± 1.5 EQ/WL in Y ± 0.45 EQ/WL in X

1.2 DL + 1.2LL ± EQ/WL in X ± 0.36 EQ/WL in Y

1.2 DL + 1.2LL ± EQ/WL in Y ± 0.36 EQ/WL in X

Service design of foundations includes checking their stability, elastic settlements and the bearing pressure. The following basic load combinations for the service design of foundations:

DL + LL

DL + 0.8 LL ± 0.8 EQ

DL ± EQ

DL + 0.8 LL ± 0.8 WIND

DL ± WIND

Structural Analysis

INTRODUCTION

The building was modeled in ETABS v9.7.4, a very well known building analysis and design software. ETABS was used because of its user friendliness due to object based modeling and advanced modeling capabilities such as modeling shear walls using shell elements. ETABS also designs beams, columns and shear walls based on IS 456:2000 and IS 13920:1993 provisions. The design is covered in the next chapter.

This chapter covers the following:

- Lateral analysis and design approach;
- modeling structural elements such as beams, columns, walls, slabs and defining diaphragms in ETABS;
- load definitions in ETABS;
- Overall building results such as story drifts under the application of code based earthquake as well as deflections and drifts under wind loading;
- Modeling foundations in SAFE.

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LATERAL ANALYSIS AND DESIGN APPROACH SUMMARY

Design Objectives

The objective of the design is to ensure that the overall building behavior meets stated performance objectives at serviceability and code design levels. The resulting design provides a level of safety and overall building occupant comfort equivalent to that provided by building code requirements (Indian and in some instances American) as well as good practices for tall buildings.

Performance Objectives

The specific performance objectives for the design of the building are as follows:

- **Design Basis Wind** (50 year Return Period) – **Code Design Level** – Structure to remain mostly elastic with some minor damage to structural and non structural elements
- **Design Earthquake – Code Design Level** – Structure designed to approximately Life Safety Level ("approximately" since code is not probabilistic). Structure is designed to resist design earthquake for site without collapse but possibly some damage to structural and non structural damage.

MODELING IN ETABS v 9.7.4

Modeling in ETABS is done using objects. Just prior to performing analysis, ETABS automatically converts these objects to finite elements such as line and shell elements.

This section gives an overview of how the building was modeled in ETABS using various finite-elements such as line elements and shell elements.

Global Direction

The longer span of the building coincided with global X direction in ETABS and the shorter span was along the global Y direction. Z direction in ETABS points upwards with reference to the building base.

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Modeling of Beams

Modeling of beams in ETABS was done using line elements, just like in any other finite element program such as STAAD*Pro*.

Modeling of Columns

Modeling of columns in ETABS was also done using line elements, just like in any other finite element program such as STAAD*Pro*.

Modeling of Shear Walls

Shear walls were modeled in ETABS using the object based wall modeling capability. Meshing of walls can be done either automatically or manually in ETABS. To avoid any inherent errors, manual meshing of the walls was done.

Shell elements of walls can be assigned *pier labels*. At the time of recovering results of shell elements, ETABS integrates the stresses automatically in elements labeled as a pier and outputs forces in terms of axial forces, shear forces and moments rather than stresses. Thus user-friendly results for design of walls are obtained from ETABS.

ETABS also designs walls assigned as a pier based on IS 456:2000 and IS 13920:1993 provisions. This is covered in the next chapter.

Modeling of Slabs

Slabs were modeled in ETABS using shell elements depending on the geometry..

Defining Diaphragms

The diaphragm action can be taken care of in ETABS by assigning a semi-rigid diaphragm to slab elements on a floor.

Analysis of Foundation of Building

The foundation system is a mixture of only raft as per the strata availability. The entire raft is analysed in SAFE. Support reactions from ETABS can be directly exported to SAFE. Raft are modeled as shell elements with required strips defined to integrate the shear and moment for a particular width to calculate the reinforcement requirement. Modulus of subgrade reaction can be assigned in SAFE is as per geotechnical report.

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Design of the Structure

Introduction

The shear walls and coupling beams were designed as per provisions of IS 13920.

The beams and columns which are not part of lateral load resisting elements were designed for deformation compatibility and ductility as per IS 456:2000 and IS:13920 provisions.

Cover Requirements Based on Fire Resistance and Exposure Condition

Clear cover to reinforcement was based on fire resistance as well as exposure condition. All structural members are assigned a minimum fire rating of 2 hours, except slabs are assigned 1.5 hours. Moderate Exposure condition was assigned to beams, slabs, columns,walls,footings and retaining wall.

Cover Requirements

Element	*Fire Requirements*	*Durability Requirements*	*Cover Provided*
Slabs	25mm	30 mm	30mm
Beams	30 mm	30 mm	30 mm bottom 30mm sides and top
Columns	40 mm	30 mm	40 mm
Walls (Similar to Columns)	40 mm	30 mm	40 mm
Footings	40 mm	30 mm	50 mm
Raft Slab	40 mm	30 mm	50 mm
Retaining Wall	30 mm	30 mm	30 mm

Grade of Reinforcement and Concrete

As per IS 1786, Fe 500D reinforcement is used for the project.

High Strength concrete of up to M50 grade is used in the buildings. A particular grade has been assigned in the plans. This grade is used for calculating Ec i.e. the stiffness properties. However, a grade lower than that is specified for strength, due to the variability of RMC concrete. The grade of concrete is specified at 28 days. Note that

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high grade concrete will gain approximately 10% more, hence the added margin of safety, which is not considered in the design.

Concrete Grade

Element	*Grade Specified*	*Grade used for computing Ec Value*	*Grade used for strength design*
Slabs & Beams	M35	M35	M35
Coupling Beams	M35	M35	M35
Columns	M50 M40 M35	M50 M40 M35	M50 M40 M35
Walls	M50 M40 M35	M50 M40 M35	M50 M40 M35
Footings	M30	M30	M30
Raft Slab	M30	M30	M30
Retaining Wall	M45	M35	M35

Coupling Beams

There are two types of confining reinforcement allowed for coupling beams. Either the entire beam has to be confined like columns (this detailing is not present is IS 13920) or the bundle of inclined reinforcement is to be confined. The latter is very difficult to achieve on site. Hence, the former detailing, part of ACI 318-08 was used to detail coupling beams.

DESIGN OF BEAMS

The beams are designed only for gravity loads. The provisions of ACI 318-08 are used to design them since they are not part of lateral load resisting system. As explained this means following the clauses of IS 13920 described above.

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DESIGN OF SHEAR WALLS

Shear walls were designed for the same load combinations provided in Chapter 3. ETABS and RCDC was used for the longitudinal and shear reinforcement requirements of the shear walls.If boundary elements are required the entire wall is provided with boundary elements.

