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 CHENNAI

GHTC-India Category:
Precast Concrete Construction System – Precast components assembled at site

Technology:
Industrialized 3-S system using RCC Precast Columns, Beams, Semi-Precast Solid Slab with AAC Block masonry

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 Six Light House Projects (LHPs)

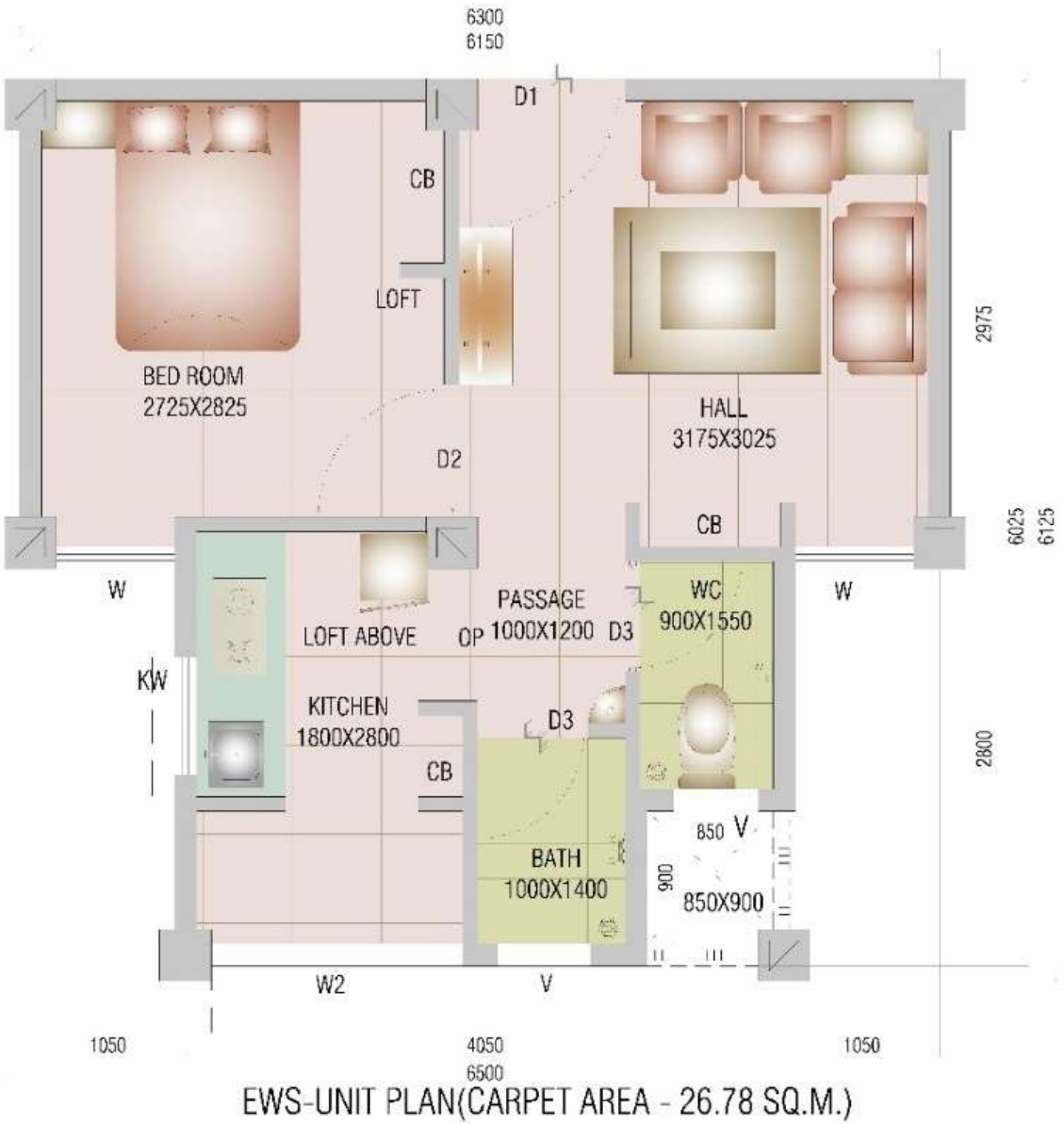
LHP Location			Chennai (Tamil Nadu)	Rajkot (Gujarat)	Indore (Madhya Pradesh)	Ranchi (Jharkhand)	Agartala (Tripura)	Lucknow (Uttar Pradesh)
Sl. No	**Particulars**	**Units**						
1	Name of Technology	Name	Precast Concrete Construction System-Precast Components	Monolithic Concrete Construction using Tunnel 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	G+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:
  - 1152 houses will be constructed in G+5 configuration.
  - The total plot area is around 30,000 Sqm and carpet area of each house is approximately 27 Sqm.
  - There are 12 residential blocks.
  - The project also includes social infrastructure such as Aganwadi, Shops, Milk Booth, Library and Ration Shop.

Typical floor plan

At each floor there are 16 dwelling units

Typical Dwelling Unit Plan



EWS-UNIT PLAN(CARPET AREA - 26.78 SQ.M.)

- Each dwelling unit comprises of one hall, one Bedroom, Kitchen, WC and Bath.
- The carpet area of each unit is 26.78 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
  - Fire fighting services as per NBC norms

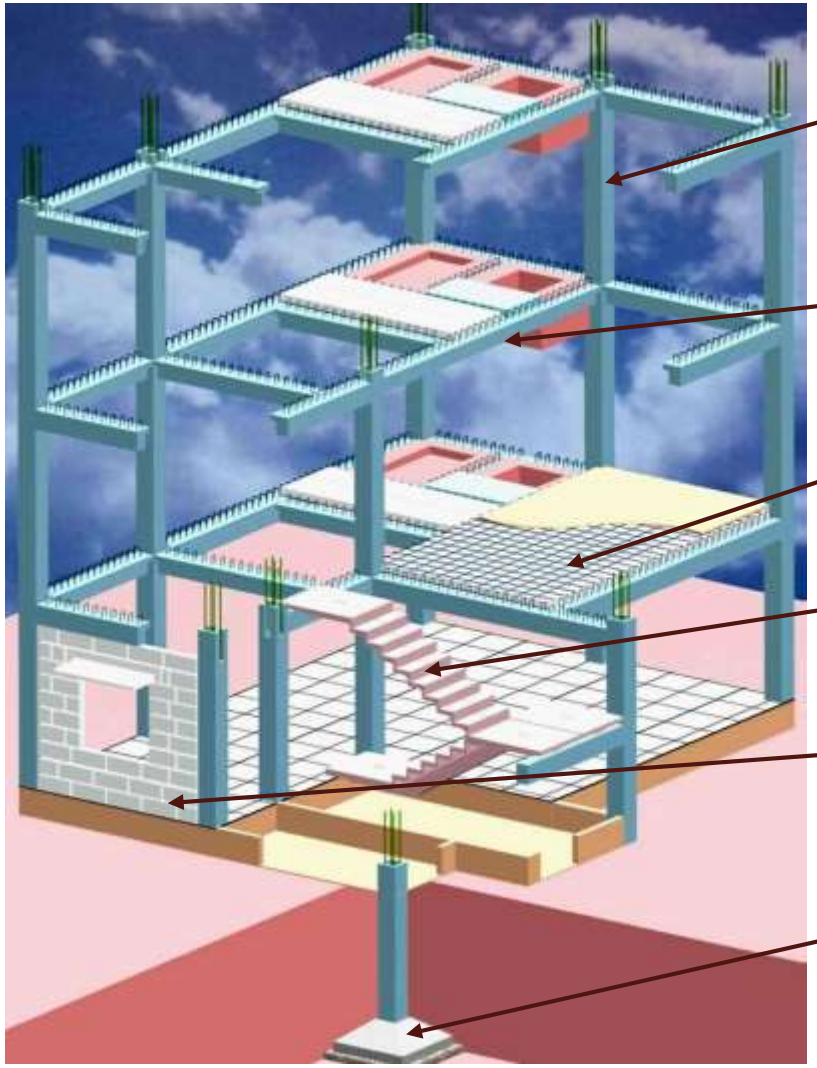
Prevalent Construction Systems

Technology being Used

Load bearing Structure

RCC Framed Structure

Precast Concrete Construction System-Precast Components Assembled at Site



Precast RCC Hollow Columns – core filled in-situ with self-compacting concrete.

Partially Precast RCC Beam – top part being cast with column and slab for monolithicity

Partially Precast slab with reinforced concrete screed

Precast staircase

Autoclaved Aerated Blocks (AAC) masonry for walls. This can also be replaced with precast RCC shear wall

Conventional RCC footing with precast stem column upto plinth level

Structural Elements

- Foundation
- Structural System
- Floor/ Roof Slab
- AAC Block Masonry

Foundation

- As per geo-technical investigations, bearing capacity, soil strata, water table, etc.
- Typical isolated footing along with some combined footings of varying sizes depending on the load.

Foundation

- Precast RCC Stem columns upto plinth level and connected with precast plinth beam.
- The stem columns have notches in which precast beams are placed.

Structural System

- Industrialized 3-S (Strength, Safety, Speed) prefab method of construction is based on mass produced precast structural components (columns, beams, shear walls, slabs, stairs etc.) onsite or offsite.
- The methodology of construction includes assembly of precast RCC hollow columns, beams and partially precast RCC solid slabs at site. The slabs shall have in-situ reinforced concrete laid on top after erection thereby making them monolithic.
- The filler walls are of AAC blocks.

