

# RACHNA 2.0

RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

## Two-Days Vocational Training on 'Innovative Construction Technologies & Best Construction Practices'

Location: **DHP, Guwahati , Assam ,** | Date: **22<sup>nd</sup> – 23<sup>rd</sup> March 2023**  
**Training #67 (RACHNA 2.0)**

**Climate Smart Building Cell - Light House Project Agartala**

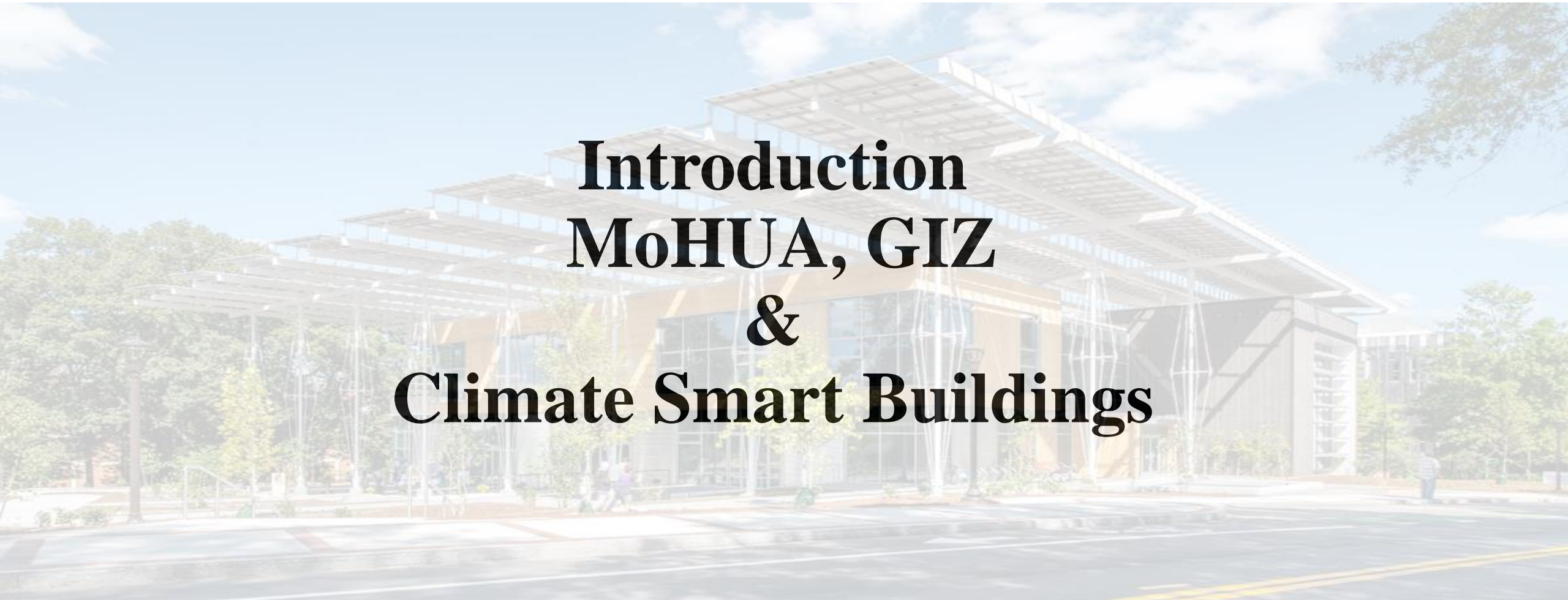


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Indo German Energy Programme: <https://www.giz.de/en/worldwide/15767.html>

GHTC - India: <https://ghtc-india.gov.in/>

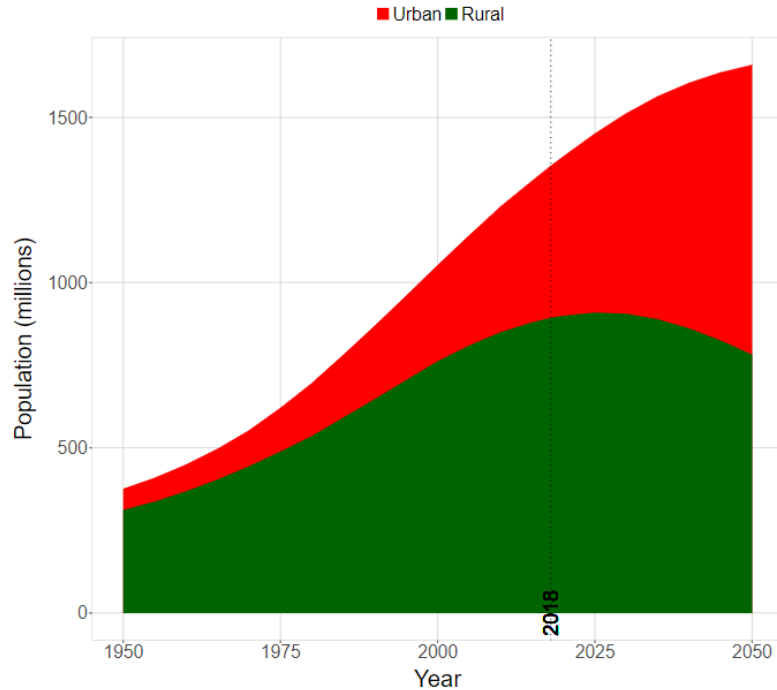


# Introduction MoHUA, GIZ & Climate Smart Buildings



## Growing Opportunities with Rapid Urbanization

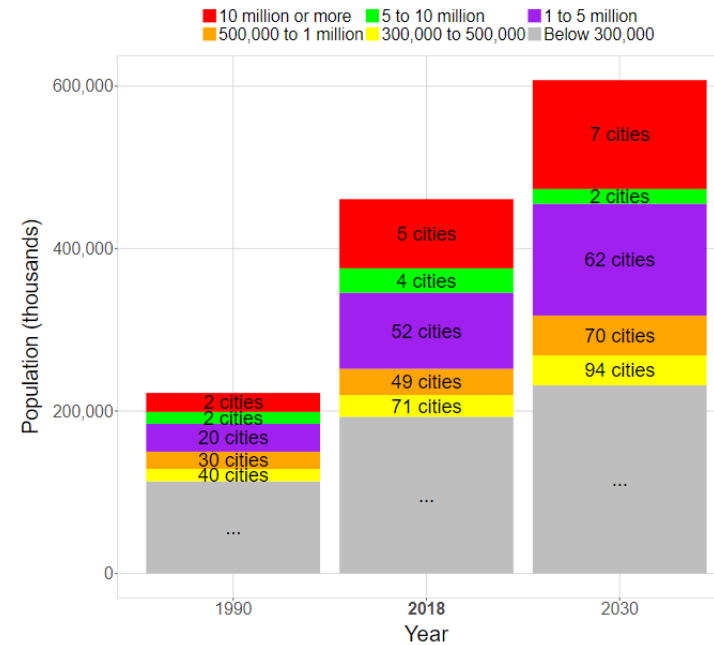
Urban and rural population  
India



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**Note:** Urban and rural population in the current country.

Urban population by size class of urban settlement  
India



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Cities, which will contribute over 80% to GDP by 2050, need to be Receptive, Innovative, and Productive to foster sustainable growth and ensure a better quality of living

## GIZ: Tasks Planned with MoHUA

The focal areas of  
**Indo-German  
cooperation**  
currently are:

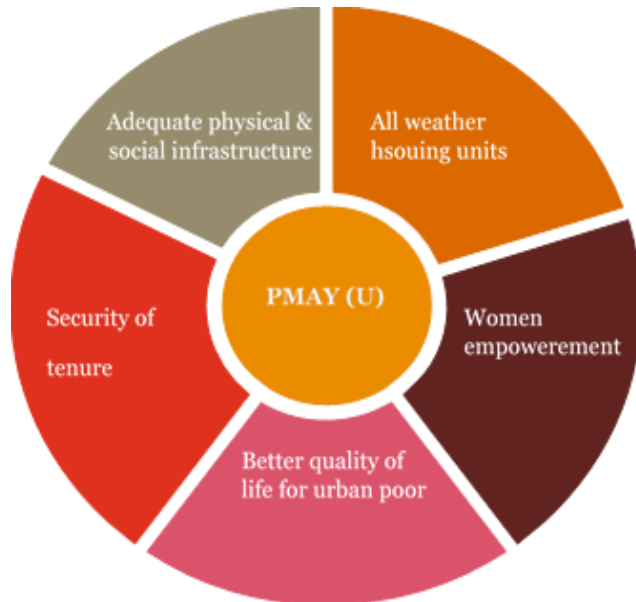
Energy

Environment,  
Preservation, and  
Sustainable Use of  
Natural Resources

Sustainable Urban  
& Industrial  
Development

Sustainable  
Economic  
Development

PMAY - Project Objectives



**Key features of PMAY-U projects**

**11.2 million**  
dwelling units are  
being constructed



**7.35 lakh  
crores**  
investment



**10 lakh**  
occupants in the  
EWS/LIG category  
benefitting

**Problems addressed through  
cafeteria approach by mission**

Construction of  
affordable housing in  
Partnership with  
Public & Private  
Sectors

Promotion of  
affordable Housing  
through Credit  
Linked Subsidy

Slum rehabilitation  
with private  
developers using  
land as a resource

Subsidy for  
beneficiary-led  
individual house  
construction/enhanc  
ement. (ISSR)





GLOBAL  
HOUSING  
TECHNOLOGY  
CHALLENGE INDIA



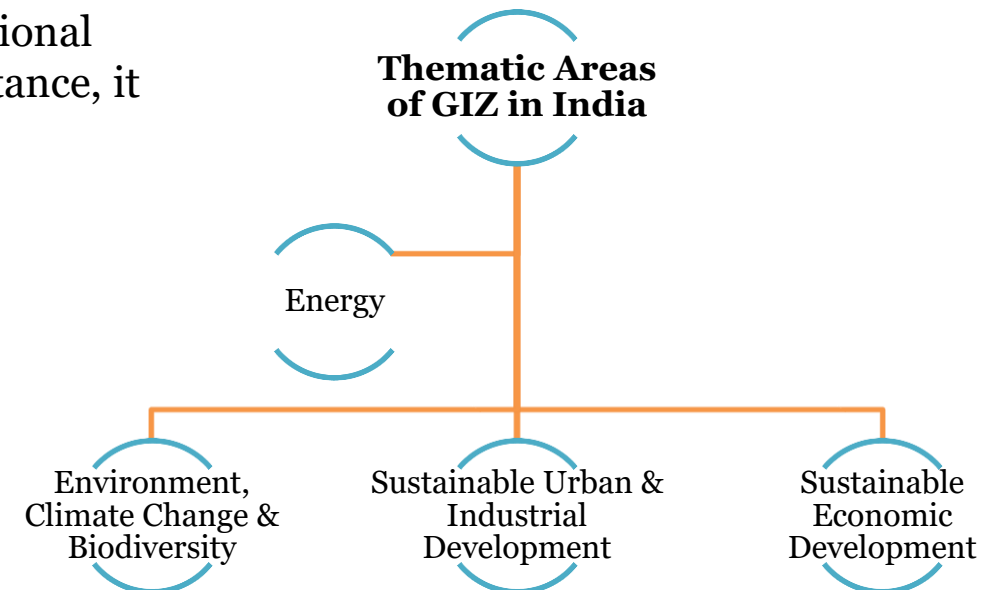
## About GIZ

- GIZ is an international cooperation enterprise for sustainable development which operates worldwide, on a public benefit basis.
- GIZ is fully owned by the German Federal Government, GIZ implement development programs in partner country on behalf of the German Government in achieving its development policy objectives.
- For over 60 years, the **Deutsche Gesellschaft für Internationale Zusammenarbeit** (GIZ) GmbH has been working jointly with partners in India for sustainable economic, ecological, and social development. Currently, GIZ has over 330 employees in India, of whom 85 per cent are national personnel.

The Govt. of India has launched several vital initiatives to address national issues & GIZ is contributing to some of those significant ones. For instance, it supports vital initiatives like Smart Cities, Skill India etc.

The thematic areas of work for GIZ in India are as follows:

- I. **Energy**
- II. **Environment, Climate Change & Biodiversity**
- III. **Sustainable urban & industrial development**
- IV. **Sustainable economic development**





## Climate Smart Buildings (CSB)

### Establishment of the Cluster Cell in Agartala, Tripura under Global housing Technology Challenge India (GHTC - India)

The **Climate Smart Buildings** project intends to address the majority of gaps identified in the affordable housing sector:

- By introducing of thermal comfort & climate resilience in the Local Government framework through Byelaws is an overarching objective.
- In order to achieve this objective, activities like documentation of LHP construction process from a sustainability perspective, knowledge transfer & capacity building through LHPs, performance monitoring & demonstration of thermal comfort in selected housing projects among others.

### State & UTs in East Cluster for establishing the Cell

Arunachal Pradesh	Assam	Manipur	Meghalaya
Mizoram	Nagaland	Sikkim	Tripura



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Ministry of Housing and Urban Affairs  
Government of India



**giz** Deutsche Gesellschaft  
für Internationale  
Zusammenarbeit (GIZ) GmbH

## Light House Projects (LHPs)

LHPs will showcase & deliver ready-to-live homes with better quality of construction in a sustainable manner.

LHPs aims introduce thermal comfort into the foray of affordable housing, a critical design & thus usability aspect will be addressed.

LHPs are model housing projects with houses built with shortlisted alternate technology suitable to the geo-climatic and hazard conditions of the region.

LHPs shall serve as LIVE Laboratories for different aspects of Transfer of technologies to field application for entire building fraternity.