DESIGN OF COLUMNS

ETABS and RCDC was used for the design of columns for the provisions of IS 456:2000 for gravity loads. IS 13920: 1993 ductility provisions were checked using an in-house EXCEL sheets.

DESIGN OF FOUNDATIONS

The load cases and service and design combinations for the design of foundations are given in Chapter 3. Since the foundations are resting on hard silt, the allowable bearing pressure for the load combinations involving earthquake loads was increased by 50% and wind loads was increased by 25%.

The rafts are analysed and designed in SAFE as discussed above.

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Concrete Column Design - P-M-M Interaction & Shear Design

Concrete Column Design - P-M-M Interaction & Shear Design

Story Level	Column Line	Section Name	Column End	PMM Ratio or Rebar %	Flexural Rebar Area	Shear22 Rebar Area	Shear33 Rebar Area
22ND	C47	C350X750M35	Top	0.800%	2100.000	0.388	0.831
22ND	C47	C350X750M35	Bottom	1.144%	3002.661	0.388	0.831
21ST	C47	C350X750M35	Top	0.849%	2227.967	0.388	0.831
21ST	C47	C350X750M35	Bottom	0.800%	2100.000	0.388	0.831
20TH	C47	C700DIAM35	Top	0.800%	3078.761	0.776	0.776
20TH	C47	C700DIAM35	Bottom	0.800%	3078.761	0.776	0.776
19TH	C47	C700DIAM35	Top	0.800%	3078.761	0.776	0.776
19TH	C47	C700DIAM35	Bottom	0.800%	3078.761	0.776	0.776
18TH	C47	C700DIAM35	Top	0.800%	3078.761	0.776	0.776
18TH	C47	C700DIAM35	Bottom	0.800%	3078.761	0.776	0.776
17TH	C47	C700DIAM35	Top	0.800%	3078.761	0.776	0.776
17TH	C47	C700DIAM35	Bottom	0.800%	3078.761	0.776	0.776
16TH	C47	C700DIAM35	Top	0.800%	3078.761	0.776	0.776
16TH	C47	C700DIAM35	Bottom	0.854%	3286.200	0.776	0.776
15TH	C47	C700DIAM35	Top	0.800%	3078.761	0.776	0.776
15TH	C47	C700DIAM35	Bottom	1.292%	4970.781	0.776	0.776
14TH	C47	C700DIAM35	Top	1.295%	4983.153	0.776	0.776
14TH	C47	C700DIAM35	Bottom	1.680%	6463.943	0.776	0.776
13TH	C47	C700DIAM35	Top	1.761%	6778.114	0.776	0.776
13TH	C47	C700DIAM35	Bottom	2.113%	8132.607	0.776	0.776
12TH	C47	C700DIAM35	Top	2.298%	8843.856	0.776	0.776
12TH	C47	C700DIAM35	Bottom	2.552%	9820.272	0.776	0.776
11TH	C47	C700DIAM40	Top	2.277%	8763.098	0.776	0.776
11TH	C47	C700DIAM40	Bottom	2.545%	9794.419	0.776	0.776
10TH	C47	C700DIAM40	Top	2.794%	10751.708	0.776	0.776
10TH	C47	C700DIAM40	Bottom	2.979%	11464.692	0.776	0.776
9TH	C47	C700DIAM40	Top	3.420%	13162.622	0.776	0.776
9TH	C47	C700DIAM40	Bottom	3.578%	13768.843	0.776	0.776
8TH	C47	C700DIAM40	Top	4.037%	15536.178	0.776	0.776
8TH	C47	C700DIAM40	Bottom	4.086%	15725.115	0.776	0.776
7TH	C47	C800M40	Top	2.359%	11859.108	0.887	0.887
7TH	C47	C800M40	Bottom	2.462%	12374.500	0.887	0.887
6TH	C47	C800DIAM50	Top	1.551%	7796.132	0.887	0.887
6TH	C47	C800DIAM50	Bottom	1.690%	8495.755	0.887	0.887
5TH	C47	C800DIAM50	Top	2.005%	10076.580	0.887	0.887
5TH	C47	C800DIAM50	Bottom	2.121%	10663.017	0.887	0.887
4TH	C47	C800DIAM50	Top	2.527%	12703.468	0.887	0.887
4TH	C47	C800DIAM50	Bottom	2.595%	13042.574	0.887	0.887
3RD	C47	C800DIAM50	Top	3.001%	15086.288	0.887	0.887
3RD	C47	C800DIAM50	Bottom	3.061%	15386.154	0.887	0.887
2ND	C47	C800DIAM50	Top	3.556%	17875.202	0.887	0.887
2ND	C47	C800DIAM50	Bottom	3.620%	18197.968	0.887	0.887
1ST	C47	C800DIAM50	Top	4.096%	20588.984	0.887	0.887
1ST	C47	C800DIAM50	Bottom	4.174%	20981.677	0.887	0.887
G.F.	C47	C800X1000M50	Top	1.024%	8195.216	0.887	1.108

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DCPL DUCON CONSULTANT (P) LTD. A'BAD.

Concrete Column Design - P-M-M Interaction & Shear Design

Story Level	Column Line	Section Name	Column End	PMM Ratio or Rebar %	Flexural Rebar Area	Shear22 Rebar Area	Shear33 Rebar Area
G.F.	C47	C800X1000M50	Bottom	0.888%	7102.236	0.887	1.108
1ST BM	C47	C800X1000M50	Top	1.308%	10465.334	0.887	1.108
1ST BM	C47	C800X1000M50	Bottom	1.293%	10345.576	0.887	1.108
2ND BM	C47	C800X1000M50	Top	1.634%	13074.344	0.887	1.108
2ND BM	C47	C800X1000M50	Bottom	1.729%	13833.026	0.887	1.108

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Concrete Beam Design - Flexural & Shear Design Rebar Areas

Concrete Beam Design - Flexural & Shear Design Rebar Areas

Story Level	Beam Bay	Section Name	Location	Top Rebar Area	Bottom Rebar Area	Shear Rebar Area
1ST BM	B147	B230X700M35	End-I	6.766E-04	3.940E-04	3.455E-04
1ST BM	B147	B230X700M35	Middle	2.737E-04	7.849E-04	3.290E-04
1ST BM	B147	B230X700M35	End-J	6.997E-04	0.000	3.569E-04

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SUMMARY OUTPUT DATA - UNIFORM REINFORCING PIER SECTIONS - DESIGN (INDIAN IS 456-2000)