Floor/ Roof Slab

- The partially precast slab, precast beam and column are assembled together and wet jointed through screed of reinforced concrete laid on top making it monolithic structure.

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

- Quality of construction is enhanced significantly due to pre-casting of components by using sophisticated moulds and machineries in factory like environment, assured curing, assured specified cover to reinforcement, proper compaction of concrete results in to dense and impermeable concrete etc. Thus lesser maintenance cost during lifetime of project.
- Inbuilt eco-friendly method of construction in terms of more off-site works in controlled factory like environment results in to significant reduction in wastage of water, natural resources, air pollution and noise pollution.
- Safety of workforce achieved automatically as most of the works are carried out at ground floor in factory like environment, which ultimately enhances the work efficiency and quality.
- Wooden shuttering material is completely avoided and wastage of other construction materials reduced significantly; which results in to conservation of scarce natural resources like soil, sand, aggregate, wood etc.
- Advance procurement of major construction materials, advance pre-casting of structural components and assured completion of work within stipulated completion period will save cost towards escalation & early returns on investments, thus Substantial cost benefit to the client.

Limitations

- Capital intensive since establishment of precast factory is required.
- Minimum number of dwelling units required to achieve cost economy.
- Skilled manpower is required for production and erection of precast components.

Mass scale field implementation of new technology

Light House Project at Chennai

on

Design & Build Basis

Agency & Technology Provider:

M/s B. G. Shirke Construction Technology Pvt. Ltd., Pune

Design Philosophy

- The aim of design is to achieve an acceptable probability that structures being designed will perform satisfactorily during their intended life as per the guidelines provided under IS 456.
- The limit state method of design is adopted. The design of various members is carried out in accordance with the provisions, laid down in IS 456, IS 16700 and IS 13920.
- To meet the durability & service ability requirements, various provisions as regards to maximum w/c ratio, minimum cement content, minimum percentage of steel, detailing of reinforcement, curtailment of reinforcement etc., as laid down in IS456 and other applicable national / international codes are complied with.
- The RC moment resisting frames are detailed as per '3-S' system and relevant applicable BIS/International standards' provisions to meet the design ductility level.

Design Basis

- Safe Bearing capacity: 25 T/m^2, depth of foundation varying from 2.5 to 3.5 m
- Shallow Foundation as per IS-1080-1985 and IS-1904:1986. Minimum M35 grade of concrete is proposed for RCC structural elements in sub-structure.
- Structural Frame
  - Composite precast RCC solid slabs, precast RCC solid beams (T shape / L shape / rectangular) and precast dense concrete reinforced hollow core columns shells (core of which is concreted after erection using self-compacting concrete with the provision for suitable reinforcement for effective jointing), are manufactured in special steel moulds at site factory under stringent quality control and ISO / OSHAS quality norms.
  - The jointing of various precast RCC elements is proposed as 'Wet Jointing' i.e. concreting with self-compacting concrete for achieving required rigid joints.
- Wind speed: High damage risk zone with basic wind speed (V_b=50m/sec) as per IS875(Part-3)
- Design wind speed:

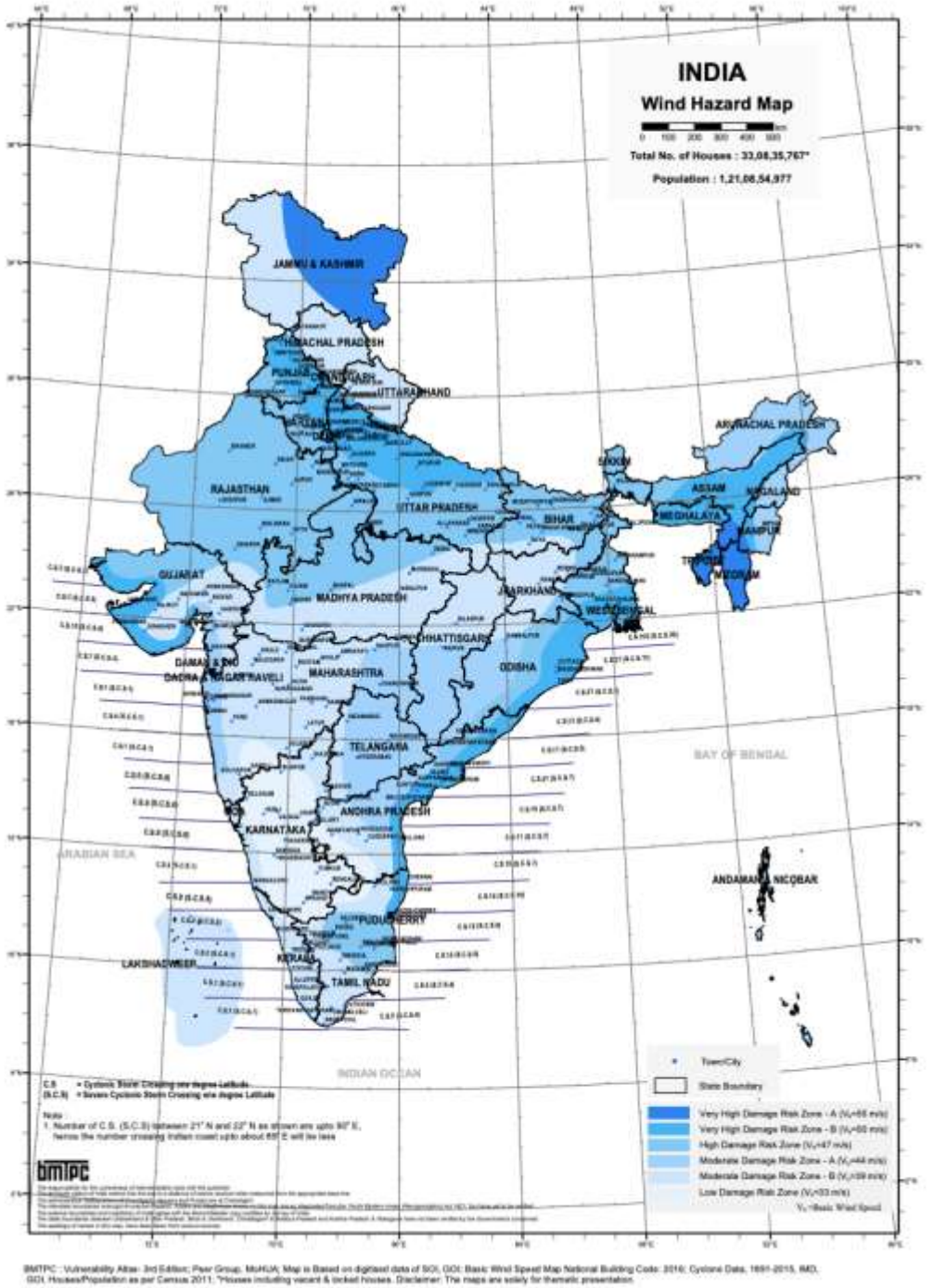
  $V_z=V_b.k_1.k_2.k_3.k_4$

  k_1 (Risk Coefficient)=1

  k_2 (Size factor)=as per height

  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=5 (Table-9 iv of IS: 1893 (Part-1):2016), Z=0.16, I=1.2, R=5, Damping Ratio=5%.
  - Design Horizontal Seismic Coefficient (A_h)

