प्रधान मंत्री आवास योजना-शहरी

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Ministry of Housing and Urban Affairs
Government of India

स्वच्छ भारत
एक कदम स्वच्छता की ओर

LIGHT HOUSE PROJECT AT RAJKOT

GHTC-I Category:

Monolithic Concrete Construction System

Technology:

Monolithic Concrete Construction using Tunnel Formwork

CONTENTS

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Global Housing Technology Challenge - India (GHTC-I)

Broad Category	***Technologies (Nos.)***
Precast Concrete Construction System - 3D Precast volumetric	4
Precast Concrete Construction System – Precast components assembled at site	8
Light Gauge Steel Structural System & Pre-engineered Steel Structural System	16
Prefabricated Sandwich Panel System	9
Monolithic Concrete Construction	9
Stay In Place Formwork System	8
Total	54

Summary of Light House Project (LHP)

LHP Location			Chennai (Tamil Nadu)	Rajkot (Gujarat)	Indore (Madhya Pradesh)	Ranchi (Jharkhand)	Agartala (Tripura)	Lucknow (Uttar Pradesh)
Sl. No	**Particulars**	**Units**						
1	Name of Technology	Name	Precast Concrete Construction System- Precast Components	Monolithic Concrete Construction using Tunnel Formwork	Prefabricated Sandwich Panel System	Precast Concrete Construction System – 3D Volumetric	Light Gauge Steel Frame System (LGSF) with Pre-Engineered Steel Structural System	Stay in Place Formwork System
2	No. of Houses	No.	1,152	1,144	1,024	1,008	1,000	1,040
3	No. of Floors	No.	G+5	S+13	S+8	G+8	G+6	S+13
4	Plot Area	Sqm	33,596	39,599	41,920	31,160	24,000	20,000
5	Per House Carpet Area	Sqm	26.58	39.77	29.04	29.85	30.00	34.50
6	Project Cost	INR (in Cr)	116.27	118.90	128.00	134.00	162.50	130.90
7	Per House cost (with infrastructure)	INR (in Lakh)	10.09	10.39	12.50	13.29	16.25	12.58

- Have a look at the project brief:
  - 1144 houses will be constructed in Stilt+13 configuration.
  - The total plot area is around 39,600 Sqm and carpet area of each house is approximately 39.77 Sqm.
  - There are 11 residential blocks.
  - The project also includes Community Centre and Health Centre.

Typical floor plan

Block Plan

At each floor there are 08 dwelling units

Project Layout Plan

Typical Dwelling Unit Plan

Unit Plan

- Each dwelling unit comprises of one living room, one Bedroom, one study room, Kitchen and two toilets.
- The carpet area of each unit is 39.77 sq.mt. The sizes of individual rooms & service areas conform to NBC norms.
- **Other special features:**
  - Green rating as per GRIHA
  - Use of renewable resources:
    - Rain water harvesting
    - Solar lighting
  - Solid waste management
  - STP with recycling of waste water

Unit 3D View

Prevalent Construction Systems → **Technology being Used**

Load bearing Structure

RCC Framed Structure

Monolithic Concrete Construction using Tunnel Formwork

Tunnel formwork
- Customized formwork

Assembly of Formwork

Concreting after Placing formwork

Structure after removal of formwork
- Shear Wall Construction

Structural Elements

- Foundation
- Structural System – Monolithic Shear Wall and Slab
- AAC Block Masonry

Foundation

- As per geo-technical investigations, bearing capacity, soil strata, water table, etc.
- Typical raft foundation of varying sizes depending on the load.

Foundation

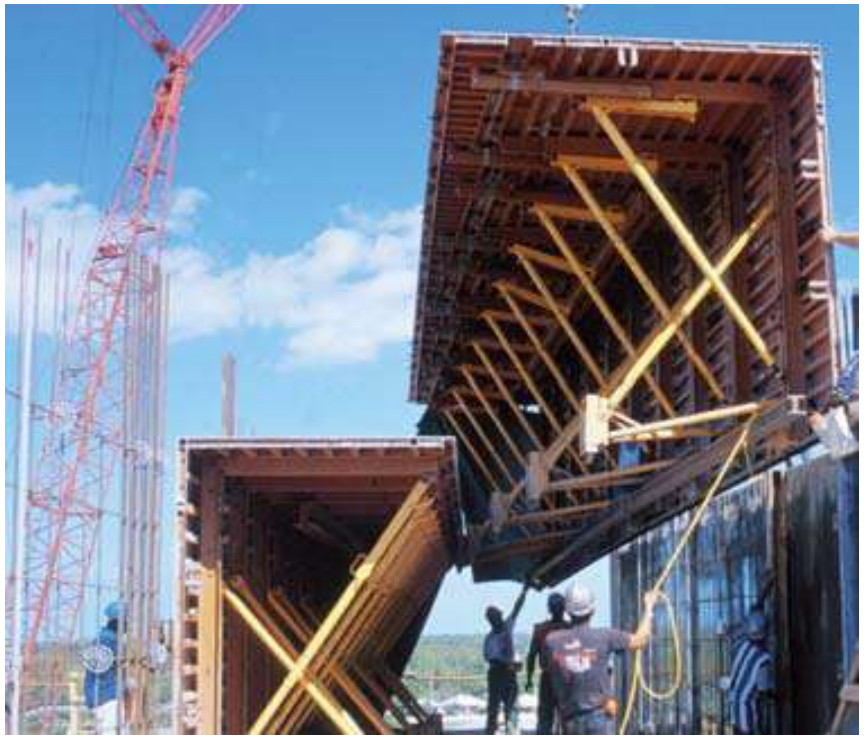
- Concreting of raft footing with M25 concrete as per Structural Drawing.
- Formwork for shear walls up to plinth beam.