### Aim & Concept





## Climate Smart Buildings Cells: Work Packages

**WP1:** Facilitate implementation and monitoring of Light House Projects (LHPs)

**WP 2:** Technical assistance to enhance thermal comfort in upcoming Demonstration Housing Projects (DHPs) and ARHCs (Affordable rental housing complexes) and other Public/Private housing projects

**WP 3:** Inclusion of climate resilience and thermal comfort requirements in building byelaws and Local Government framework

**WP 4:** Capacity development of Govt officials and private stakeholders on thermal comfort



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प्रधान मंत्री  
आवास योजना-शहरी  
Pradhan Mantri Awas Yojana-Urban



Ministry of Housing and Urban Affairs  
Government of India



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# Session 1

**LHP Agartala & its construction technology**

**GHTC – Brief on other construction technologies**





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## Global Housing Technology Challenge - India (GHTC-I)

<i>Broad Category</i>	<i>Technologies (Nos.)</i>
<i>Precast Concrete Construction System - 3D Precast volumetric</i>	4
<i>Precast Concrete Construction System - Precast components assembled at site</i>	8
<b><i>Light Gauge Steel Structural System &amp; Pre-engineered Steel Structural System</i></b>	16
<i>Prefabricated Sandwich Panel System</i>	9
<i>Monolithic Concrete Construction</i>	9
<i>Stay In Place Formwork System</i>	8
<b>Total</b>	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



## Light House Projects

Following are the details of Construction Technologies being employed at the Light House Projects selected under the Global Housing Technology Challenge (GHTC) – India



### Monolithic Concrete Construction using Tunnel Formwork

- LHP Location: Rajkot, Gujarat
- No. of Houses: 1144



### Prefabricated Sandwich Panel System

- LHP Location: Indore, Madhya Pradesh
- No. of Houses: 1024



### Precast Concrete Construction System – Precast Components Assembled at Site

- LHP Location: Chennai, Tamilnadu
- No. of Houses: 1152



### Precast Concrete Construction System – 3D Volumetric

- LHP Location: Ranchi, Jharkhand
- No of Houses: 1008



### Light Gauge Steel Structural System & Pre-engineered Steel Structural System

- LHP Location: Agartala, Tripura
- No of Houses: 1000



### PVC Stay in Place Formwork System

- LHP Location: Lucknow, Uttar Pradesh
- No of Houses: 1040





# Monolithic Tunnel Formwork Technology – LHP Rajkot

In **‘TunnelForm’ technology**, concrete walls and slabs are cast in one go at site giving monolithic structure using high-precision, re-usable, room-sized, Steel forms or molds called ‘TunnelForm’.

‘TunnelForm’ system uses customized engineered steel formwork consisting of two half shells which are placed together and then concreting is done to form a room size module. Several such modules make an apartment.



## Construction Process

Stripping of the  
formwork from the  
previous day.



Positioning of the  
formwork for the  
current day's  
phase, with the  
installation of  
mechanical,  
electrical and  
plumbing services.



Installation of  
reinforcement in  
the walls and slabs.



Concreting



# Monolithic Tunnel Formwork Technology – LHP Rajkot

## Special Features

Facilitating rapid construction of multiple/ mass modular units (similar units).

Making structure durable with low maintenance requirement.

The precise finishing can be ensured with no plastering requirement.

The concrete can be designed to use industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resource

Being Box type monolithic structure, it is safe against horizontal forces (earthquake, cyclone etc.)

The large number of modular units bring economy in construction.







# Prefabricated Sandwich Panel System – LHP Indore

- Factory made **Prefabricated Sandwich Panel System** is made out of cement or calcium silicate boards and cement mortar with EPS granules balls, and act as wall panels.
- Under this LHP, houses are being constructed using Prefabricated Sandwich Panel System with Pre-Engineered Steel Structural System.
- In this system the **EPS Cement Panels** are manufactured at the factory in controlled condition, which are then dispatched to the site. The panels having tongue and groove are joint together for construction of the building.



## Special Features

Being dry walling system, brings speed in construction, water conservation (no use of water for curing of walling components at site).

The sandwich panels have light weight material as core material, which brings resource efficiency, better thermal insulation, acoustics & energy efficiency.

Being light in weight results in lower dead load of building & foundation size.



## Precast Concrete Construction System – Precast Components Assembled at site – LHP Chennai

An already established technology for building construction, Precast concrete construction is a system where the individual precast components such as walls, slabs, stairs, column, beam etc, of building are manufactured in plant or casting yard in controlled conditions. The finished components are then transported to site, erected & installed. The technology provides solution for low rise to high rise buildings, especially for residential and commercial buildings.



The construction process comprises of manufacturing of precast concrete Columns, Beams and Slabs in steel moulds.

The reinforcement cages are placed at the required position in the moulds.



Concrete is poured and compaction of concrete is done by shutter/ needle vibrator.



Casted components are then moved to stacking yard where curing is done for required time and then these components are ready for transportation and erection at site.



These precast components are installed at site by crane and assembled through in-situ jointing and/or grouting etc.



## Precast Concrete Construction System – Precast Components Assembled at site – LHP Chennai

### Special Features

Nearly all components of building work are manufactured in plant/casting yard & the jointing of components is done In-situ leading to reduction in construction time.

The controlled factory environment brings resource optimization, improved quality, precision & finish.

The concrete can be designed 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 resources.

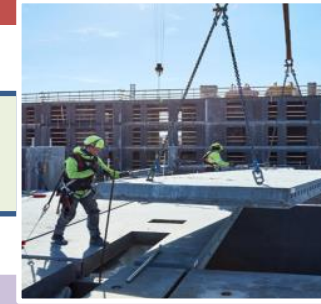
Eliminates use of plaster.

Helps in keeping neat & clean construction site and dust free environment.

Optimum use of water through recycling.

Use of shuttering & scaffolding materials is minimal.

All weather construction & better site organization.





# Precast Concrete Construction System – 3D Volumetric – LHP Ranchi

**3D Volumetric concrete** construction is the modern method of building by which solid precast concrete structural modules like room, toilet, kitchen, bathroom, stairs etc. & any combination of these are cast monolithically in Plant or Casting yard in a controlled condition

## Construction Process

Sequential construction in the project here begins with keeping the designed foundation of the building ready, while manufacturing of precast concrete structural modules are taking place at the factory.

Factory finished building units/modules are then installed at the site with the help of tower cranes.



Gable end walls are positioned to terminate the sides of building. Pre stressed slabs are then installed as flooring elements.



Rebar mesh is finally placed for structural screed thereby connecting all the elements together.



Consecutive floors are built in similar manner to complete the structure.





# Precast Concrete Construction System – 3D Volumetric – LHP Ranchi

## Special Features



About 90% of the building work including finishing is complete in plant/casting yard leading to significant reduction in construction & occupancy time.

The controlled factory environment brings resource optimization, improved quality, precision & finish.

With smooth surface it eliminates use of plaster.

The monolithic casting of walls & floor of a building module reduces the chances of leakage.

The system has minimal material wastage (saving in material cost), helps in keeping neat & clean construction site and dust free environment.

Use of Optimum quantity of water through recycling.

Use of shuttering & scaffolding materials is minimal.

All weather construction & better site organization



## Light Gauge Steel Structural System & Pre – engineered Steel Structural System – LHP Agartala

**Light Gauge Steel Frame (LGSF) System** uses factory made galvanized light gauge steel components.

The components/sections are produced by cold forming method and assembled as panels at site forming structural steel framework upto G+3 building.



### Construction Process

The sequence of construction comprises of foundation laying, fixing of Pre-Engineered Steel Structural System, fixing of tracks, fixing of wall panels with bracings as required, fixing of floor panels, decking sheet, fixing of electrical & plumbing services and finally fixing of concrete walling panels with light weight concrete as infill.

The other options of dry walling components such as sandwich panels with insulation material in between can also be used.

Similarly, the floors can either be composite slab/deck slabs/precast hollow core slabs as per the need & requirements.



## Light Gauge Steel Structural System & Pre – engineered Steel Structural System – LHP Agartala

### Special Features

High strength to weight ratio. Due to light weight, significant reduction in design earthquake forces is achieved. Making it safer compared to other structures.

Fully integrated computerized system with Centrally Numerical Control (CNC) machine primarily employed for manufacturing of LGSF sections provide very high Precision & accuracy.

Construction being very fast, a typical four storied building can be constructed within one month.

Structure being light, does not require heavy foundation

Structural element can be transported to any place including hilly areas to remote places easily making it suitable for far flung regions including difficult terrains.

Structure can be shifted from one location to other without wastage of materials.

Steel used can be recycled multiple times

The system is very useful for post disaster rehabilitation work.





## PVC Stay in Place Formwork System – LHP Lucknow

- The plant manufactured rigid poly-vinyl chloride (PVC) based polymer components serve as a permanent stay-in-place finished form-work for concrete walls. In order to achieve speedier construction, strength and resource efficiency, the composite structure with Pre-Engineered Steel Structural System as structural members is being used in the present project.



### Construction Process

Construction is done in a sequential manner where at first, the Prefabricated PVC Wall panels and Pre-Engineered Steel Structural Sections as per the design are transported to the Site.

Then, these Sections are erected on the prepared foundation using cranes and required connections.



Floor is installed using decking sheet. Once the structural frame and floor is installed and aligned, wall panels are fixed on decking floor.



The pre-fabricated walling panels having provisions of holes for services conduits, are fixed along with the reinforcement & cavities inside the wall panels are filled with concrete.



Upon installment of wall panels, flooring and ceiling, the finishing work is executed.



# PVC Stay in Place Formwork System – LHP Lucknow

## Special Features

Having formwork already as part of system, the construction of building is faster as compared to conventional buildings. The formwork needs some support only for alignment purpose.

In case of concrete as filling material, the curing requirement of concrete is significantly reduced, thus saving in precious water resources.

The formwork system does not have plastering requirement & gives a very aesthetic look.





# Walling Material Case Studies, Light House Projects

## Light House Project: Lucknow



- PVC Stay in Place Formwork System
- S and 13 Floors
- Rigid polyvinyl chloride (PVC) based formwork system serves as a permanent stay-in-place durable finished form-work for concrete walls
- The PVC extrusions consist of the substrate (inner) and Modifier (outer). The two layers are co-extruded during the manufacturing process to create a solid profile.



# LIGHT HOUSE PROJECT AT AGARTALA

## *GHTC-India Category*

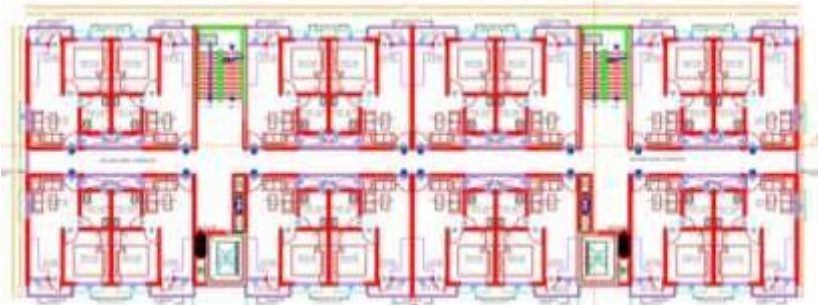
Light Gauge Steel Structural System & Pre-engineered Steel Structural System

## *Technology*

Light Gauge Steel Framed (LGSF) System with Pre-engineered Steel Structural System

- Total Plot area is 24168 Sqm.
- Ground coverage of the project is 29% and FAR achieved is 2.43
- Proposed organized green space is 31%.
- The project also includes Anganwadi, Health Centre and community hall of 480 Sqm, 700 Sqm and 500 Sqm respectively in G+1 configuration

Typical floor plan

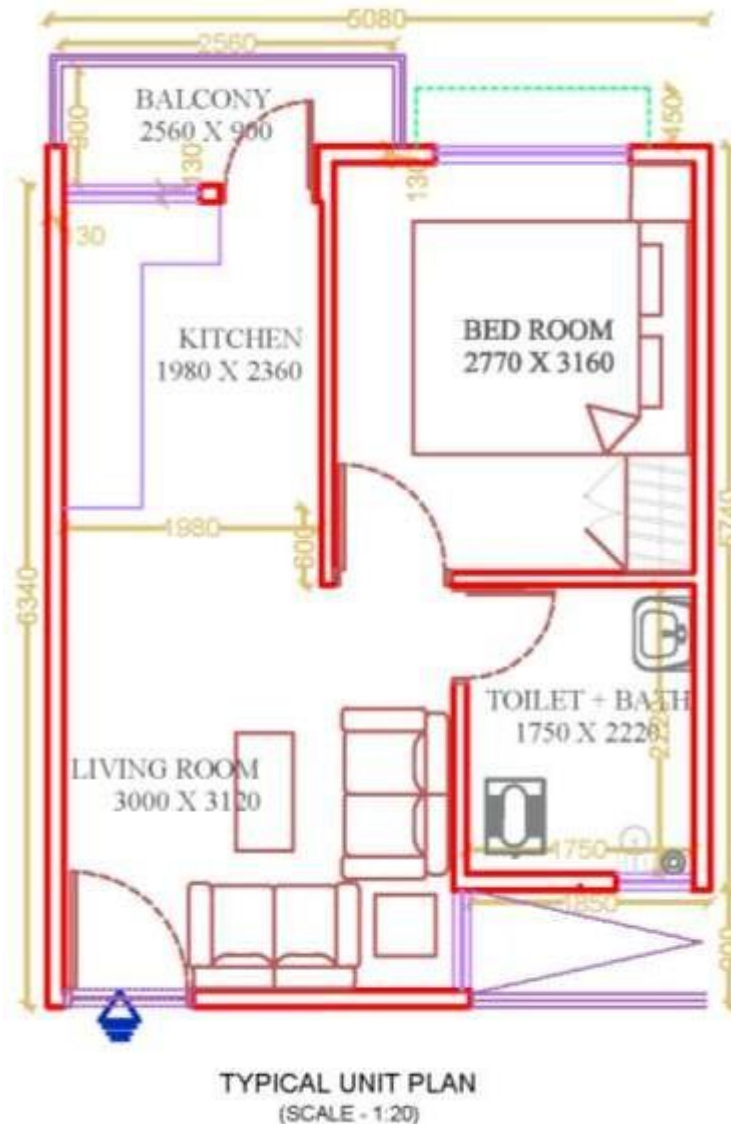


- 16 dwelling units each in A & G Block; 22 Units in B Block; 18 Units in C Block and 24 units each in D, E & F per floor with a provision of lifts and staircase.