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

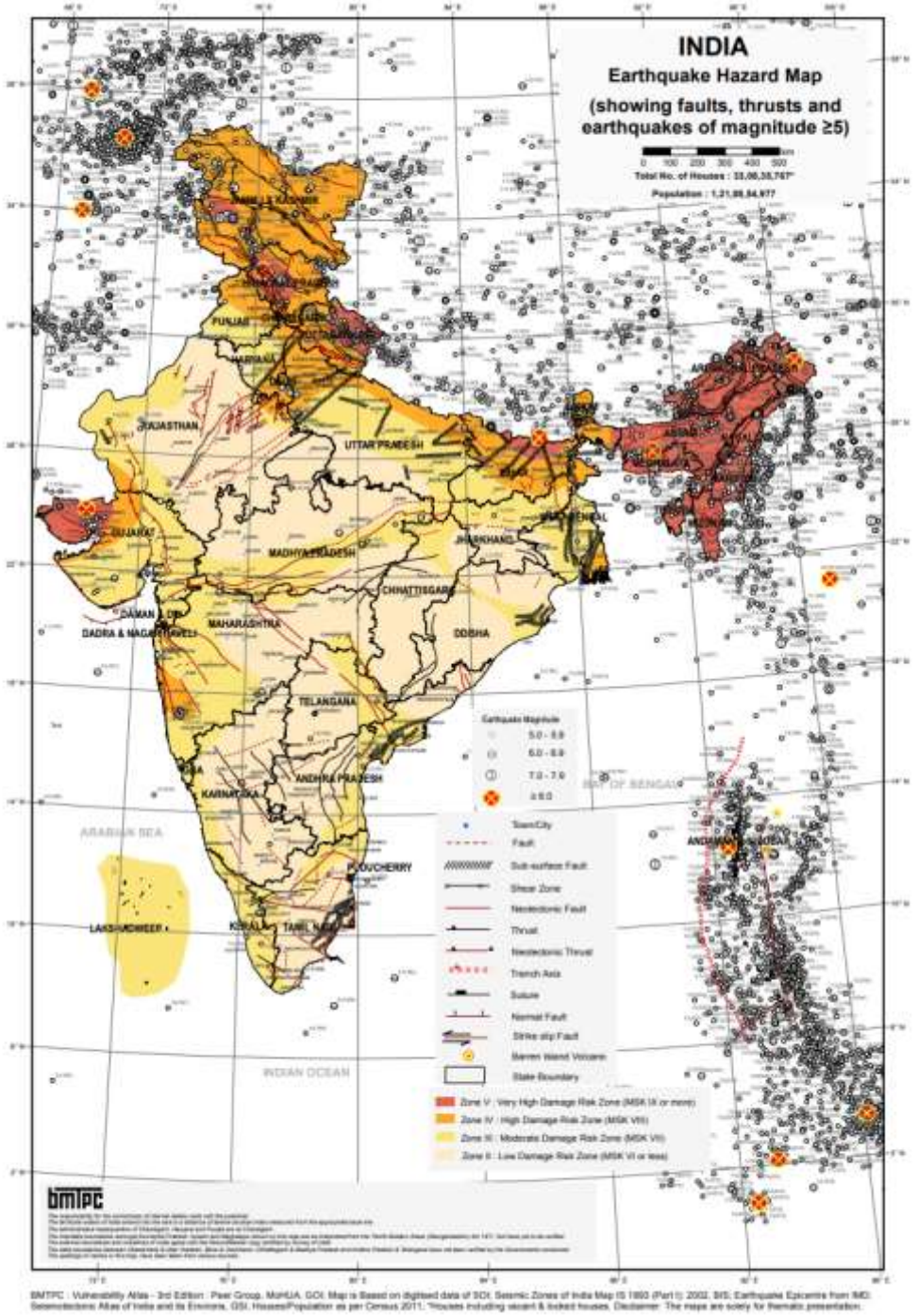
S_a/g is design acceleration coefficient for different soil types corresponding to natural period (T) of building

  - 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.
  - Moment resisting forces are designed to resist the total design force in proportion to their lateral stiffness.
- Precast slabs have rebar lattice girders projecting above precast surface. Whenever, two or more panels are forming one slab of a room, such panels have in-situ topping of reinforced concrete laid over slab after erection and the thickness of such screed is as recommended in IS: 1893 / IS: 13920 there by making them ‘‘composite’’. Staircase is also of precast RCC.
- Reinforced cement concrete used for floor elements are minimum M35 Grade and minimum M40 Grade for vertical load bearing elements.
- Thermal comfort levels are ensured as per IS: 3792 by selecting walling material having thermal transmittance well within 2.56 W/m'K.

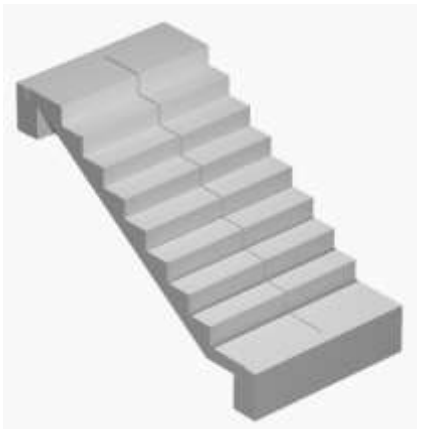


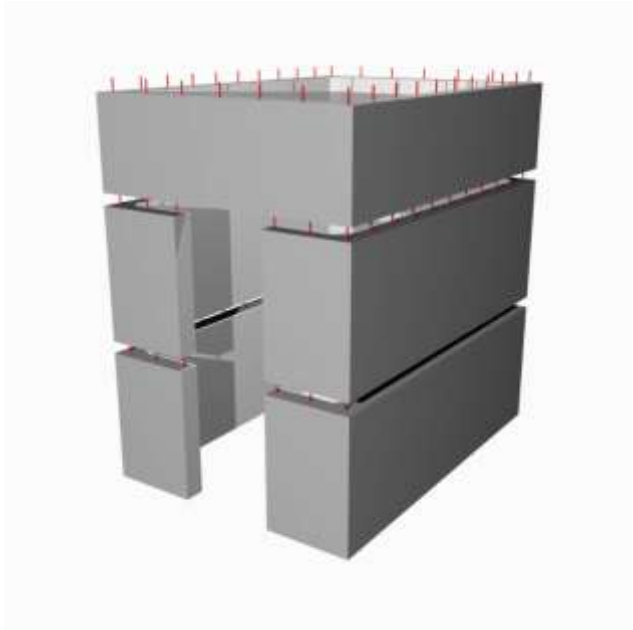
STRUCTURAL ANALYSIS & DESIGN

- 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 M40 (IIT Madras)

1. Mix Proportions:

C	:	W	:	F.A	:	CA*
1	:	0.37	:	1.787	:	2.225

2. Cement content **(84.26%)** = **375 kg/m^3**
3. G.G.B.S content (JSW) **(15.73%)** = **70 kg/m^3**
4. Water content = **164.65 lit**
5. Admixture (Fosroc Auracast 270M) = **3.11 lit**
6. Fine aggregate content (M-sand) = **795 kg/m^3**
7. Coarse aggregate content = **990 kg/m^3**
   (Quantity of 12.5 mm size aggregate = **594 kg/m^3**
   Quantity of 20 mm size aggregate = **396 kg/m^3)**
8. Compressive Strength of concrete obtained at
   a. 7 days = **46.76 N/mm^2**
9. Slump = **70 mm**

BATCHING PLANT

Casting of Precast Elements

CASTING OF PRECAST ELEMENTS

- Let's take you to a tour of typical casting yard which is setup at site for production of beam columns and slabs including other components like staircase, sunshades and lintels etc.

CASTING OF PRECAST ELEMENTS

- Casting of partially precast slabs

CASTING OF PRECAST ELEMENTS

Precast Beam

Precast slab

Precast Column

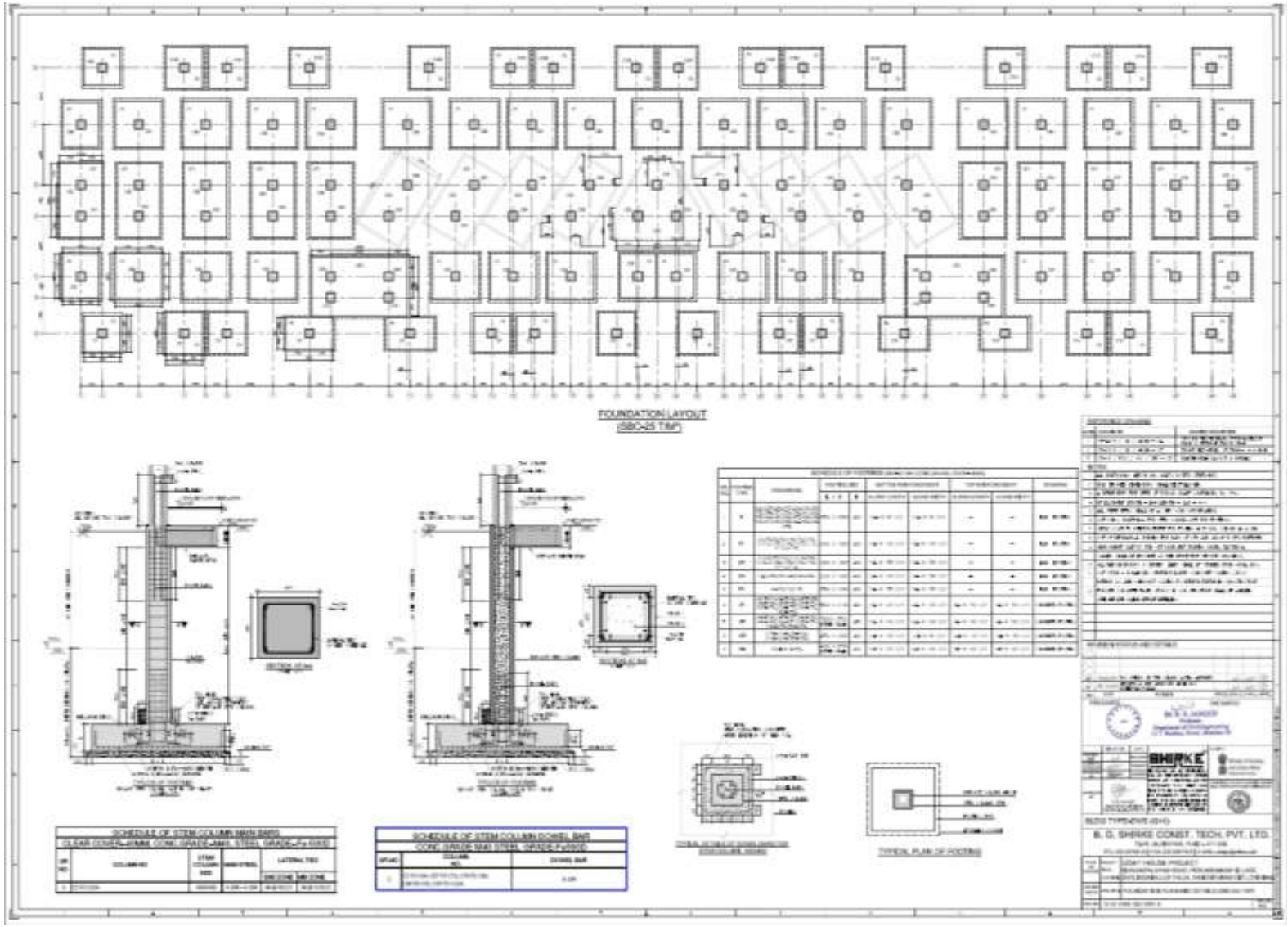
Precast Stairs

Construction Sequence

- Sub-Structure: Foundation
- Super-structure: Structural System
  Floors/ Slab
  AAC Block Masonry for walls
- MEP: Plumbing & Electrical
- Finishing