Foundation

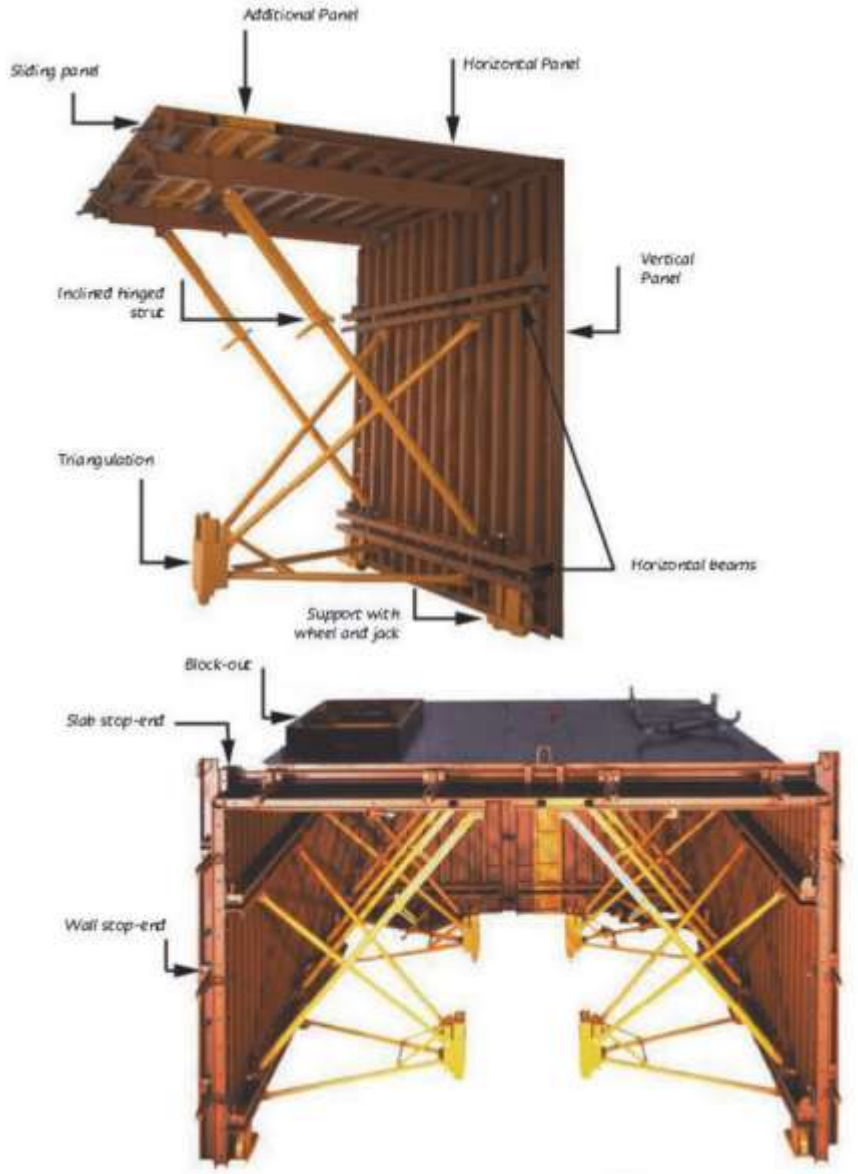
- Shear Wall up to Plinth level

Structural System

- Tunnel formwork is customized engineering formwork based on two half shells which are placed together to form a room or cell. Several cells make an apartment.
- The construction of structure is divided into phases. Each phase consists of a section of the structure that will be cast in one day. The phasing is determined by the programme and the amount of floor area that can be poured in one day.
- The infill walls are of Autoclaved Aerated Concrete (AAC) blocks and being used for partition walls.



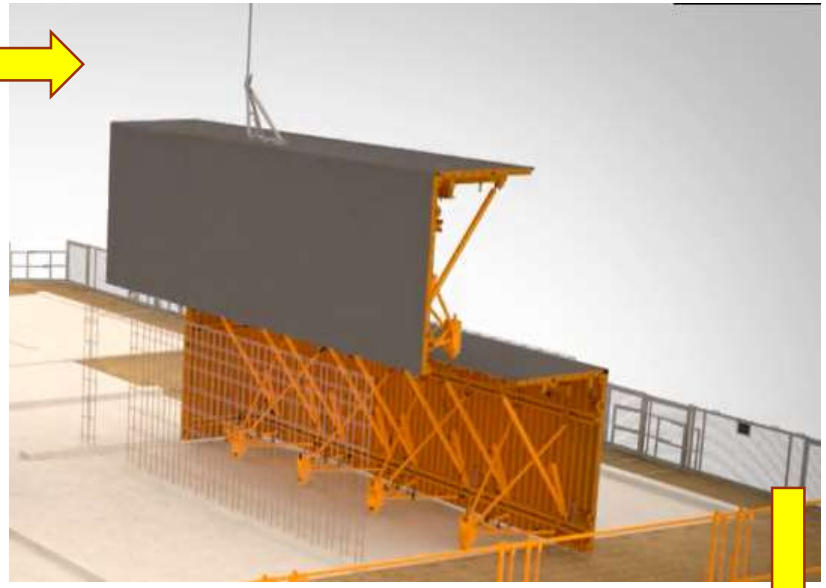
Assembly of Tunnel Formwork

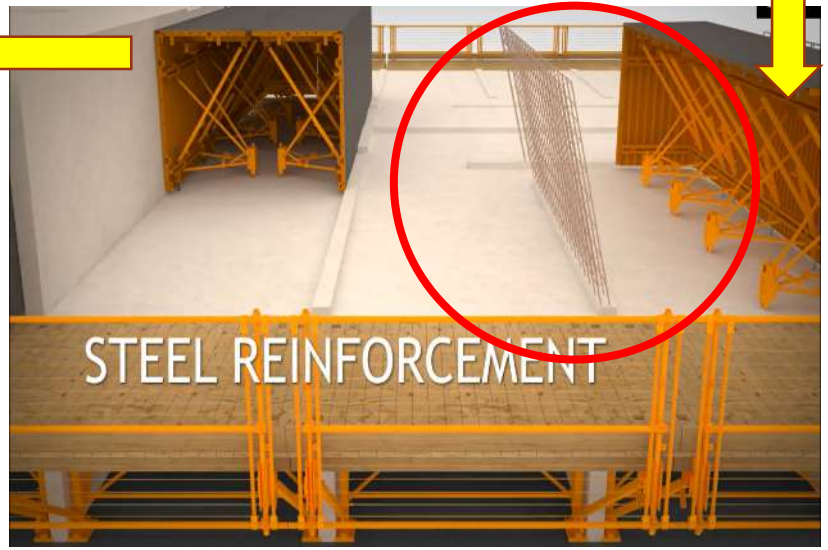


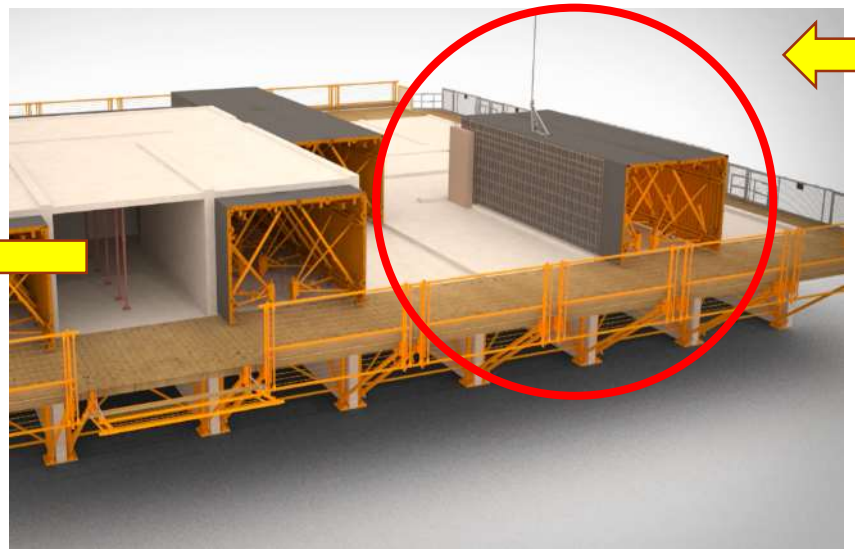
Work Cycle with Tunnel Formwork

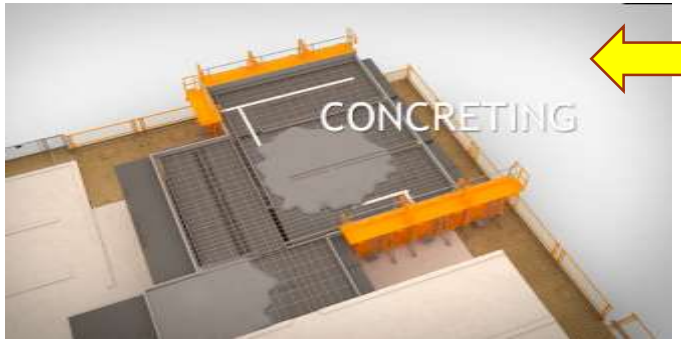
The on-site implementation of 24 hour cycle is divided into following operations.

1. Stripping of the formwork from the previous day.
2. Positioning of the formwork for the current day's phase, with the installation of mechanical, electrical and plumbing services.
3. Installation of reinforcement in the walls and slabs.
4. Concreting.









Structural System

- Placement of tunnel formwork for slab and wall

- Concreting after placement of reinforcement on slab and wall.

Structural System

- After placement of reinforcement, the slab is cast monolithically with the walls.

Placement and leveling of concrete

Structural Elements

- Finished Monolithic structure with shear wall and slab

Autoclaved Aerated Concrete (AAC) Blocks for Wall

- Autoclaved Aerated Concrete (AAC) blocks are lightweight, precast manufactured using foam concrete and suitable as masonry unit. These are non-load bearing infill walls.

Advantages

- Facilitates rapid construction of multiple/ mass modular units (similar units)
- Results in durable structure with low maintenance requirement
- The precise finishing can be ensured with no plastering requirement
- The concrete can use industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBFS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resource
- Being Box type structure, highly suitable against horizontal forces (earthquake, cyclone etc.)
- The large number of modular units bring economy in construction

Limitations

- A lead time of about 3 months is required for initiation of work, as the formwork are custom designed, manufactured and prototype approved before manufacturing required number of sets of formwork
- Post construction alterations are difficult
- All the service lines are to be pre-planned in advance
- Economy in cost is achieved with large number of multi storied modular units.