- There are 7 blocks in Ground + 6 configuration with 1000 houses along with basic and social infrastructure.

## ■ Typical Dwelling Unit plan



Each dwelling unit consists of one living, one bed room, a kitchen, a toilet and a balcony. The carpet area of each unit is 30.03 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

### Load bearing Structure



### RCC Framed Structure

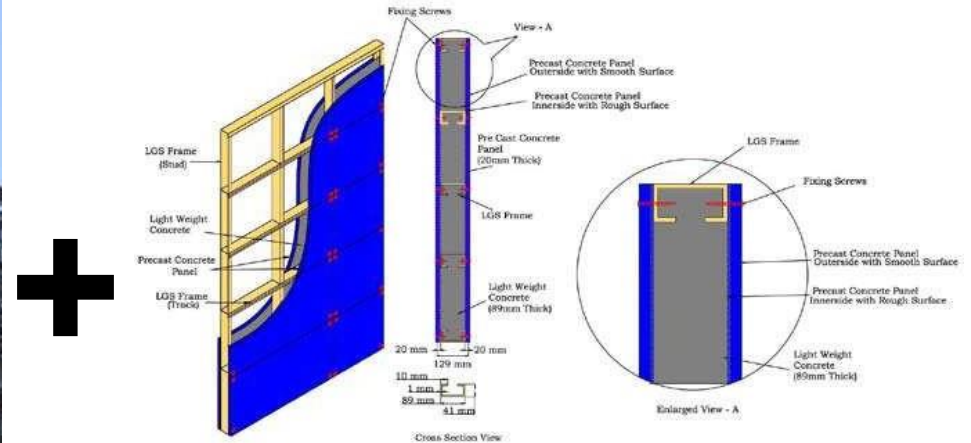


## Technology being Used

### Steel Frame Structure



### Light Gauge Steel Framed Walling System



Light Gauge Steel Framed System (LGSF) is based on factory made galvanised light gauge steel components. The components/sections are produced by cold forming method and assembled as panels at site forming structural or non structural steel framework of a building of varying sizes of wall and floor.

In order to meet structural requirements, Hybrid system comprising of **Light Gauge Steel Frame System with Pre-Engineered Steel Structural System** has been adopted in the present project.

# Structural Elements

- Foundation
- Structural System
- Floor/ Roof Slab
- Wall Panels





### Foundation

- Pile Foundation ( Bored Cast-in-situ Concrete Piles) as per geo-technical investigations, bearing capacity, soil strata, water table, etc.
- RCC Raft on the Piles and then RCC pedestal on the Raft
- Anchor bolts and Base plate of varying sizes and diameter as per structural design for erecting Pre-Engineered Steel Structure.
- RCC plinth beam and grade slab at plinth level.
- RCC shear walls for staircases and lift on RCC raft and water proofing with kota stone.





# Structural Elements

## Structural system

- Pre-Engineered Building (PEB) system comprising of built-up fabricated I-sections for beams and columns



# Structural Elements

## Floor/ Roof Slab

- The floor/ roof is deck slab which comprises of deck sheet, reinforcement with concrete screed



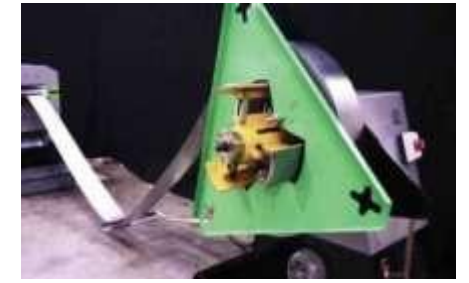
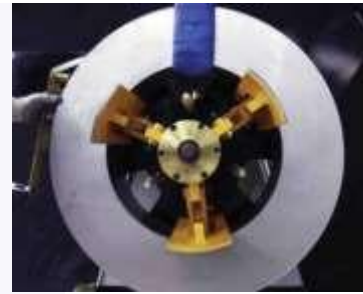
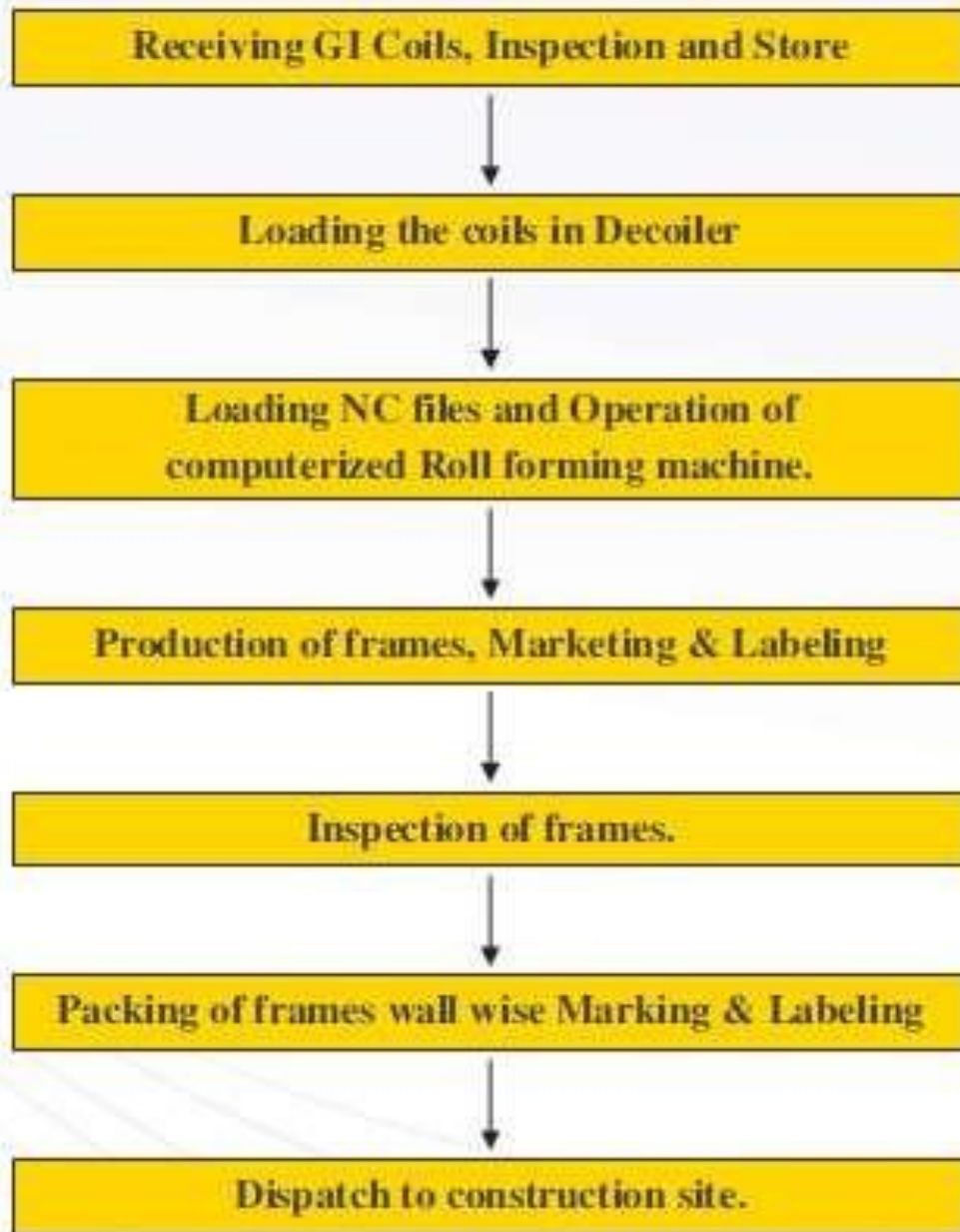


# Structural Elements

## Wall Panels –Light Gauge Steel Frame System

- LGSF is a “C” cross-section made of galvanised light gauge steel with built in notch, dimpling, slots, service holes etc. and produced by computerized cold roll forming machine.
- These frames are assembled using self driven metal screws to form into LGSF wall and roof structures of a building.
- Provisions for doors, windows, ventilators and other cut outs as required are incorporated in the LGSF.
- Cement concrete panels are fixed on both side of the wall and then filled with light weight concrete.
- Cement fibre board as an alternative to the above panels are used for cladding with infill of rockwool.





▪ Flow Diagram of manufacturing plant for fabrication of Light Gauge Steel Frame System



## Light Gauge Steel Frame System



- Photos of manufacturing plant

### ■ Wall Frame

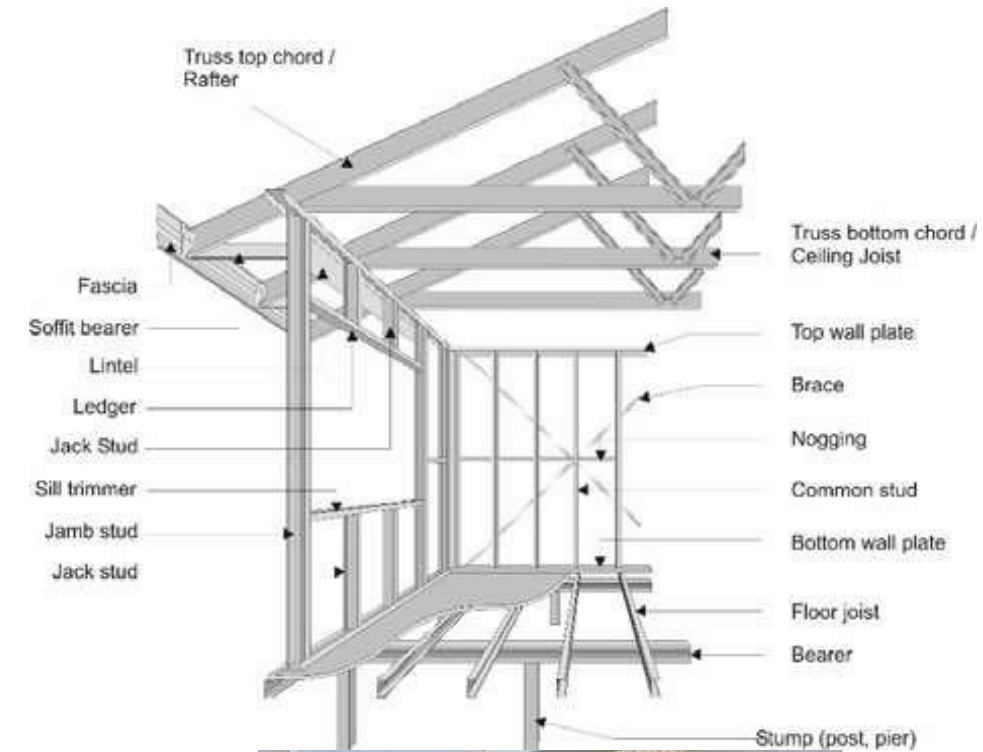
- Factory finished custom designed cold form Light Gauge Steel Framed structure comprising of steel wall panel, trusses, purlins etc are manufactured out of minimum 0.75 mm thick steel sheet as per design requirements.
- The steel sheet shall be galvanized (AZ-150 gms Aluminium Zinc Alloy coated steel having yield strength 300- 550 Mpa) conforming to AISI specifications and IBC 2009 for cold formed steel framing and construction.
- IS 800-2007 (Code of practice for general construction in steel) and IS: 801- 1975 (Code of Practice for Use of Cold Formed Light Gauge Steel Structural Members In General Building Construction).





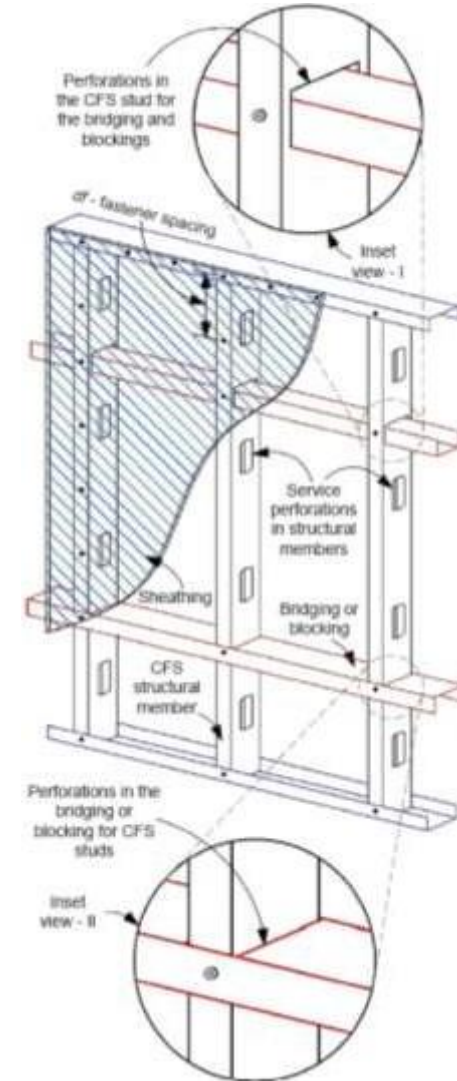
### ■ Wall Frame...contd.