Story Label	Pier Label	Sta Loc	Edge Bar	End Bar	Edge Spacing	Required Ratio	Current Ratio	Pier Leg	Shear Av mm^2/m	B-Zone(L) Length	B-Zone(R) Length
O.H.W.T	P50	Top	12d	12d	250.000	0.0032	0.0041	T 1	575.000	Not Needed	Not Needed
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	Not Needed	Not Needed
TER	P50	Top	12d	12d	250.000	0.0035	0.0041	T 1	575.000	Not Needed	Not Needed
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	Not Needed	Not Needed
22ND	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	Not Needed	Not Needed
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	Not Needed	Not Needed
21ST	P50	Top	12d	12d	250.000	0.0029	0.0041	T 1	575.000	Not Needed	Not Needed
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	Not Needed	Not Needed
20TH	P50	Top	12d	12d	250.000	0.0036	0.0041	T 1	575.000	Not Needed	Not Needed
		Bot	12d	12d	250.000	0.0030	0.0041	B 1	575.000	Not Needed	Not Needed
19TH	P50	Top	12d	12d	250.000	0.0037	0.0041	T 1	575.000	Not Needed	Not Needed
		Bot	12d	12d	250.000	0.0031	0.0041	B 1	575.000	Not Needed	Not Needed
18TH	P50	Top	12d	12d	250.000	0.0037	0.0041	T 1	575.000	Not Needed	Not Needed
		Bot	12d	12d	250.000	0.0030	0.0041	B 1	575.000	Not Needed	Not Needed
17TH	P50	Top	12d	12d	250.000	0.0035	0.0041	T 1	575.000	Not Needed	Not Needed
		Bot	12d	12d	250.000	0.0028	0.0041	B 1	575.000	Not Needed	Not Needed
16TH	P50	Top	12d	12d	250.000	0.0033	0.0041	T 1	575.000	920.000	Not Needed
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	Not Needed	Not Needed
15TH	P50	Top	12d	12d	250.000	0.0030	0.0041	T 1	575.000	1035.000	Not Needed
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1035.000	1035.000
14TH	P50	Top	12d	12d	250.000	0.0029	0.0041	T 1	575.000	1150.000	1035.000
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1150.000	1150.000

13TH	P50	Top	12d	12d	250.000	0.0027	0.0041	T 1	575.000	1265.000	1150.000
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1265.000	1265.000
12TH	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	1380.000	1265.000
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1380.000	1380.000
11TH	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	1380.000	1265.000
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1380.000	1380.000
10TH	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	1495.000	1380.000
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1495.000	1495.000
9TH	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	1610.000	1495.000
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1610.000	1610.000
8TH	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	1725.000	1610.000
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1725.000	1725.000
7TH	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	1725.000	1725.000
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1840.000	1840.000
6TH	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	1610.000	1610.000
		Bot	12d	12d	250.000	0.0025	0.0041	B 1	575.000	1725.000	1725.000
5TH	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	1725.000	1725.000
		Bot	12d	12d	250.000	0.0029	0.0041	B 1	575.000	1725.000	1840.000
4TH	P50	Top	12d	12d	250.000	0.0025	0.0041	T 1	575.000	1840.000	1840.000
		Bot	12d	12d	250.000	0.0041	0.0041	B 1	575.000	1840.000	1955.000
3RD	P50	Top	12d	12d	250.000	0.0036	0.0041	T 1	575.000	1840.000	1955.000
		Bot	12d	12d	250.000	0.0048	0.0041	B 1	575.000	1955.000	2070.000
2ND	P50	Top	12d	12d	250.000	0.0048	0.0041	T 1	575.000	1955.000	2185.000
		Bot	12d	12d	250.000	0.0072	0.0041	B 1	575.000	2070.000	2300.000
1ST	P50	Top	12d	12d	250.000	0.0346	0.0041	T 1	591.478	2185.000	2300.000
		Bot	12d	12d	250.000	0.0418	0.0041	B 1	589.738	2415.000	2530.000

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G.F.	P50	Top	12d	12d	250.000	0.0233	0.0041	T 1	575.000	2300.000	2530.000
		Bot	12d	12d	250.000	0.0187	0.0041	B 1	575.000	2185.000	2415.000
1ST BM	P50	Top	12d	12d	250.000	0.0074	0.0041	T 1	575.000	2185.000	2415.000
		Bot	12d	12d	250.000	0.0047	0.0041	B 1	575.000	2185.000	2300.000
2ND BM	P50	Top	12d	12d	250.000	0.0268	0.0041	T 1	575.000	2185.000	2300.000
		Bot	12d	12d	250.000	0.0276	0.0041	B 1	575.000	1380.000	2185.000

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DUCON CONSULTANT (P) LTD. * GHAZIABAD *

Definitions:

1.	A	=	Plan area of footing base
2.	AstPrv	=	Area of tensile reinforcement provided
3.	Astrqd	=	Area of tensile reinforcement required
4.	Asv	=	Area of shear reinforcement required
5.	AsvPrv	=	Area of shear reinforcement provided
6.	A1	=	Bearing area of footing at slope of 1:2
7.	A2	=	C/s Area of column
8.	B	=	Width of footing base
9.	Beff	=	Effective width of footing
10.	Boff	=	Footing offset along B
11.	B1	=	Width of sloped footing at top
12.	ColOff	=	Column offset in sloped footing
13.	D	=	Depth of footing
14.	Deff	=	Effective Depth of footing
15.	Df	=	Depth of founding layer
16.	Dw	=	Ground water level
17.	Foss	=	Safety factor against sliding
18.	Fosu	=	Safety factor against uplift
19.	L	=	Length of footing base
20.	Leff	=	Effective length of footing
21.	Loff	=	Footing offset along L
22.	L1	=	Length of sloped footing at top
23.	Mx	=	Bending Moment along column D
24.	My	=	Bending Moment along column B
25.	Muy	=	Factored moment along column B
26.	Mux	=	Factored moment along column D
27.	Netdown	=	Net downward load
28.	P	=	Axial load for footing sizing
29.	P1	=	Soil pressure at corner 1
30.	P2	=	Soil pressure at corner 2
31.	P3	=	Soil pressure at corner 3
32.	P4	=	Soil pressure at corner 4
33.	Pdelta	=	Column Load to be transferred by reinforcement
34.	Pt	=	Calculated percentage tensile reinforcement
35.	Pu	=	Factored axial load
36.	SPu	=	Upward Soil Pressure
37.	Tc	=	Design shear strength of concrete
38.	Tv	=	Nominal shear stress
39.	Vu	=	Design shear force
40.	Vus	=	Strength of shear reinforcement
41.	Vx	=	Shear along major axis
42.	Vy	=	Shear along minor axis
43.	Waterpr	=	Upward water pressure
44.	Waterup	=	Upward force due to water
45.	WFoot	=	Add. Wt. due to difference in concrete and soil density
46.	WFootc	=	Weight of footing and column with concrete density
47.	WSoil	=	Weight of soil covering footing area
48.	Zx	=	Section modulus of footing base along L
49.	Zy	=	Section modulus of footing base along B