Mass Scale Field Implementation of New Technology

Light House Project at Rajkot

on

Design & Build Basis

Agency:

M/s Malani Construction Company, Rajkot

Technology Provider:

M/s Outinord Formwork Pvt. Ltd., Pune

Design Parameters

General Description: -

- Parking + 13 Above Floor + Stair cabin
- Height of Building from Ground =43.1 m (FGL to Parapet)
- Height of Typical Floor =2.950m
- Parking Height =3.550m
- Plan Area of Building = As per architectural layout

S. No.	DEAD LOAD	
1	Concrete	25 KN/m^3
2	Brick or Block –with plaster	9 KN/m^2
3	Floor finish	1.25 KN/m^2
4	Water proofing	2.25 KN/m^2

Design Parameters

S. No.	Details of Building	
1	Type of Building	Stilt + 13 – high rise building
2	Dimension of the Building	Width of Building -14.960m
3		Length of Building -38.920m
4	Floor Height	Height of Ground Floor -3.550m
		Height of Typical Floor -2.950m
5	Grade of Concrete used	M40 for all Wall, Slabs and Beam elements and M25 for footings.
6	Grade of Steel used	Fe-500
7	Live Load as per IS:875 2015 (Part 2)	For General -2 KN/m^2
		Corridor -3 KN/m^2
8	Wall Load as per IS:875 2015 (Part 1)	Masonry considered as Block wall and Applied load 1.6 KN/m^2 on Slab
9	Wall Size and loads Consider	External Wall -200 mm
		Internal Wall -150 mm
		Parapet Wall -100 mm
10	Water Tank Load	15 KN/m^2
11	Additional Lift load	12 KN/m^2

Design Basis

- Safe Bearing capacity: 25 T/m^2, depth of foundation varying from 2.0 to 2.5 m
- Raft Foundation as per IS:2950 (Part-1)-1981 (reaffirmed 2008). Minimum M25 grade of concrete is proposed for RCC structural elements in sub-structure.
- Shear wall from Raft foundation to Plinth beam.
- Plinth beam at ground level monolithic with shear wall in super structure.
- Structural Frame
- RCC Shear wall monolithic structure (outer shell) using tunnel formwork
- Inner infill walls with AAC block masonry
- Wind speed: High damage risk zone with basic wind speed (V_b=39m/sec) as per IS875(Part-3)
- Design wind speed:

  $V_z=V_b.k_1.k_2.k_3.k_4$

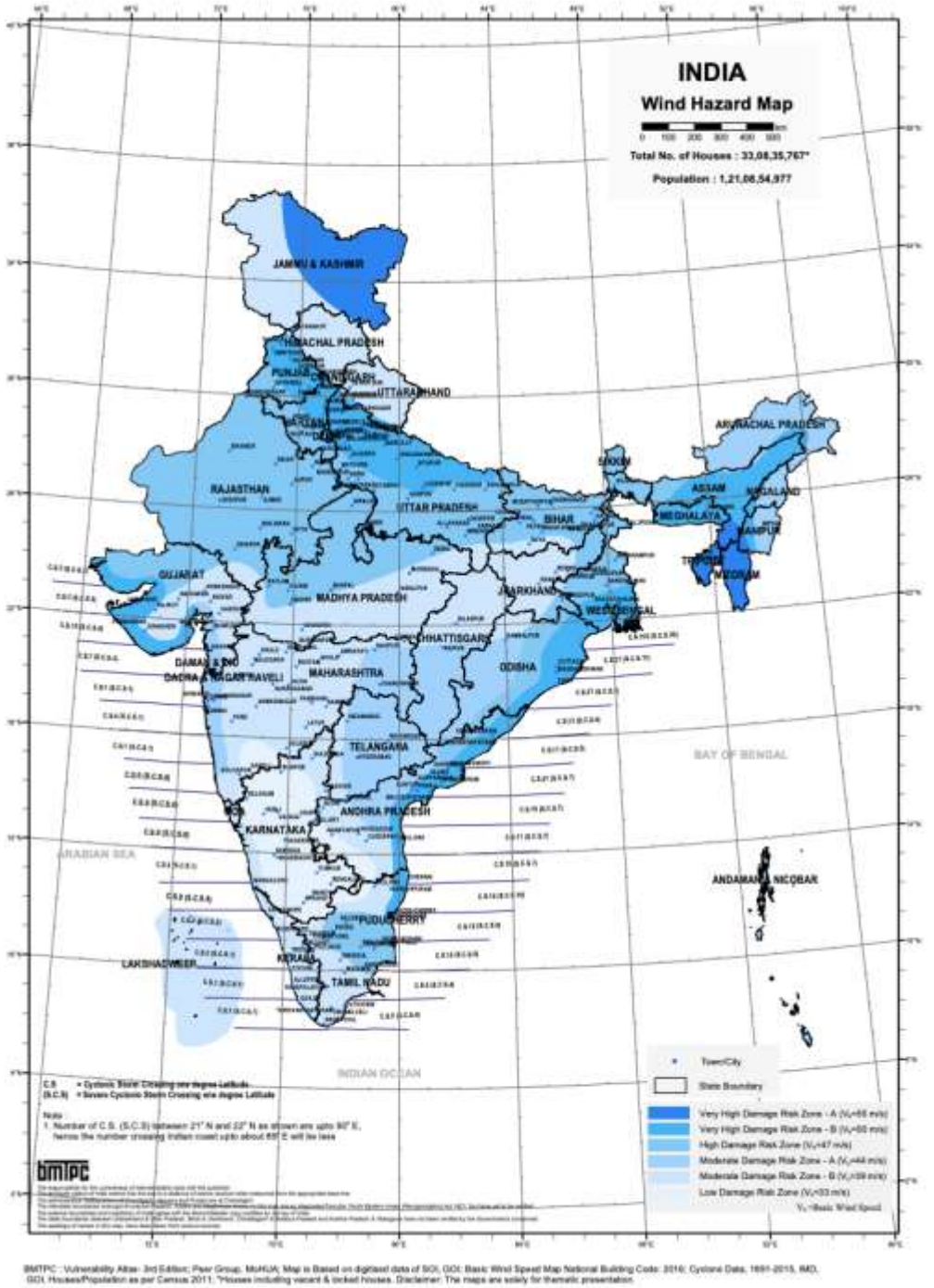
  k_1 (Risk Coefficient)=1

  k_2 (Size factor)=Category 4

  k_3 (topography factor)=1

  k_4 (importance factor)=1

- Wind Pressure (P_z) = $0.6.Vz^2$
- Wind pressure is converted into design wind pressure and then distributed at each storey as wind force.



Design Basis

- Earthquake : Zone-III as per Seismic Zoning Map of India IS: 1893 (Part-1):2016
  - Designed as dual system with ductile RC structural walls and few special moment frames in structural steel in both direction, Response Reduction Factor=4 (Table-9 iv of IS: 1893 (Part-1):2016), Z=0.16, I=1.2, R=4, Damping Ratio=5%.
  - Design Horizontal Seismic Coefficient (A_h)

