1. INTRODUCTION

The clients SHAFALYA INFRASTRUCTURE has appointed to develop structural schemes and design for proposed construction at SATELLITE, AHMEDABAD, GUJARAT.(F.P. 08/T.P.S. NO. 6)

This DBR focuses on the projects having Two Towers with 3 Basement which all are separated.

- 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' requirement 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: SHAFALYA
Location: AHMEDABAD (ZONE –III), GUJARAT

2.1 AGENCIES and ADDRESSES

Client: SHAFALYA INFRASTRUCTURE
Design Architects: ADS Architects
Structural Consultants: UMANG PATEL
203, PARISHRAM ELEGANT, NR. HCG HOSPITAL,
SOLA-SCIENCE CITY ROAD, AHMEDABAD

2.2 PROJECT

The project consists of 3 Basement Floor + Ground Floor+ 18 Floor Above + OHWT for Block A and 3 Basement Floor + Ground Floor+ 17 Floor Above + OHWT for Block B. Structural form should contribute to the building character and identity, while being efficient, cost effective and simple to construct. The Building will be RCC Shear walls and beams, slab. RCC Shear walls are provided, which will be act as a lateral load resisting elements. Provisions are in corporate into the design in 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 DIMENSIONS

2.3.1 PLAN DIMENSIONS

TOWER	DIMENSION IN X-DIRECTION (m)	DIMENSION IN Y-DIRECTION (m)
TOWER-A+B(GROUND FLOOR)	79.28	75.18
TOWER-B (1ST FLOOR)	26.45	75.18
TOWER-A(TYPICAL)	40.61	25.83
TOWER-B (TYPICAL)	24.27	52.43
SOCIETY OFFICE(G+1)	6.55	13.34

2.3.2 FLOOR HEIGHTS

BLOCK	Total Height of Building (meter)	2nd & 3rd Basement (meter)	1ST Basement (meter)	Ground Floor (meter)	1st Floor (meter)	Typical Floor (meter)	OHWT Bottom (meter)	OHWT Top (meter)	No. of storey
A	64.56 (Ground Lvl to Terrace Floor Lvl)	3.58	4.34	4.11	4.11	3.35	2.8	2.08	18 (Above Ground Floor)
B	61.21 (Ground Lvl to Terrace Floor Lvl)	3.58	4.34	4.11	4.11	3.35	2.8	2.08	17 (Above Ground Floor)
SOCIETY OFFICE	7.5 (Ground Lvl to 1st floor Slab Lvl)	-	-	3.8	3.7	-	-	-	G+1

3. STRUCTURAL DESIGN STANDARDS ANDCODES

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):2015 - Wind Loads
IS 875(Part 5):1987 - Special loads and load combinations
IS 1893(Part 1):2016 - Criteria for earthquake resistance design of structure.

3.1.2 CONCRETE DESIGN

IS 456: 2000 - Plain and Reinforced Concrete - Code of practice
SP 34 - Handbook on Concrete Reinforcement & Detailing
IS 1904 - Indian Standard Code of practice for design & construction of foundations in Soil: General Requirements
IS 13920:2016- Ductile design and detailing of Reinforced Concrete Structures subjected to Seismic Forces
IS 16700: 2017 - Criteria for Structural Safety of tall concrete Building.
IS 3370: 2009 - Code of practice for concrete structure for storage of liquid.

4. DESIGN PARAMETERS

4.1 Material of Construction

4.1.1 RCCWORKS

The building will be primarily RCC shear wall structure with peripheral beams, lift walls and floor slabs being used as diaphragms in distribution of lateral forces.

