LIGHT HOUSE PROJECT: LIVE LABORATORIES

WEBINAR SERIES: e-learning & webcasting of LHPs for TECHNOGRAHIS

March – November 2022

An 'e-Learning series and webcasting of LHP's construction process' to widespread the knowledge about the technology, construction process, sustainability, and mass cum fast construction to TECHNOGRAHIs.

Webinar Session #12 at Light House Project Agartala, Tripura

Date: 29.07.2022, Friday Time: 1500

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

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

सत्यमेव जयते

Ministry of Housing and Urban Affairs
Government of India

स्वच्छ भारत
एक कदम स्वच्छता की ओर

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

CONTENTS

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

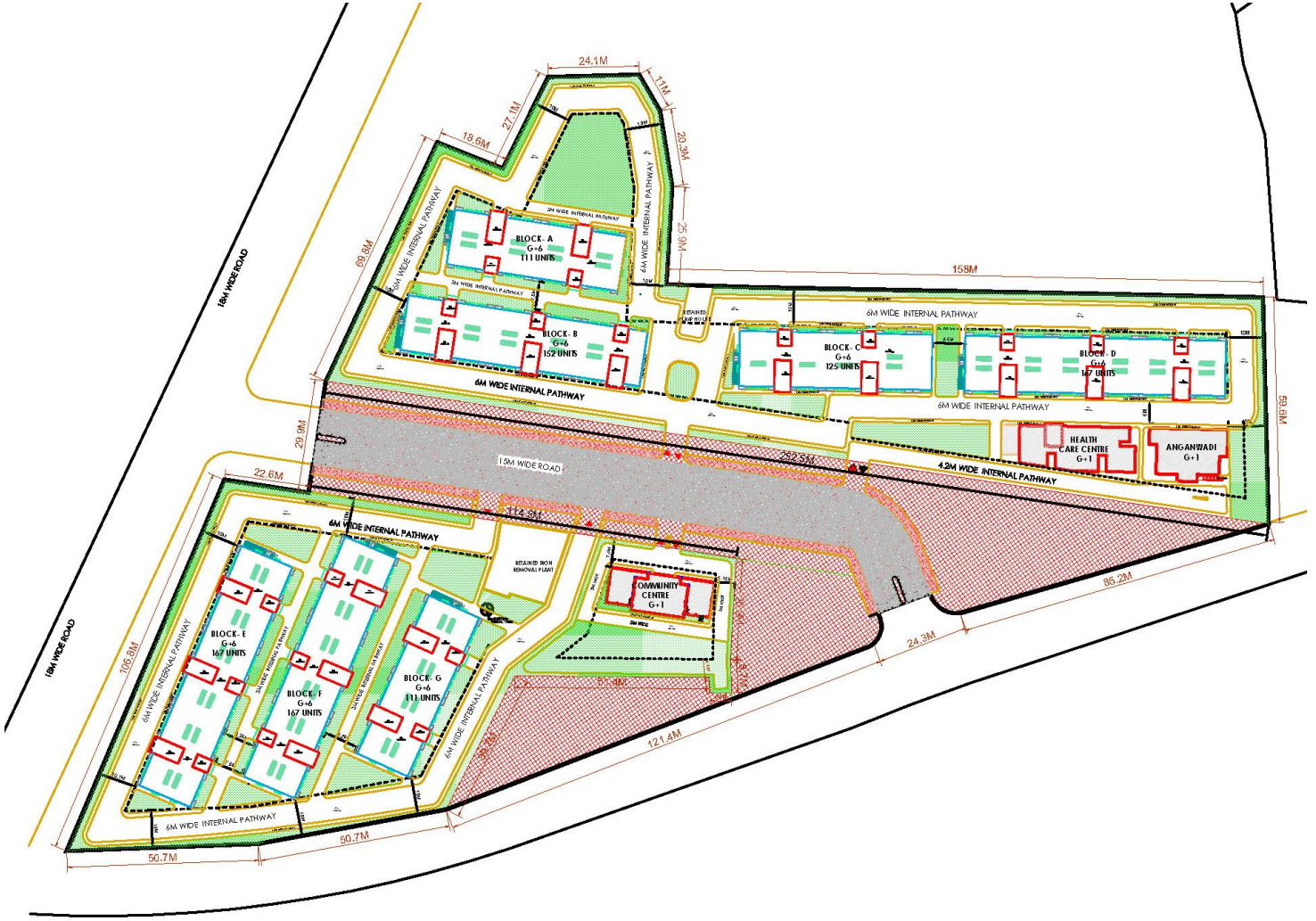
Global Housing Technology Challenge - India (GHTC-I)

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

- 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

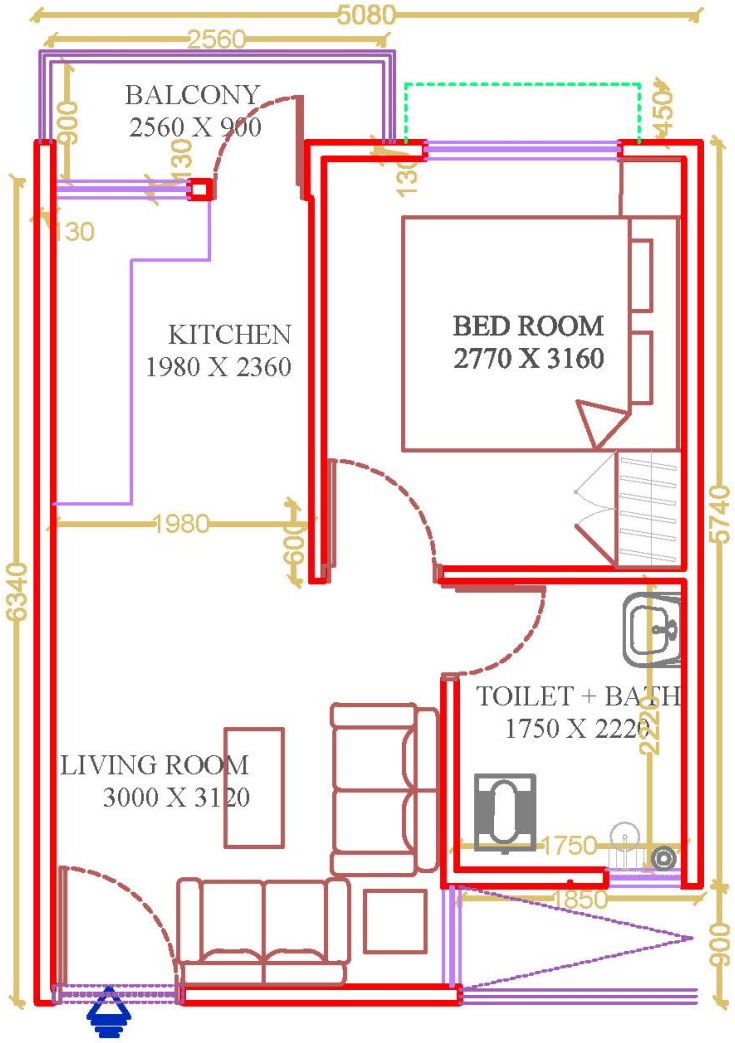


Typical floor plan

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

- 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.

- Typical Dwelling Unit plan



TYPICAL UNIT PLAN
(SCALE - 1:20)

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

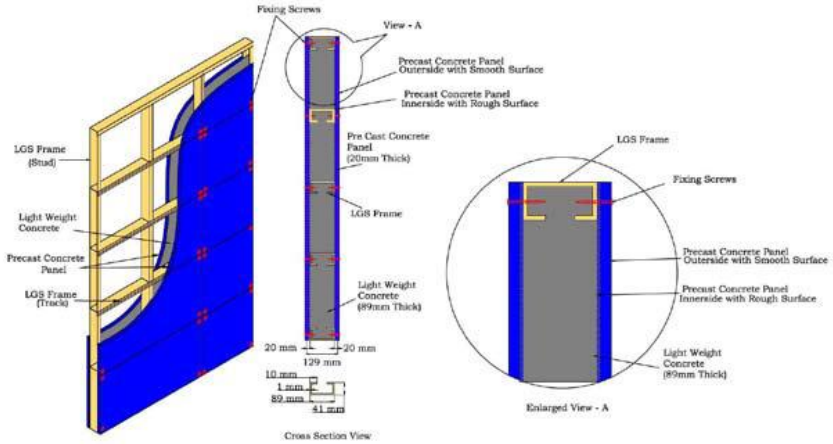
Technology being Used

Load bearing Structure

RCC Framed Structure

Steel Frame Structure

Light Gauge Steel Framed Walling System

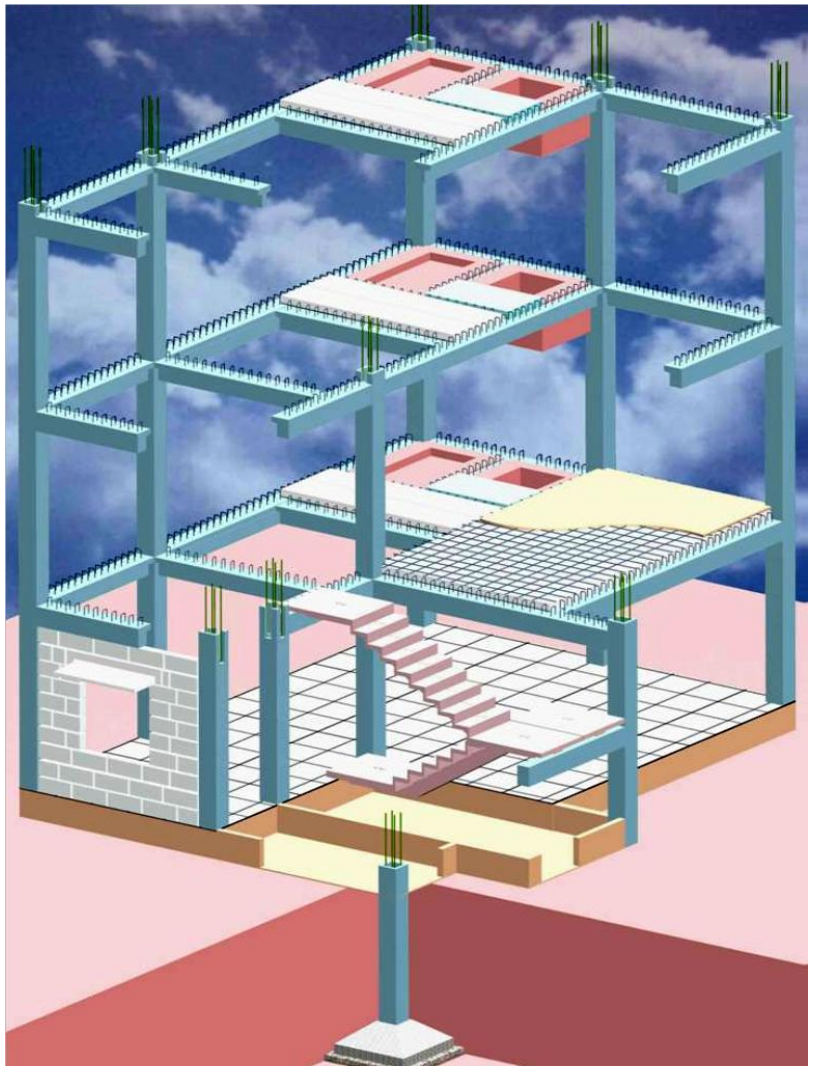


Light Gauge Steel Framed System (LGSF) is based on factory made galvanised light gauge steel components. The components/sections are produced by cold forming method and assembled as panels at site forming structural or non structural steel framework of a building of varying sizes of wall and floor.

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 system

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

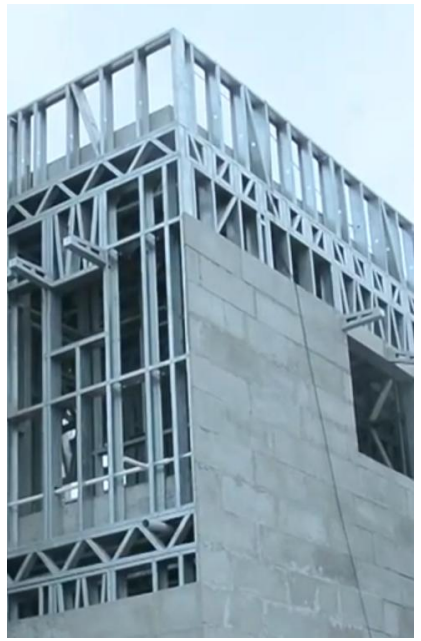
Floor/ Roof Slab

- 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.