FOUNDATION

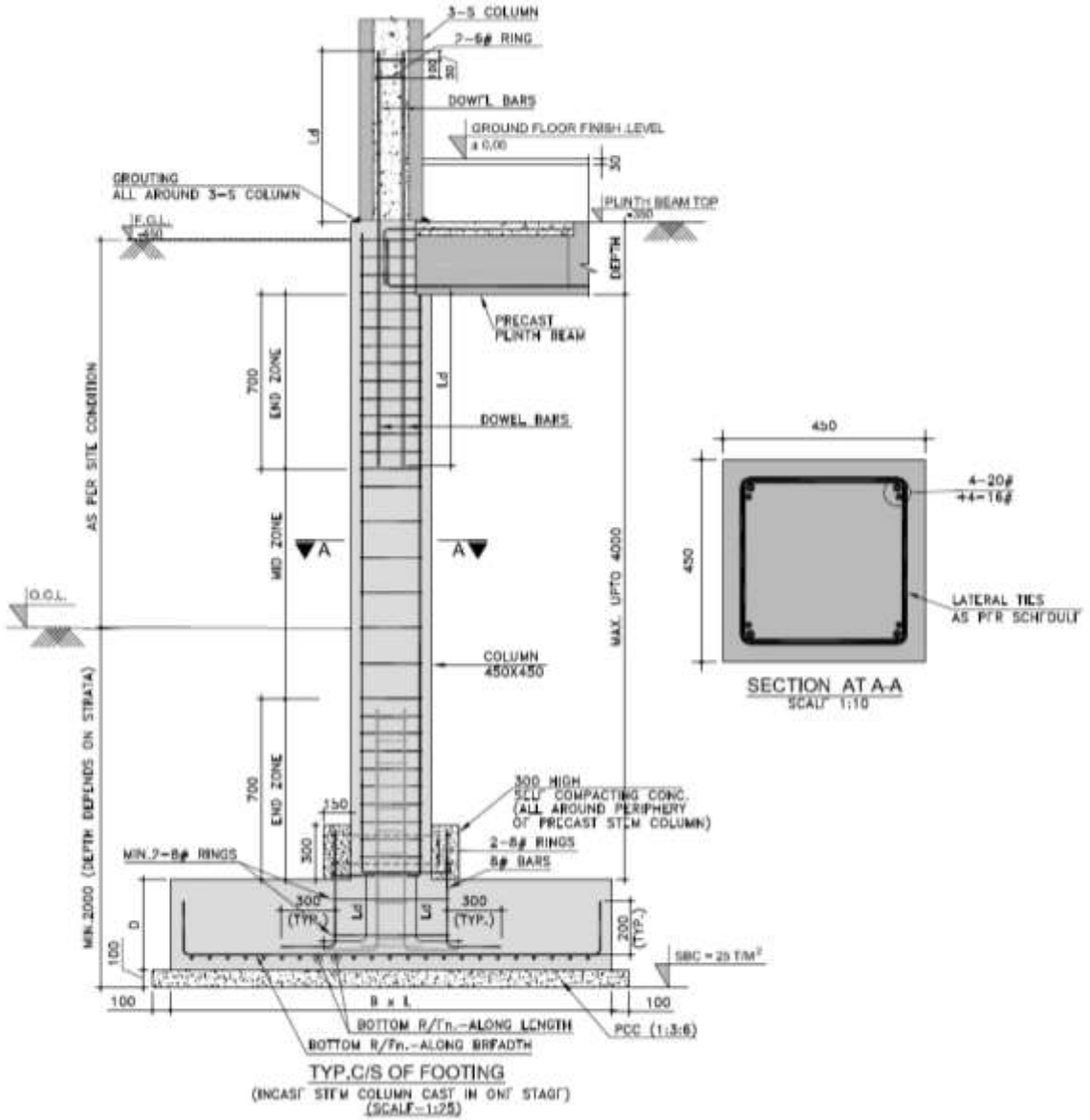
Structural Drawings



FOUNDATION

Concrete & Reinforcement Steel Specifications

- Isolated footing / combined footing have been used of varying size depending on the load.
- The footing is designed for SBC of 25 T/m^2 as calculated in soil investigation report.
- After leveling of the ground 100 mm thick PCC is placed and depth of the footing is 450mm.
- M35 grade of concrete has been used with cover of 50mm. reinforcement has been placed as per the drawings.
- Dowels are left in place to place the precast stem column self compacting concrete is placed around the stem column for its alignment.
- Anti corrosive coating is applied on reinforcement in such sub-structure due high chloride content in the sub soil.
- Exposed surfaces of RCC in sub-structure have been applied with bitumen paint before refilling.



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.

FOUNDATION

- In Chennai project, ground water was encountered during the excavation which was continuously drained during the foundation work.

FOUNDATION

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

FOUNDATION

Plate Load Test

- Safe bearing capacity of 25t/m^2 has been considered for design of isolated and combined footing based on the soil investigation done at site by the construction agency.
- The construction agency also conducted plate load test to verify the SBC at representative locations.
- The plate load test was conducted at a depth of 3.0 m from ground level.
- Plate used for test was 0.3mX0.3m having area of 0.09sqm.Capacity of the jack 200KN.
- Least count of settlement gauge was 0.01mm and hydraulic pressure gauge of 10 kg/sq.cm.
- Load increment was done for 24 hrs. Maximum load applied was 576KN. The gross settlement was 4.04mm which was well within the acceptable limit.

FOUNDATION

- After PCC, isolated and combined RCC footings of varying thickness depending upon structural design with M35 concrete are placed.

FOUNDATION

- After PCC, isolated and combined RCC footings of varying thickness depending upon structural design with M35 concrete are placed.

FOOTING REINFORCEMENT

CASTING OF FOOTING

CASTING OF FOOTING

FOOTING COMPLETE

FOUNDATION

Stem Column

- Precast stem column are placed on the RCC footing.
- The size of the typical stem column is 450mmX450mm and its' height is upto the plinth beam. Main bars consist of 4No 20 dia and 4 no. 16 dia.
- The grade of concrete used is M40.
- Column core is formed by using EXPAMESH which acts as a sacrificial formwork to maintain the dimensional accuracy.
- Clear cover to reinforcement is kept at 40mm. OPC cement of grade 53 with C3A content (5% to 8%) has been used below ground level due to high chloride content in the soil as recommended in soil investigation report.
- Exposed surfaces of RCC in sub-structure have been applied with bitumen paint before refilling.

FOUNDATION

- Backfilling of foundation after completion of erection of stem column and plinth beam.

STEM COLUMN ERECTION

STEM COLUMN ERECTION

STEM COLUMN WORK IN PROGRESS

FOUNDATION

- After erection of these hollow core stem columns, precast plinth beam are integrated in the column notches.

Plinth Beam Erection work in progress

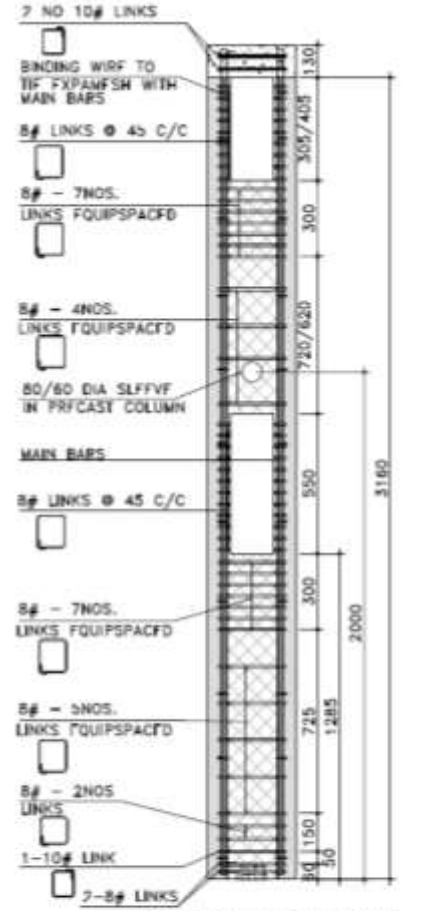
Backfilling work in progress

Backfilling works in progress

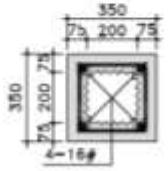
STRUCTURAL SYSTEM

Precast Column in Superstructure

- Hollow core precast columns are used which are filled with the self compacting concrete after placement of precast beams for monolithic joint.
- Typical size of the Precast column in ground floor and upper floors is 350mm by 350mm having varying height depending upon the architectural requirement.
- Grade of concrete used is M40 and clear cover to reinforcement is 40mm. Demoulding of side shutter is done after 12 hrs of concreting and 18 hrs for bottom shuttering.