- The framing section shall be cold form C-type having minimum web depth 89 mm x 39mm flange x 11mm lip in required length as per structural design
- Duly punched with dimple/slot at required locations as per approved drawings.
- The slots will be along centre line of webs and shall be spaced minimum 250mm away from both ends of the member.
- The frame can be supplied in panel form or knock down condition in specific dimensions and fastened with screws extending through the steel beyond by minimum of three exposed threads.
- All self drilling tapping screws for joining the members shall have a Type II coating in accordance with ASTM B633(13) or equivalent corrosion protection of gauge 10 & 12, TPI 16 & 8 of length 20mm.
- The frames shall be fixed to RCC slab or Tie beam over Neoprene rubber using self expanding carbon steel anchor bolt of dia as per approved drawings, design subject to minimum 12mm diameter and 121mm length conforming to AISI 304 and 316 at 500mm c/c with minimum embedment of 100mm in RCC and located not more than 300mm from corners or termination of bottom tracks complete in all respects.



### ■ Wall Frame...contd.

- Fasteners and Connectors
  - **Frame assembly screws:** Shall be galvanized steel screws self-drilling type of size 10 x 25 mm having Truss-head and shall be as per ASTM C 1513-10.
  - **Wall Erection Screws:** Shall be galvanized steel screws self-drilling type of size 8 x 25 mm having Hex Washer head and shall be as per ASTM C 1513-10.
  - **Precast Concrete Panels Fixing Screws:** Shall be of galvanized steel screws self-drilling type of size 8 x 50 mm having CS head and shall be as per ASTM C 1513-10.
  - **Wall and Foundation Anchor Bolt:** Shall be of high tensile galvanized steel of size 10 x 100 mm/ 10 x 150 mm and 12 x 100 mm/ 12 x 150 mm and shall be as per ASTM C 1513-10.



Cold-formed steel structural members with perforations (service openings and opening for continuity members)

### ■ Wall Frame...contd.

- Cladding of LGSF Panels
  - 20mm thick Precast Concrete (M20) Panels (PCP) are used as facing sheets for construction of walls on both sides. Metal moulds, concrete mixing machine and vibration tables are used for manufacturing the panels at onsite or offsite.
  - The panels are designed to withstand the concrete weight pumped in between the gap of the panels without failure and buckling.
  - The steel reinforced precast concrete panels (PCP), has one side rough surface and the other side smooth surface. The PCP's are fixed on either side of Light Gauge Steel Frame Structures (LGSFS) with studs and tracks using mechanical fasteners. While fixing, the rough side of the panels are facing inside and smooth side is facing outside. Each PCP is fixed with 6 screws.
  - Light weight concrete is pumped in to the gap between two PCPs. The concrete bonds with the rough surface of the panels. Thus, the LGSFS and PCPs are firmly joined to make a monolithic steel-concrete structure.





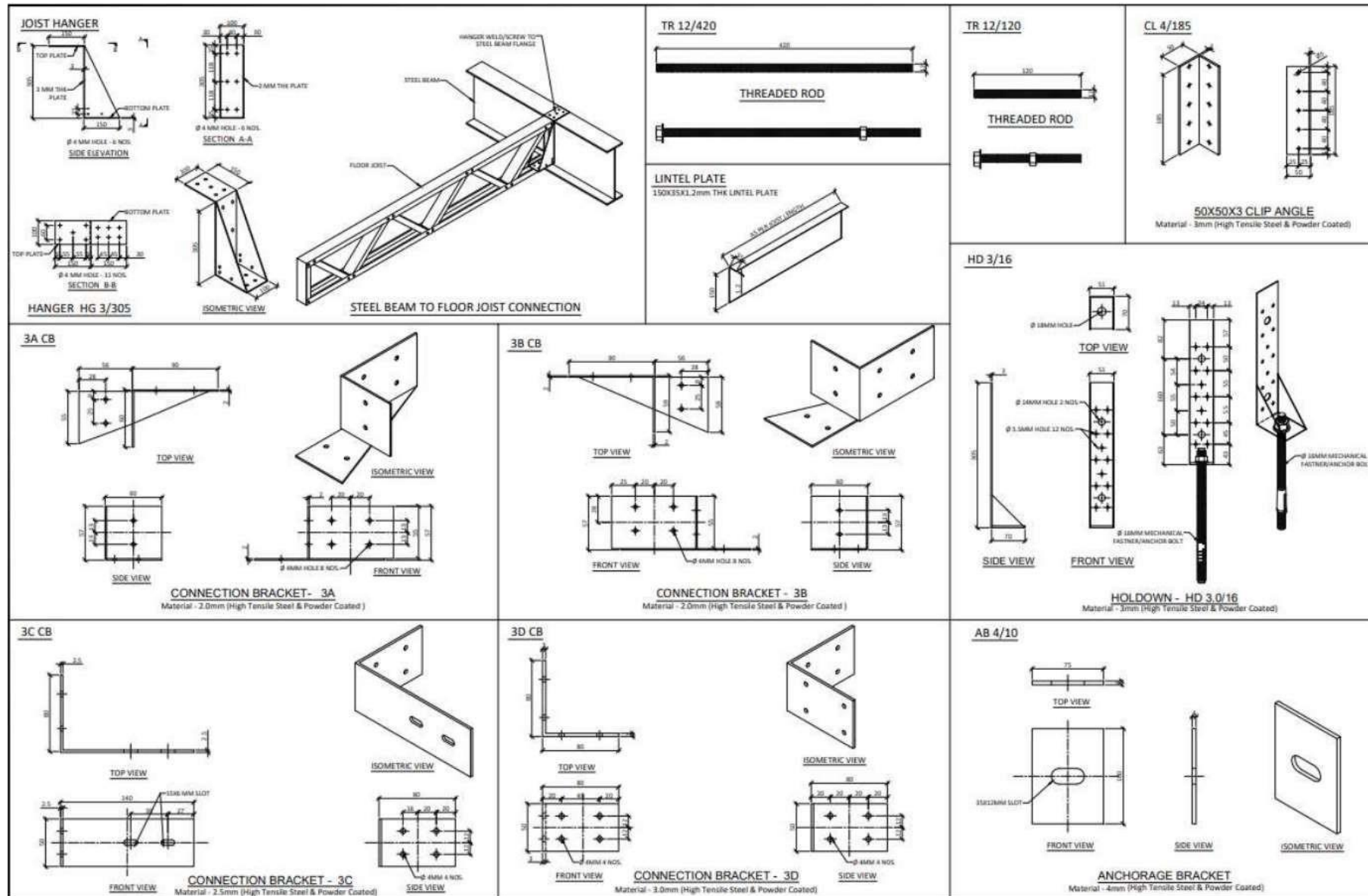
### ■ Wall Frame...contd.

- Core of wall panels
  - The concrete used for infill wall is light weight and free flow.
  - The density shall be 1500-1800 Kg/m<sup>3</sup> after adding/mixing foam or EPS beads as per the design mix. The light weight concrete shall be of grade M5 to M10 as required.
  - The light weight concrete shall be mixed and used at site.



# Light Gauge Steel Frame System

## Structural connections of LGSF panels



### Advantages

- Due to light weight, significant reduction in design earthquake forces is achieved. Making it safer compared to other structures.
- Fully integrated computerised manufacturing of LGSF sections provide very high precision & accuracy.
- Speedier
- Structure being light, does not require heavy foundation
- Structural elements can be transported to any place including hilly areas/ remote places easily
- Structure can be shifted from one location to other with minimum wastage of materials.
- Steel used can be recycled multiple times
- The system is very useful for post disaster rehabilitation work.



### Essential Requirements

- The labours are required to be trained for fabrication/assembly works
- Plumbing & electrical services need to be pre-planned.
- Door and Window position shall not be changed after pouring of light weight concrete.
- Erection of panels shall be under supervision of trained staff.
- Post construction alteration is difficult.
- Proper care should be taken for fixing of tiles on the walls.
- Electrical cables need to be properly insulated with minicircuit breakers.



Being first time mass scale field implementation of new  
technology

the Light House Project at Agartala is on

**Design & Build Basis**

Technology Provider and Construction Agency:

**M/s Mitsumi Housing Pvt. Ltd., Ahmedabad**

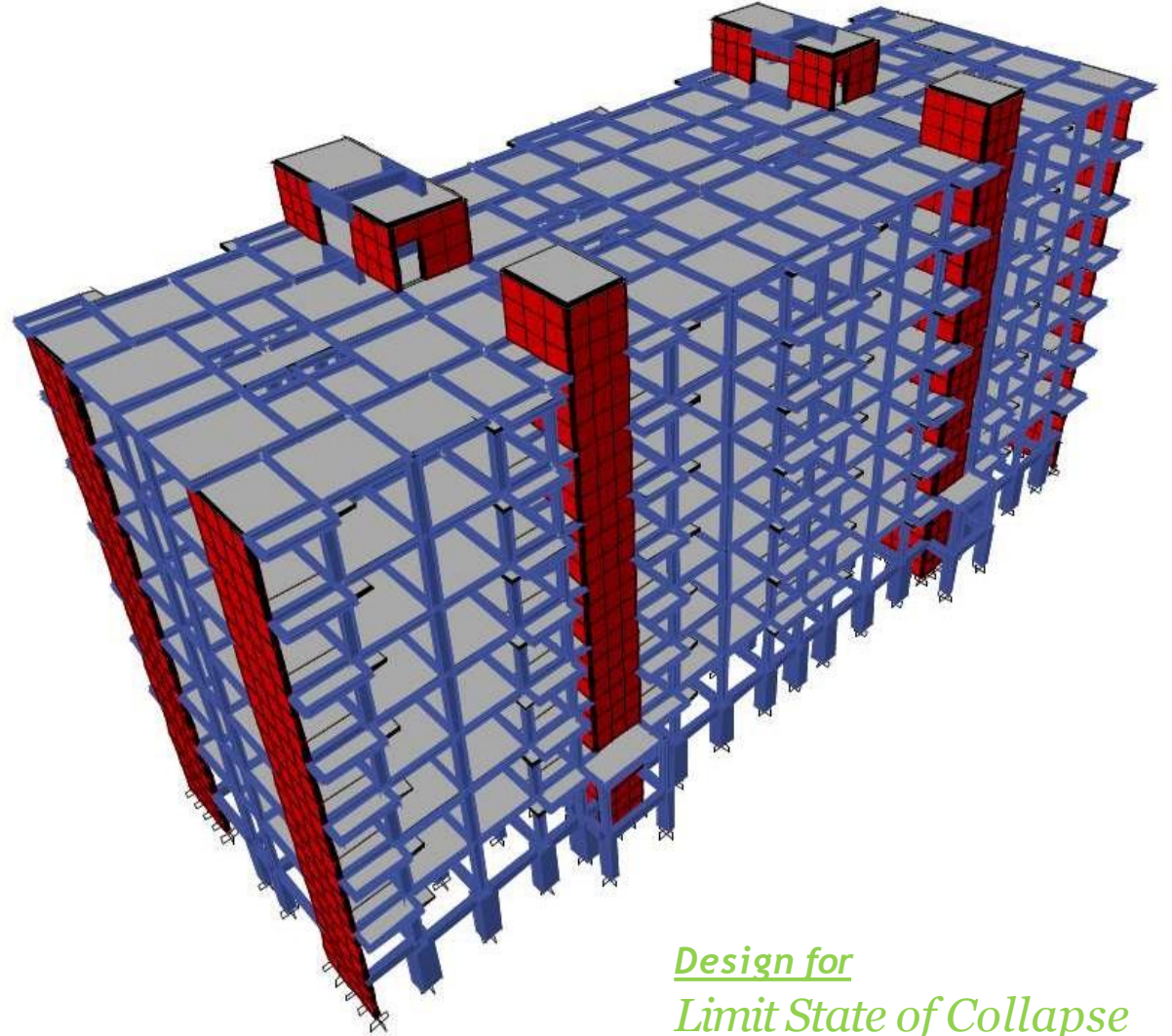
# STRUCTURAL ANALYSIS & DESIGN

- 3D Model of typical tower with PEB Structure

- Load Combinations :

- 1.5 (DL+LL)
- 1.2 (DL+LL $\pm$ EL/WL)
- 1.5 (DL $\pm$ EL/WL)
- 0.9DL  $\pm$ 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.)*



- Steel 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 softwares.
- The softwares can also be used for structural design as per Indian Standards.
- AUTOCAD for drawings