$$A_h=(Z/2).(S_a/g).(I/R)$$

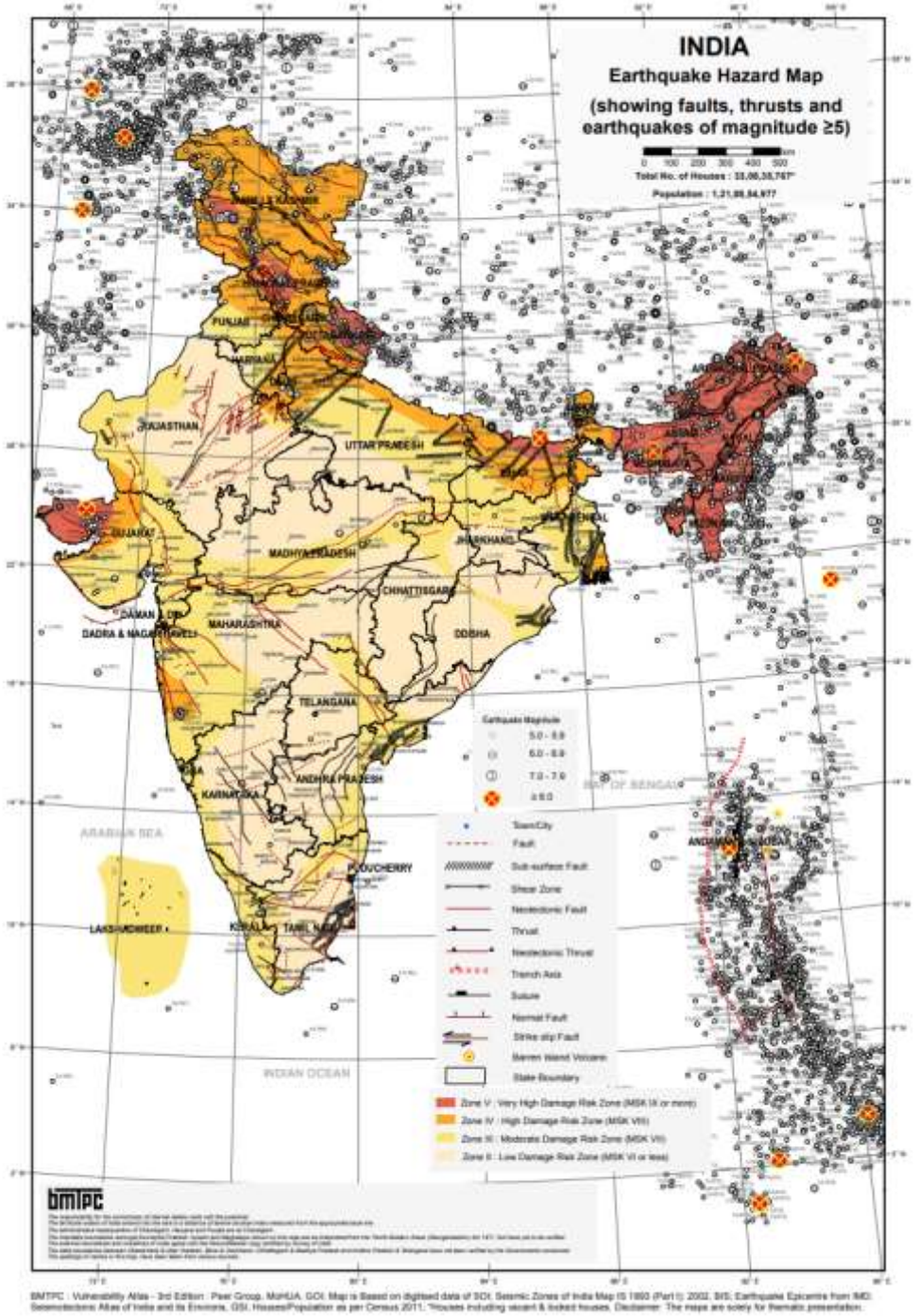
S_a/g is design acceleration coefficient for different soil types corresponding to natural period (T) of building

  - Design Lateral Force (V_B)

$$V_B=A_h.W$$

W is seismic weight of building

  - 3D dynamic analysis using response spectrum method using ETABS.



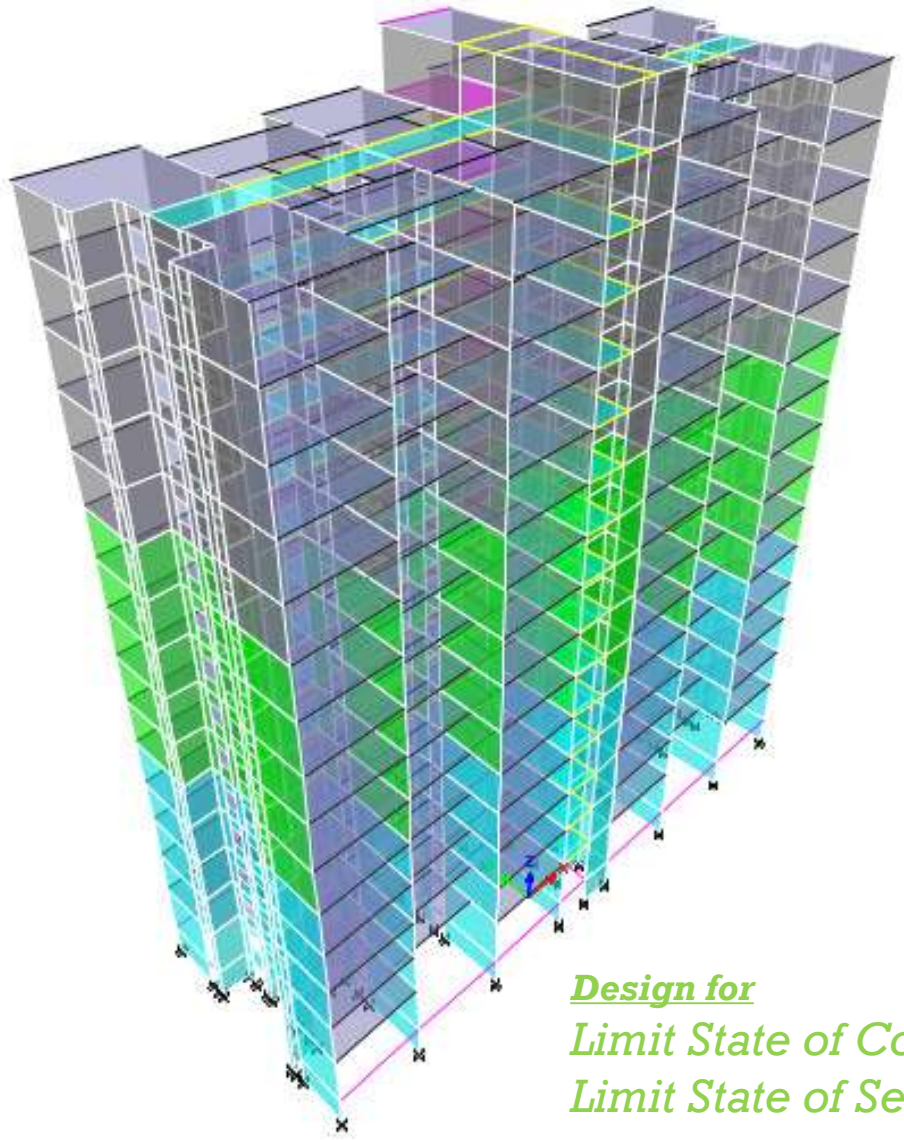
STRUCTURAL ANALYSIS & DESIGN

- 2D and 3D Modeling

- Load Combinations :
  - 1.5 (DL+LL)
  - 1.2 (DL+LL±EL/WL)
  - 1.5 (DL±EL/WL)
  - 0.9DL ±1.5EL/WL

(EL/WL implies Earthquake/Wind Load in +X, -X, +Y, and –Y, directions . Lateral forces shall be considered acting from all directions but one at a time.)