Receiving GI Coils, Inspection and Store

Loading the coils in Decoiler

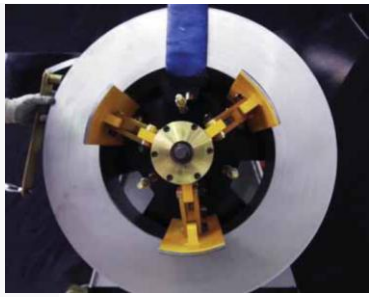
Loading NC files and Operation of computerized Roll forming machine.

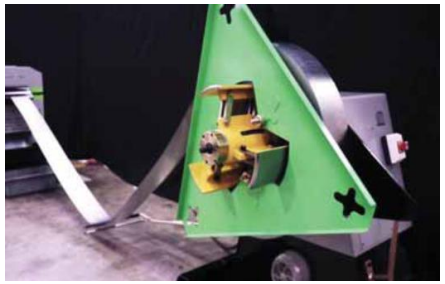
Production of frames, Marketing & Labeling

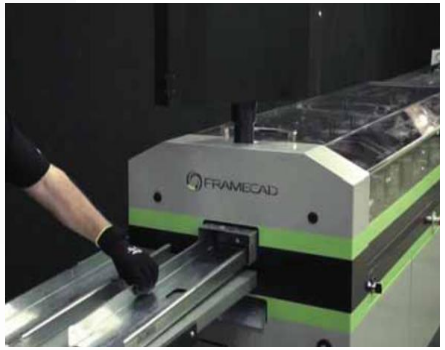
Inspection of frames.

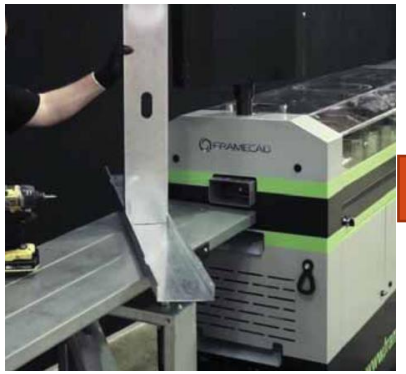
Packing of frames wall wise Marking & Labeling

Dispatch to construction site.









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

Light Gauge Steel Frame System

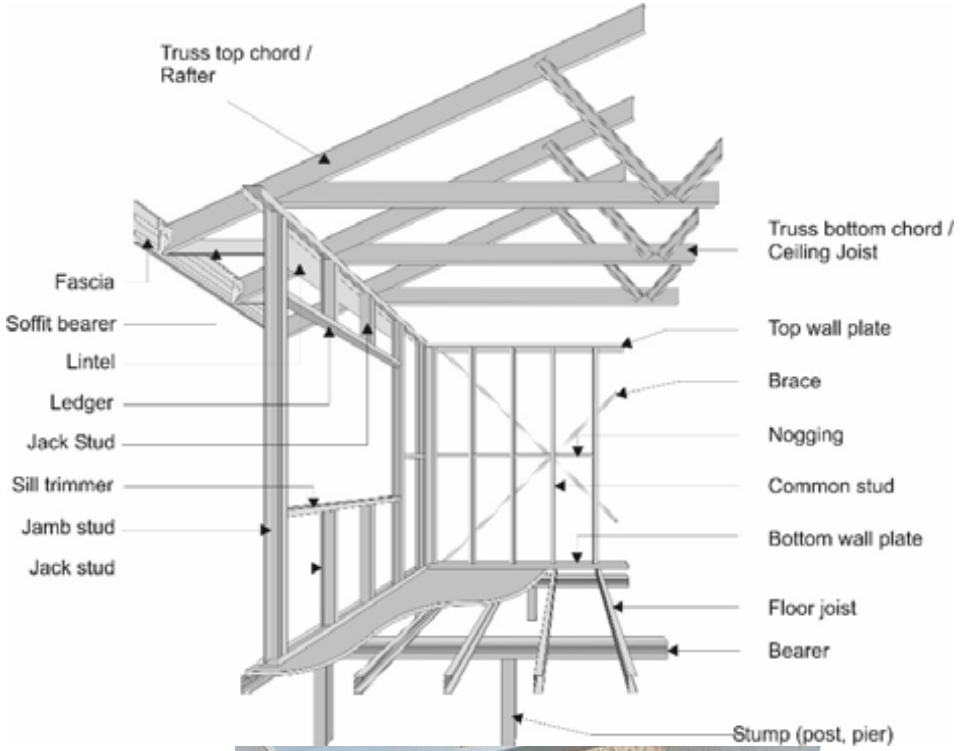
- Photos of manufacturing plant

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.

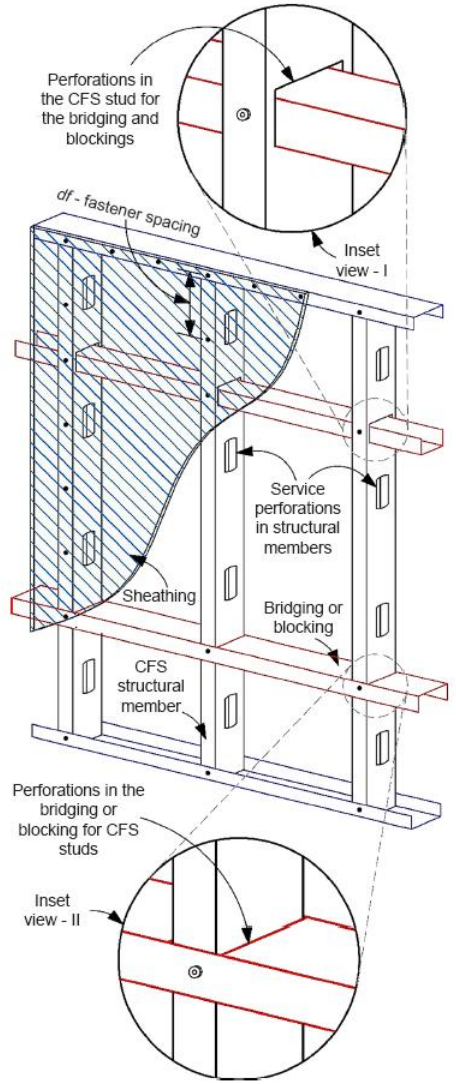
Wall Frame…contd.

- 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.

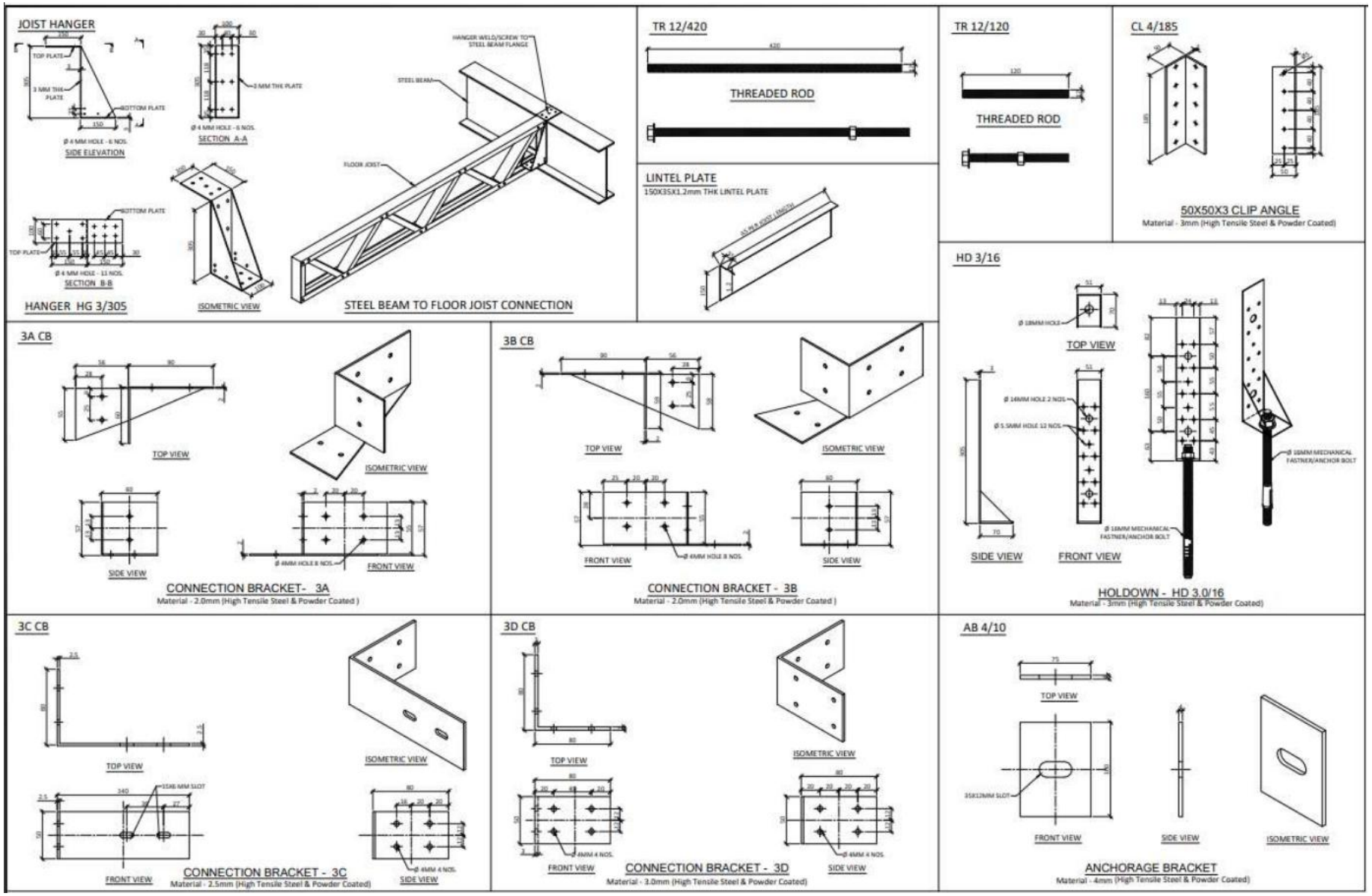
- Cladding of LGSF Panels
  - 20mm thick Precast Concrete (M20) Panels (PCP) are used as facing sheets for construction of walls on both sides. Metal moulds, concrete mixing machine and vibration tables are used for manufacturing the panels at onsite or offsite.
  - The panels are designed to withstand 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^3 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 mini circuit 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

Design Basis

- Structural Frame as RC Steel Hybrid structure
  - Sub-structure up to the plinth level in RCC
  - Superstructure is wall using HR Steel built-up I sections with lift and staircase wells in RCC as shear wall
- Vertical Safe Design Load: 70 MT, Lateral Safe Design Load: 2.2MT
- Pile foundation as per IS-2911(Part1):2010
- Raft foundation as per IS-2950 (Part-1)-1981 (reaffirmed 2008)
- Wind speed: Very high damage risk zone with basic wind speed (V_b=55m/sec)
- 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.

BMTPC : Vulnerability Atlas- 3rd Edition; Peer Group, MoHUA; Map is Based on digitised data of SOI, GOI; Basic Wind Speed Map National Building Code: 2016; Cyclone Data, 1891-2015, IMD, GOI. Houses/Population as per Census 2011; *Houses including vacant & locked houses. Disclaimer: The maps are solely for thematic presentation.