SECTIONAL ELEVATION



C/S. SECTION OF COLUMN
(COLUMN SIZE = 350X350X3160)

STRUCTURAL SYSTEM

Precast Column in Superstructure

- Column core is formed by using EXPAMESH which acts as a sacrificial formwork to maintain the dimensional accuracy.
- A sleeve 60mm dia is created in the column at the time of casting to insert a steel rode with hook to lift the column.
- A mesh of mild steel is placed in the hollow core column which acts as sacrificial form work.

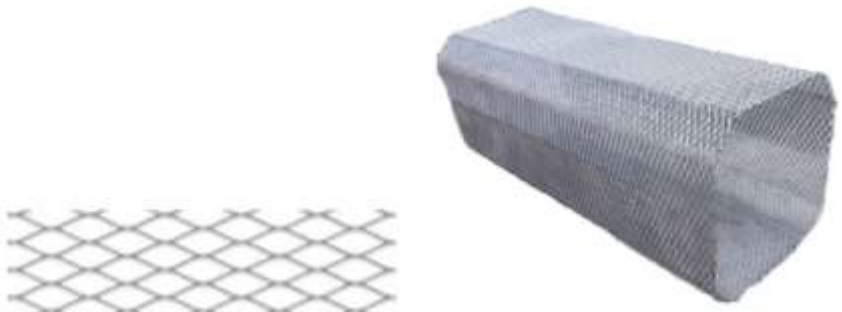
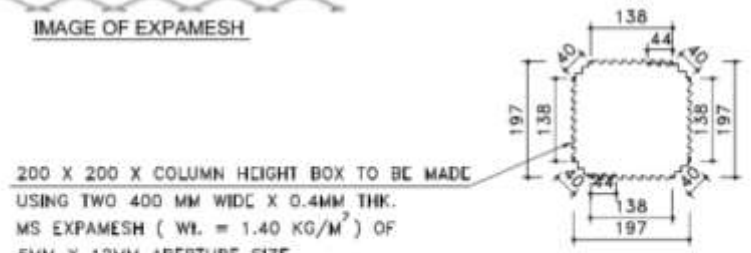
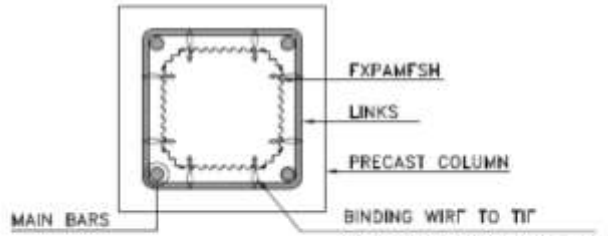


IMAGE OF EXPAMESH



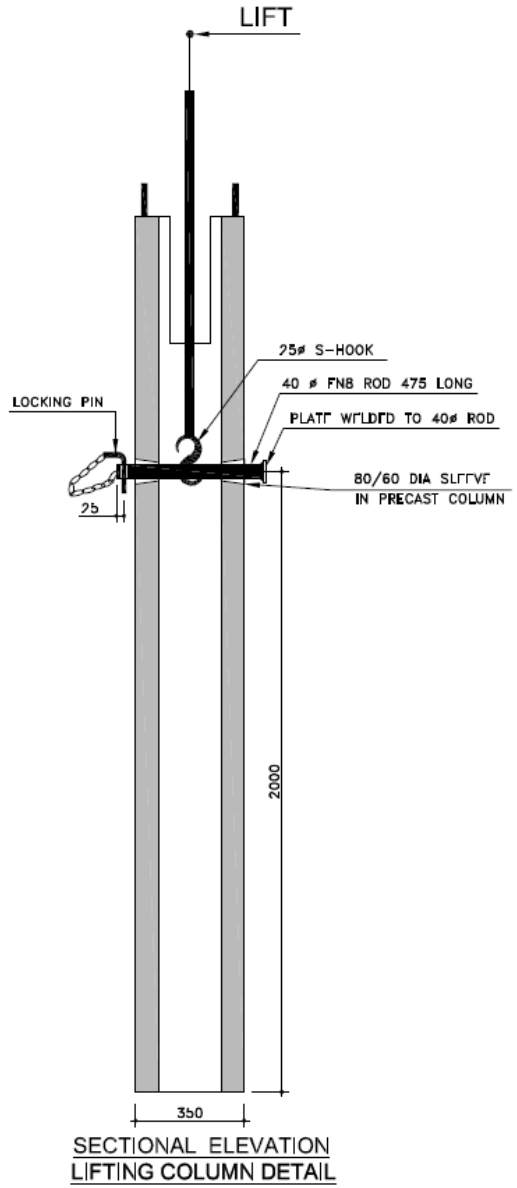
EXPAMESH DETAILS



DETAILS OF EXPAMESH

SCALE 1:10

COLUMN CORE FORMED USING EXPAMESH AS SACRIFICIAL FORMWORK



SECTIONAL ELEVATION
LIFTING COLUMN DETAIL

STRUCTURAL SYSTEM

Erected Precast columns with notches and dowels over plinth beam

STRUCTURAL SYSTEM

- Placement of ground floor beam on columns.

STRUCTURAL SYSTEM

Wet jointing of stem column with plinth beam

Grouting of beam – column joint

Beam – column - slab wet jointing

- All the connections and jointing of various structural components are accomplished through in-situ **self-compacting concrete/micro concrete/non shrink grout** as per structural design and codal provisions.

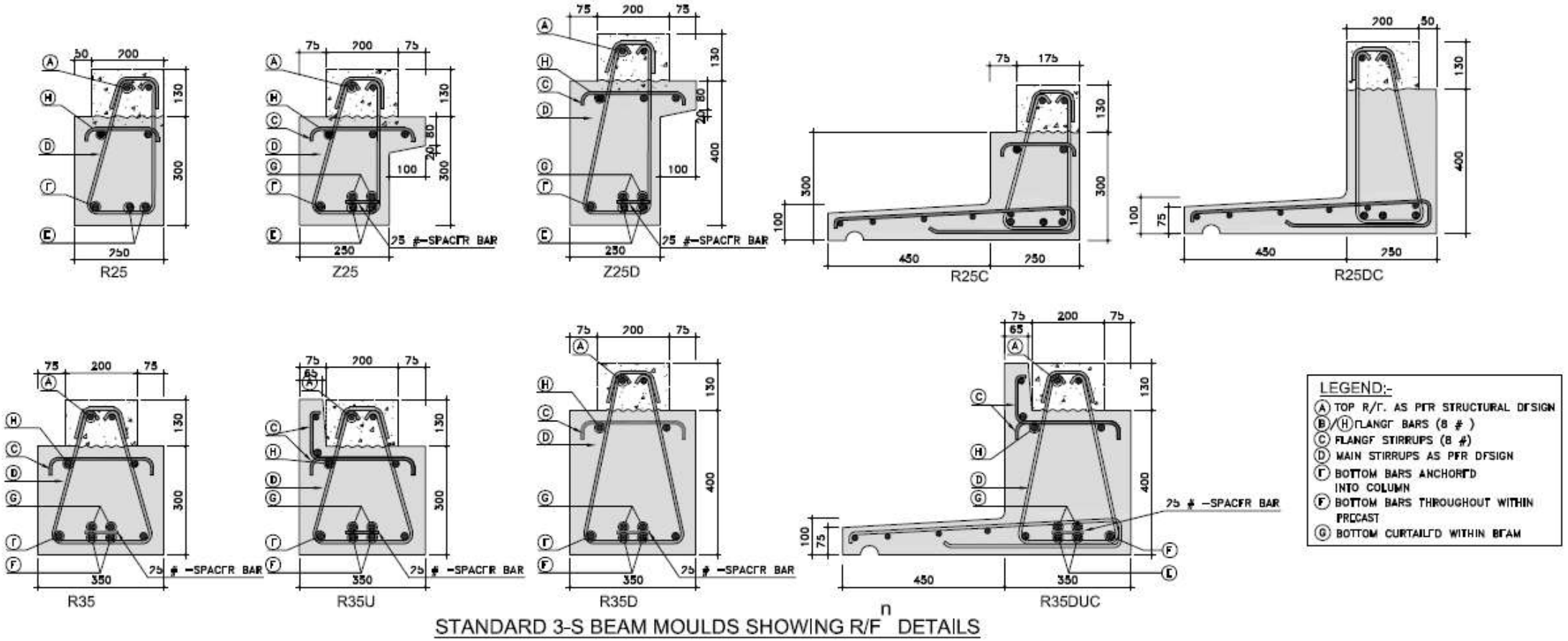
STRUCTURAL SYSTEM

- A typical beam column joint showing monolithic action and continuity thus ensuring better seismic resistance