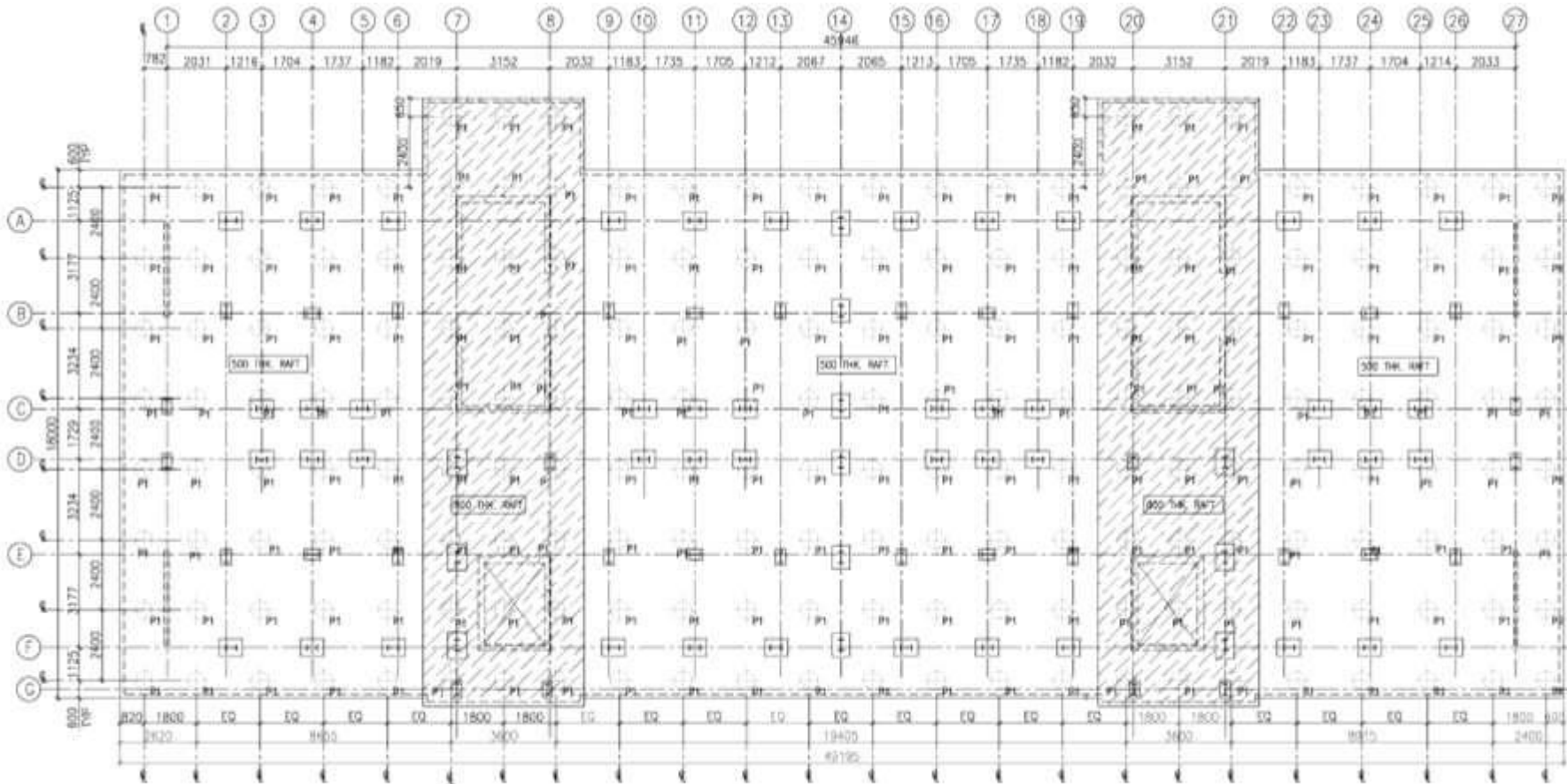
Design for  
*Limit State of Collapse*  
*Limit State of Serviceability*

# Construction Sequence

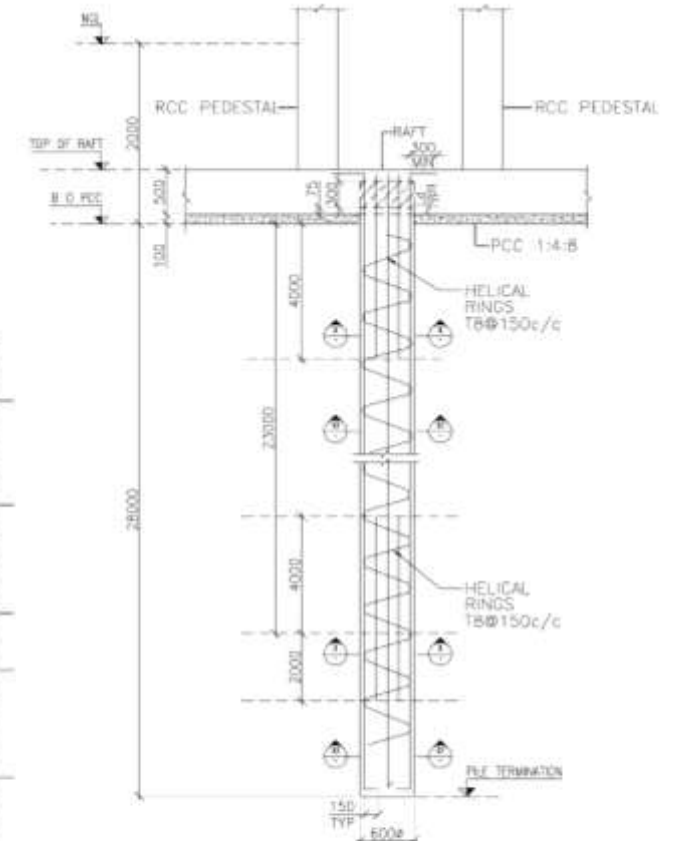
- Sub-Structure: Foundation
- Super-structure: Structural system  
Floors  
Wall Panels
- MEP: Plumbing & Electrical
- Finishing

# Structural Drawings

# FOUNDATION



PILE LAYOUT



PILE-P1-600#

• 6-T20(ø)+  
6-T16

SECTION-X-X



PILE-P1-600#

• 6-T20(ø)+  
6-T16

SECTION-X1-X1

FFL

NGL

900 MAX.

2500

TOP OF RAFT

BOTTOM OF PCC

800

300

500

REINF AS PER DETAIL

SHEAR WALL

TIES

PCC

PILE

Ld TYP

SECTION 1

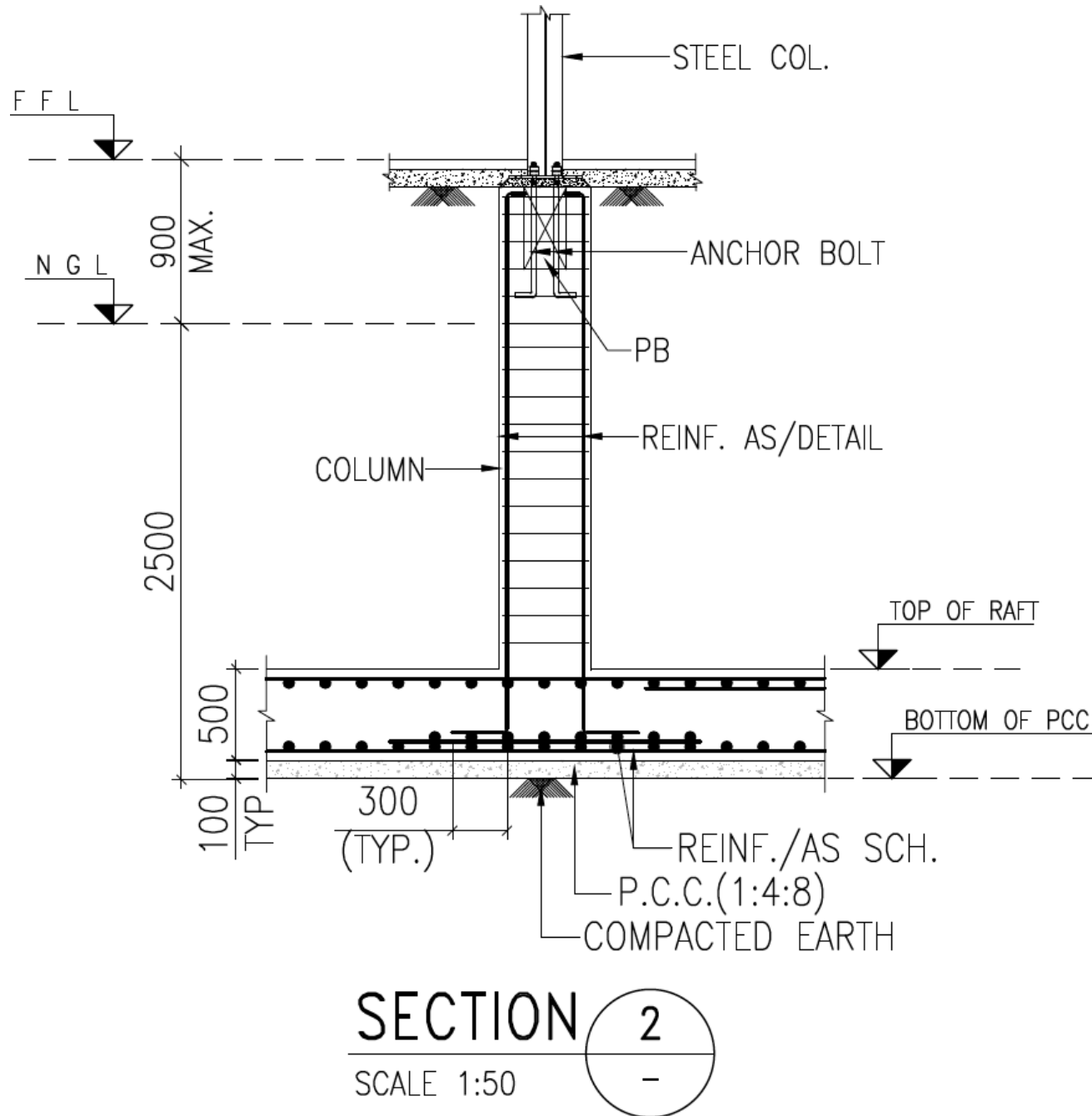
SCALE 1:50

- A section showing the placing of raft on the piles.





# FOUNDATION



- A section of the foundation showing the raft, concrete pedestal, location of the anchor bolts & base plate and steel column in super-structure.

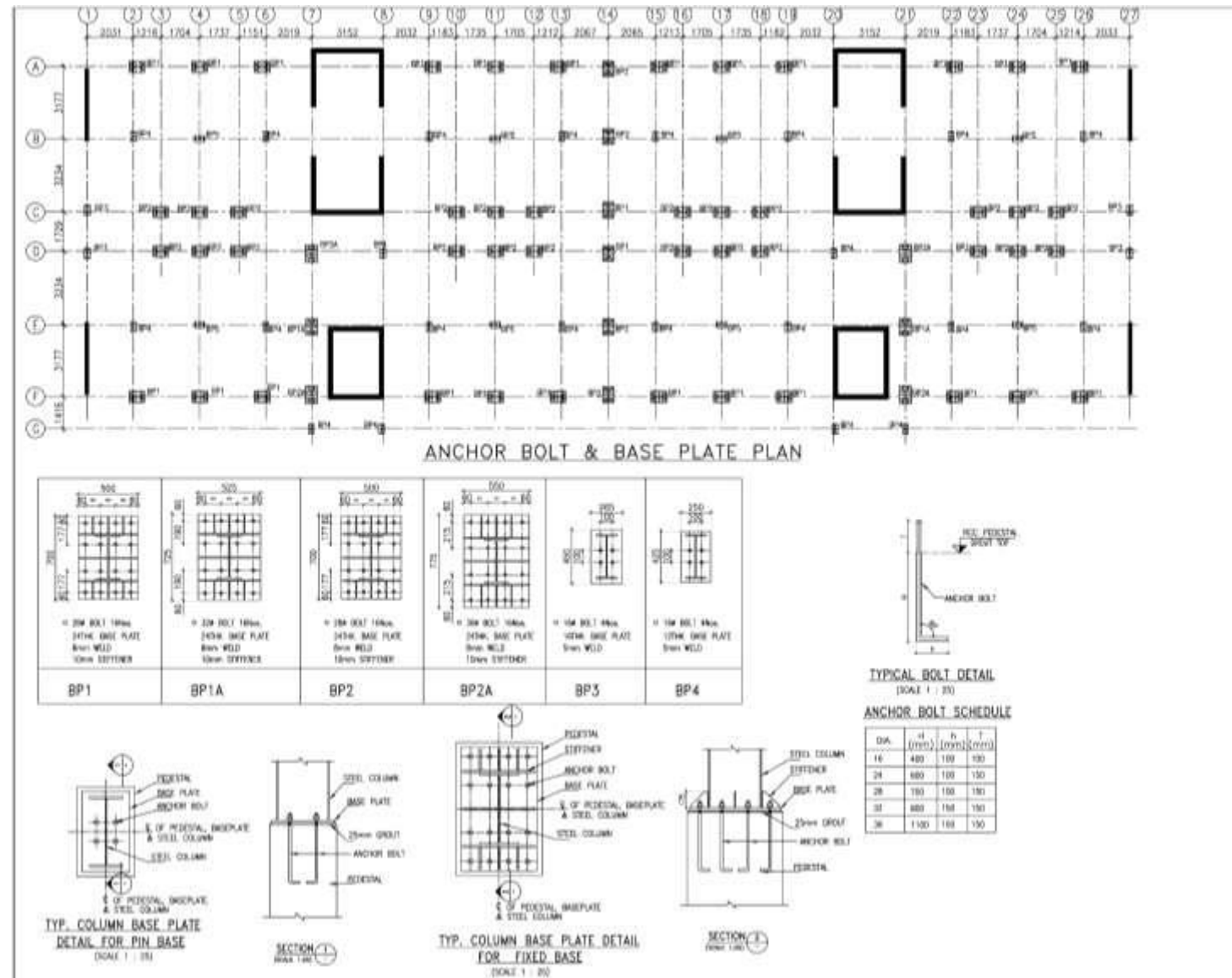
# FOUNDATION



- Fixing of anchor bolts with templates over which factory made built up columns with base plate will be erected.