Design Basis

- Earthquake : Zone-V as per Seismic Zoning Map of India IS: 1893 (Part-1):2016
  - Designed as ductile RC structural walls and few special moment resisting frames in structural steel in both direction, as per Table 9 (iv) (d) of IS 1893 (Part I): 2016.
  - Zone factor 0.36 (As per Table 3-IS:1893-2016), Importance factor 1.2 (As per Table 8-IS:1893-2016), Response Reduction Factor 5 (As per Table 7-IS:1893-2016) and Damping Ratio 5%.
  - Design Horizontal Seismic Coefficient (A_h)

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

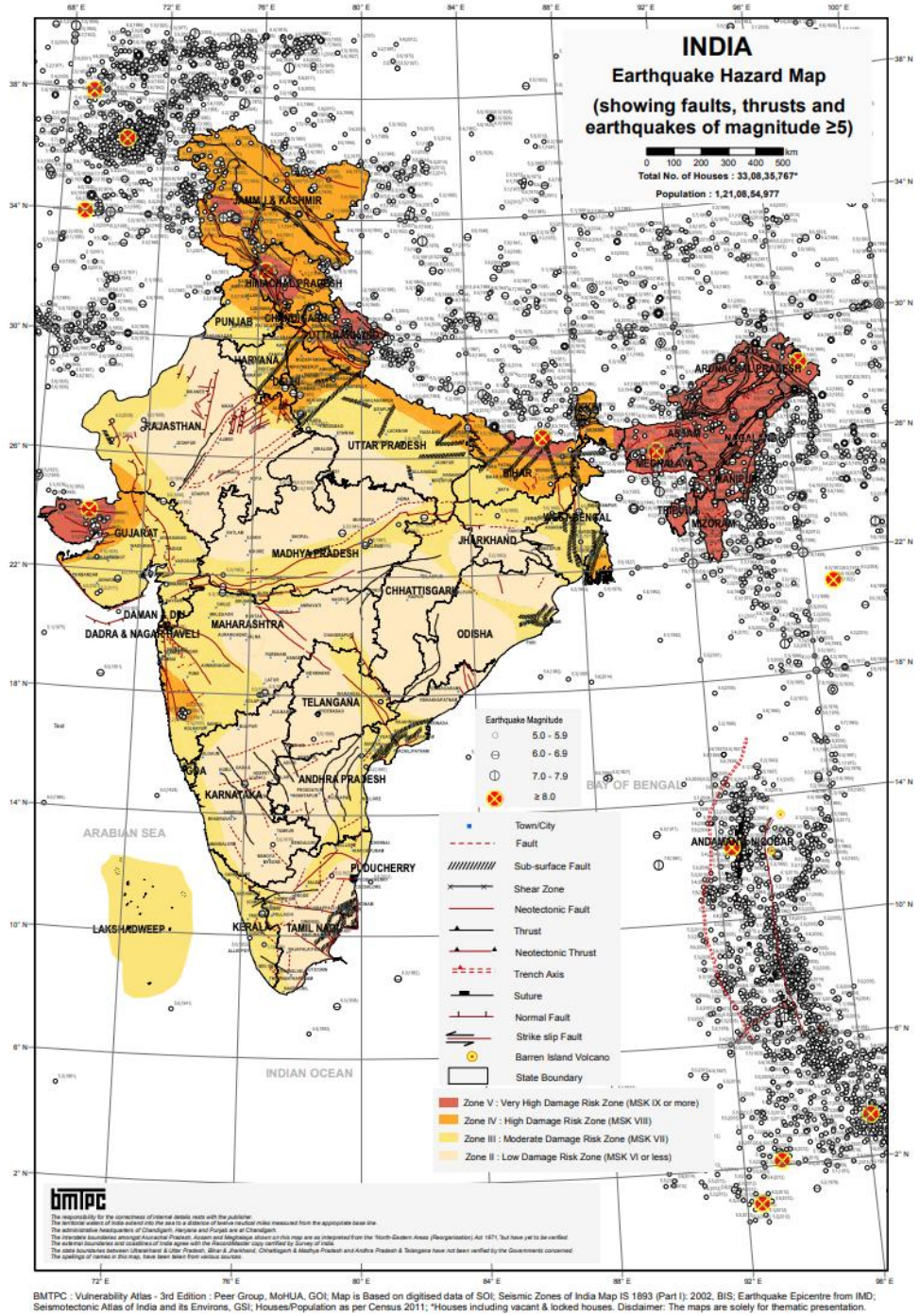
S_a/g is design acceleration coefficient for different soil types corresponding to natural period (T) of building

  - Design Lateral Force (V_B)

$$V_B=A_h.W$$

W is seismic weight of building

  - Linear dynamic analysis has been done to obtain the design lateral forces
  - Steel columns fixed for moment frames and pinned for ordinary frames at top of RC pedestal and support reaction at the location for sub-structure design. Some columns – beams frames as rigid joint frames to cater lateral loads in addition to gravity loads and other as pinned jointed frames to cater gravity loads only.
  - Rigid diaphragms in horizontal direction at floor levels as per Cl.7.6.4 of IS:1893(Part-1):2016.
- Design has been carried out as per IS 456-2000, IS 800-2007 and NBC-2016.



BMTPC : Vulnerability Atlas - 3rd Edition : Peer Group, MoHUA, GOI; Map is Based on digitised data of SOI; Seismic Zones of India Map IS 1893 (Part I): 2002, BIS; Earthquake Epicentre from IMD; Seismotectonic Atlas of India and its Environs, GSI; Houses/Population as per Census 2011; *Houses including vacant & locked houses. Disclaimer: The maps are solely for thematic presentation.

Design Standards

Loads

Is:875 (part-1)-1987 (reaffirmed 2018)	Code of practice for design loads (other than earthquake)for buildings and structures part 1 dead loads - unit weights of building material and stored materials (incorporating is:1911-1967)
Is 875 : part 2 : 1987 (reaffirmed 2018)	Code of practice for design loads (other than earthquake) for buildings and structures: part 2 imposed loads
Is 875 : part 3 : 2015	Design loads (other than earthquake) for buildings and structures - code of practice - part 3 wind loads
Is 1893: part 1 : 2016	Criteria for earthquake resistant design of structures - part 1 : general provisions and buildings

Design Standards

Structural Steel

Is 800 : 2007 (reaffirmed 2017)	General construction in steel - code of practice
Is 801 : 1975 (reaffirmed 2016)	Code of practice for use of cold formed light gauge steel structural members in general building construction
Is 806 : 1968 (reaffirmed 2017)	Code of practice for use of steel tubes in general building construction
Is 808 : 1989 (reaffirmed 2014)	Dimensions for hot rolled steel beam, column, channel and angle sections
Is 813 : 1986	Scheme of symbols for welding
18: 816-1969 (REAFFIRMED 1969)	CODE OF PRACTICE FOR USE OF METAL ARC WELDING FOR GENERAL CONSTRUCTION IN MILD STEEL
Is 1161:2014	Steel tubes for structural purposes
Is 2062:2011	Hot rolled medium and high tensile structural steel
Is 4000 : 1992 (reaffirmed 2017)	Code of practice for high strength bolts in steel structures
Is 4923:2017	Hollow steel sections for structural use — specification (second revision)
Is 11384 : 1985 (reaffirmed 2017)	Code of practice for composite construction in structural steel and concrete

Design Standards

RCC

Is 456 : 2000 (reaffirmed 2016)	Plain and reinforced concrete - code of practice
Is 3370 : part 1 : 2009 (reaffirmed 2019)	Concrete structures for storage of liquids - code of practice - part 1 : general requirements
Is 3370 : part 2 : 2009 (reaffirmed 2019)	Concrete structures for storage of liquids - code of practice - part 2 : reinforced concrete structures
Is 4326 : 2013 (reaffirmed 2018)	Earthquake resistant design and construction of buildings - code of practice
Is 5525 : 1969 (reaffirmed 2018)	Recommendations for detailing of reinforcement in reinforced concrete works
Is 1786 : 2008 (reaffirmed 2018)	High strength deformed steel bars and wires for concrete reinforcement - specification
Is 10262 : 2019	Concrete mix proportioning-guidelines
Is 13920 : 2016	Ductile detailing of reinforced concrete structures subjected to seismic forces - code of practice

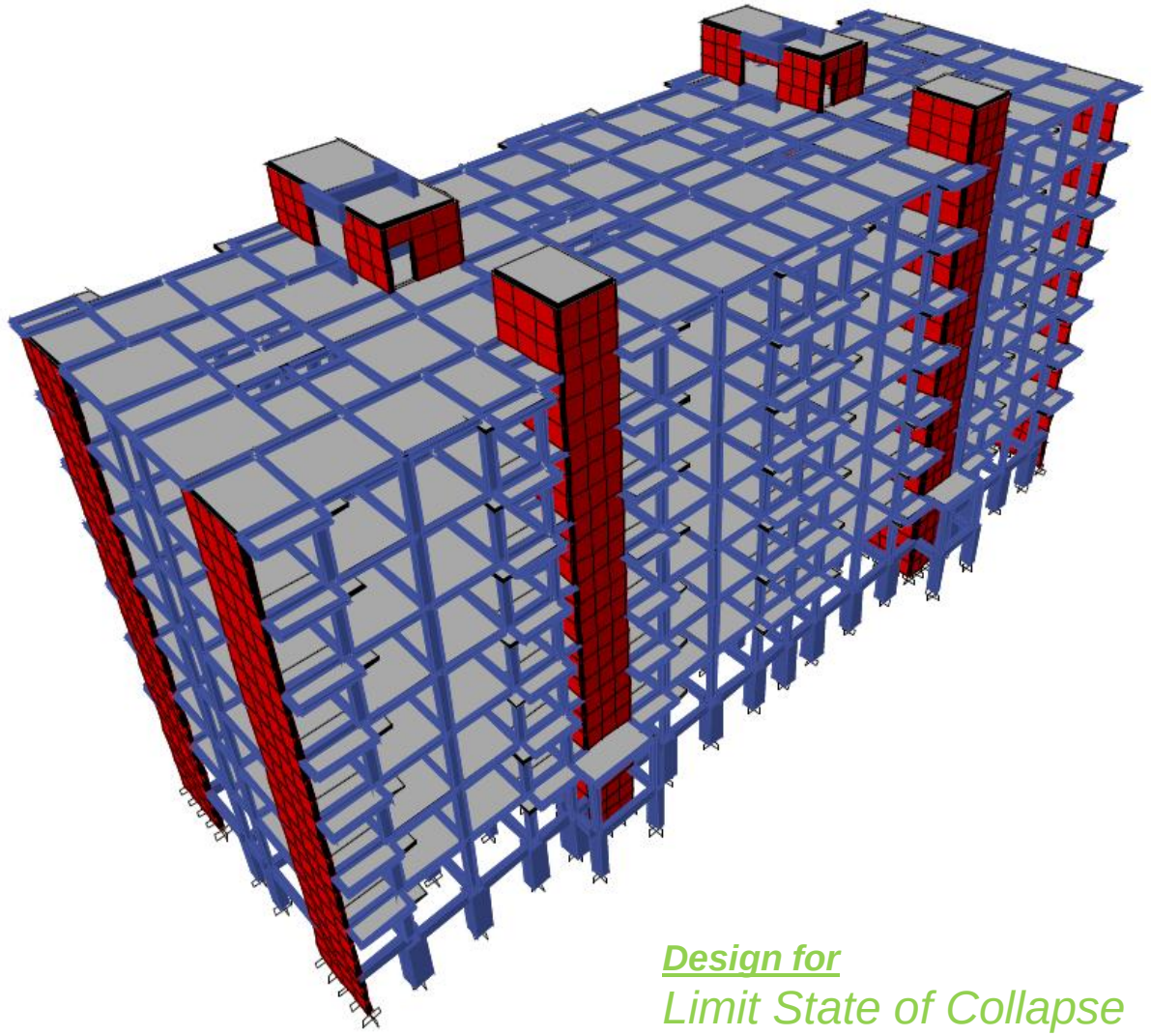
Design Standards

Foundation

Is 1080 : 1985 (reaffirmed 2016)	Code of practice for design and construction of shallow foundations om soils (other than raft, ring and shell)
Is 1904 : 1986 (reaffirmed 2015)	Code of practice for design and construction of foundations in soils: general requirements
Is 2950 : part 1 : 1981 (reaffirmed 2018)	Code of practice for design and construction of raft foundations - part 1 : design
IS 2911 (Part 1& 4) : 2013	Design and construction of pile foundations — code of practice
Is 2974 : part 5 : 1987 (reaffirmed 2018)	Code of practice for design and construction of machine: foundations part 5 foundations for impact machines other than hammers (forging and stamping press, pig breakers, drop crusher and jolter)
Is 8009 : part 2 : 1980 (reaffirmed 2015)	Code of practice for calculation of settlement of foundations: part 2 deep foundations subjected to symmetrical static vertical loading

STRUCTURAL ANALYSIS & DESIGN

- 3D Model of typical tower with PEB Structure



- 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.)