Before Jointing

After Jointing

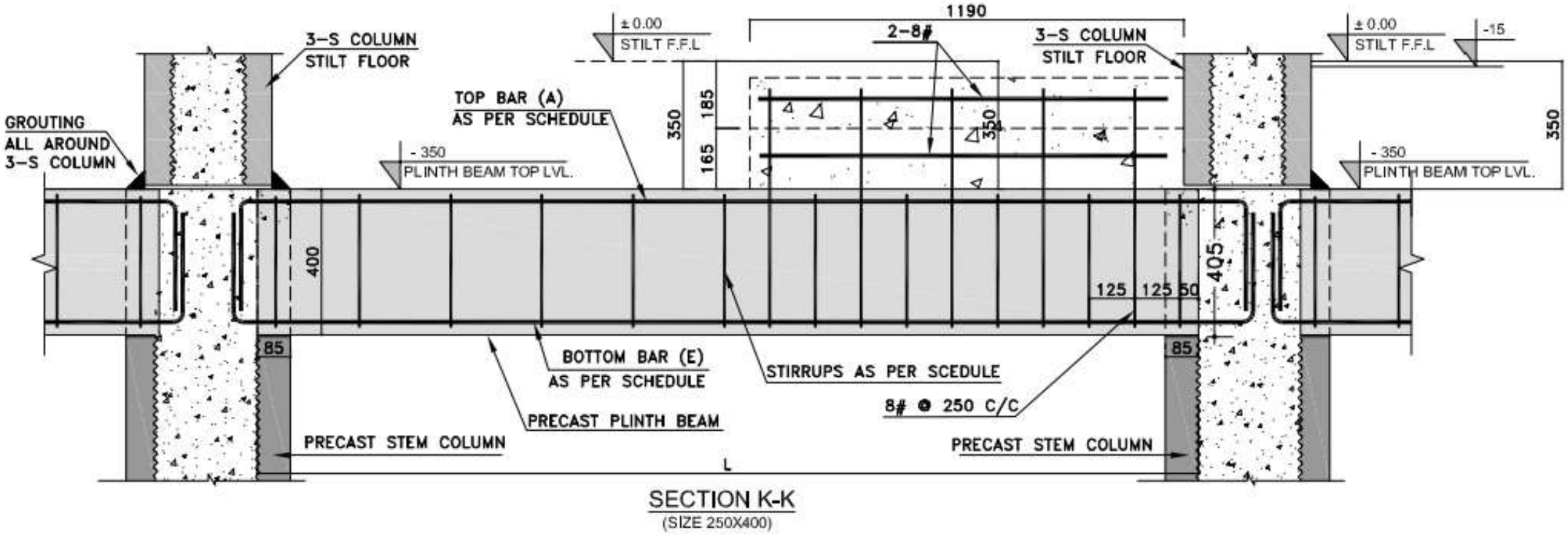
STRUCTURAL SYSTEM



STANDARD 3-S BEAM MOULDS SHOWING R/F DETAILS

Typical beam details

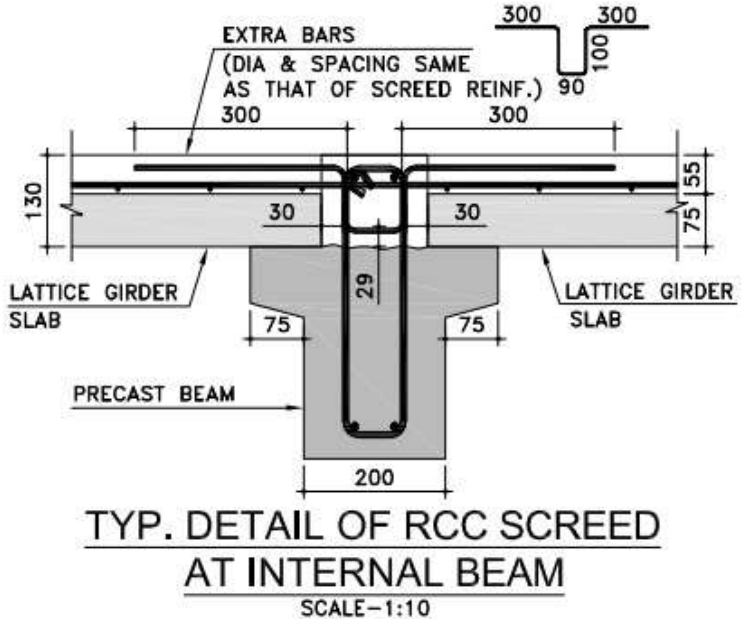
STRUCTURAL SYSTEM



SECTION K-K
(SIZE 250X400)