# FOUNDATION

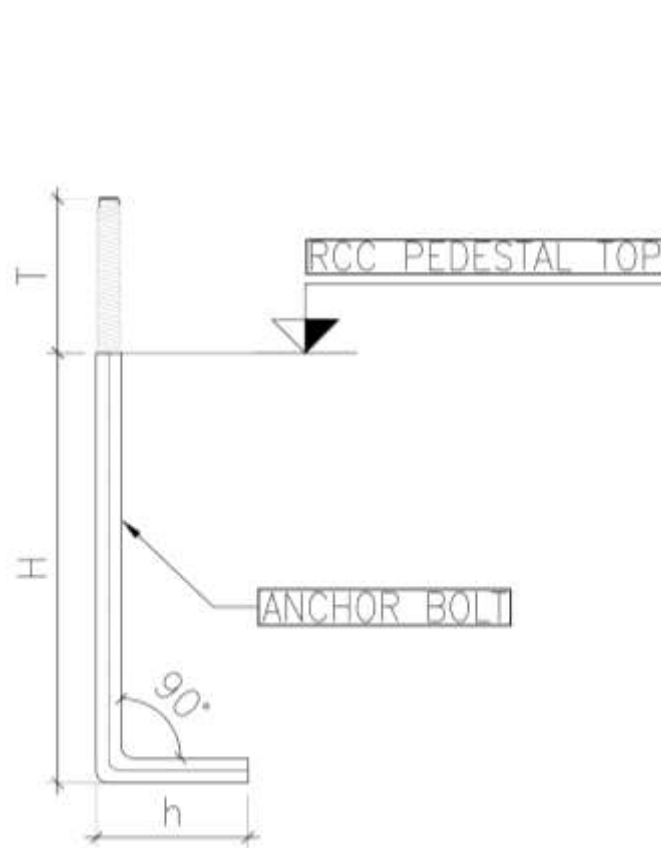
## Anchor Bolt & Base Plate Plan





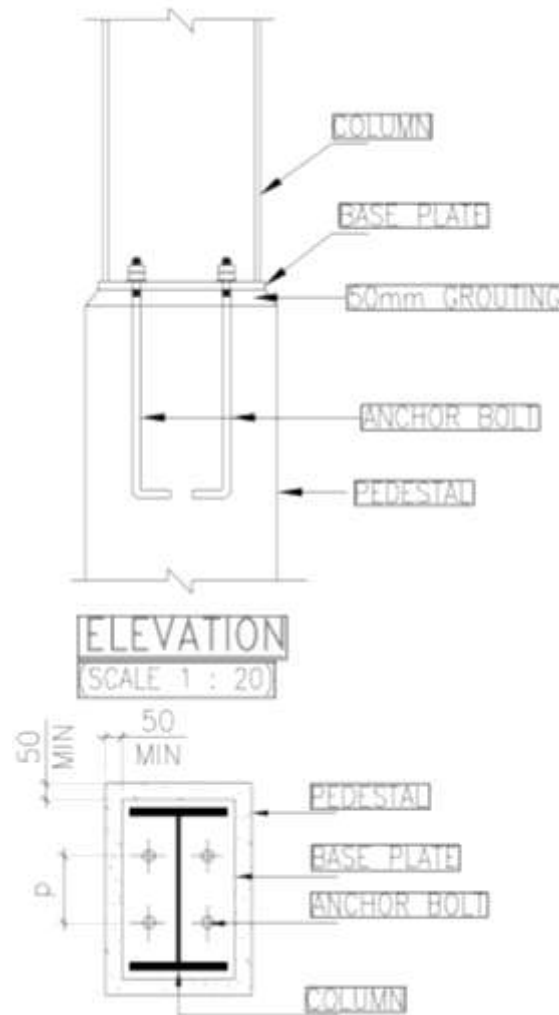
# FOUNDATION

- Connection details of built up steel column at plinth level (Stilt) with foundation (plinth beam)



a) Typical anchor bolt detail

Anchor bolt is inserted below plinth level upto height  $H$  and projected above plinth up to height  $T$



b) Typical base plate detail

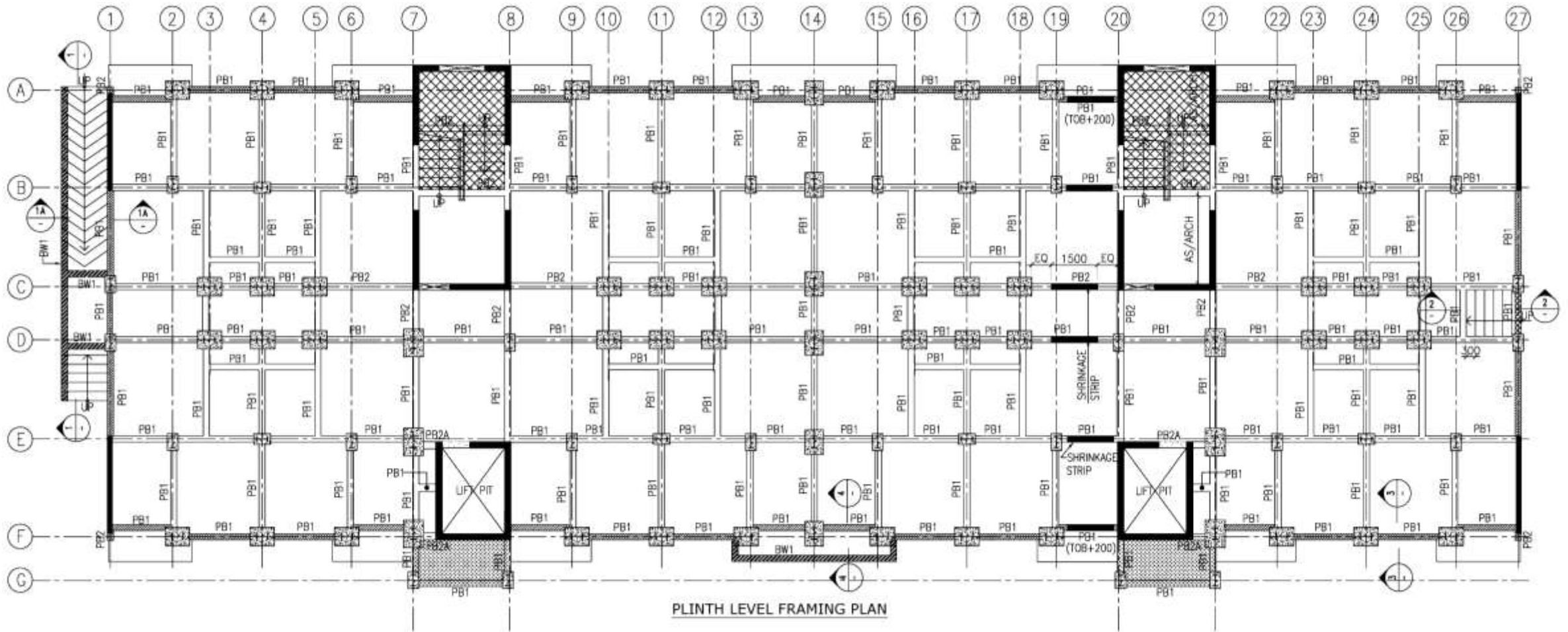
The built up steel I column is being fixed with anchor bolts and base plate

Dia (mm)	H (mm)	h (mm)	T (mm)
16	400	100	100
24	500	100	150
28	700	100	150
32	900	150	150
36	1100	150	150

Anchor bolt schedule



# FOUNDATION



- On concrete pedestal, plinth beam are casted in M25 concrete and backfilling is done.

# FOUNDATION



- The project starts with layout and marking of piles on field.
- After the layout at site, the boring of piles is undertaken with the help of Hydraulic Rigs. The depth of the borehole is 30m from NGL and diameter of pile is 600 mm. Total number of piles in the project is approx. 1750.



# FOUNDATION



- Steel Cages with helical reinforcement are prepared at site and inserted in the pile holes.



# FOUNDATION



- After flushing of bore hole with bentonite slurry, pouring of M 30 Grade concrete through trimming pipe in piles is undertaken.
- Laying of Raft in M30 concrete as per the structural design with reinforcement is to be completed in concrete above the piles.



# FOUNDATION





# FOUNDATION





# FOUNDATION





# FOUNDATION



Bending of Reinforcement bars for insertion into raft



# FOUNDATION



PCC for raft



# FOUNDATION



Curing of PCC



# FOUNDATION



Placing of Reinforcement for raft



# FOUNDATION



Placing of Reinforcement for raft



# FOUNDATION



Reinforcement and casting of stub-columns on raft



# FOUNDATION



Reinforcement and casting of stub-columns on raft

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# FOUNDATION



Reinforcement and casting of stub-columns on raft



# FOUNDATION



Reinforcement and casting of stub-columns on raft



# FOUNDATION



Reinforcement for plinth beam and placing of templates for starting of PEB structure



# FOUNDATION



RCC shear wall construction for lift and staircase



# FOUNDATION



Fixing of foundation bolts for base plates



# FOUNDATION

## Concrete & Reinforcement Steel Specifications

Item	Concrete Grade
Piles, raft, shear wall	M30
Plinth beam, Grade slab, Pedestals, Water tank, Sewage Treatment Plant (STP)	M25

- Mix design for concrete and all Concrete work shall conform to IS 456-2000 & Liquid retaining structures shall conform to IS 3370:2009
- Reinforcement Steels being used is TMT bars of Fe 500 as per IS 1786-2008.

# FOUNDATION

## Concrete mix design M25 and M30 (IIT Delhi)

Amrit Cement											
Concrete Grade	Water	Cement	Fine Aggregate		Coarse Aggregate		Plasticizer	Slump		Comp. Strength	
			Zone-IV	Zone-II	10mm	20mm		Initial	After 1 hour	7 days	28 days
M-30	165	387	217	506.4	434	651	1.25%	170	145	31.63	40.89
M-25	170	347	219.4	512	439	658	1.00%	155	120	24.52	34.52

Dalmia Cement											
Concrete Grade	Water	Cement	Fine Aggregate		Coarse Aggregate		Plasticizer	Slump		Comp. Strength	
			Zone-IV	Zone-II	10mm	20mm		Initial	After 1 hour	7 days	28 days
M-30	165	387	217	506.4	434	651	1.25%	175	155	33.63	41.7
M-25	170	347	219.4	512	439	658	1.00%	150	130	23.55	33.93

28 days Target Strength: M30- 38.25MPa  
28 days Target Strength: M25- 31.65MPa



# Dynamic Load Test





# Batching Plant



To bring resource efficiency, optimization of building materials and for quality control, a computerized batching plant has been established at site.

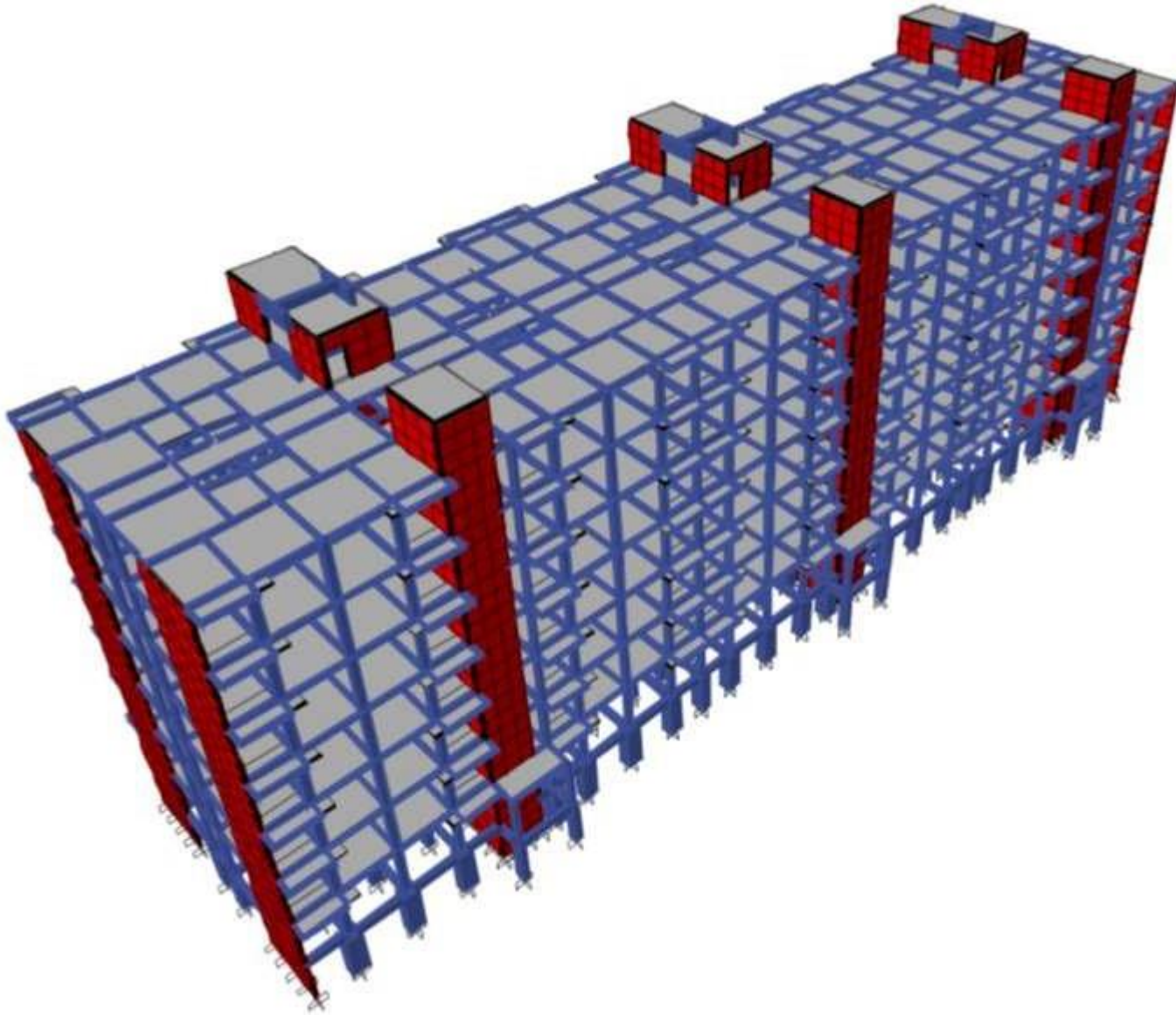


# Concrete Testing



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.