- Density of reinforced concrete shall be: 25kN/m3
- GradeofConcreteM10willbeusedinfilling, plum concrete, leveling courses and other non-structural items. Density of reinforced concrete is assumed as 25kN/m3.
- Minimum cement content, water cement ratio etc. will conform to IS 456:2000 provisions for durability and strength criteria. (As per approved mix design from concrete supplier and contractor)
- Ordinary Portland cement of grade 53 or higher confirming to IS 8112 and IS 12269 are specified for concrete grades ranging up-to M45.
- 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: 2008 with Fe 500 d Fy = 500 N/mm2 TMT bars will be used as Reinforcing-bars in concrete elements.
- Elongation of reinforcement should not be less than 14.5% as per IS 1786:2008
- All mix design of concrete should be got approved prior to execution of work.
- Take out 6cubes from every batch of concrete and report of the same of 7 days and 28 days must be submitted to us.
- For reinforcement report should be carried out at every 30 ton for each category and elongation test should be performed and should not be less than14.5%.
- Grade to be used,
  Columns / Shear Walls: M45
  Beam & Slab: M35
  Footing: M35

4.2 LOADINGPARAMETERS

4.2.1 SELFWEIGHTS

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

- Density of Reinforced Concrete: 25.0kN/m3.
- Density of Plain Concrete: 24.0kN/m3.
- Density of Steel: 78.5kN/m3.
- Density of Plasters: 20.0kN/m3.
- Density of Soil (Unsaturated): 18.0kN/m3.
- Density of Soil (Saturated): 21.0kN/m3.
- Density of water: 10.0kN/m3
- Density of Light Weight Cinder Filling Material: 7.0kN/m3.
- Density of Brick Masonry: 20.0kN/m3
- Density of Block Masonry: 6.50kN/m3

4.2.2 IMPOSED GRAVITY LOADS

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

*4.2.2.1 LIVE LOAD (As per IS: 875-part II-1987)**

- Basement roof slab = 5.00kN/m2
- Hollow plinth roof slab = 2.00kN/m2
- Typical floor roof slab (Reducible Live) = 2.00kN/m2
- Terrace (Reducible Live) = 1.5kN/m2
- Lobby/Balcony, Passages = 3.00kN/m2
- Staircase (Reducible Live) = 3.00kN/m2
- Commercial/Shop = 4.00kn/m2
- Fire tender =15kN/m2
- Live load reduction:
  As per IS 875 part-II-1987, clause 3.2 Reduction in imposed load on floors may be made in designing columns, walls, piers, their supports and foundations.

4.2.2.2 SUPER IMPOSED DEADLOAD

- Floor Finish on Basement roof slab = 2.5kN/m2
- Floor Finish load on Typical floor roof Slab = 1.5kN/m2
- Sunk (300 mm light weight filling) = [(0.300*7) +(0.075*24)] = 3.9kN/m2
- Floor finish load on Terrace Slab (100mm screed x 24 = 2.4) = 2.5kN/m2
- Lift Machine Room (LMR) =10.00kN/m2
- Water (OHWT) = 15 kN/m2 (Considering 1.5m height)
- Floor finish load on Stair (FF) = 3kN/m2
  *Specific loads given by vendors will be adopted wherever applicable.

4.2.2.3 SELF - WEIGHT OF DIFFERENT WALLS

- At Typical Roof Slab for Height 3.35m Block Wall For,
  1) 115 mm thick =[(3.35-0.575) x 0.115 x6.5] + [(0.012+0.012) x3.35 x20] =3.68kN/m
  2) 230 mm thick = [(3.35-0.575) x 0.230 x6.5] + [(0.012+0.012) x3.35 x20] =5.76kN/m
- At1st floor Roof Slab for Height 4.11 m Block Wall For,
  1) 115 mm thick = [(4.11-0.575) x 0.115 x6.5] + [(0.012+0.012) x4.11 x20] =4.62kN/m
  2) 230 mm thick =[(4.11-0.575) x 0.230 x6.5] + [(0.012+0.012) x4.11 x20] =7.25kN/m
- At Ground floor Roof Slab for Height 3.5 m Block Wall For,
  1) 115 mm thick = [(3.5-0.575) x 0.115 x6.5] + [(0.012+0.012) x 3.5 x20] = 3.87kN/m
  2) 230 mm thick = [(3.5-0.575) x 0.230 x6.5] + [(0.012+0.012) x3.5 x20] = 6.05kN/m