- Structural system can be easily modeled in the CAD software such as STAADPRO, ETABS, SAFE, SAP, ABACAS and others for detailed structural analysis.
- 2D/ 3D Static and dynamic linear and non-linear analysis can be carried out using these software.
- The software can also be used for structural design as per Indian Standards.
- AUTOCAD for drawings



Design for

Limit State of Collapse

Limit State of Serviceability

Concrete mix design for M25 (NCCBM, Ahmedabad)

Mix Constituents	Saturated surface dry Condition For One Cubic Meter (Kg)
Cement OPC 53 Grade (Ultratech)	261
GGBS	112
Water	171.58
Fine Aggregate (45.30)	843
Coarse Aggregate Fraction I (20mm-50 %) Fraction II (10mm-50 %)	 548 548
Admixture @ 0.7% by wt. of Cement Content	2.61
Water- Cement Ratio	0.46

BATCHING PLANT

QUALITY CONTROL LAB AT SITE

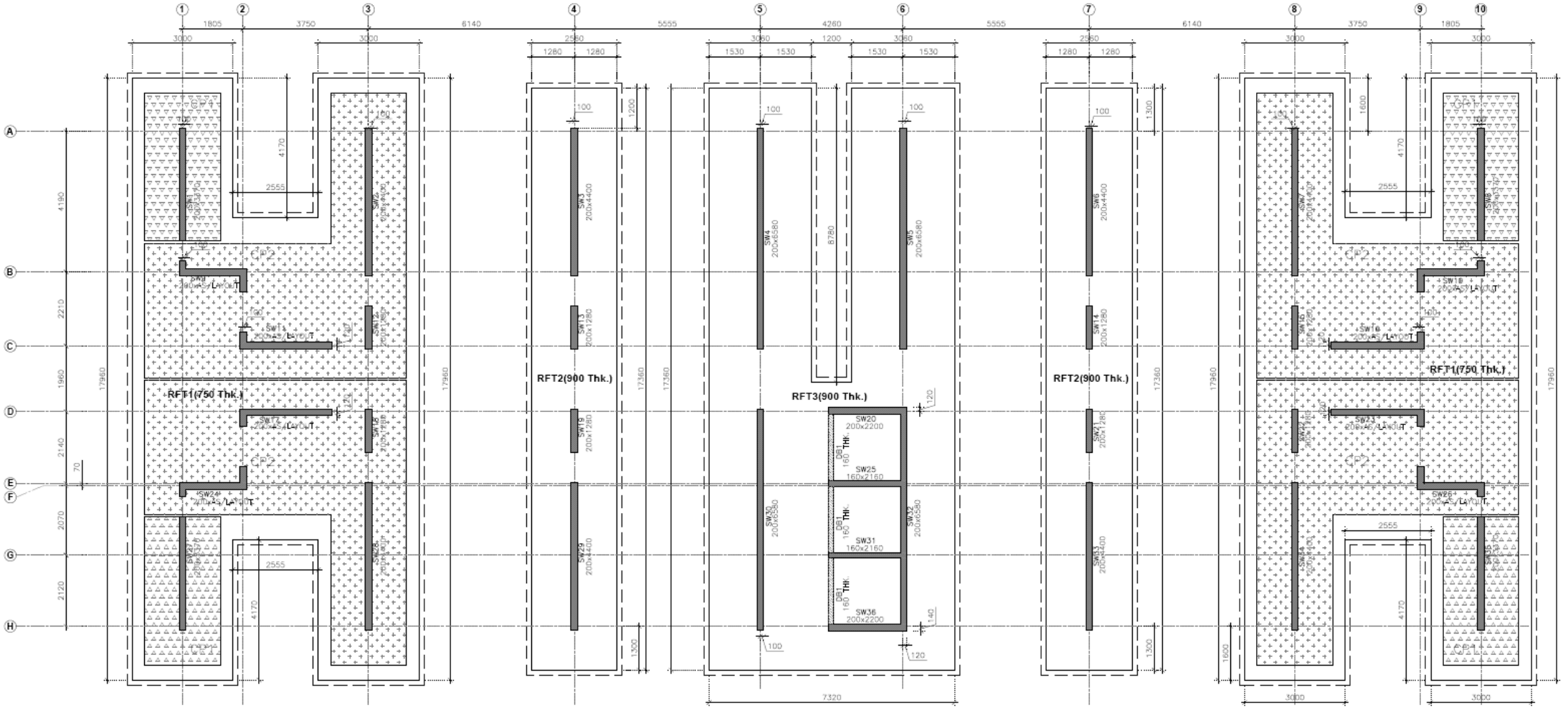
- Quality control and quality assurance is essential for a project and therefore a quality control lab has been established at site for testing of raw materials and finished products.

Construction Sequence

- Sub-Structure: Foundation
- Super-structure: Structural System – Monolithic
  Shear Wall and Slab
  AAC Block Masonry for walls
- MEP: Plumbing & Electrical
- Finishing

FOUNDATION

Structural Drawings



STRUCTURAL LAYOUT AT FOUNDATION LEVEL.

ALL CENTER LINE & DIMENSION REFER AS PER ARCH DRG.

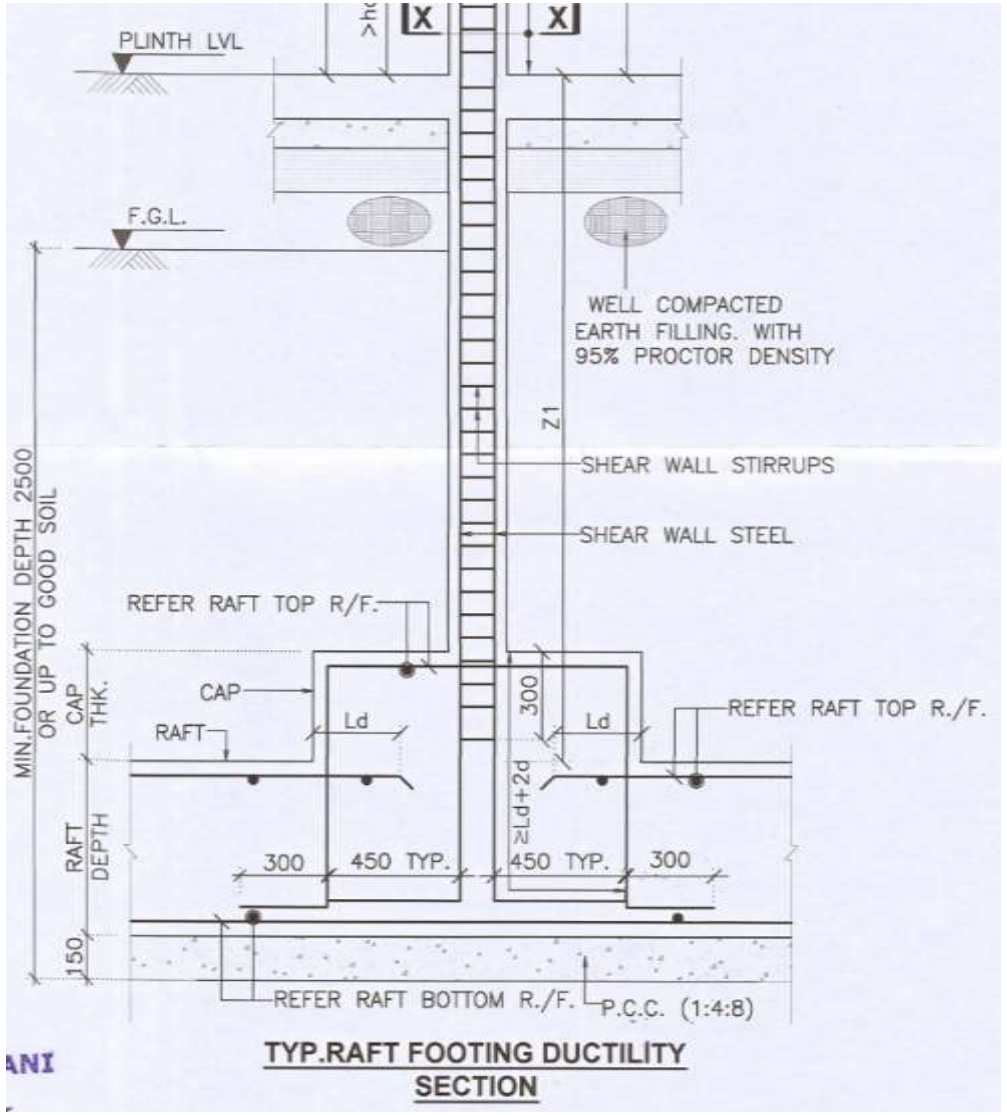
—THUS MARKED 450 THK.CAP ABOVE RAFT

—THUS MARKED 900 THK.CAP ABOVE RAFT

FOUNDATION

Concrete & Reinforcement Steel Specifications

- Raft foundation with Shear wall upto Plinth level has been used.
- The raft foundation is designed for SBC of 25 T/m^2 as calculated in soil investigation report.
- After leveling of the ground 150 mm thick PCC is placed and depth of the raft footing is 750 to 900mm.
- M25 grade of concrete has been used with cover of 50mm. reinforcement has been placed as per the drawings.
- Above raft footing, shear wall of 200mm thickness is designed upto Plinth level. Grade of concrete in shear walls is M40.
- Above shear wall, plinth beam of 230 x 600 mm is cast with M25 grade of concrete.