# STRUCTURAL SYSTEM



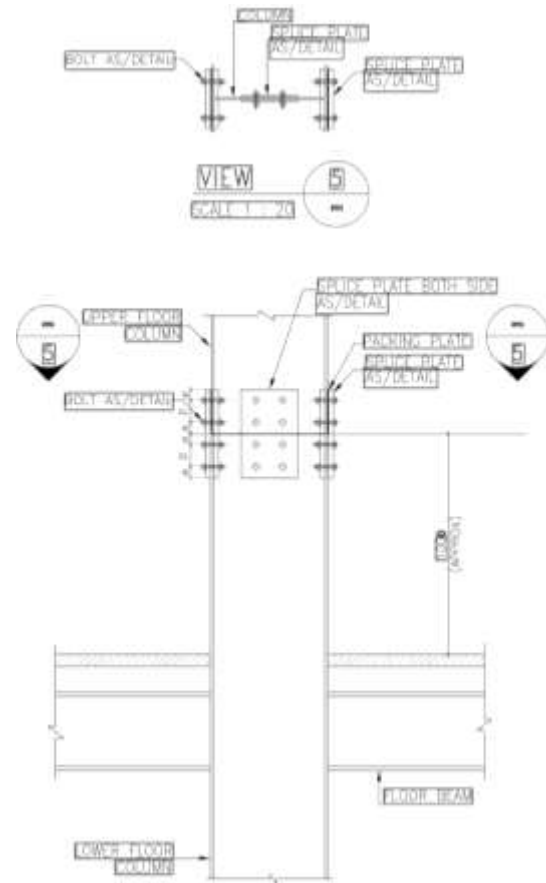
In the present lecture, the structural system and other details are being explained through drawings, sketches and text.

The work on super-structure is yet to start and actual on-ground picture will be covered subsequently.



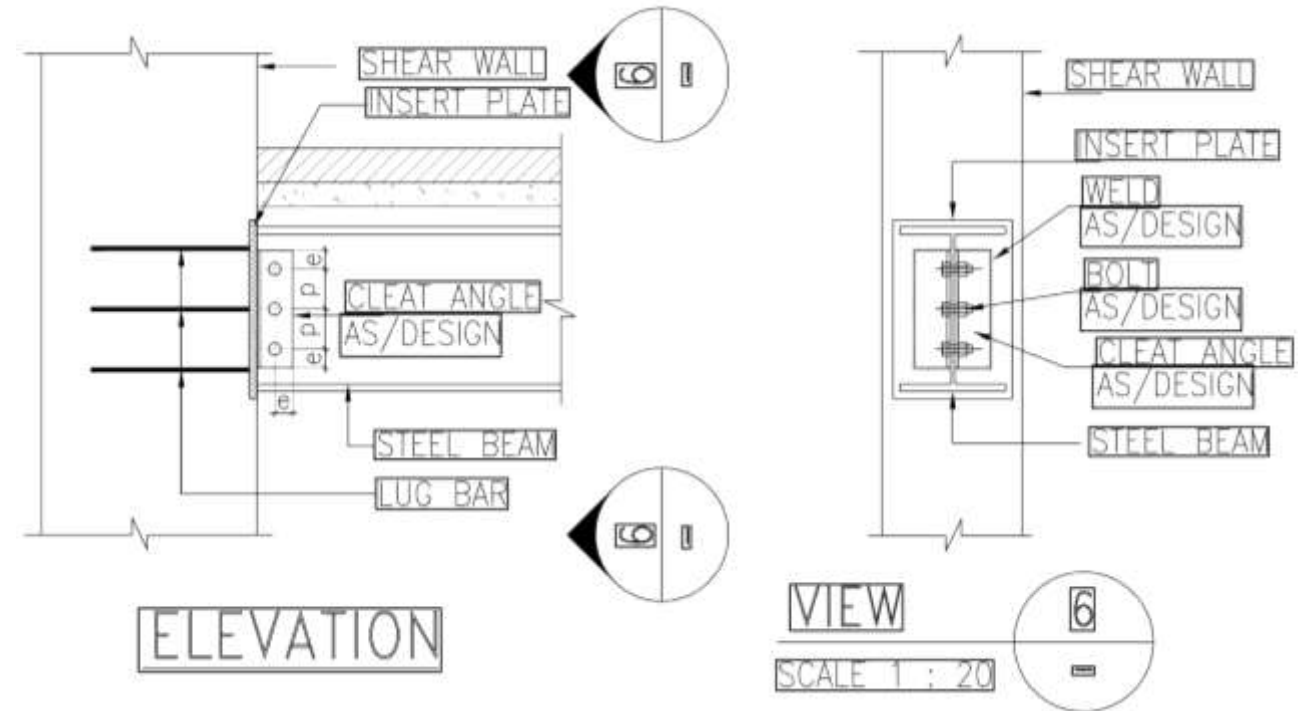
# STRUCTURAL SYSTEM

## ■ Column-Column Connections



### a) Column Splice detail

Columns are being spliced through nut & bolts connection along with plates both in web and flange portion

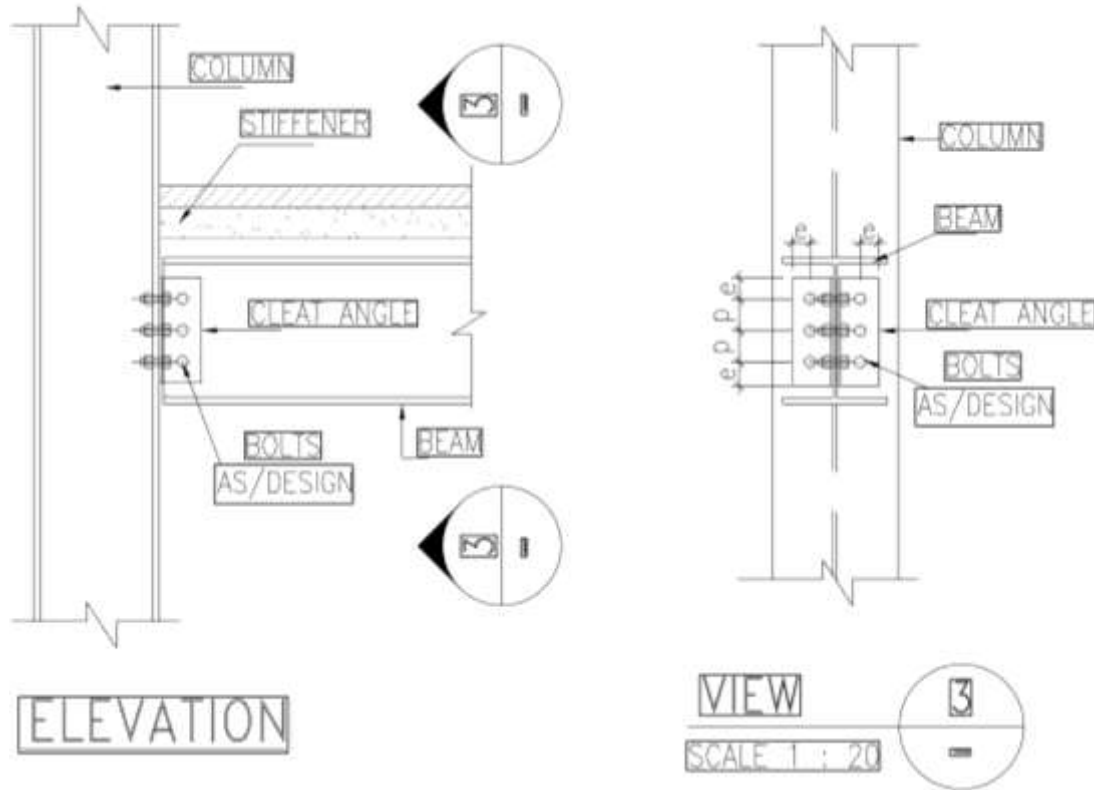


### b) Shear wall to steel beam connection

Insert plate along with lug bar are cast during the casting of shear walls and steel beam is connected to the wall with bolted connection through insert plate

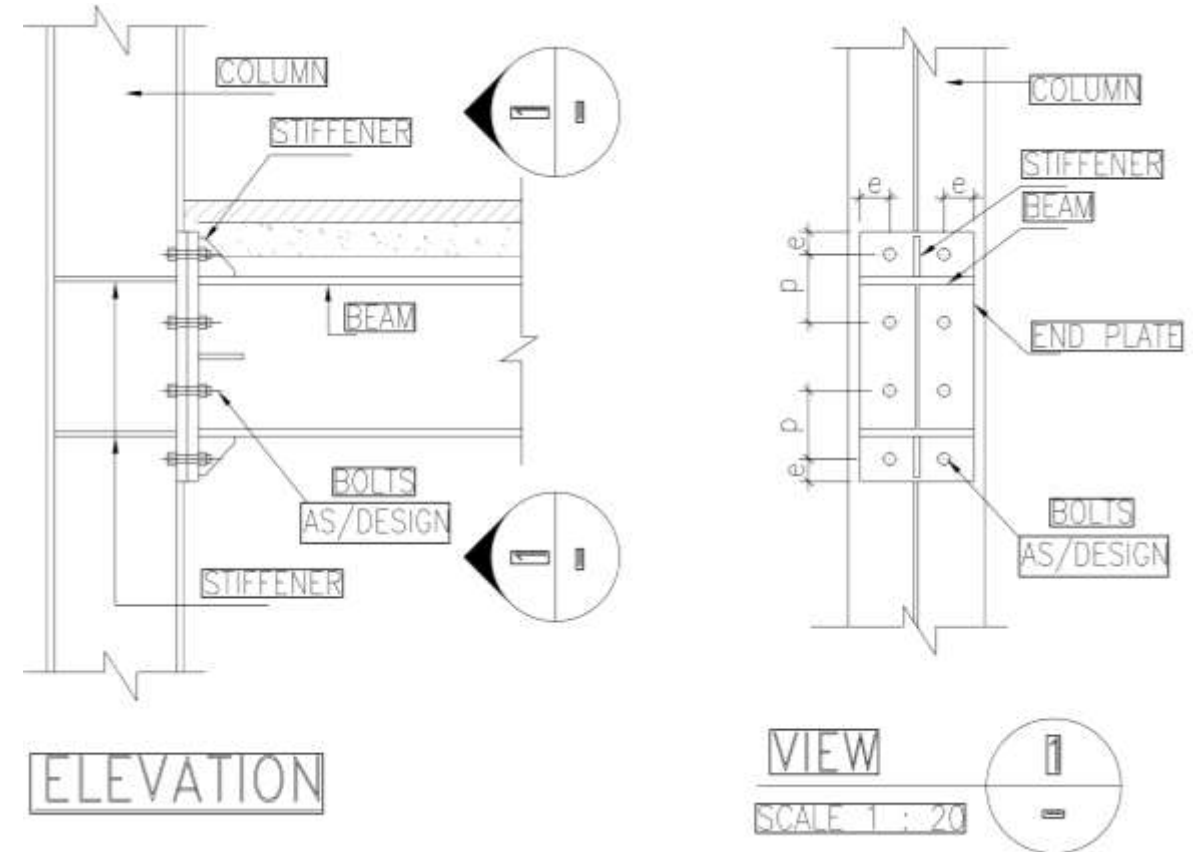
# STRUCTURAL SYSTEM

- Typical beam column shear and moment connections



a) Typical beam to column flange shear connection

Steel beam is being connected to the column through cleat angle connected to the web portion of beam