- 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

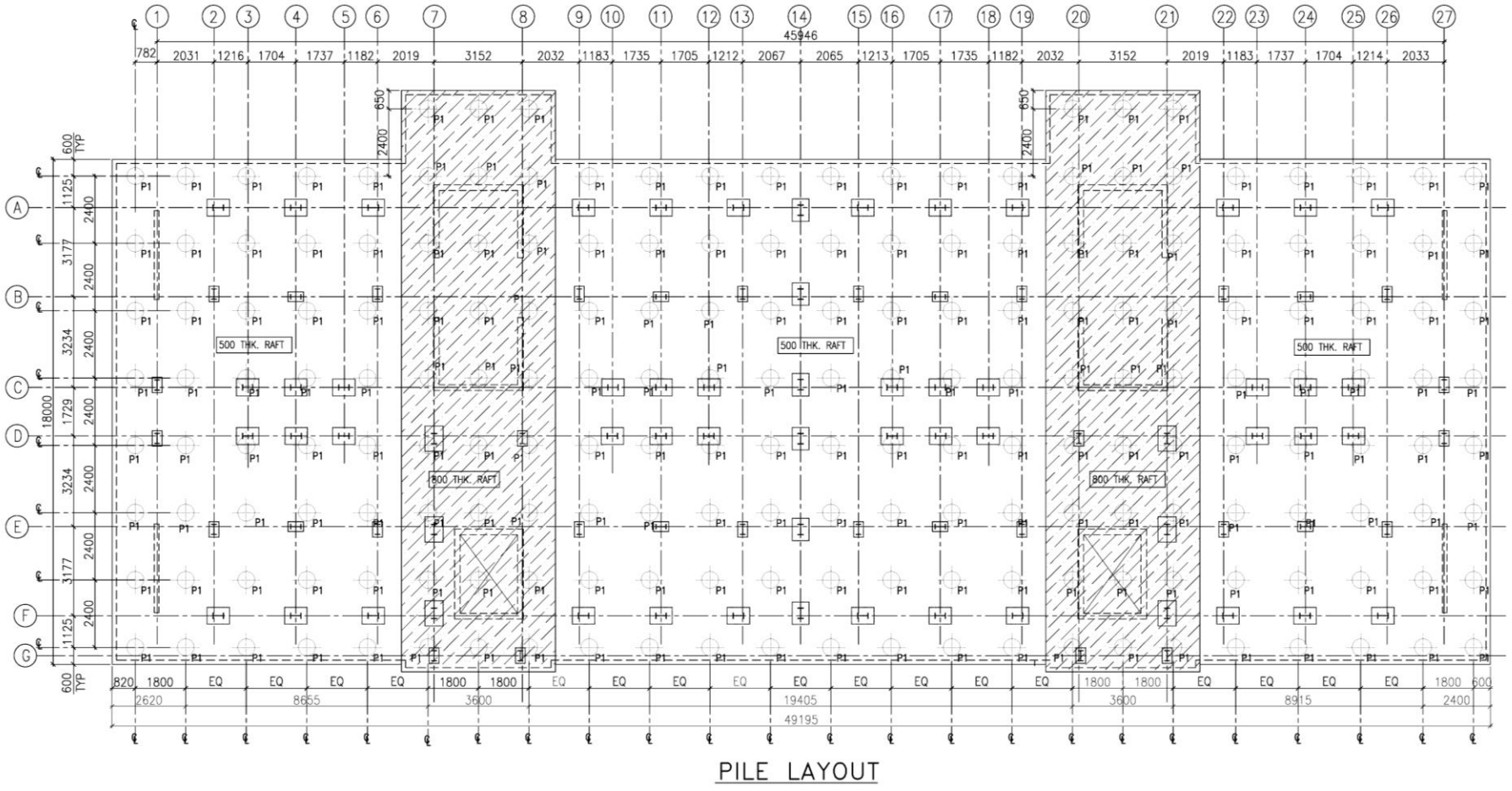
Limit State of Serviceability

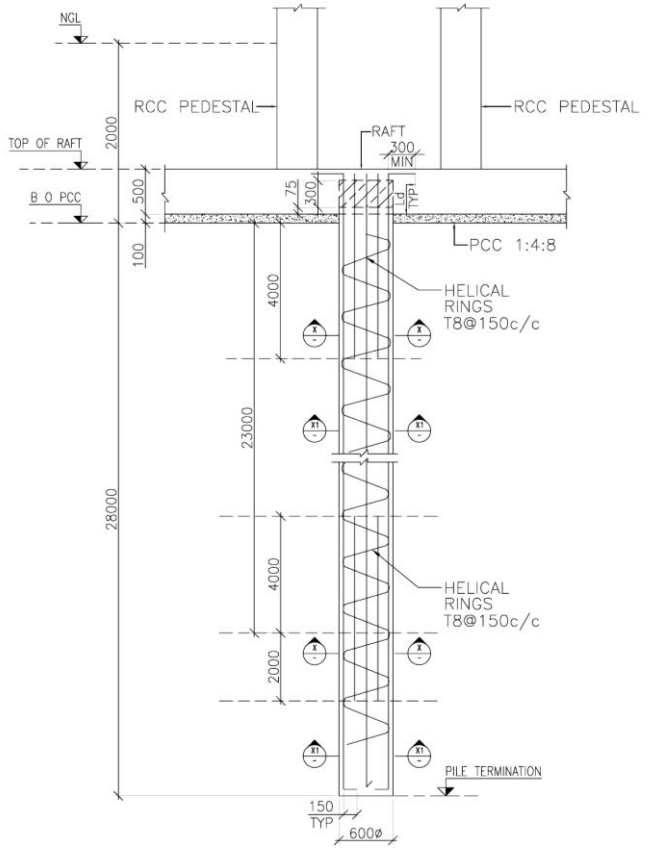
Construction Sequence

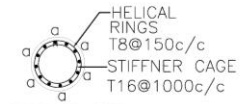
- Sub-Structure: Foundation
- Super-structure: Structural system
  Floors
  Wall Panels
- MEP: Plumbing & Electrical
- Finishing