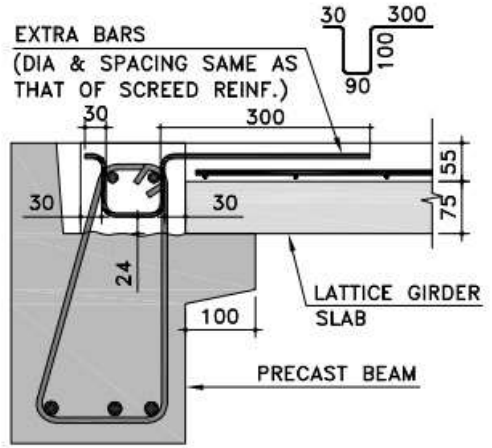
Typical Joint between Beam & Column

STRUCTURAL SYSTEM



TYP. DETAIL OF RCC SCREED AT INTERNAL BEAM

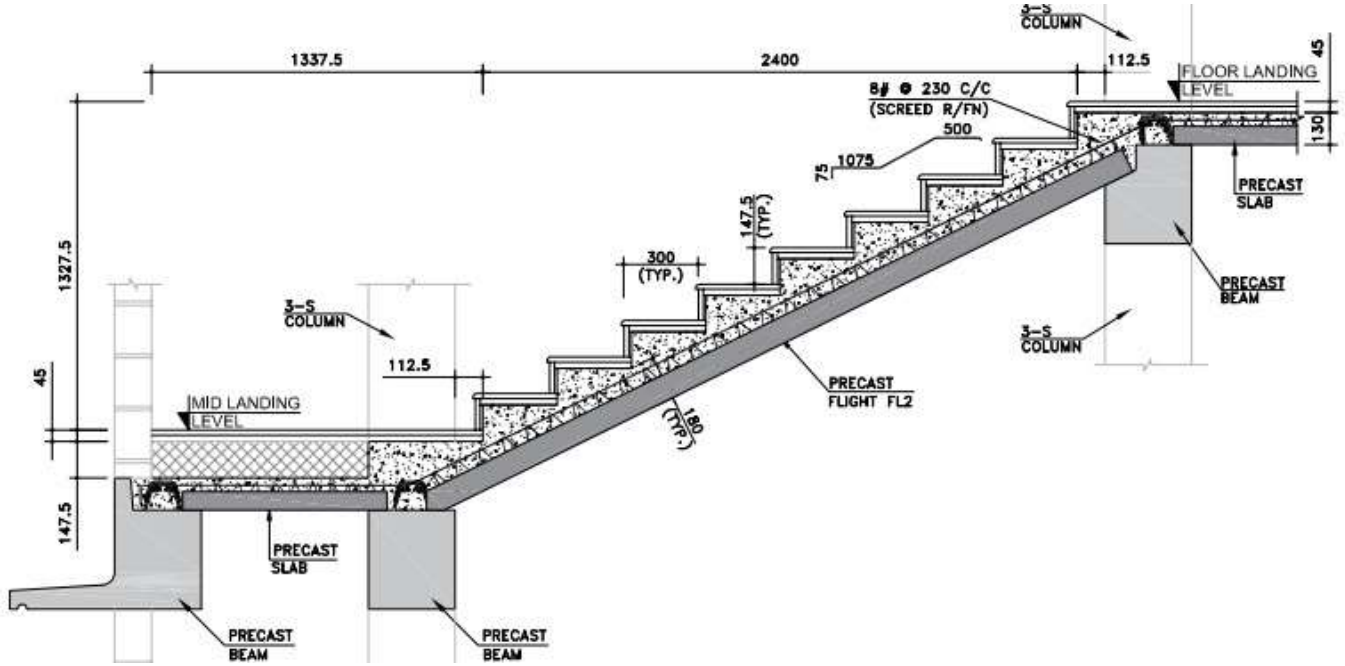
SCALE–1:10



TYP. DETAIL OF RCC SCREED AT PERIPHERAL BEAM

SCALE–1:10

Typical Joint between Beam & slab

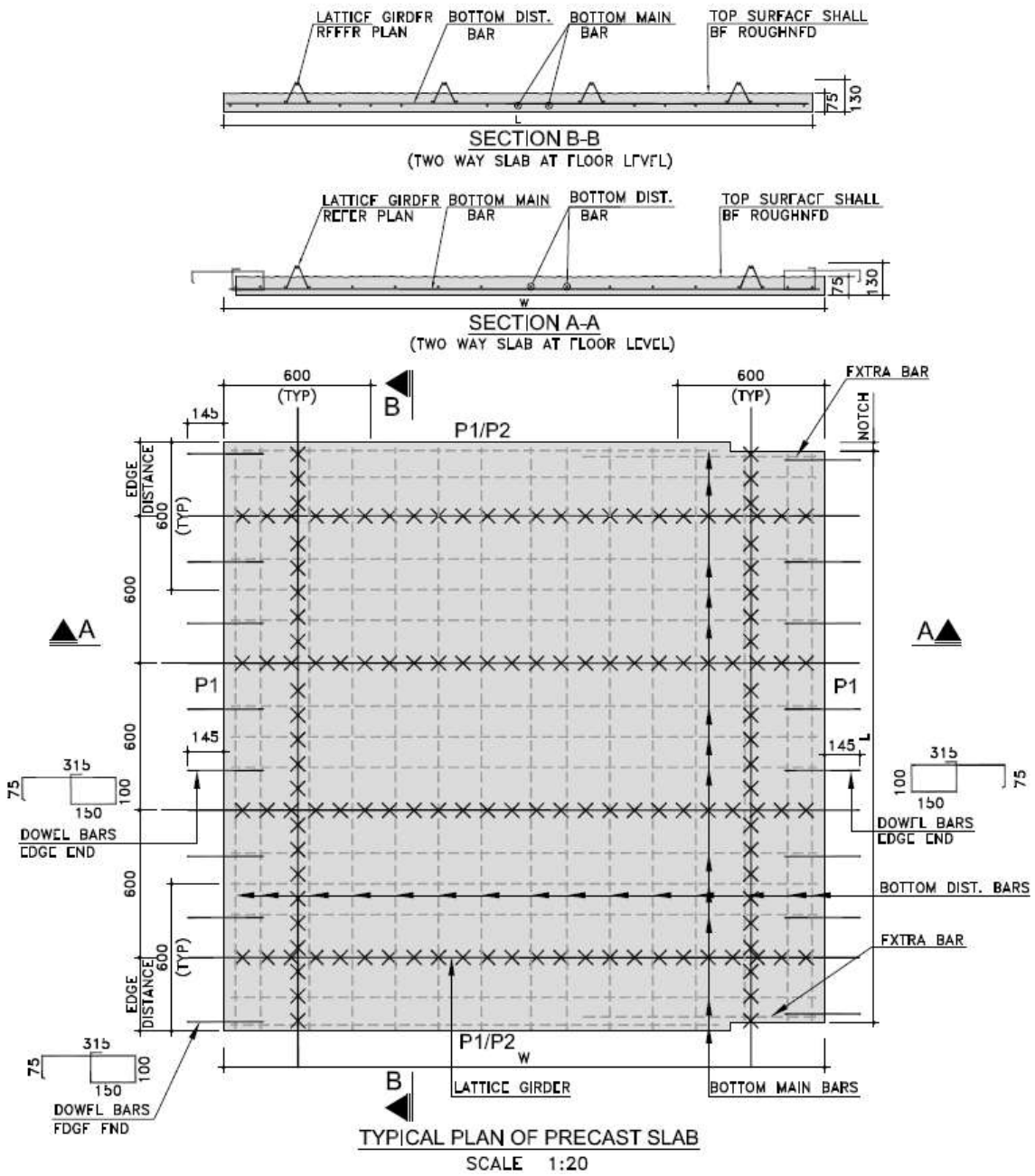


Typical Staircase connection detail

FLOORS/ SLAB

- After erection of beams and column, partially precast slabs are placed with required bearing on the beams.

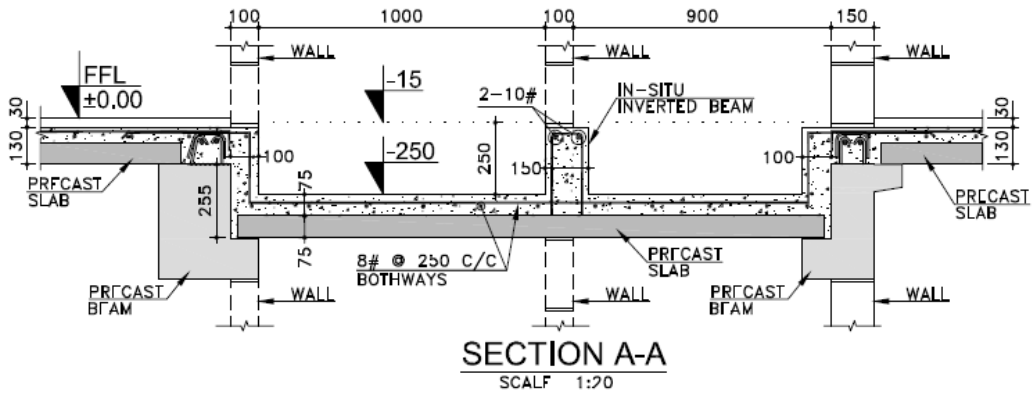
FLOORS/ SLAB



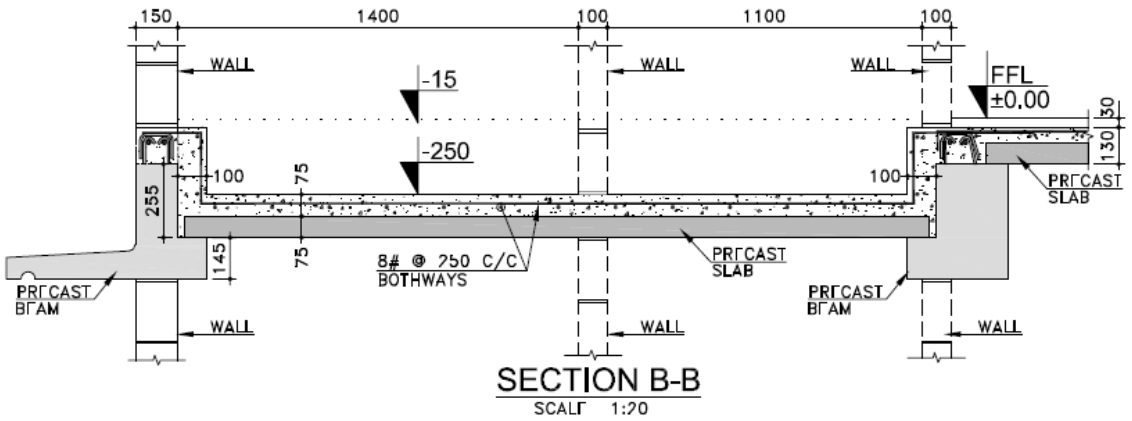
REPRESENTS TMT STEEL OF Fe500D GRADE CONFORMING IS: 1786
DEVELOPMENT LENGTH = LAP LENGTH = (Ld) = 41ø
ALL OTHER ITEMS SHALL BE AS PER WORK SPECIFICATION.
USE CONC. GRADE–M35 FOR PRECAST SLAB.
USE OF MECHANICAL SPLICING FOR BARS OF 25ø AND ABOVE IS RECOMMENDED
APPROPRIATE SLEEVES FOR WET RISER,FIRE FIGHTING RISER, ELECTRICAL
CABLES SHALL BE PROVIDED AS PER RESPECTIVE SERVICES DRAWINGS.
CLEAR COVER TO R/F FOR SLAB = 20 MM.

- Typical beam - slab details

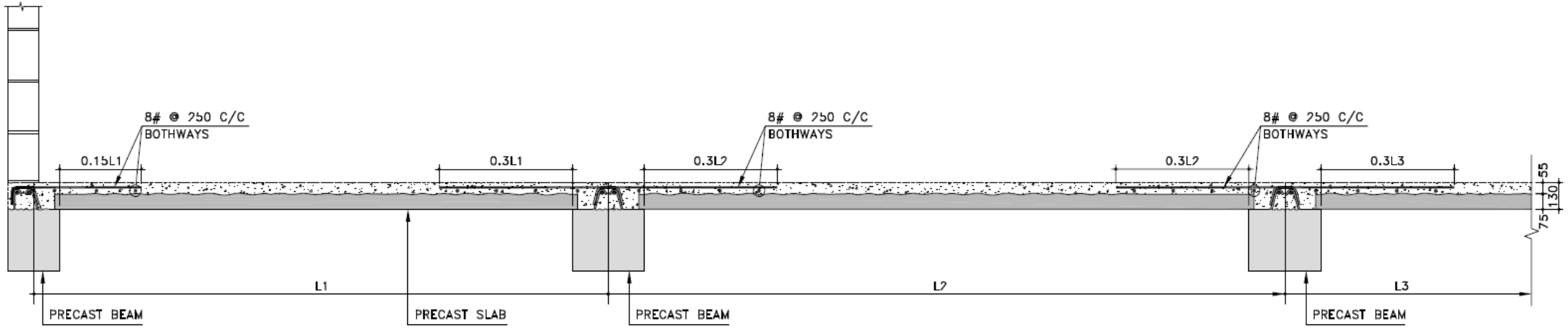
FLOORS/ SLAB



SECTION A-A
SCALE 1:20



SECTION B-B
SCALE 1:20



SECTION AT C-C

- Typical beam - slab details

FLOORS/ SLAB

- Finally the screed concrete (55mm thickness) is poured over the partially precast slab to ensure monolithic continuous action and ductile behavior of the structure.

FLOORS/ SLAB

- Structural integrity and monolithic behavior is achieved in this technology through wet jointing using dowel bars/ continuity reinforcement placed at connection joints and filled with in-situ self-compacting concrete of higher strength in hollow cores of column.


PARTIAL PRECAST SLAB

Partial Precast Slab

PARTIAL PRECAST SLAB WITH REINFORCEMENT

First Floor Column, Beam Erection

SECOND FLOOR COLUMN, BEAM ERECTION

SECOND FLOOR COLUMN, BEAM ERECTION

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/m3 as per IS 2185 (Part-3).