- At1st Basement floor Roof Slab for Height 4.34 m Block Wall For,
  1) 115 mm thick = [(4.34-0.6) x 0.115 x6.5] + [(0.012+0.012) x 4.34 x20] =4.88kN/m
  2) 230 mm thick = [(4.34-0.6) x 0.230 x6.5] + [(0.012+0.012) x 4.34 x20] =7.67kN/m
- At2nd and 3rd Basement floor Roof Slab for Height 3.58 m Block Wall For,
  1) 115 mm thick = [(3.58-0.6) x 0.115 x6.5] + [(0.012+0.012) x 3.58 x20] =3.95kN/m
  2) 230 mm thick = [(3.58-0.6) x 0.230 x6.5] + [(0.012+0.012) x3.58 x20] = 6.17kN/m
- 115 mm thick Block Wall for 1.05m Height = 1.05 x 0.115 x 6.5 = 1.29kN/m
- 230 mm thick RCC Wall for 1.75m Height = 1.75 x 0.23 x 25 = 10kN/m
- Wall loads are considered as per architectural plans at respective levels.

4.2.3 SEISMIC LOADS

The seismic load calculations will be carried out in accordance with IS 1893 (Part 1): 2016. As per the 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 **1.2 as it is residential building** with occupancy more than 200 person as per IS 1893:2016,response reduction factor **R will be taken as '4'**, the structure would be designed as a Building with ductile RC Structural Walls, and the **soil type will be taken as 2** as per Geotechnical report. 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):2016. Since the structure is a Reinforced Concrete structure, an approximate damping value of 5% will be considered.

For calculation of design seismic forces of building, the reduction of imposed loads mentioned inTable-10 IS1893 (Part 1): 2016 is considered.

Time period calculation (As per IS:1893-part I-2016)

- ***BLOCK-A***

	With Infill walls	**Shear wall time period**	**Without Infill walls time period**
	0.09 x h/(Dx)^0.5	[0.075 x (h^0.75)]/(A_w^0.5)	[0.075 x (h^0.75)]
X-direction =	0.874 sec	0.725 sec	1.655 sec
Y-direction =	1.096 sec	0.724 sec	1.655 sec

Therefore, Time period taken as,
X-direction = 0.874sec
Y-direction = 1.096sec

- ***BLOCK-B***

	With Infill walls	**Shear wall time period**	**Without Infill walls time period**
	0.09 x h(Dx)^0.5	[0.075 x (h^0.75)]/(A_w^0.5)	[0.075 x (h^0.75)]
X-direction =	1.069 sec	0.883 sec	1.587 sec
Y-direction =	0.604 sec	0.885 sec	1.587 sec

Therefore, Time period taken as,
X-direction = 1.069 sec
Y-direction = 0.885sec

4.2.4 WIND LOADS

IS 875-Part.III-2015 is used for application of wind force.
Basic wind speed (Vb) = 39m/s (Ahmedabad)
The Design Wind Speed is given by Vz = k1 x k2 x k3 x k4 x Vb
Where, k1 = Probability factor = 1;
k2 = Terrain, height and structure size factor;
k3 = Topography factor,
k4 = Important factor for cyclonic region,
k1 = k3 = k4 = 1 for this case.

The structure falls under **Category -3** (Terrain with numerous closely space obstructions having size of buildings up to 10m in height with or without a few isolated tall structures.)

	BLOCK-A	***BLOCK- B***
Ht =	64.56 m	61.21 m
Dx =	40.615 m	24.27 m
Dy =	25.832 m	52.43 m
Cfx =	1.12	1.21
Cfy =	1.27	1.04

Dynamic effects (as per IS:875-part-III, clause-9, pg.45),In addition to this, in model analysis, 1st mode time period is more than 1, thus frequency become less than 1, hence dynamic effects of wind have been considered using Gust factor method along wind and across wind effects as per IS 875.