FOUNDATION

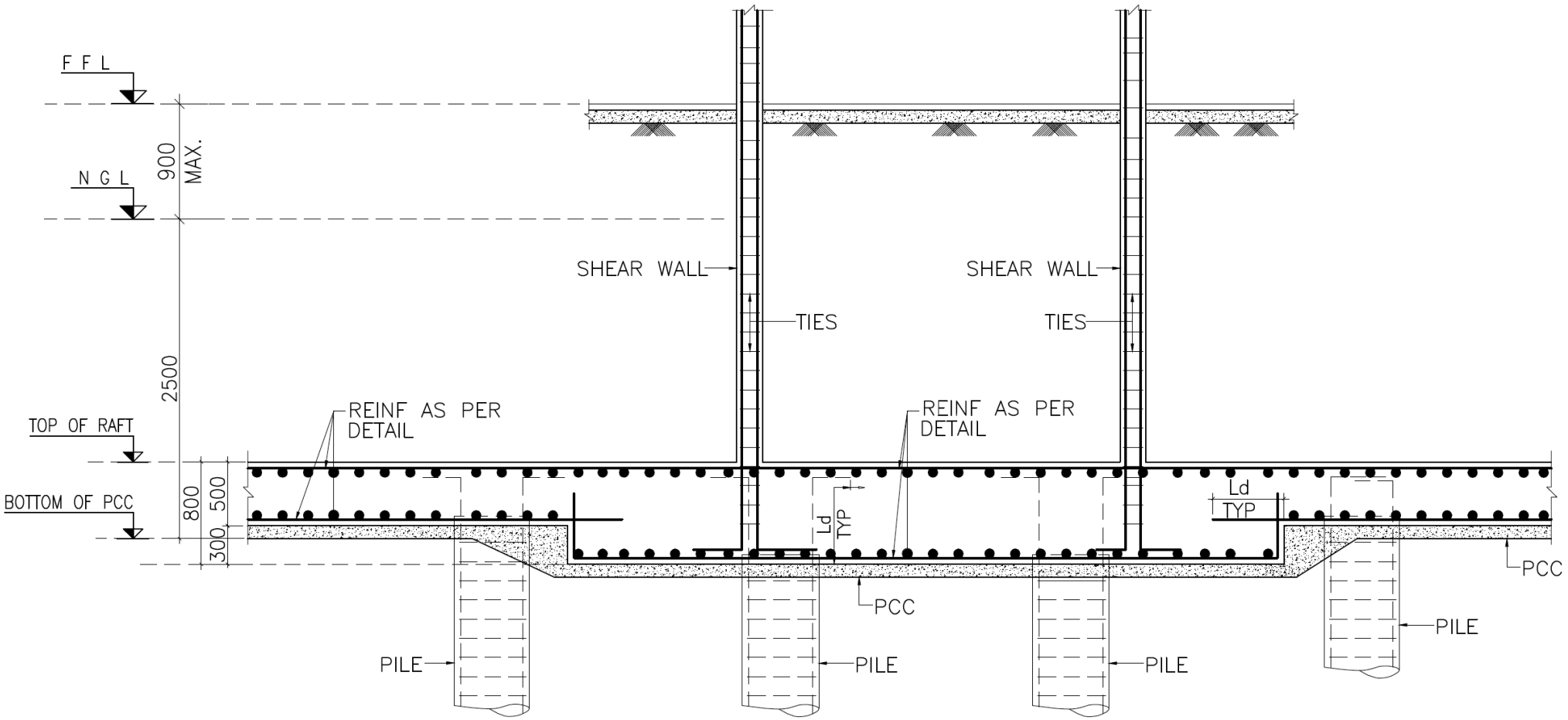
Structural Drawings





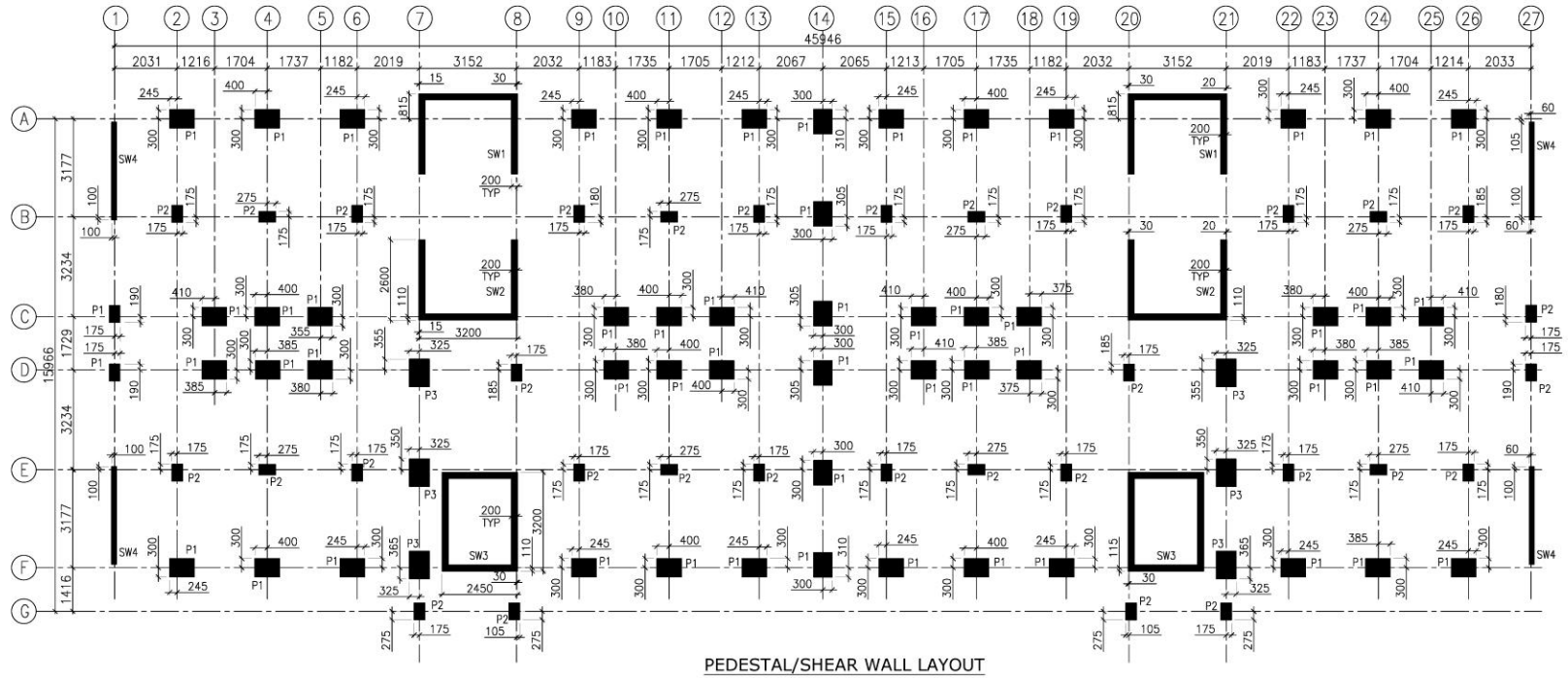


FOUNDATION



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

FOUNDATION



PEDESTAL SCHEDULES

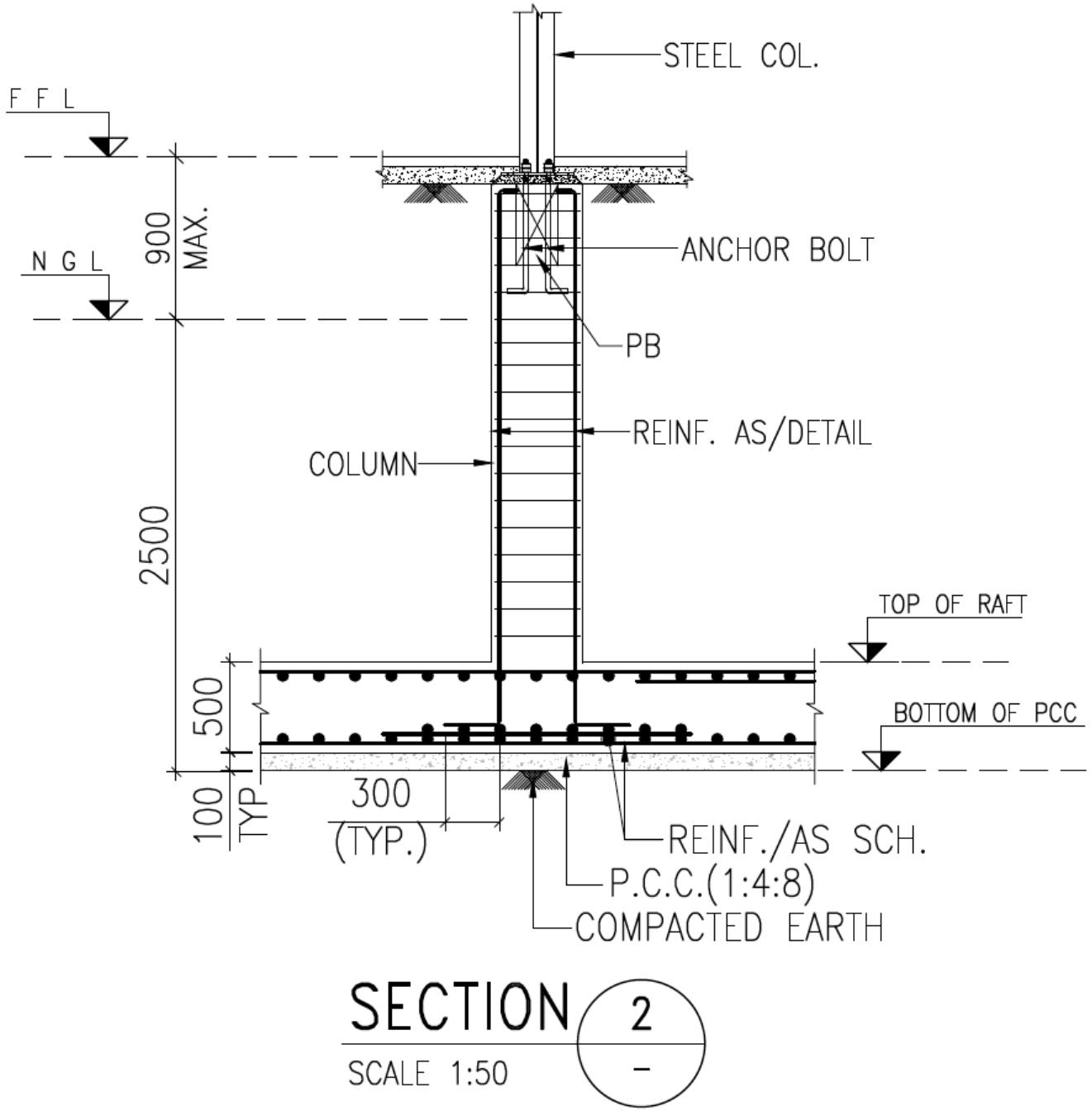
FOUNDATION TO TERMINATION LVL								
	SIZE	(600x800)		(350x550)		(650x900)		
	MAIN REINF	16–T16(a)+ 08–T12		04–T16(a)+ 08–T12		26–T16		
	TIES SET	6/SETS (w+2x+3y)		3/SETS (w+2x+3y)		7/SETS (w+2x+3y+z)		
	TIES SET	①		②		①		
	CONC. MIX	M25		M25		M25		
PEDESTAL MKD.		P1		P2			P3	

TIES SCHEDULE

		TIE GROUP ①	TIE GROUP ②
ZONE–A	OUTER	T8@75c/c	T8@75c/c
	INNER	T8@75c/c	T8@75c/c
ZONE–B	OUTER	T8@200c/c	T8@175c/c
	INNER	T8@200c/c	T8@175c/c

- The RCC raft is casted on the piles. Then concrete pedestal are casted in M25 concrete.

FOUNDATION



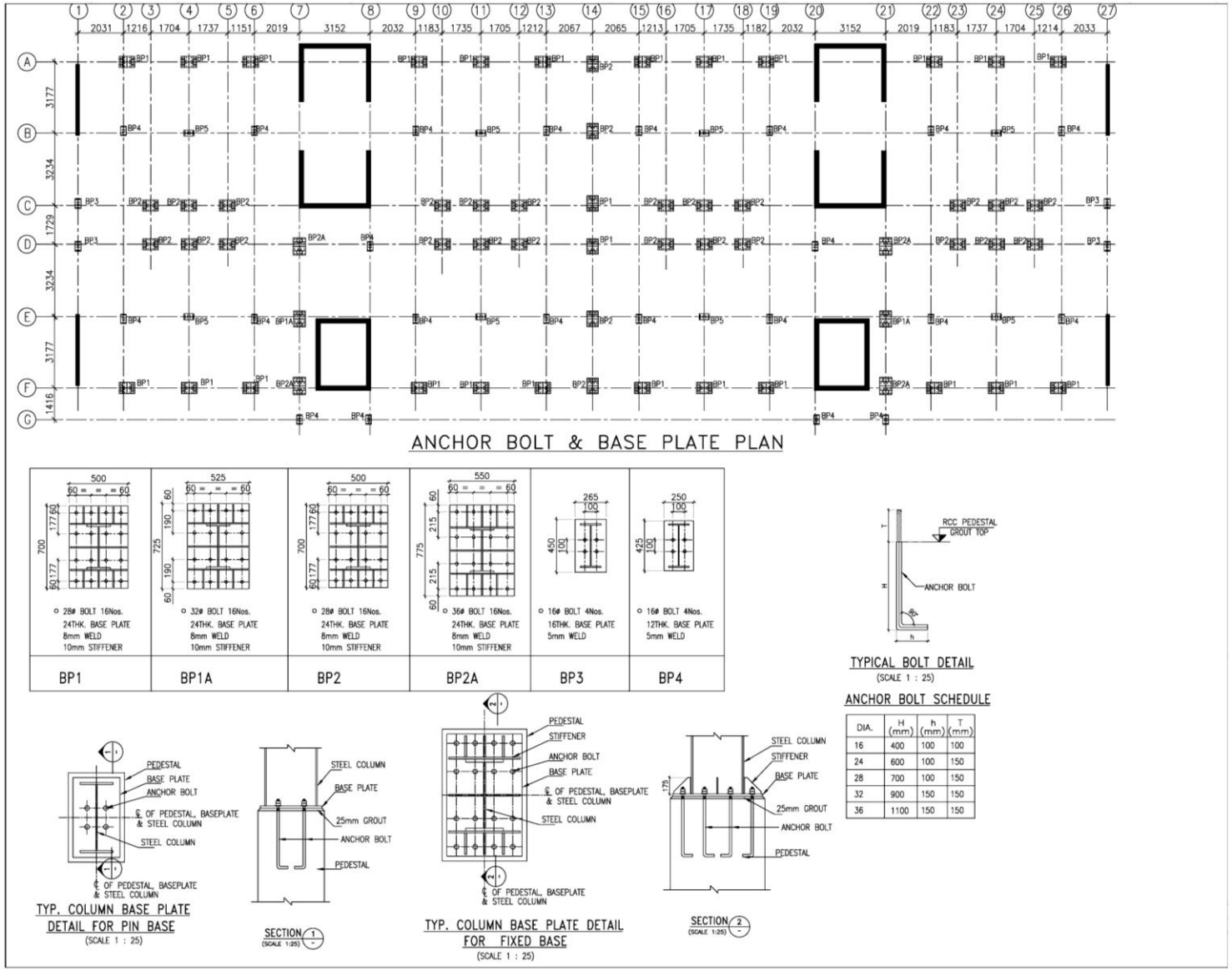
- A section of the foundation showing the raft, concrete pedestal, location of the anchor bolts & base plate and steel column in super-structure.

FOUNDATION

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

FOUNDATION

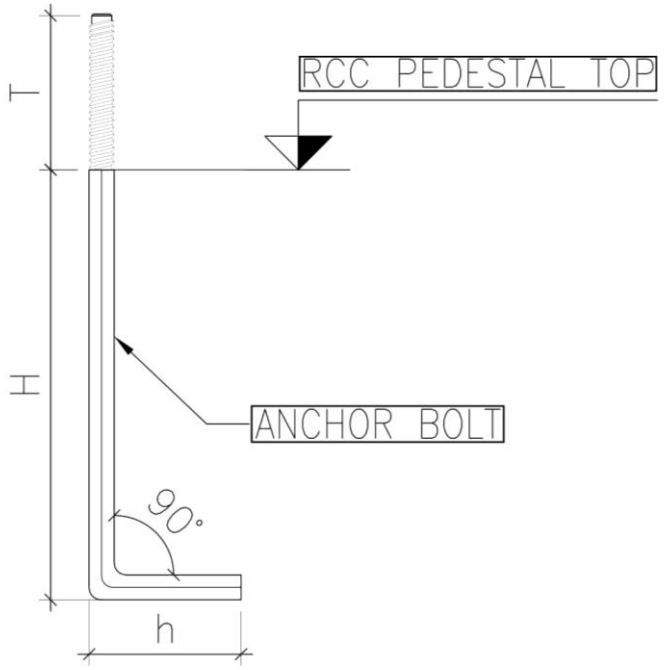
Anchor Bolt & Base Plate Plan

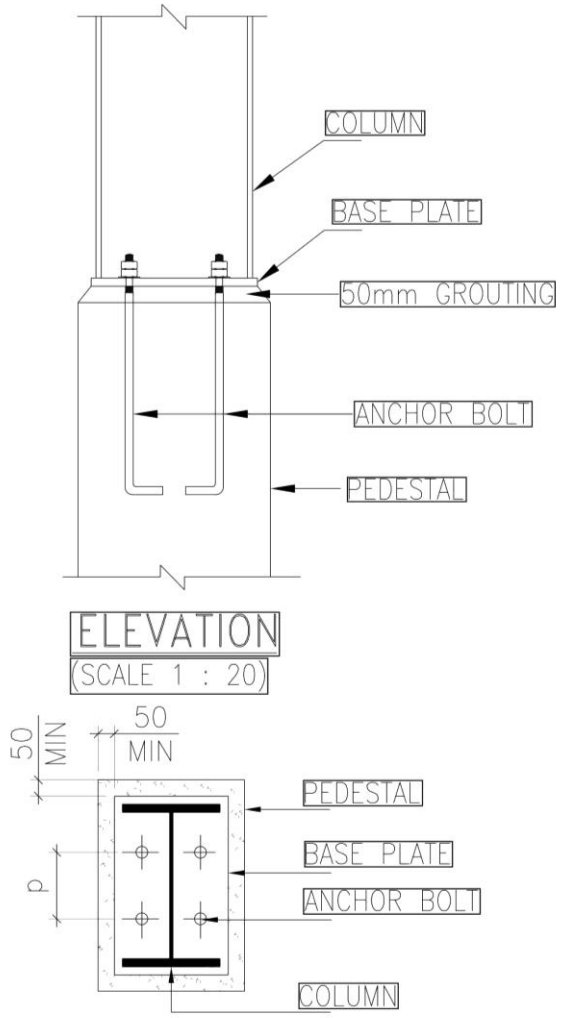


DIA.	H (mm)	h (mm)	T (mm)
16	400	100	100
24	600	100	150
28	700	100	150
32	900	150	150
36	1100	150	150