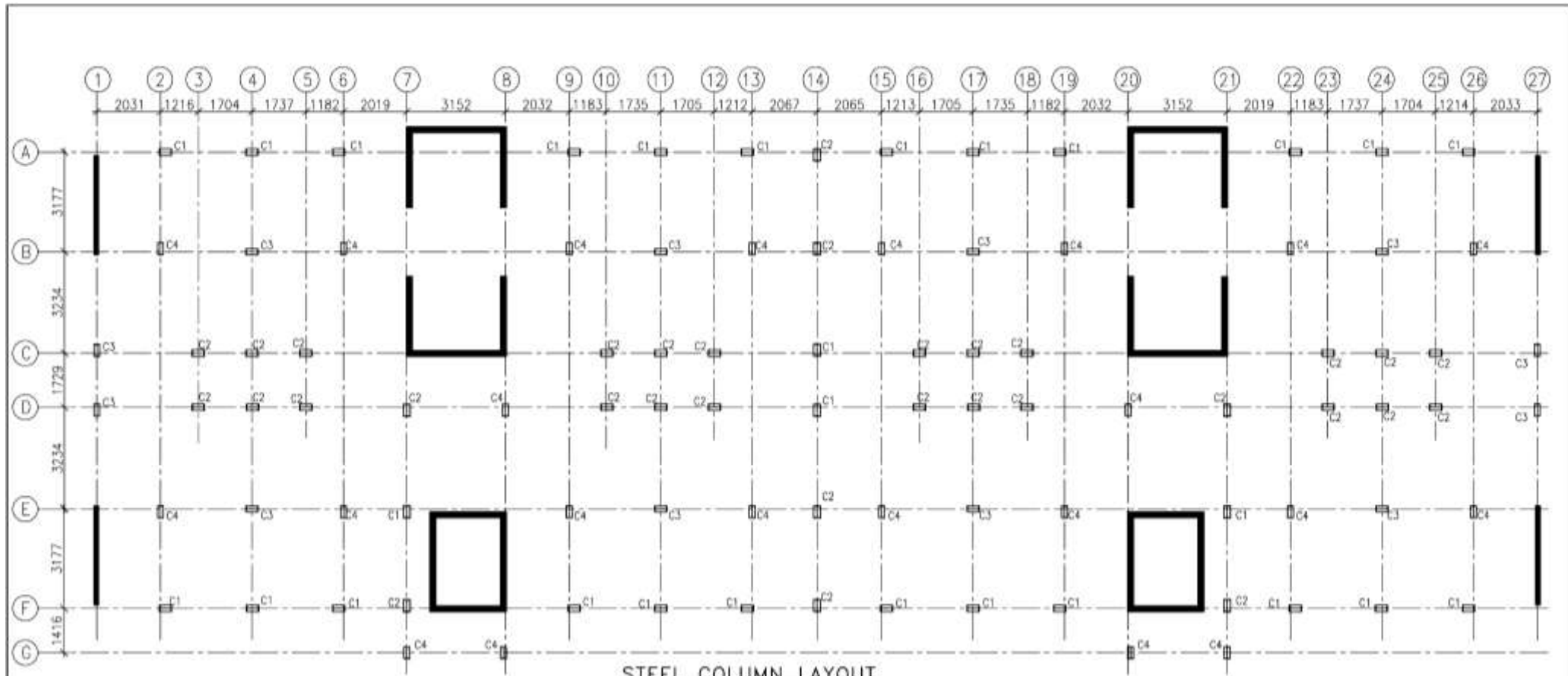
b) Typical beam to column flange moment connection

The steel beam is being connected to column through plates on flange & web portion



# STRUCTURAL SYSTEM

- Steel column layout in superstructure



STEEL COLUMN SCHEDULE

COLUMN MKG.	GR TO 2nd FLOOR		2nd TO 4th FLOOR		4TH TO TERMINATION	
	WEB	FLANGE	WEB	FLANGE	WEB	FLANGE
C1	350x10	200x16	350x10	200x16	350x10	200x16
C2	350x10	200x16	350x10	175x16	350x8	175x16
C3	350x8	175x12	350x8	175x10	350x6	175x10
C4	350x8	175x10	350x6	175x10	350x6	175x10



# STRUCTURAL SYSTEM





# STRUCTURAL SYSTEM



Erection of PEB structure

# STRUCTURAL SYSTEM



Erection of steel columns & beams



# STRUCTURAL SYSTEM



Erection of steel columns & beams



# STRUCTURAL SYSTEM



Erection of LGSF wall panels



# STRUCTURAL SYSTEM

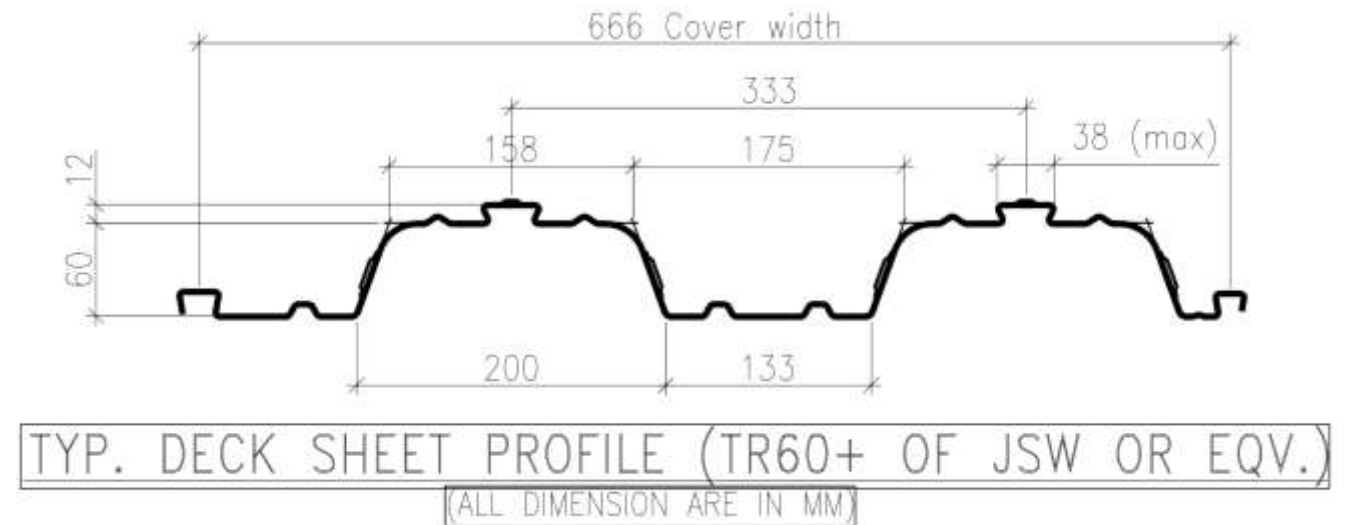


Erection of LGSF wall panels

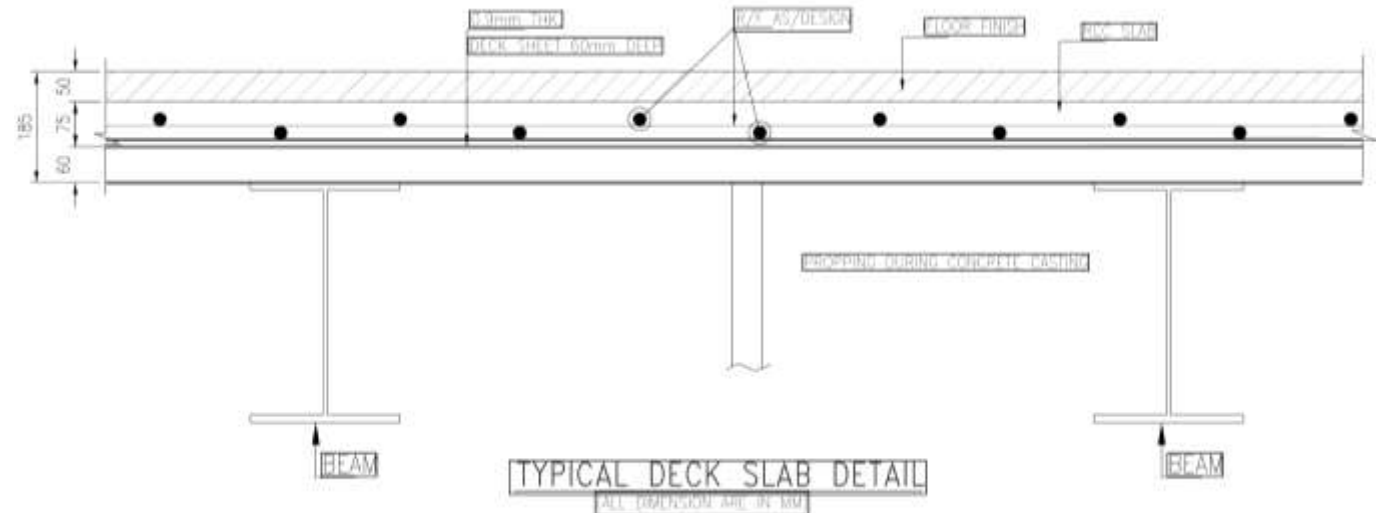
# FLOORS

- Floor slab details : Deck slab

- After erection of steel beams and column (PEB Structure), steel deck sheet of thickness 0.9 mm are placed with required bearing on the beams.
- Concrete screed of 75 mm is poured on the deck sheet in M25 with reinforcement as per structural design.
- Structural design for reinforcement is as per IS 456-2000.
- Generally, nominal reinforcement is provided in concrete screed of deck slab to take care of shrinkage & cracking.



a) Typical deck sheet profile

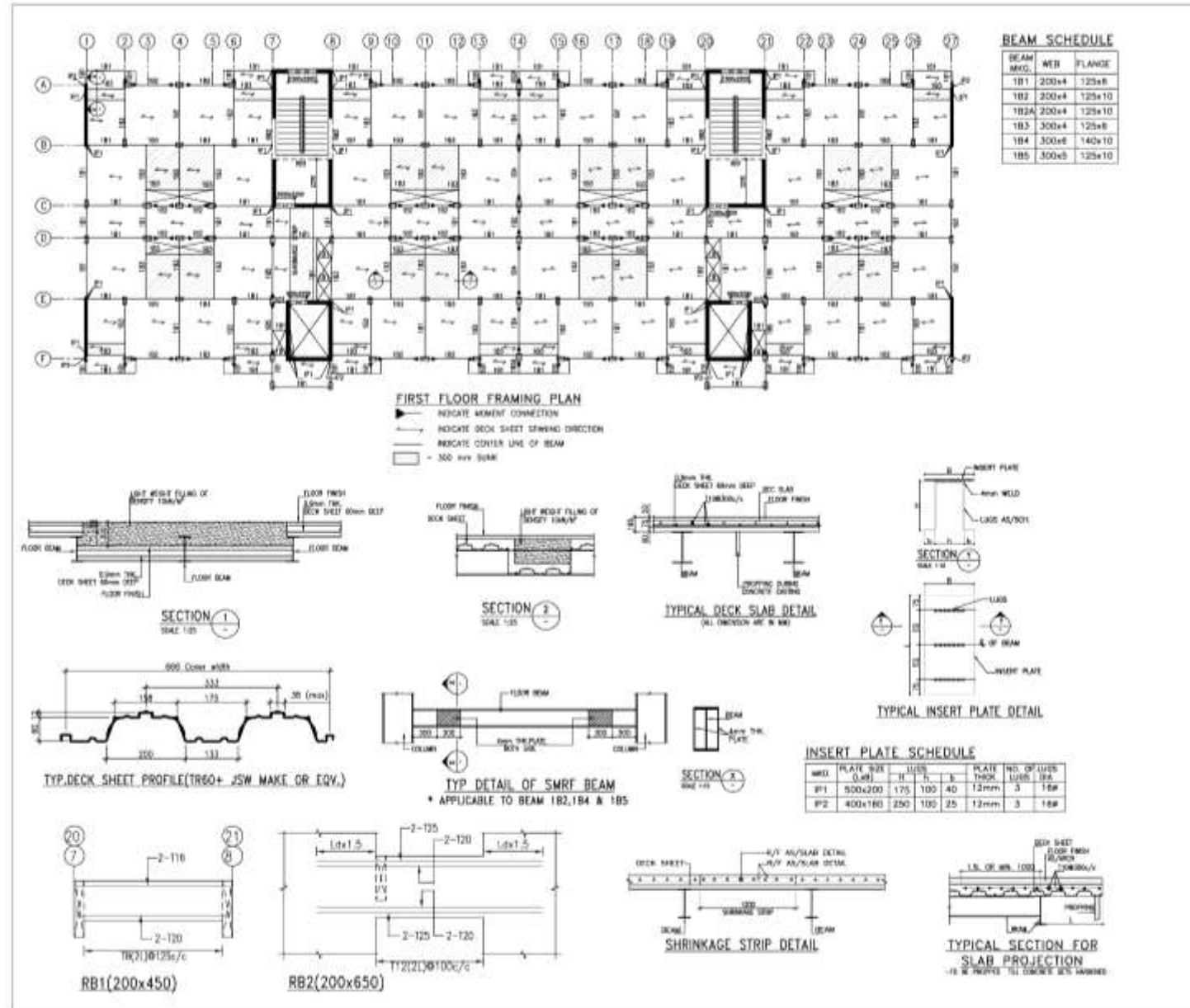


b) typical deck slab detail



# FLOORS

## ■ Typical Floor Framing Plan







Placing of deck slab and reinforcement





Screed concrete on deck slab



# WALL PANELS

## Construction & Installation Process with LGSF

Construction is done in a following sequential manner:

1. Transportation of LGSF and Steel Sections as per the design to the site.
2. Erection of built up sections for structural frames on RCC foundations using cranes and connections as designed (connection details already explained)
3. Installation of decking sheets on structural frame at floor level followed by pouring of concrete screed with nominal reinforcement.
4. Fabrication of LGSF frames with the connecting screws at site as per design.
5. The wall position shall be marked on the floor and the wall structure placed on the marking. After completing the same, straightness, square and the levels shall be checked by magnetic spirit level. The bottom track shall then be connected with the floor using anchor bolts at the required spacing.
6. The precast concrete panels shall be fixed on the LGSF wall structure on studs and tracks by using metal screws. The panels shall be fixed first on the outer side of the LGSFS wall. Electrical/plumbing pipes/conduits shall be fixed as designed and cut-outs for services shall be marked on the panel.
7. Self-compacting concrete of required grade/light weight concrete shall be mixed using concrete mixing machine and then pumped into the gap between two panels using a special pumping unit.
8. Upon installment of wall panels, flooring and ceiling, the finishing work is executed.





# Wall Panels

- Typical view of LGSF panels and steel frame construction



- The plumbing and electrical services are incorporated before laying of light weight concrete between the panels





# 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.



# OTHER 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.





Thank You