FOUNDATION

- The typical project starts with layout and excavation.
- After the layout at site, the excavation of each block is done using mechanical excavators upto the required depth of foundation.
- Hard rock was encountered during the excavation which required extra efforts and time to reach the required depth

FOUNDATION

- Before laying the foundation, the plain cement concrete is laid.
- The foundation work started with the PCC of 100 mm thickness.

FOUNDATION

- After PCC, laying of reinforcement and shuttering for raft foundation is done.

FOUNDATION

- Concreting of raft footing with M25 concrete was done as per Structural Drawing

FOUNDATION

- Reinforcement and concreting of shear wall with M25 concrete upto plinth beam level

FOUNDATION

- Plinth beam is constructed above the shear wall.

FOUNDATION

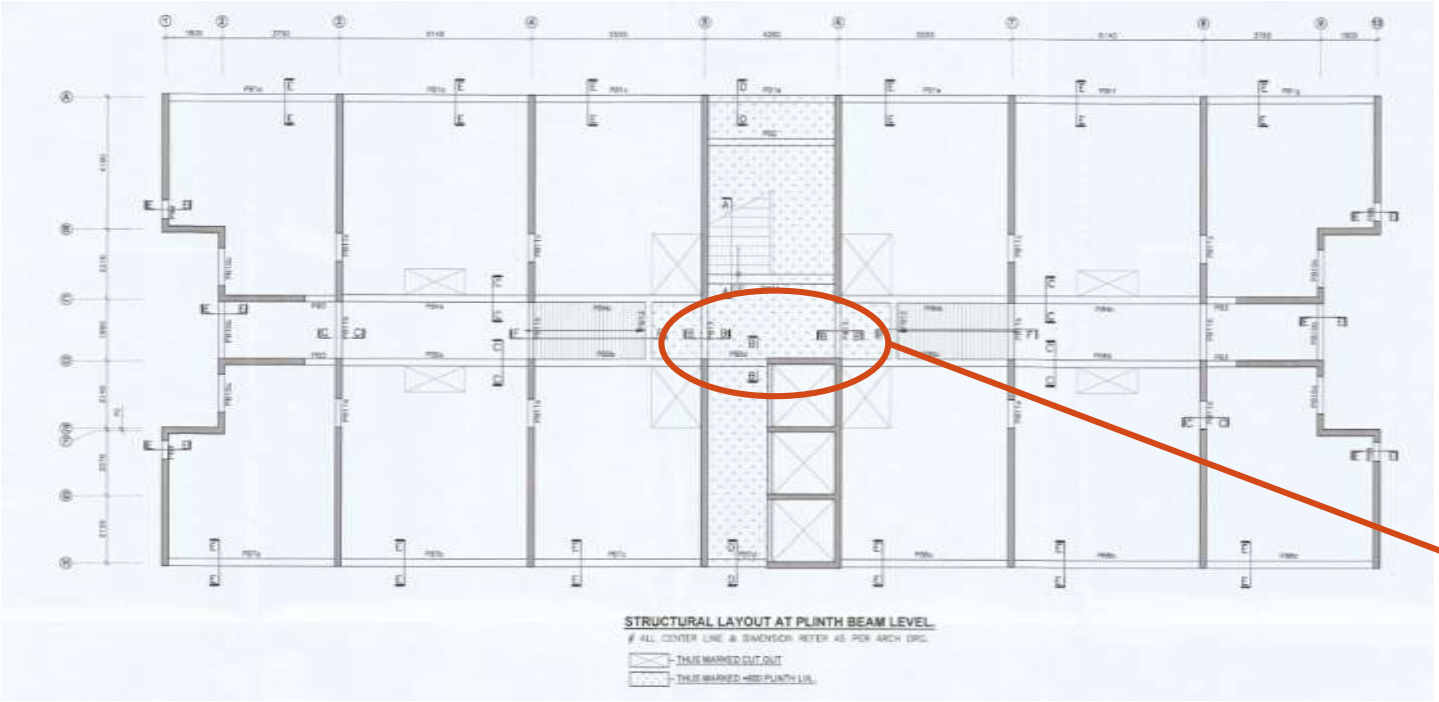
- Plinth beam is constructed above the shear wall.

FOUNDATION

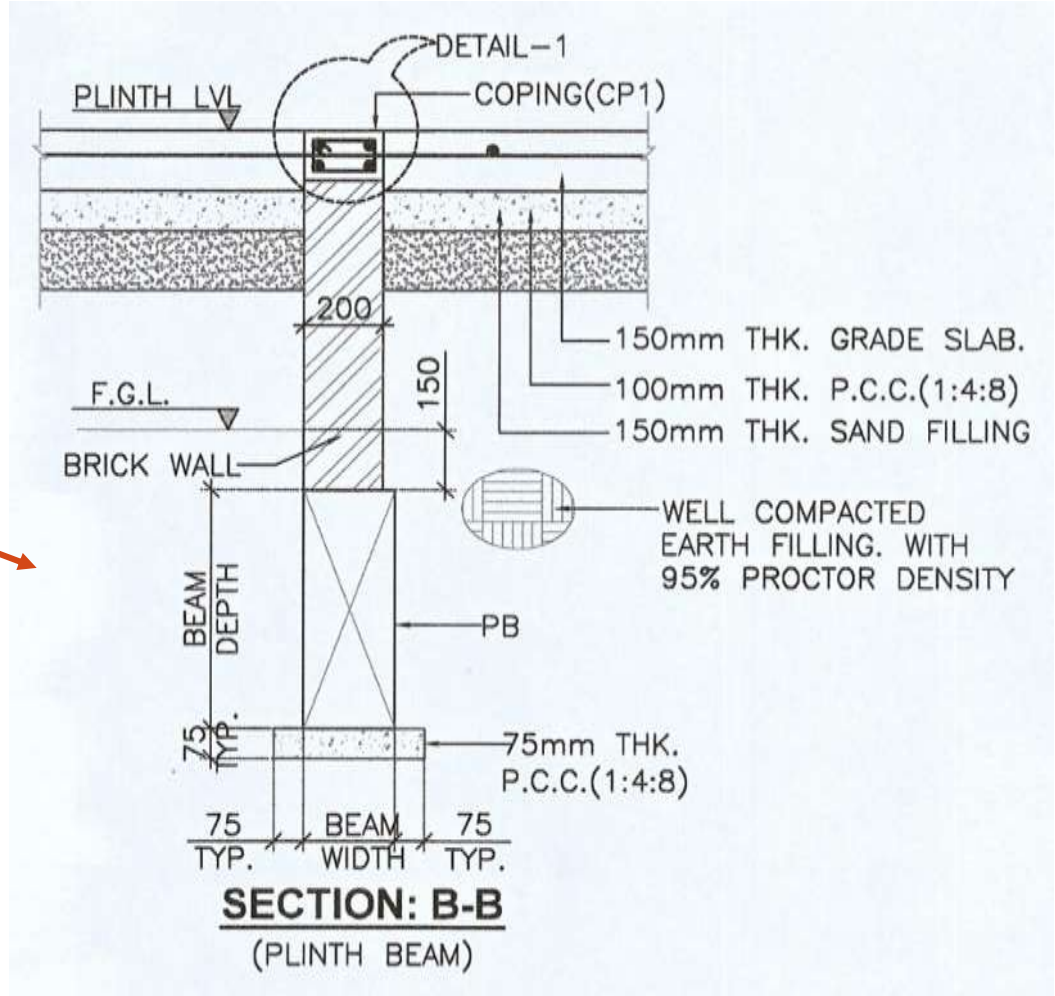
- Backfilling of foundation after completion of shear wall up to plinth beam.