FOUNDATION

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





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

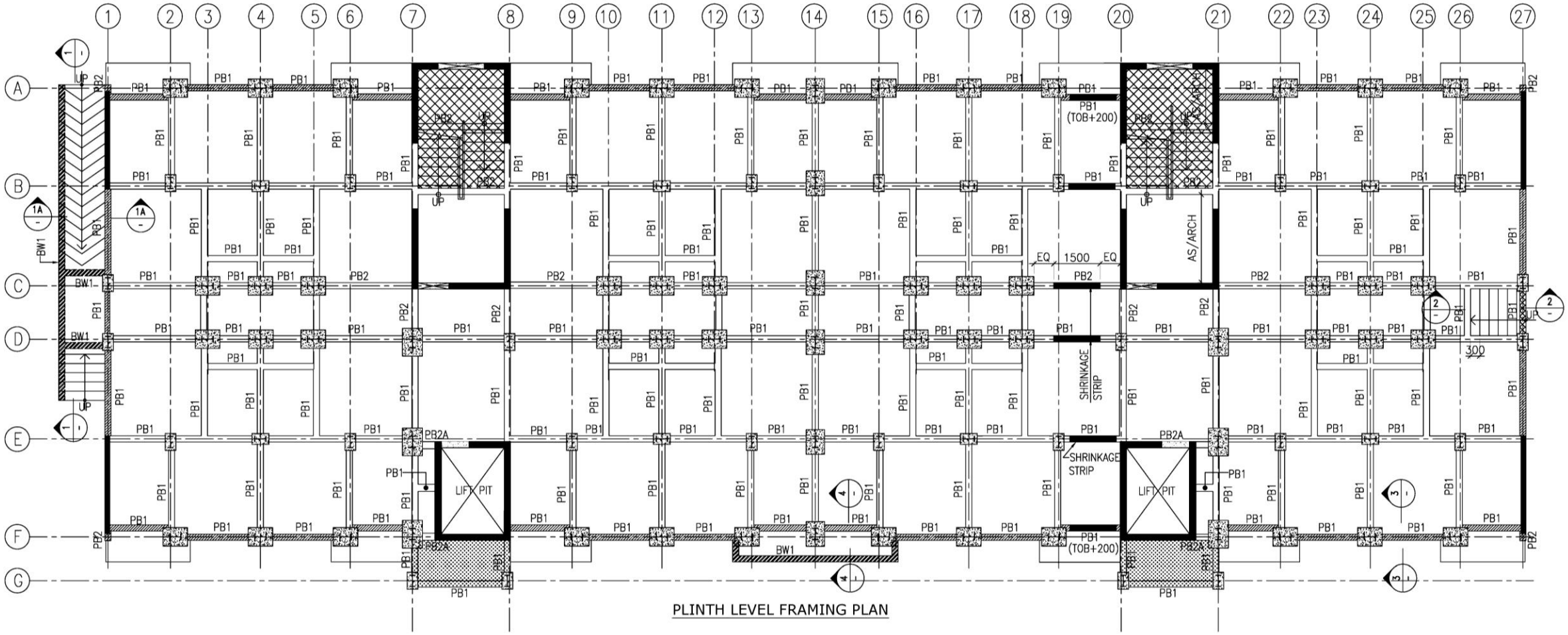
a) Typical anchor bolt detail

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

FOUNDATION



PLINTH LEVEL FRAMING PLAN

- 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

Filing of concrete in piles

FOUNDATION

Excavation and pile head breaking

FOUNDATION

FOUNDATION

Bending of Reinforcement bars for insertion into raft

FOUNDATION

FOUNDATION

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

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.

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

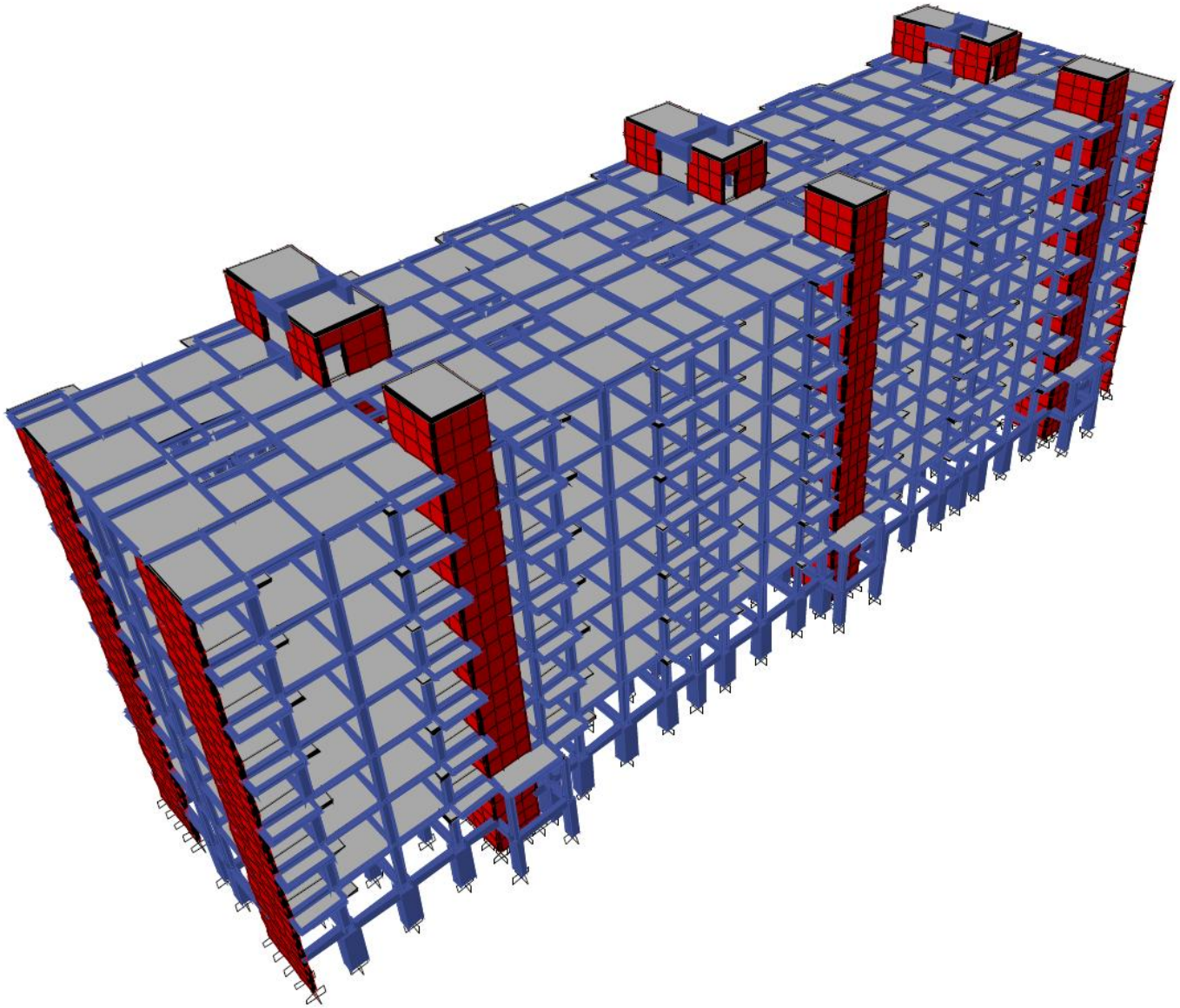
Batching Plant

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

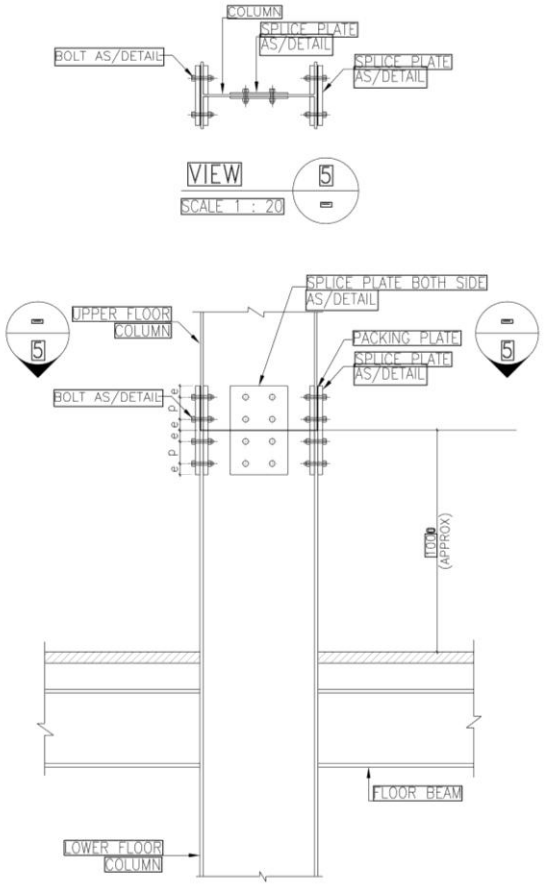


In the present lecture, the structural system and other details are being explained through drawings, sketches and text.