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IS 456 - 2000

	Parameter		Reference
1.	Ptmax	:	Cl. 26.5.2.1
2.	Ptmin	:	Cl. 26.5.2.1
3.	Pt	:	Cl. 38
4.	Tc	:	Cl. 40.2.1
5.	Tcmax	:	Cl. 40.2.3
6.	Asv	:	Cl. 40.4
7.	Min Shear Reinf	:	Cl. 26.5.1.6
8.	Max Stirrup Spacing	:	Cl. 26.5.1.5
9.	Punching Shear design	:	Cl. 31.6.3
10.	Load transfer	:	Cl. 34.4
11.	Ptnominal	:	Cl. 34.5.2

Design Code	: ISCode	
Footing No	: FC59	
Column No	: C59	(600mm X DIA)
Concrete Grade	: M30	
Steel Grade	: Fe500	
Clear Cover	: 50 mm	
Df	: 12 M	
Dw	: 0 M	
Density of Soil	= 21	KN/CuM
Soil Bearing Capacity	= 255	KN/SqM
Permissible SBC Increse for EQ	= 25	%
Permissible SBC Increse for Wind	= 25	%
Live Load Reduction	= 0	%
Permissible area of loss of contact	= 0	%
Design cross section by	: Average pressure	

Footing Type	:	Pad	
Footing Size (LxBxD)	:	3850mm X 3850mm X 1025mm	
Effective Self Weight	=	60.77	KN

Check For Maximum Soil Pressure:

Critical load combination	:	(DEAD) +(FF) +(MCROOM) +(SUNK) +(SERVICE) +(WALL) +(WATER) +(BIGLIVE) +(LIVE) +(EQPY)	
Pcomb	=	3674.10	KN

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P	=	Pcomb + Effective Self Weight	
P	=	3734.87	KN
Mx	=	29.48	KN.m
My	=	-23.67	KN.m
P/A	=	251.97	KN/SqM
Mx/Zx	=	3.1	KN/SqM
My/Zy	=	-2.49	KN/SqM
Maximum Soil Pressure	=	257.56	KN/SqM
Allowable Soil Pressure	=	1.25x255	KN/SqM
	=	318.75	KN/SqM

Check For Minimum Soil Pressure:

Critical Load Combination	:	(SUNK) +(WALL) +(WATER) +(FF) +(DEAD) +(MCROOM) +(SERVICE) +(BIGLIVE) +(LIVE) -(EQPY)	
Pcomb	=	3574.98	KN
P	=	Pcomb + Effective Self Weight	
P	=	3635.75	KN
Mx	=	29.85	KN.m
My	=	-26.25	KN.m
P/A	=	245.29	KN/SqM
Mx/Zx	=	3.14	KN/SqM
My/Zy	=	-2.76	KN/SqM
Minimum Soil Pressure	=	239.39	KN/SqM
	>	0	
Offset Along L (Loff)	=	1625	mm
Offset Along B (Boff)	=	1625	mm

Design For Bending:

Bottom Steel Along L:

Critical LoadCombination	=	1.5 (WALL) +1.5 (DEAD) +1.5 (FF) +1.5 (MCROOM) +1.5 (SERVICE) +1.5 (SUNK) +1.5 (WATER) +1.5 (LIVE) +1.5 (BIGLIVE) -0.45 (WINDX) +1.5 (WINDY)	
Pu	=	5461.43	KN
Mux	=	44.51	KN.m
Muy	=	-37.06	KN.m
P/A	=	368.46	KN/SqM
Mx/Zx	=	4.68	KN/SqM
My/Zy	=	-3.9	KN/SqM

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VAM CONSULTANTS (I) PVT. LTD. DCPL A'BAD.

Deff	=	967	mm
Beff	=	3850	mm
SPu	=	373.14	KN/SqM
Mu	=	SPu X B X Loff X Loff / 2	
	=	1896.72	KN.m
Pt	=	0.124	%
Ast Rqd	=	4604	Sqmm
Ast Prv	=	T16 @ 175	
	=	4624	Sqmm

Distributed Across Total Width

Top Steel Along L:

D	=	1025.00	mm
	>	1000	mm, Hence
Ast	=	360	Sqmm/M
	=	360 X 3.85	
	=	1386	Sqmm
Ast Prv	=	T10 @ 230 c/c	
	=	1414	Sqmm

Bottom Steel Along B:

Critical LoadCombination	=	1.5 (WALL) +1.5 (DEAD) +1.5 (FF) +1.5 (MCROOM) +1.5 (SERVICE) +1.5 (SUNK) +1.5 (WATER) +1.5 (LIVE) +1.5 (BIGLIVE) -0.45 (WINDX) +1.5 (WINDY)	
Pu	=	5461.43	KN
Mux	=	44.51	KN.m
Muy	=	-37.06	KN.m
P/A	=	368.46	KN/SqM
Mx/Zx	=	4.68	KN/SqM
My/Zy	=	-3.9	KN/SqM

Deff	=	951	mm
Leff	=	3850	mm
SPu	=	372.35	KN/SqM
Mu	=	SPu X L X Boff X Boff / 2	
	=	1892.74	KN.m
Pt	=	0.128	%
Ast Rqd	=	4675	Sqmm
Ast Prv	=	T16 @ 170	
	=	4825	Sqmm

Distributed Across Total Length

Top Steel Along B:

D	=	1025.00	mm
	>	1000	mm, Hence
Ast	=	360	Sqmm/M

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DUCOM CONSULTANTS (P) LTD. DCPL A'BAD.

	=	360 X 3.85	
	=	1386	Sqmm
Ast Prv	=	T10 @ 230 c/c	
	=	1414	Sqmm

Design For One Way Shear:

Along L:

Critical Section @ d from Column Face

	=	967	mm
Critical LoadCombination	=	1.5 (WALL) +1.5 (DEAD) +1.5 (FF) +1.5 (MCROOM) +1.5 (SERVICE) +1.5 (SUNK) +1.5 (WATER) +1.5 (LIVE) +1.5 (BIGLIVE) -0.45 (WINDX) +1.5 (WINDY)	
Pu	=	5461.43	KN
Mux	=	44.51	KN.m
Muy	=	-37.06	KN.m
P/A	=	368.46	KN/SqM
Mx/Zx	=	4.68	KN/SqM
My/Zy	=	-3.9	KN/SqM
Deff	=	967	mm
Beff	=	3850	mm
SPu	=	373.14	KN/SqM
Vu	=	SPu X (Loff - d) X B	
	=	945.26	KN
Tv	=	Vu / (Beff X Deff)	
	=	0.25	N/Sqmm
Tc	=	0.27	N/Sqmm
Tv	<	Tc	

Along B:

Critical Section @ d from Column Face

	=	951	mm
Critical LoadCombination	=	1.5 (WALL) +1.5 (DEAD) +1.5 (FF) +1.5 (MCROOM) +1.5 (SERVICE) +1.5 (SUNK) +1.5 (WATER) +1.5 (LIVE) +1.5 (BIGLIVE) -0.45 (WINDX) +1.5 (WINDY)	
Pu	=	5461.43	KN
Mux	=	44.51	KN.m
Muy	=	-37.06	KN.m
P/A	=	368.46	KN/SqM
Mx/Zx	=	4.68	KN/SqM
My/Zy	=	-3.9	KN/SqM
Deff	=	951	mm
Leff	=	3850	mm
SPu	=	372.35	KN/SqM
Vu	=	SPu X (Boff - d) X L	

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	=	966.22	KN
Tv	=	Vu / (Leff X Deff)	
	=	0.26	N/Sqmm
Tc	=	0.27	N/Sqmm
Tv	<	Tc	

Design For Punching Shear:

Critical Section @ d/2 from Column Face

	=	480	mm
		Critical LoadCombination	=	1.5 (WALL) +1.5 (DEAD) +1.5 (FF) +1.5 (MCROOM) +1.5 (SERVICE) +1.5 (SUNK) +1.5 (WATER) +1.5 (LIVE) +1.5 (BIGLIVE) -0.45 (WINDX) +1.5 (WINDY)
Pu	=	5461.43	KN
Mux	=	44.51	KN.m
Muy	=	-37.06	KN.m
P/A	=	368.46	KN/SqM
Mx/Zx	=	4.68	KN/SqM
My/Zy	=	-3.9	KN/SqM
Deff	=	959	mm
Leff	=	1560	mm
Beff	=	960	mm
SPu	=	Average Pressure	
	=	368.46	KN/Sqm
Vu	=	SPu X ((L X B)-(Leff X Beff)	
	=	4565.91	KN
Tv	=	Vu / (2 X (Leff + Beff) X Deff))	
	=	0.76	N/Sqmm
Tc	=	1.37	N/Sqmm
Tv	<	Tc	

Load Transfer Check For Load Transfer From Column To Footing

Critical Load Combination	=	1.5 (WALL) +1.5 (DEAD) +1.5 (FF) +1.5 (MCROOM) +1.5 (SERVICE) +1.5 (SUNK) +1.5 (WATER) +1.5 (LIVE) +1.5 (BIGLIVE) -0.45 (WINDX) +1.5 (WINDY)	
Pu	=	5461.43	KN
A2	=	0.36	SqM
A1	=	22.09	SqM
Base Area	=	14.82	SqM
A1	>	Base Area	
Thus, A1	=	14.82	
Modification Factor	=	SqureRoot(A1/A2) <= 2	

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SquareRoot(A1/A2) =	6.4161	
Thus, Modification Factor	=	2
Concrete Bearing Capcity	=	0.45 X Fck X Modication Factor X Column Area
	=	9720 KN
Concrete Bearing Capcity	>	Pu, Hence Safe.

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Static Base Shear in X-direction		
Story	Load	VX
O.H.W.T	EQPX	0
TER	EQPX	-1661.81
22ND	EQPX	-3077.76
21ST	EQPX	-4558.48
20TH	EQPX	-5294.06
19TH	EQPX	-6014.57
18TH	EQPX	-6681.76
17TH	EQPX	-7285.95
16TH	EQPX	-7841.07
15TH	EQPX	-8344.91
14TH	EQPX	-8798.1
13TH	EQPX	-9205.46
12TH	EQPX	-9567.17
11TH	EQPX	-9887.43
10TH	EQPX	-10167.97
9TH	EQPX	-10412.14
8TH	EQPX	-10621.75
7TH	EQPX	-10800.42
6TH	EQPX	-10950.2
5TH	EQPX	-11074.02
4TH	EQPX	-11174.03
3RD	EQPX	-11252.81
2ND	EQPX	-11313.28
1ST	EQPX	-11363.48
G.F.	EQPX	9386.22
1ST BM	EQPX	8982.33
2ND BM	**EQPX**	**7626.98**

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Static Base Shear in Y-direction		
Story	Load	VY
O.H.W.T	EQPY	0
TER	EQPY	-1661.81
22ND	EQPY	-3077.76
21ST	EQPY	-4558.37
20TH	EQPY	-5293.95
19TH	EQPY	-6014.45
18TH	EQPY	-6681.78
17TH	EQPY	-7286
16TH	EQPY	-7841.12
15TH	EQPY	-8344.94
14TH	EQPY	-8798.16
13TH	EQPY	-9205.56
12TH	EQPY	-9567.28
11TH	EQPY	-9887.53
10TH	EQPY	-10168.08
9TH	EQPY	-10412.27
8TH	EQPY	-10621.91
7TH	EQPY	-10800.58
6TH	EQPY	-10950.35
5TH	EQPY	-11074.2
4TH	EQPY	-11174.2
3RD	EQPY	-11252.98
2ND	EQPY	-11313.46
1ST	EQPY	-11363.67
G.F.	EQPY	17719.53
1ST BM	EQPY	8976.92
2ND BM	**EQPY**	**4234.65**

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TABLE: Story Stiffness-X			
Story	Load Case	Stiffness X	soft storey check
TER	EQX	593780	-
22ND	EQX	977498	1.65
21ST	EQX	1456193	1.49
20TH	EQX	1579253	1.08
19TH	EQX	1800388	1.14
18TH	EQX	1923842	1.07
17TH	EQX	2037609	1.06
16TH	EQX	2136145	1.05
15TH	EQX	2230402	1.04
14TH	EQX	2320109	1.04
13TH	EQX	2410875	1.04
12TH	EQX	2500167	1.04
11TH	EQX	2606841	1.04
10TH	EQX	2711931	1.04
9TH	EQX	2834804	1.05
8TH	EQX	2967740	1.05
7TH	EQX	3168127	1.07
6TH	EQX	3367215	1.06
5TH	EQX	3625878	1.08
4TH	EQX	3960499	1.09
3RD	EQX	4436204	1.12
2ND	EQX	4891306	1.10
1ST	EQX	3915312	0.80
G.F.	EQX	19469261	4.97

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TABLE: Story Stiffness-Y			
Story	Load Case	Stiffness y	soft storey check
TER	EQY	379244	-
22ND	EQY	631998	1.67
21ST	EQY	882010	1.40
20TH	EQY	950489	1.08
19TH	EQY	975797	1.03
18TH	EQY	994523	1.02
17TH	EQY	1011663	1.02
16TH	EQY	1033270	1.02
15TH	EQY	1056299	1.02
14TH	EQY	1082982	1.03
13TH	EQY	1112438	1.03
12TH	EQY	1146695	1.03
11TH	EQY	1186646	1.03
10TH	EQY	1233358	1.04
9TH	EQY	1287410	1.04
8TH	EQY	1355692	1.05
7TH	EQY	1446563	1.07
6TH	EQY	1569874	1.09
5TH	EQY	1719821	1.10
4TH	EQY	1895553	1.10
3RD	EQY	2091613	1.10
2ND	EQY	2434477	1.16
1ST	EQY	1992602	0.82
G.F.	EQY	26834627	13.47