STRUCTURAL SYSTEM

Structural Layout at Plinth Beam Level

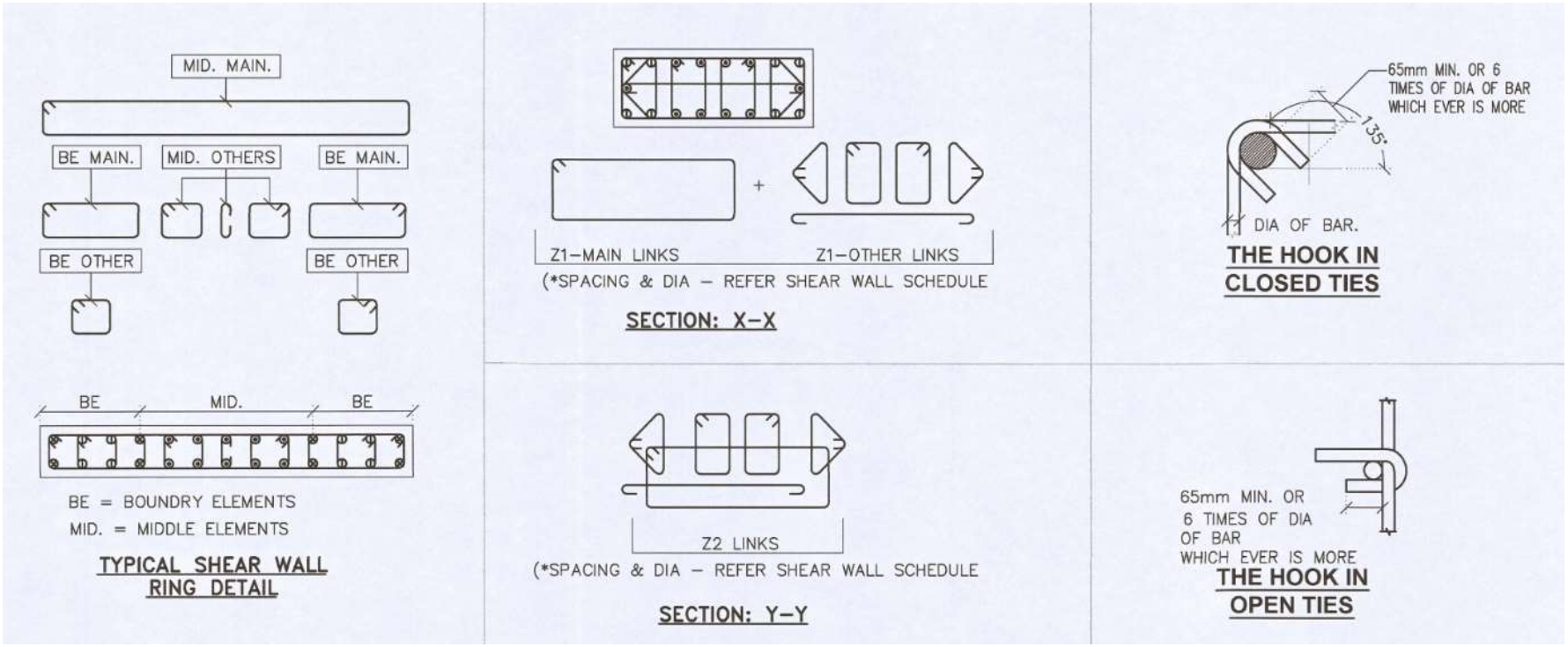


SCHEDULE OF BEAM SIZE		
SR.NO.	BEAM SIZE	BEAM NUMBER
1	230 X 600	PB1,PB2,PB4,PB5,
		PB6,PB7,PB8,PB12.
2	200 X 600	PB3,PB9,PB10,PB11,PB13.
3	300 X 600	PB14.