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

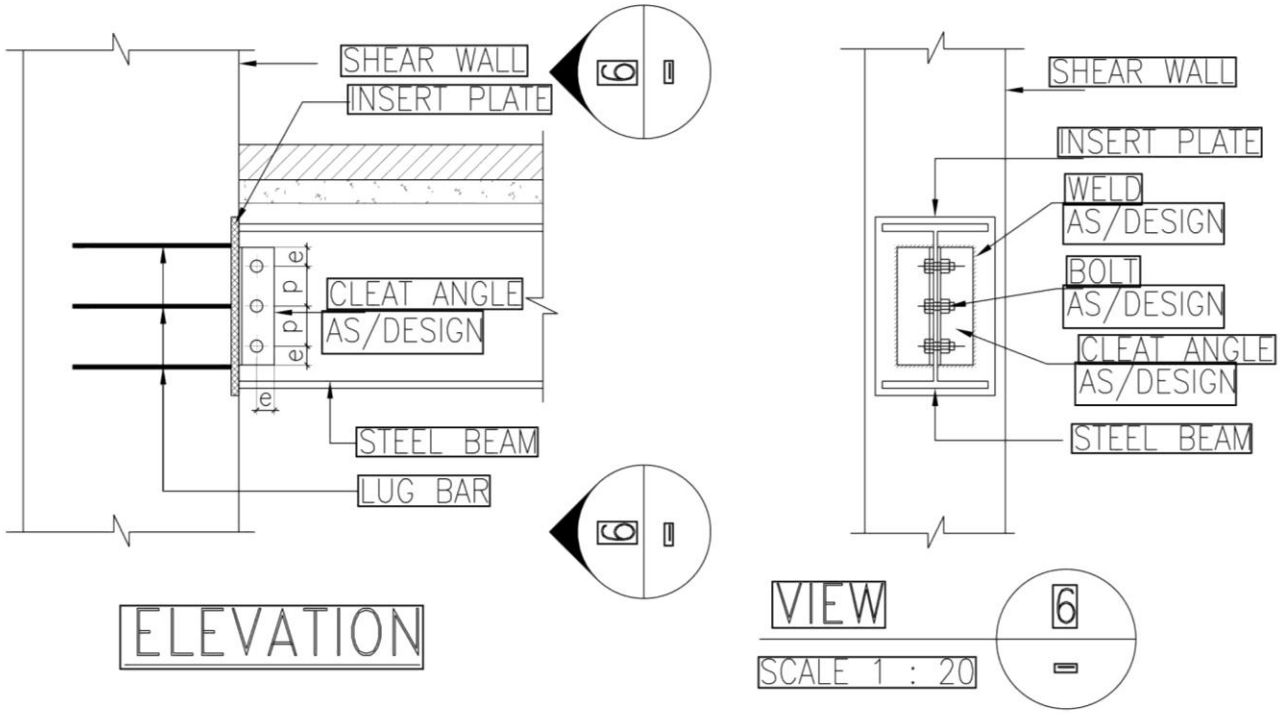
STRUCTURAL SYSTEM

- Column-Column Connections



a) Column Splice detail

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



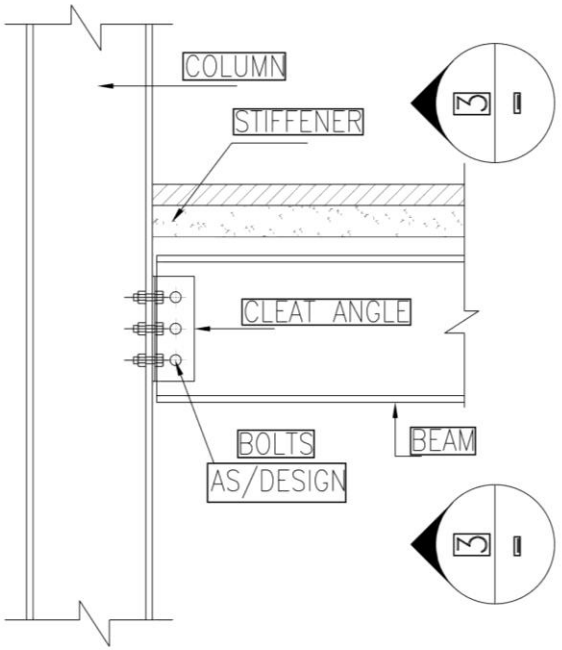
b) Shear wall to steel beam connection

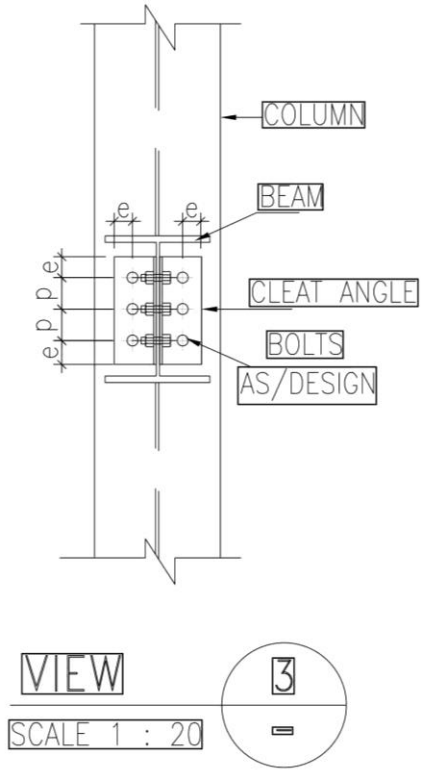
Insert plate along with lug bar are cast during the casting of shear walls and steel beam is connected to the wall with bolted connection through insert plate

A typical length of column being fabricated for the project is of 6m.

STRUCTURAL SYSTEM

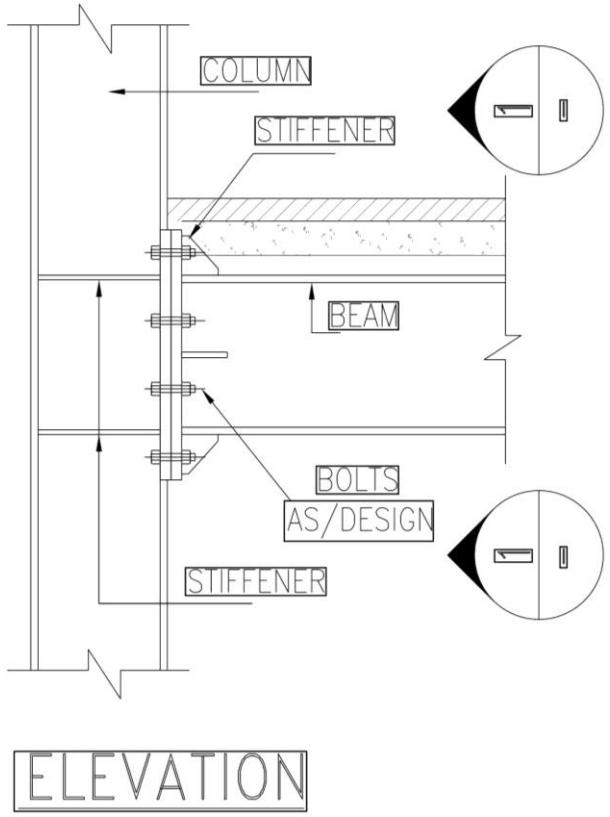
- Typical beam column shear and moment connections