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Dr. Santosh Kumar
Managing Director

Former:
Sr. Vice President- Reliance

To

Ahmedabad Urban Development Authority/
Ahmedabad Municipal Corporation
Sardar Vallabh Bhai Patel Sankul
Usmanpura, Ashram Road,
Ahmedabad-380014

Letter No. VAM/bSAFAL-Seventy/Ahmd/2015-16/122 Dated:18.02.2015

SUB: Peer Review of Structural Design of "SEVENTY proposed residential building on f.p. #70 s.r. #1061, TPS #51 (Vejalpur), MOJE: Vejalpur, Taluka: City-West) Distt. Ahmedabad

REF: Received from M/s Safal Constructions Pvt. Ltd., Ahmedabad

Enclosed please find the following documents, duly signed and stamped by Main Consultant & Peer Review Consultant:

1. Two Copies of Review Report.
2. Two copies of Check List of "Technical Design Parameters".
3. Two sets of Structural drawings.
4. Profile of Peer Review Structural Consultant.
5. Profile of Principal Structural Consultant.
6. Soft copy of Design File, Structural Drawings and Peer Review Report, in CD.

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Lucknow: The Princeton Review , 9 Shahnajaf Road (1st Floor) Hazratganj, Lucknow (UP), (M) 8004927531
Ahmedabad: Shop#235, Sangath Mall-1, Motera., Ahmedabad (Guj.) (M) 9227977712

PROJECT DATA SHEET
UNIT NO.___
DESIGNS (R & B) GANDHINAGAR.

Sr.No	Description			
1	Name of Project	SEVENTY (3 Basement+ Ground Floor + 22 Upper floor) Proposed Residential Building On f.p. no : 70 s.r. N.O : 1061 , T.P.S. NO. : 51 (Vejalpur) MOJE : Vejalpur, Taluka : City-West, Dist : Ahmedabad.		
2	Project file No.			
3	Project Team	EE	DEE	AE
		N.A.	N.A.	N.A.
4	Project Referred by :			
		Name of office	Contact Person	Telephone Nos.
(a)	Circle	N.A.	N.A.	N.A.
(b)	Division	N.A.	N.A.	N.A.
(c)	Sub-Division	N.A.	N.A.	N.A.
5	Consultants of the project :			
(a)	Nature of consultancy		Architect	Structural Consultant
(b)	Name of the firm		VITAN ARCHITECTS	DUCON Consultants Pvt. Ltd.
(c)	Address		25, VIJAY COLONY, STADIUM ROAD,NARANPURA, AHMEDABAD-380013	A3-A4,3rd FLOOR, SAFAL PROFITAIRE, CORPORATE ROAD,NR.AUDA GARDEN, PRAHLADNAGAR AHMEDABAD-380051
(d)	Authorized Representative		Chitrang Shah	Nikunj Shah
(e)	Telephone,Fax,E-mail		079-27681199	40073196, 65410630
6.(a)	Nature of Project		Budgeted/Re-construction/Retrofiting	

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7.(a)	Work order office letter outward No. With date	N.A.
(b)	Stipulated date of completion of work as per agreement	N.A.
(c)	Stipulated date of completion of work as per agreement	N.A.
8	Details of Building	
(a)	Type	Frame Structure
(b)	Total Floor area in m^2	44708
(c)	Total height from GL in m	78.5 m
(d)	No. Of storeys	3rd basement + 2nd basement + 1st basement + G + 22 + L.M.R.+ O.H.W.T
(e)	Base dimension bx in m	69.35
(f)	Base dimension bz in m	58.44
9	Exposure condition:	
(a)	Type	Moderate
(b)	Minimum Grade of RCC	M35
(c)	Minimum Grade of PCC	M15
10	Fire Resistance Rating in Hours	
(a)	Building height up to 15 m	1 Hour
(b)	Building height more than15 m	2 Hour
11	Nominal Cover (Clear cover) in mm (To main reinforcement considering exposure condition & fire resistance)	
(a)	Footing	50 mm
(b)	Column	40 mm
(c)	Beam below Ground level	30 mm
(d)	Beam above Ground level	30 mm
(e)	Slab	25 mm
12	Dead Loads :	
(a)	Earth	18.0 kN/m^3
(b)	Water	10.0 kN/m^3
	Brick masonry with plaster/finish on both faces	
(c)	115 mm thk	N.A.

(d)	230 mm thk	N.A.
(e)	350 mm thk	N.A.
(f)	PCC	24.0 kN/m^3
(g)	RCC	25.0 kN/m^3
13	Imposed Load (As per IS:875:1987)	
(a)	Occupancy	Imposed load (kN/m^2)
	Residential Area	2
	Residential Corridors/Staircase	3
	Basement Area	5
	MEP Services	5
	Fire Fighter	12
	Club House and Gym	4
(b)	Roof load: accessible	1.5 kN/m^2
(c)	Roof load : not accessible,Slope angle.	N.A.
(d)	Water Tank :	
	(1) Type	RCC
	(2) Capacity in Litres	28000
	(3) Height in m	2.05
	(4) Diameter in m	N.A.
	(5) Nos. & position	2 nos @ 21st Floor
14	Earthquake Load Data :	
(a)	Earthquake Zone	III
(b)	Zone Factor 'Z'	0.16
(c)	Importance Factor 'I'	1
(d)	Response Reduction Factor 'R'	5
(e)	Natural period : Tx (sec)	1.444
(f)	Natural period : Tz (sec)	1.444

DESIGNS(R&B) CIRCLE, GANDHINAGAR

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(g)	Live Load Reduction Factor	25 % (for LL < 3 kN/m^2) 50 % (for LL>3 kN/m^2)
(g)	Ductility Detailing as per IS: 13920-1993	Yes
15	Soil Data :	
(a)	Soil Report No. & Date	MK/50/12-13,DEC 2013
(b)	Depth of foundation below GL	12.85 m
(c)	SBC	500 kN/m^2
(d)	Type of soil	Stiff Clay
(e)	N-Value	34

CERTIFICATE

It is hereby certified that the building Structure of Project SEVENTY proposed Residential has been designed For following: Building on fp. #70, S.P.#1061, TPS #61, Moje: Vajalpur, Taluk: city West AHMEDABAD

(A) Latest revision/amendments of following IS Codes considered in the design:

(1) IS:456:2000	..... Yes ✓
(2) IS:1893:2002	..... Yes ✓
(3) IS:13920:1993	..... Yes ✓
(4) IS:4326:1993	..... Yes ✓
(5) IS:875:1987	..... Yes ✓

(B) SBC, N-Value and foundation depth are taken as per the Soil Report NO.**MK/50/12-13**Dt. **DEC,2013** Prepared by **M.K.SOIL TESTING LABORATORY.**

(C) The design is based on he sound engineering practice and undersigned are solely responsible for he correctness of design and soundness, durability & strength of the structure.