4.3 STIFFNESS MODIFIERS

According to IS 16700-2017, stiffness modifiers for flexural capacity only

	Service Case	Design Case
Slab	35 percent of I_{gross}	25 percent of I_{gross}
Beam	70 percent of I_{gross}	35 percent of I_{gross}
Walls & Columns	90 percent of I_{gross}	70 percent of I_{gross}

5. STRUCTUR ALANALYSIS

The structural form should contribute to the building character and identity while it is being efficient, cost effective and simple to construct. The structure is modeled for concrete shear walls and analyzed. Structure will be subjected for earthquake analysis by using minimum wall section at floors. Structure will be analyzed using ETABS19. The analysis results generated by software will be cross verified by hand calculations for critical members.

Type of Analysis Performed

- Dynamic Analysis (Response Spectrum Analysis)
- Second Order P-Delta Analysis

5.1 DEFLECTIONCRITERIA

- The final deflection due to all loads including the effects of temperature, creep and shrinkage and measured from the as-cast level of the supports of floors, roofs and all other horizontal members should not normally exceed span/250.

- The deflection including the effects of temperature, creep and shrinkage occurring after erection of partition and the application of finishes should not normally exceed span/350 or 20 mm whichever is less.

5.2 CRACKINGCRITERIA

- In liquid retaining structure, the maximum calculated surface width of cracks for direct tension and flexure or restrained temperature and moisture effects shall not exceed 0.2 mm with specified cover.

6. 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 are the load combinations and the member forces will be considered for arriving at the design forces.

• Concrete Design criteria Load combination	• Concrete Service Criteria Load combination
1. 1.5 (DL + LL)	14. DL + LL
2. 1.2 (DL + LL + SpecX)	15. DL + LL + SpecX
3. 1.2 (DL + LL + SpecY)	16. DL + LL + SpecY
4. 1.5 (DL + SpecX)	17. DL + SpecX
5. 1.5 (DL + SpecY)	18. DL + SpecY
6. 0.9 DL + 1.5 SpecX	19. DL + LL ± WX
7. 0.9 DL + 1.5 SpecY	20. DL + LL ± WY
8. 1.2 (DL +LL ± WX)	21. DL ± WX
9. 1.2 (DL + LL ± WY)	22. DL ± WY
10. 1.5 (DL ± WX)	
11. 1.5 (DL ± WY)	
12. 0.9 DL ± 1.5 WX	
13. 0.9 DL ± 1.5 WY	

7. STRUCTURALDESIGN

7.1 DESIGNMETHOD

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 pre dominantly concrete and steel with consideration for strength and durability. The Reinforcing bars to be used in concrete elements are conforming to IS: 1786-2008 with Fy=500 N/mm2.

Covers to Reinforcement

Clear cover for all 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 to main steel,

- For footing: 50mm for Sides & Bottom
- For Column:40mm
- For Beam (continuous): 30mm for Sides & Bottom
- For Beam (simply supported): 40mm for Bottom
- For Slab: For Continuous - 25mm& For Simply supported - 35mm.
- For RCC shear wall: 40mm

8. SOIL INVESTIGATION & BEARINGCAPACITY

The allowable net soil bearing capacity as 400 kN/m^2 for Foundation with settlement of 75 mm at 13.5 m depth below Existing Ground Level and Modulus of Sub grade Reaction is considered as 39200 kN/m^3 as per soil report of AHMEDABAD ENGINEERING RESEARCH INSTITUTE, AHMEDABAD, With reference to REPORT NO.: RPT/AERI/3300002 dated on February 2022.

The water table was encountered at 20 m (average) from existing ground level in the bore-log during investigation (As per Soil Report). If the foundation pressure governs in earthquake combination, then SBC will enhance up to 50% as per IS 1893-2016, Table 1.

9. CONCLUSIONS &RECOMMENDATIONS

This brief concept has been formulated based on the architectural scheme provided by ADS Architects. The report suggests a concept level structural design of Project of SHAFALYA 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 details of the structural design 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.