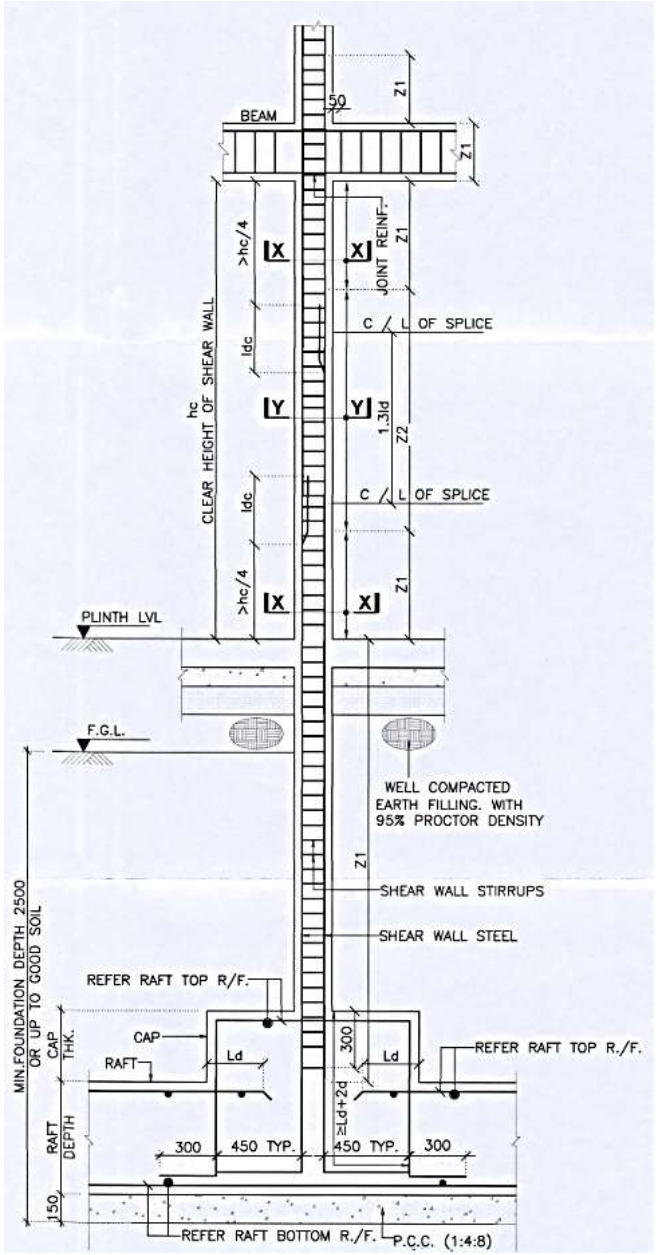


STRUCTURAL SYSTEM

Typical details of Shear Wall



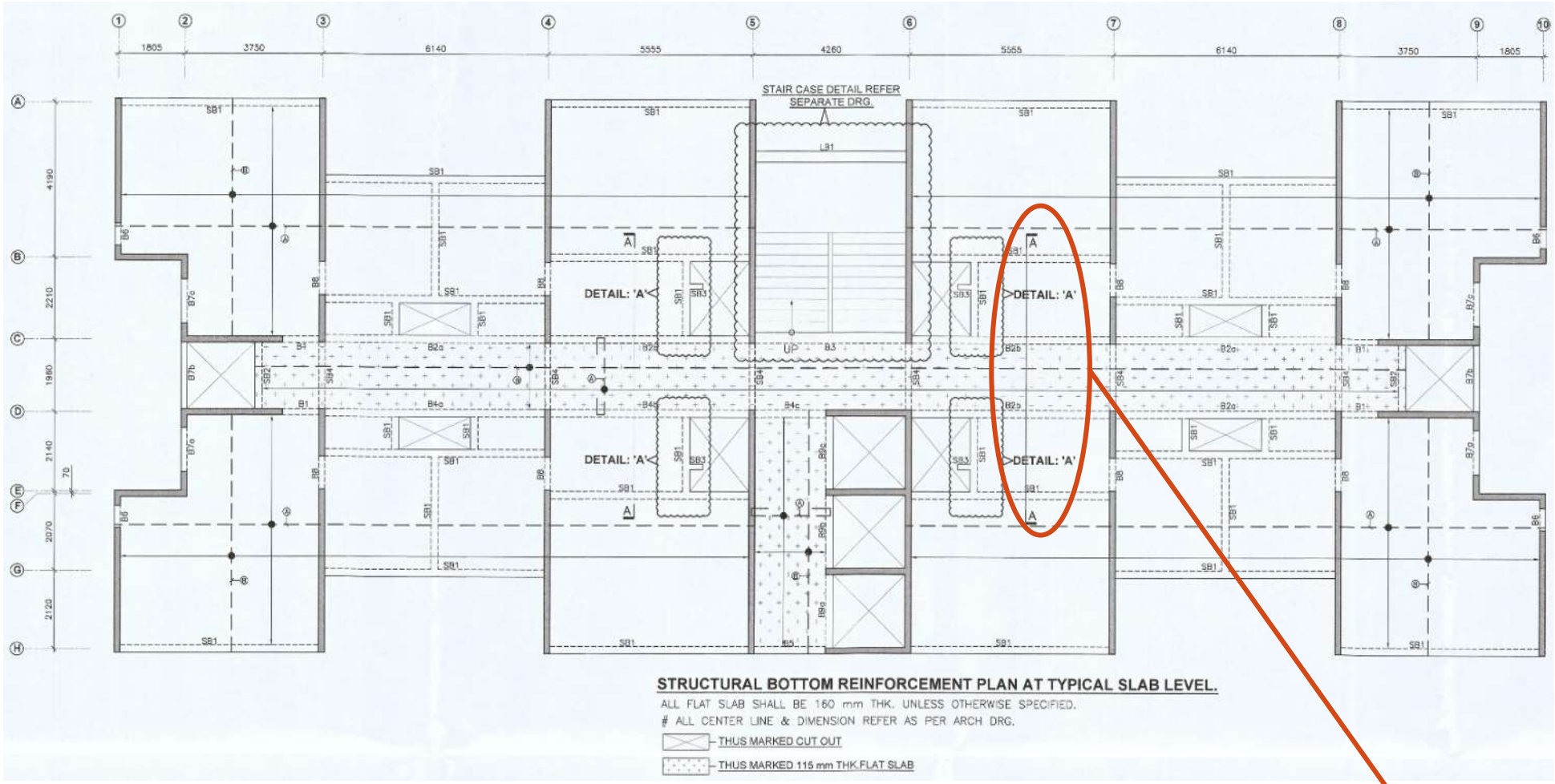
db – DIAMETER OF THE BAR
ldc – DEVELOPMENT LENGTH
hc – CLEAR HEIGHT OF SHEAR WALL



STRUCTURAL SYSTEM

Typical Reinforcement Details of Shear Wall

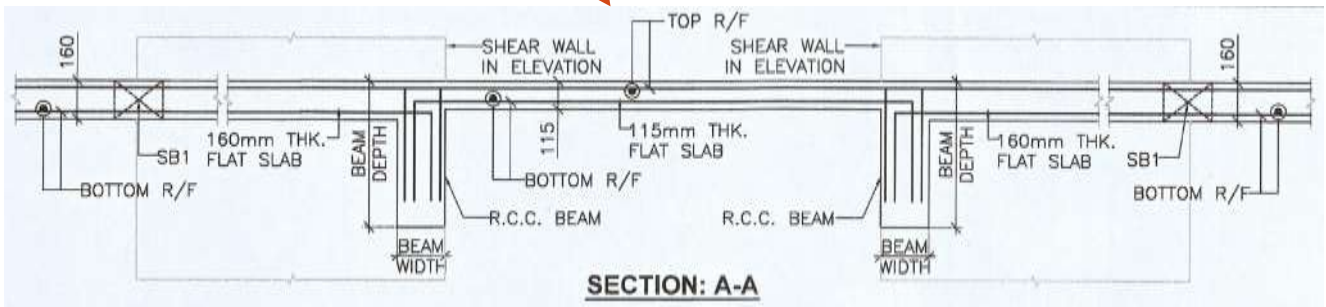
STRUCTURAL SYSTEM



SCHEDULE OF BEAM SIZE		
SR.NO.	BEAM SIZE	BEAM NUMBER
1	160 X 600	B1.
2	200 X 600	B2,B4,B5,B9.
3	300 X 600	B3,LB1.
4	160 X AS/LS	B6,B7,B8.

SCHEDULE OF FLAT SLAB REINFORCEMENT	
SYMBOL	BOTTOM STEEL
A	T10–200 c/c THRU AT BOTTOM
B	T8–200 c/c THRU AT BOTTOM

SCHEDULE OF SLAB REINFORCEMENT	
SYMBOL	TOP STEEL
D	T8–400 c/c EXTRA AT TOP
E	T16–200 c/c EXTRA AT TOP
F	T20–200 c/c EXTRA AT TOP
G	T8–200 c/c EXTRA AT TOP
H	T12–200 c/c EXTRA AT TOP



Structural Reinforcement Plan at Typical Slab level

STRUCTURAL SYSTEM

Typical Reinforcement at Slab level

STRUCTURAL SYSTEM

Concreting of Slab

STRUCTURAL SYSTEM

Shear Wall after removal of Tunnelform

STRUCTURAL SYSTEM

Shear Wall and Slab after removal of Tunnelform

AAC BLOCK MASONRY

Autoclaved Aerated Concrete (AAC) Blocks for Wall

- Autoclaved Aerated Concrete (AAC) is a lightweight, precast, foam concrete building material suitable for producing concrete masonry unit like blocks. Composed of sand, calcined gypsum, lime, cement, water and aluminum powder, AAC products are cured under heat and pressure in an autoclave.
- After construction of frame with precast beam column and slab, internal walls are constructed using Autoclaved aerated concrete (AAC) blocks having density 451-550 kg/m^3 as per IS 2185 (Part-3).

MEP

In Shear walls, the plumbing and electrical services are incorporated before casting.

In AAC Block walls, the plumbing and electrical services are incorporated as done in conventional method of construction i.e. chasing and filling

FINISHING ITEMS

- The finishing items include pressed steel door frame with flush shutters and PVC doors in toilets.
- uPVC frame with glazed panel and wire mesh shutter are used in windows.
- Vitrified tiles are used in flooring in rooms and kitchen.
- Anti-skid ceramic tiles are used in bath & WC.
- Kota stone flooring is used in common areas & Staircase steps.

INFRASTRUCTURE ITEMS

- The external infrastructure includes
- Laying of Sewerage Pipe Line,
- RCC storm water drain,
- Provisions for Fire Fighting
- Bituminous Internal Road & Paver blocks for Pathway,
- Providing Lifts in building blocks,
- Landscaping of site,
- Street light with LED lights,
- Solar Street Light System,
- Sewerage Treatment Plant (STP),
- External Electrification,
- Water Supply System including underground water reservoir,
- Compound wall with Boundary Gates,
- Horticulture facilities,
- Rain Water Harvesting,
- Solid Waste Management.

Present Stage of Work (As on March 10, 2022)

Activities		Progress
Foundation work	:	Completed in all 11 blocks.
Superstructure work	:	8 Blocks completed (Block no.13,47,8,9,10 & 11) Block No. 2 – Ground+3 work is in progress Block No. 5- Ground +3 work is in progress
Sample Unit	:	Completed
Masonry work	:	Completed – 6 blocks In progress – 4 blocks
Internal Building work	:	Internal plaster is completed in 6 blocks. Kitchen slab, tile work and plumbing are in progress. Installation of lifts is also in progress.
Internal (electrical work)	:	In progress – 8 blocks
Social & Physical Infrastructure works	:	After completion of Structure work, the Internal finishing is in progress in Anganwadi cum Shopping Complex and community centre both.
External Infrastructure	:	Infrastructure works including Sewer line, storm water drains, water supply works, boundary wall, etc. are in progress.

Towers in Progress Photographs

Towers in Progress Photographs

Onsite Photographs

Tower 1

Tower 2

Onsite Photographs

Tower 3

Tower 4

Onsite Photographs

Tower 5

Tower 6

Onsite Photographs

Tower 7

Tower 8

Onsite Photographs

Tower 9

Tower 10

Onsite Photographs

Tower 11

One completed building with the technology is shown here

Chennai, India

Live status of LHP site can be accessed at

https://ghtc-india.gov.in

Further learning on the project will be covered in due course.

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