Consultant	peer-Review Consultant	Signed in my presence (Executive Engineer)
	Dr. Santosh Kumar	Div.____
Name:_____	Name:_____	Name:_____
Sign:_____	Sign:_____	Sign :_____

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Check List for the Main Structural Consultant

The main structural consultant is required to submit following information.

1) Provide Design Basis Report as per the document Annexure-I.

- **Design basis report attached as per the description given in Annexure-I.**

2) Provide description of Sub-structure and Super-structure as per the format given in the Annexure-II & III enclosed.

- **Description given in structural concept report.**

3) Provide brief Description of Structural System with sketches, images of drg. etc. with specific focus on Lateral load resisting system.

- **Description given in structural concept report.**

4) Provide brief note on modelling, software used etc. Clearly mention whether infill / partition wall is idealized as part of lateral load system?

- **Description given in structural concept report.**

5) Provide the height of building in mt.

- **Description given in structural concept report.**

5A) Provide plan dimensions of the building (mt x mt).

- **Description given in structural concept report.**

6) Provide following EQ loading details.

(a) Zone Factor	**= 0.16**
(b) Importance factor	**= 1**
(c) Response Reduction factor	**= 5**
(d) Soil Type	**= II (Medium)**
(e) % LL considered in seismic	**= Big LL 50 % (LL>3) & small LL 25 % (LL<3)**
(f) Time Period in the horizontal X-direction (sec) (from formula in code)	**= 1.444 Sec**
(g) Time Period in the horizontal Z-direction (sec) (from formula in code)	**= 1.444 Sec**
(h) Total Seismic weight (Sw) of building (kN)	**= 761426 kN**
(i) Static Base-shear in X-direction (as % of Sw)	**= 7627 kN**
(j) Static Base-shear in Z-direction (as % of Sw)	**= 4235 kN**
(k) Table of distribution for static base shear I)	**= Attached**

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(l) Max. deflection at roof level. (mm) = **126.36**

(m) Max. inter storey drift./ Height = **0.0042**

7) Provide following Wind loading details.

(a) Category of building (As per NBC: Part VI : cl. 4.4.3.2a) = **Category 3**

(b) Class of building (As per NBC: Part VI : cl 4.4.3.2b) = **Class C**

(c) Basic wind speed in m/sec. = **39**

(d) Maximum wind pressure (kN/m^2) = **1.03**

(e) Force coefficient = **0.8 (windward)**

= **0.5 (Leeward)**

(f) Wind Base-shear in the horizontal X-direction(kN) = **3050 kN**

(g) Wind Base-shear in the horizontal Z-direction(kN) = **2256 kN**

(h) Gust factor calculations (if Gust-wind applied) = **N.A.**

(i) Details of wind-tunnel force data (if applicable) = **N.A.**

(j) Estimated magnitude of wind induced vibrations = **N.A.**

(k) Max. deflection at roof level (mm) = **69**

(l) Max. Inter storey drift = **0.0014**

8) Provide following data from Dynamic Analysis.

Modes	Frequency in Hz	Time Period in sec	X-participation	Y-participation
Mode 1	0.19	5.11	0.44	3.34
Mode 2	0.21	4.64	0.001	0.82
Mode 3	0.23	4.28	0.045	28.66
Mode 4	0.24	4.07	0.126	22.93
Mode 5	0.35	2.83	29.48	0.193
Mode 6	0.37	2.68	25.62	0.14
Mode 7	0.76	1.32	0.0134	0.88
Mode 8	0.9	1.26	0.0065	0.49
Mode 9	0.93	1.07	0.0376	7.65
Mode 10	0.94	1.05	0.0135	1.49

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9) Provide Table for lateral deflections (mm) at Terrace level in the following format.

Load Case	Dx-max	H/Dx	Drift-x	Dz-max	H/Dz	Drift-z
DL	11.9	6597	N.A.	14.3	5490	N.A.
DL + LL	27.6	2844	N.A.	24.5	3204	N.A.
EQx	63.66	1233	0.00098	12.66	6200	0.00059
EQz	31.9	2460	0.00091	126.36	621	0.00223
Wx	18.92	4149	0.00033	0.47	167021	0.000109
Wz	7.74	10142	0.00081	68.35	1148	0.00056

10) Provide Corner displacements (mm) for Torsional Irregularity (along x- direction) the following format.

Load Case	Corner-1	Corner-2	Corner-3	Corner-4	Avg-x	% Max./ Avg.
Eq-x	90	85	85	90	87.5	1.02 %
Wl-x	40	11	11	40	25.5	1.57 %

11) Provide Corner displacements (mm) for Torsional Irregularity (along z- direction) in the following format.

Load Case	Corner-1	Corner-2	Corner-3	Corner-4	Avg-z	% Max./
Eq-z	155	170	205	145	168.75	1.21 %
Wl-z	53	48	88	73	65.5	1.34 %

12) Provide acceleration (mg) values in the following format

Eq-x	Eq-y	Wl-x	Wl-y
N.A.	N.A.	N.A.	N.A.

13) Provide following data regarding Vertical Elements

(a) Size of maximum loaded column = **800 x 1000**

(b) Gravity load on max. loaded column = **11957 kN**

(c) Axial stress in max. loaded column (Gravity Load) = **14.95 N/mm²**

(d) Grade of max. loaded column = **M50**

(e) Axial settlement in max loaded column = **2.16 mm**

(f) Axial settlement in min loaded column = **0.49 mm**

(g) % Base-shear resisted by all columns along X (static) = **0.71 %**

(h) % Base-shear resisted by all columns along Y (static) = **0.07 %**

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14) Provide following data regarding Vertical Elements

(a) Total gravity load on floating column (provide table if there are multiple floating columns) = **As shown in Table**

(b) Size and span of girders supporting floating columns = **As shown in Table**

(c) Number of floors supported by floating columns = **As shown in Table**

(d) Deflection of girder under column (from model) = **As shown in Table**

(e) Deflection of girder under column (from s/s action) = **As shown in Table**

(f) Specific details about floating columns on cantilever girders (Refer Table below)

Column	Supporting Girder		Deflection Values		Floors Above	Total Load in
	Size	Span	Model	S/S		
450x830	830x	5000	2.67	-	22 Floors	3703 KN
450x1100	1200x	6000	1.33	-	23 Floors	5946 KN

- SIS denotes the simply supported.

15) Provide, if applicable, following data regarding soft story effect. .

(a) Stiffness of lower floor (in deflection/KN) = **Attached**

(b) Stiffness of upper floor (in deflection/KN) = **Attached**

(c) Relative stiffness ratio (upper/ lower) = **Attached**

(d) Level of soft story = **Attached**

(e) Number of floors above soft story = **Attached**

16) Provide, if applicable, following data for each cantilever.