Block size	600x200x150mm for outer walls 600x200x100mm for inner walls

Third Floor Beam, Column, Slab and Second Floor Block Masonry

FOURTH FLOOR BEAM, COLUMN, SLAB AND SECOND FLOOR BLOCK MASONRY

Fifth Floor Masonry work in Progress

EXTERNAL PLASTERING WORK IN PROGRESS

External Plastering work in Progress

OVERALL SITE VIEW

Site View

External Painting in progress

EXTERNAL PAINTING IN PROGRESS

EXTERNAL PAINTING IN PROGRESS

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.

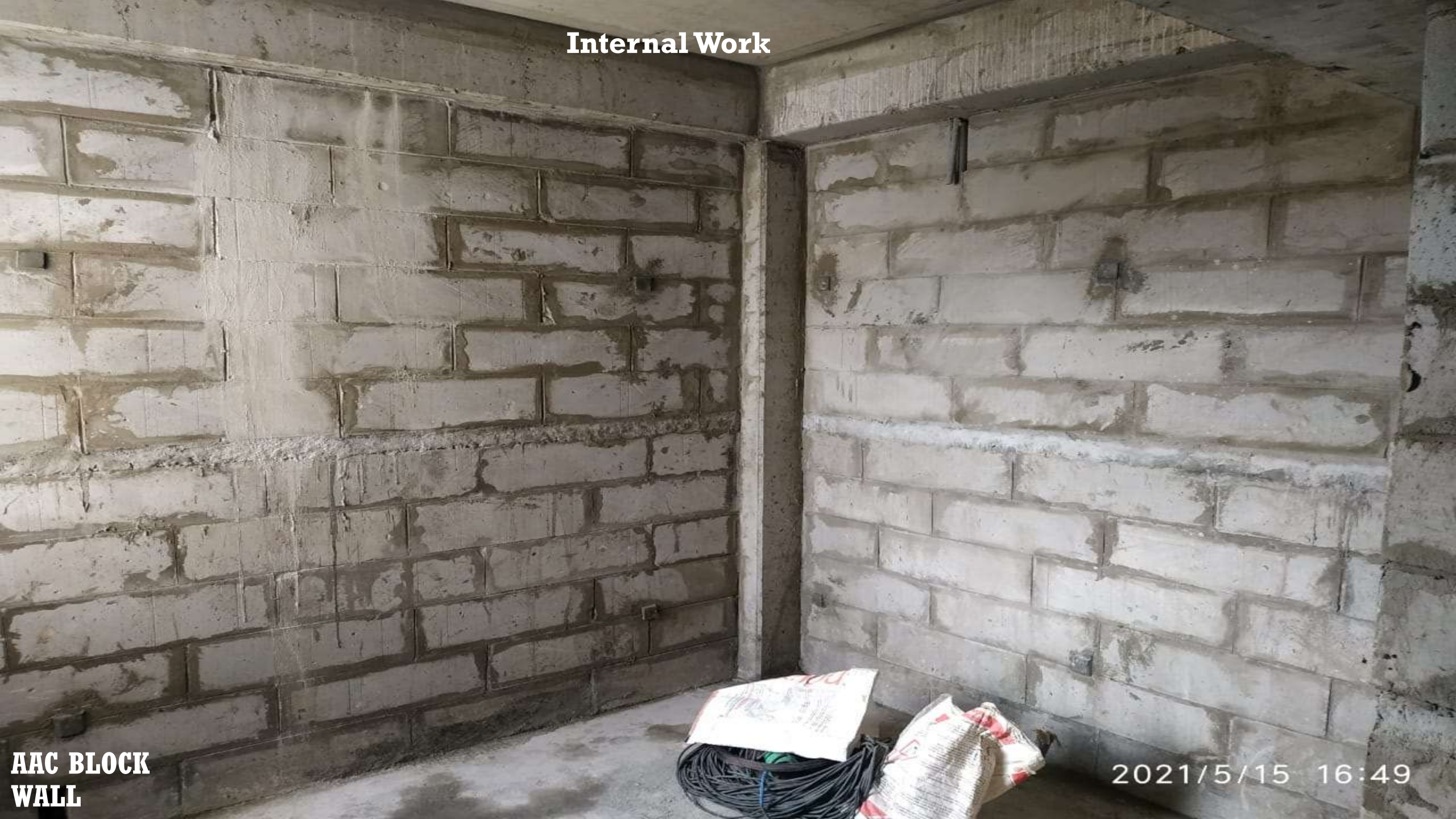
The plumbing and electrical services are incorporated as done in conventional method of construction i.e. chasing and filling

BOUNDARY WALL

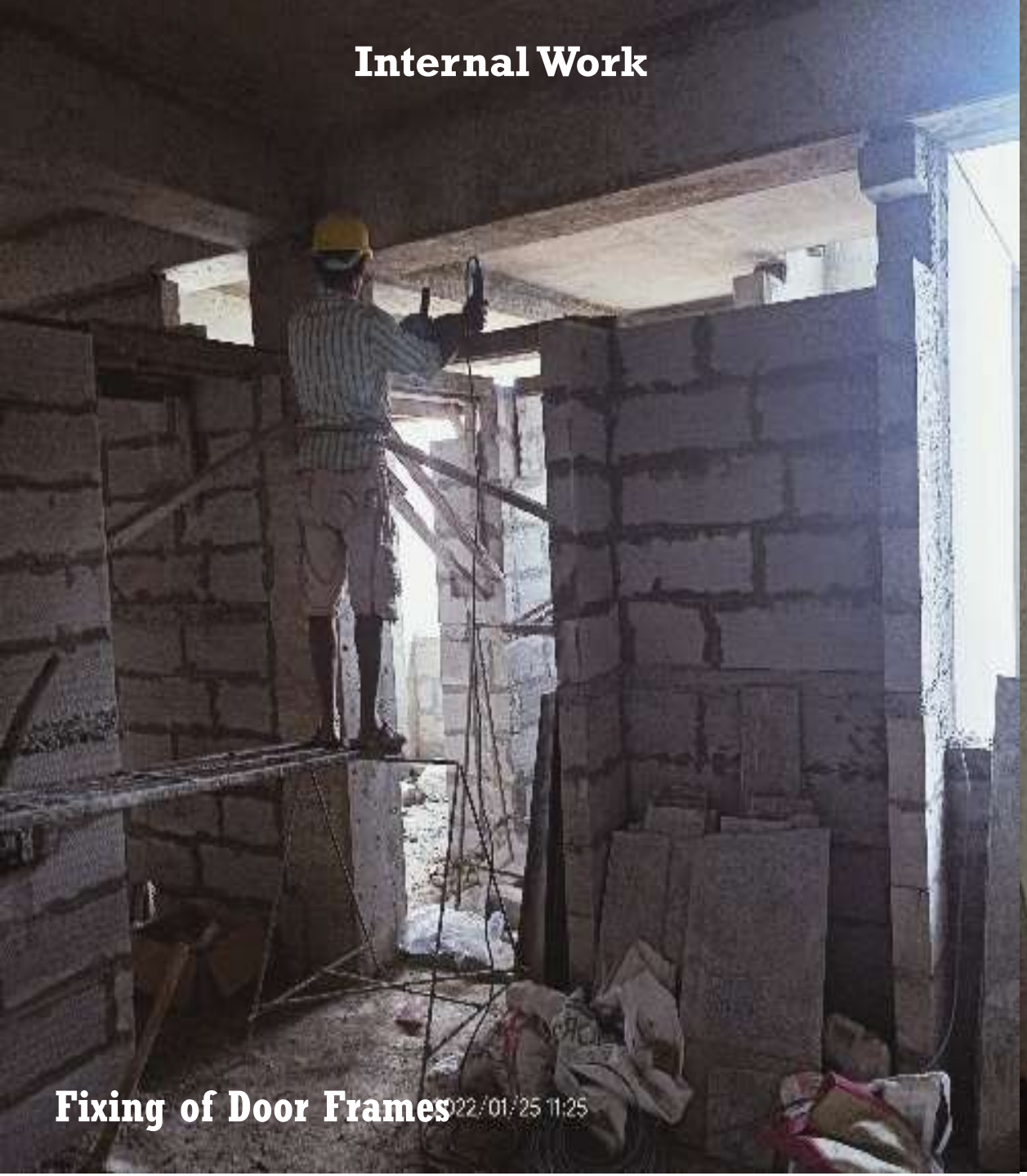

CABINET

Internal Work

TOILET


Internal Work
AAC BLOCK WALL
2021/5/15 16:49

Internal Work



Fixing of Door Frames

Kitchen Cabinet work

Internal Work

Fixing of Windows

Electrical Work


Internal Work
2022:02:12 14:34
Floor Tile work


2022:02:21 12:42
PUTTY & PRIMER WORK


Internal Work
2022/02/21 5:19
Wall Tile fixing


Internal Work
2022/02/26 15:31
Corridor Paint

Internal Work

Plumbing work


Internal Work
2022/03/15 15:40
Sanitary fitting

Internal Work

Electrical room connection

Site View

Current Project View

Current Project View

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.

Live status of LHP site can be accessed at

https://ghtc-india.gov.in

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

CONTACT US:

Ministry of Housing and Urban Affairs,
Maulana Azad Road, Nirman Bhawan,
New Delhi - 110011
E-Mail: ghtc-mhua@gov.in /
ska@bmtpc.org
Call Us at: +91-11-23063266