(a) Cantilever span = **3.8 m**

(b) Structural system = **P.T.Slab**

(c) Nature of usage = **Swimming Pool**

(d) Maximum elastic deflection under gravity load = **19 mm**

17) Provide stability calculations for uplift and overturning (model extract in case of model) = **N.A.**

18) Typical design calculations for footings = **Attached**

19) Typical design calculations for RCC columns (Or Composite Columns) = **Attached**

20) Typical design calculations for RCC walls = **Attached**

21) Typical design calculations for RC beams (Or Steel Beams) = **Attached**

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22) Typical design calculations for RCC Girders (Or Steel Girders/ Trusses) = **Attached**

23) Typical design calculations for Steel Bracings = **N.A.**

24) It is desirable to conduct Wind tunnel studies for any HRB with total height beyond normal ground level exceeding 250 mt. However, such buildings above 250 mt. height can also be designed as per the I.S.Code as well = **N.A.**

25) Provide a note on special provisions suggested for the building (like dampers etc.) Connecting Bridge shall be Dept. on M.S.M Special bearings with pin-joint on one end & roller going on another end.

26) Soft copy of model including input and output = **Attached**

27) Soft copy of Power point presentation including all above points. 28) Items 1 through 27 on CD.

Note : Provide appropriate unit against each quantity.

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APPENDIX -II

DESCRIPTION OF SUB-STRUCTURE

No. of basements		**Three Nos of Basements**
Minimum clearance between outermost basement retaining wall and compound wall		**North side – 3 m** **South Side – 7.164 m** **East Side – 3.43 m** **West Side = 3 m**
Has a Shoring system been installed ? Submit sectional detail of the shoring system		**Coutigeous piles & diaphragm wall has been used**
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 + Counterweight over raft +Rock Anchors if any (for raft spanning between columns) Whether pressure release pipes have been used? Water level assumed for uplift calculation	**Ground water table was not encountered.**
Description of the foundation for the tower block		**Raft foundation**
Nature of Foundation	Piles,Spread footings,Combined Raft,Piled Raft,etc	**Spread footings , Combined raft.**
SBC assumed T/sq.mt Attach SBC report		**50 T/m² for raft foundation & 2.25 T/m² for isolated footings**
Sub-grade elastic modulus		**5000 kN/m³ has been considered**
Retaining wall types & Sequence of backfilling	Whether Propped cantilever, Cantilever Supported between Buttresses/Counter forts, etc	**Propped Cantilevered**

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Intended Use of basements		**Car parking**
If rock anchors are used, are they grouted after installation and stressing ?		**N.A.**
Is structural steel used in the construction of the sub-structure ?		**N.A.**
If yes, what are the measures taken for its fire proofing and corrosion resistance ?		**N.A.**
Whether Expansion/Separation joints provided? Whether expansion joint/ separation joint continues through basement? If yes,detail at basement level & retaining wall junction		**N.A.**

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Appendix- III

DESCRIPTION OF SUPER STRUCTURE

No. of Floors & height of building in mt	**3 Basement + Ground +22 Upper Floors & 78.5 m heights**
Shape of Building, Plan, Elevation, Whether Symmetric in Elevation	**Rectangle**
Maximum plan dimension in either direction in mt	**37.4 mt in X-dir 31.4 Mt in y-dir**
Ratio of plan dimension	**1.336**
Typical Floor to floor height in mt. Maximum floor to floor height in entire height of building in mt	**3.3mt** **5.9 mt in G.R.level**
Aspect ratio (Height of Building till Terrace / Minimum Dimension of Building)	**2.5**
Type of floor slab	**P.T. Flat slab & connecting R.C.C. slab**
Average thickness of floor slab in mm	**175 mm**
Whether column are RCC, Composite or In structural steel	**R.C.C. column**
Lateral System Whether the Geometry of Building is Symmetric Whether the lateral load resisting system is symmetrically placed in Geometry	**Ductile Shear wall** **No** **No**
Use of floor at different levels (Residential I Commercial I industrial)	**Residential**
Use of floor at different levels (Residential I Commercial I industrial)	**Residential**
Is there any Transfer level? If yes,depth of transfer girder	**At G.F. Level** **1800 mm**

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Whether expansion joint is provided? If yes,what is the maximum plan dimension in mt	**Yes**
Whether separation gap at the joint is	**Seismic gap require as per IS 1893:2002 =R/2(Sum of cal. Storey displacement) =5/2(65+115) = 450 mm**
Max cantilever projection in mt	**3.8**

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Annexure-I

DESIGN BASIS REPORT

Following data should be part of Design Basis Report.

- **Brief Description of the Project** - Number of basements, commercial floors, residential floors, Service floors, refuge floors, projection above terrace level and number of additional I provisional floors considered in design.
- **List of Codes** - Codes which are considered in design. If any specific reference is taken from foreign codes, same should be clearly mentioned. Any specific assumption in the design should be supported by reference papers.
- **Loading Parameters** - All the loading assumptions shall be clearly mentioned in A3 size GA drawings with sunken loading, live load. Typical sections indicating the elavational/ facade features shall be shown. Assumptions and the basis of the same for the elavational features above terrace slab shall be mentioned. Calculation of Time Period for the structure, Importance factor, performance factor shall be specified. Wind terrain category, Gust wind calculations shall be mentioned.
- **Clear cover to Reinforcement** - These shall be mentioned for all structural members with minimum fire rating of 2 hours for columns, shear walls and beams and 1.5 hours for slabs.
- **Grade of concrete** - Grade of concrete for various elements viz. beams, slabs, columns, shear walls.
- **Exposure condition** - Exposure condition assigned to site should be specified.
- **Wind Tunnel Testing** - Wind tunnel analysis should be carried out for all structures with height above 250 m from the normal ground level, keeping in mind the present condition as well as the likely development in the vicinity area after the completion of the project.
- **Construction Sequence and loading parameters for the same** - If due to any site constraints the loading on the floor slabs is to be enhanced, the mention of the same and calculations for the same shall be provided.
- **Proposed Approach to Structural Analysis** - Various flooring systems considered in the structure, the software used for analysis and design approach adopted. Release in_ moments of link beams, cracked moment of Inertias for structural members along with the assumptions for the same shall be specified.
- **Load Combinations** - Various load combinations used in the design of individual members. Additional combinations from the Wind tunnel tests considered, if any.
- **Soil Profile in Brief** - In brief the soil profile of the project along with the Safe bearing capacity and the type of foundations adopted.
- **Soil Retention system** - A brief description of the soil retention system adopted for the project along with the construction sequence.
- **Key Plan** - showing Expansion I Separation joints (if any).

Added Features - If any additional features are considered in design such as dampers, out rigger beams, etc shall be specified clearly stating the purpose of the same.

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