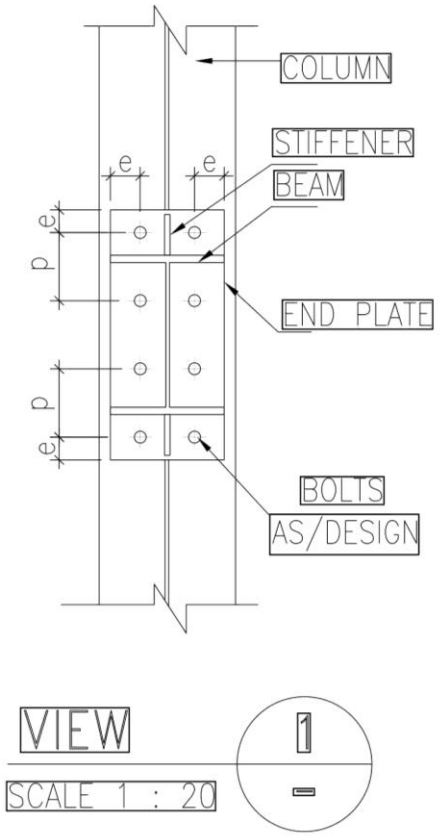




a) Typical beam to column flange shear connection

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



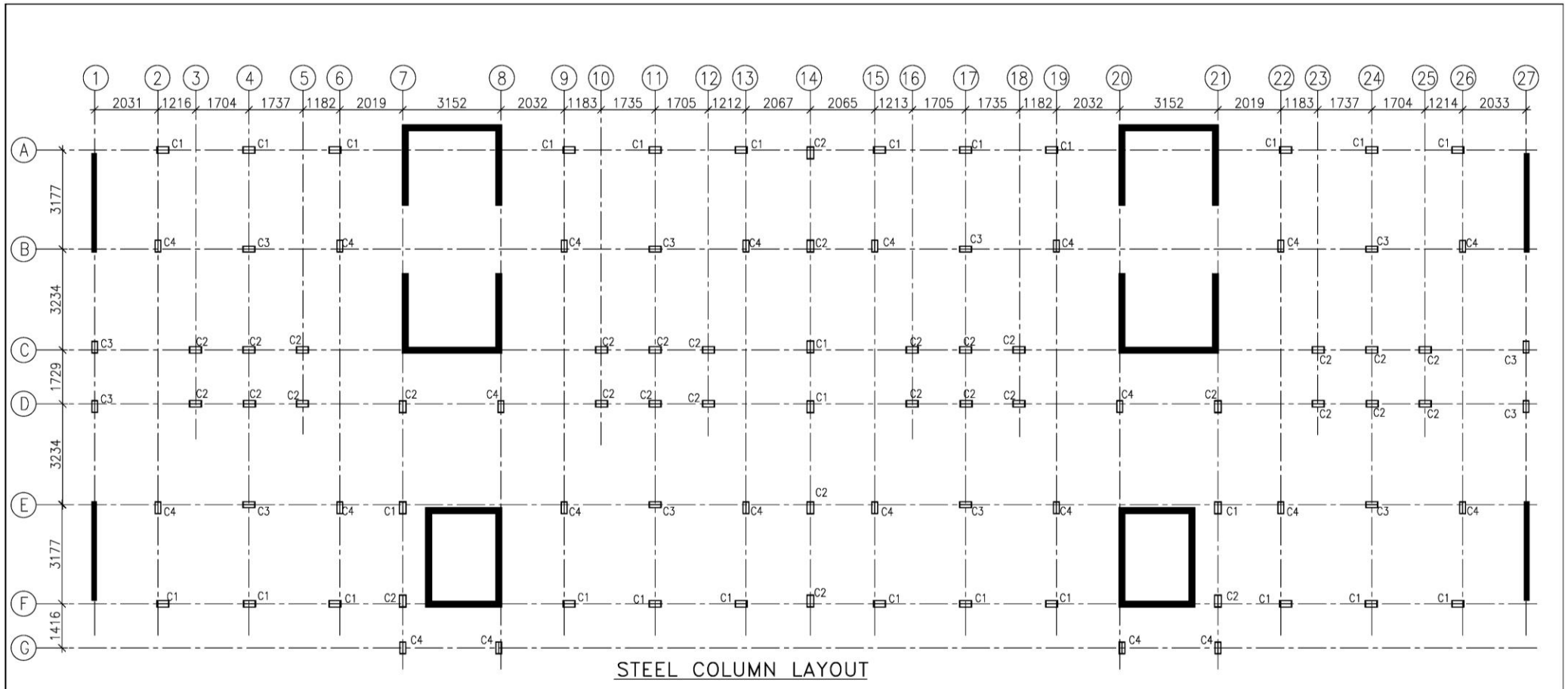


b) Typical beam to column flange moment connection

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

STRUCTURAL SYSTEM

- Steel column layout in superstructure



STEEL COLUMN LAYOUT

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

RCC shear wall in super structure

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

Current Progress

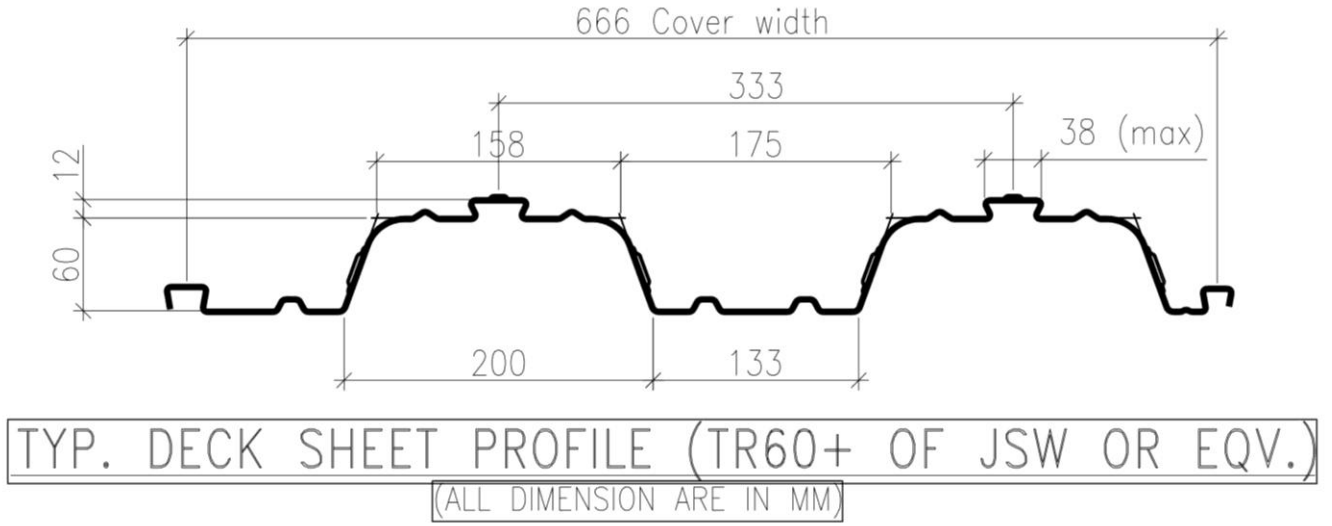
Current Progress

Current Progress

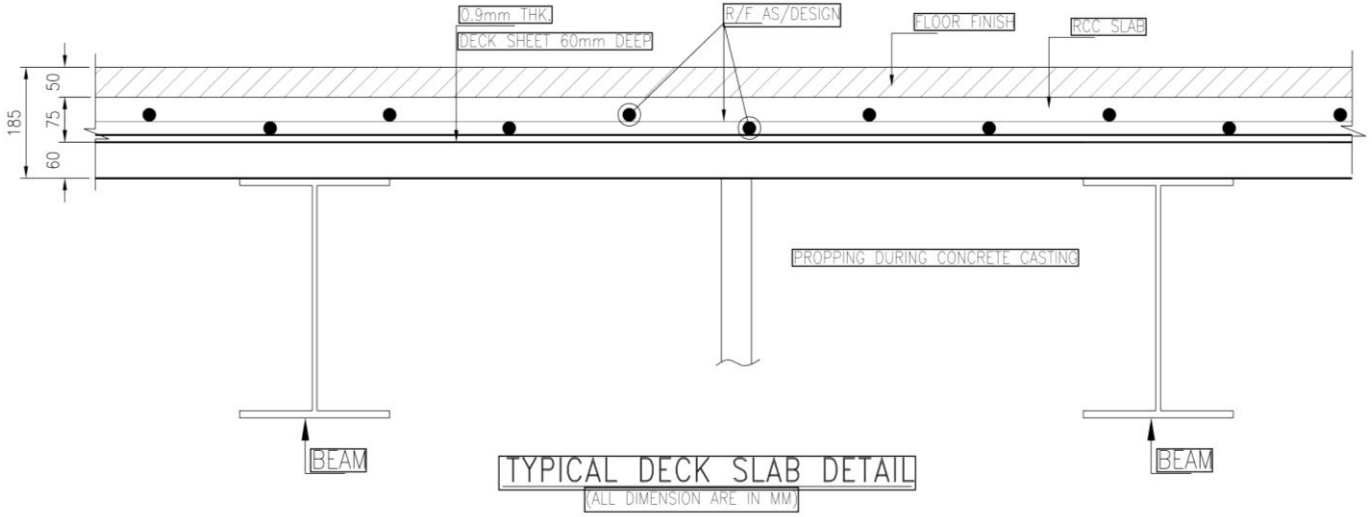
FLOORS

- 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.



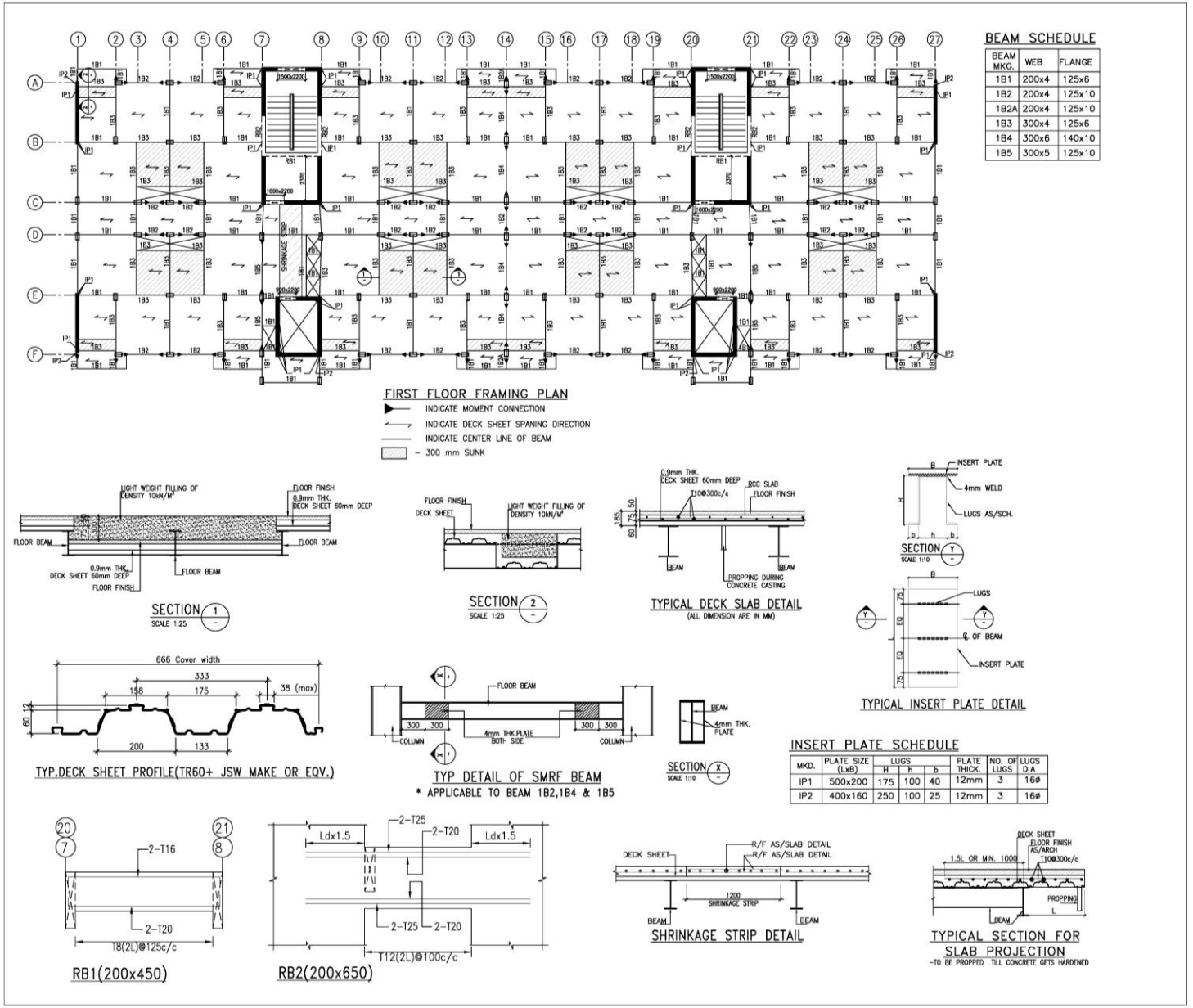
a) Typical deck sheet profile



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

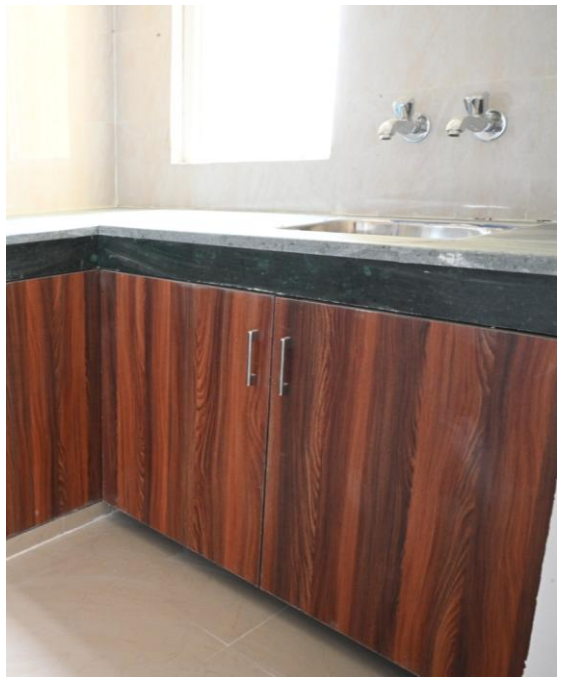
- Typical view of LGSF panels and steel frame construction

MEP

- 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.

Live status of LHP site can be accessed at

https://ghtc-india.gov.in

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

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

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Ministry of Housing and Urban Affairs
Government of India

Azadi Ka Amrit Mahotsav

bmtpc giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

LIGHT HOUSE PROJECT: LIVE LABORATORIES

WEBINAR SERIES: e-learning & webcasting of LHPs for TECHNOGRAHIS

March - November 2022

An 'e-Learning series and webcasting of LHP's construction process' to widespread the knowledge about the technology, construction process, sustainability, and mass cum fast construction to TECHNOGRAHIs.

Webinar Session #12 at Light House Project Agartala, Tripura

Date : 29.07.2022 , Friday | Time : 3:00 PM

Emerging Housing Technologies

Ministry of Housing and Urban Affairs
Govt. of India

Emerging Building Materials and Construction

QUESTIONS?

Q1. What are the conventional construction materials & technologies available for building houses ?

Q2. Are the conventional materials & technologies adequate and sustainable in present situation?

Emerging Building Materials and Construction

QUESTIONS?

Q3.

What are the opportunity and trends ?

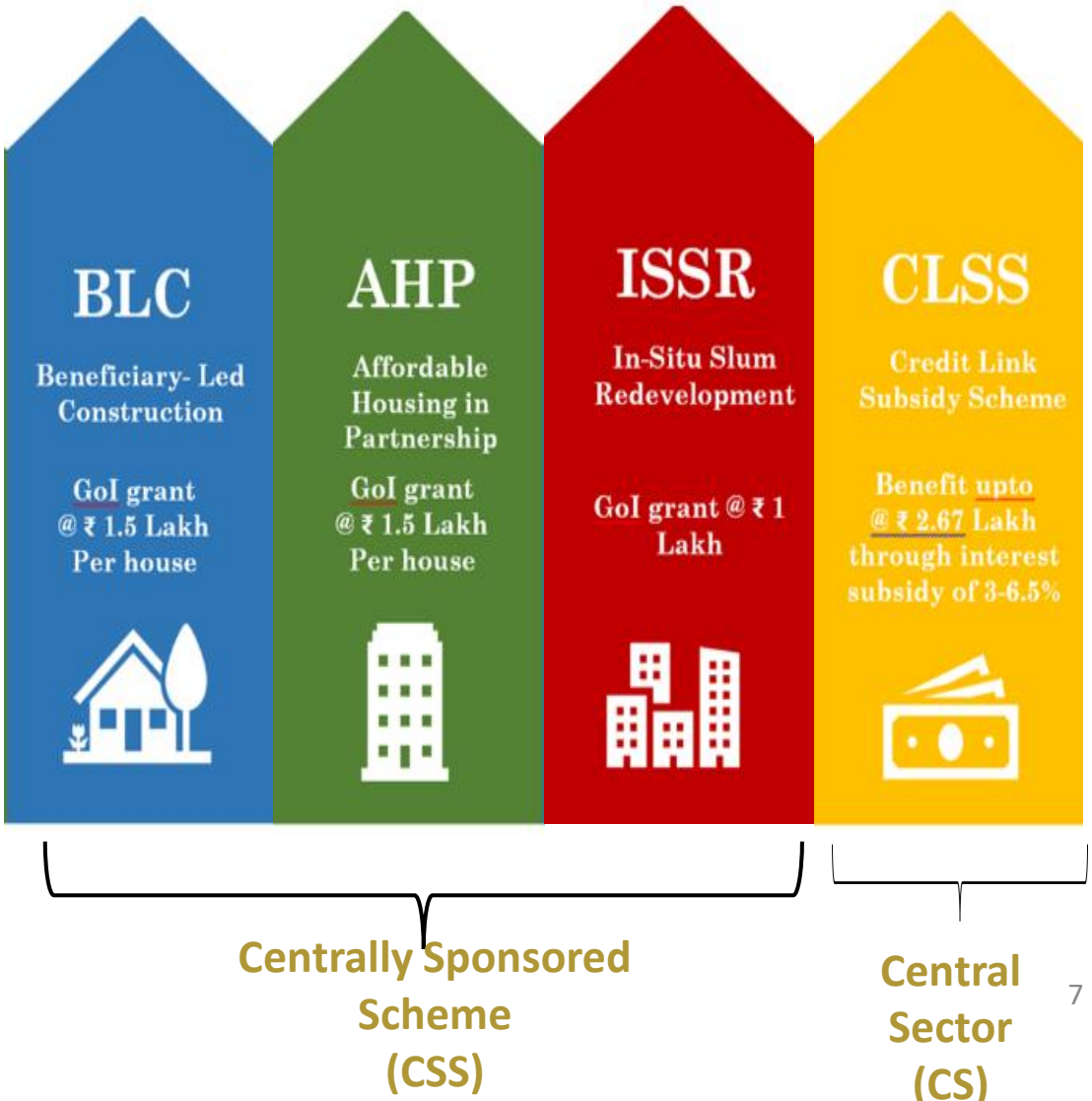

RESOURCE
VS.
CONSTRAINTS

RESOURCE VS. CONSTRAINTS

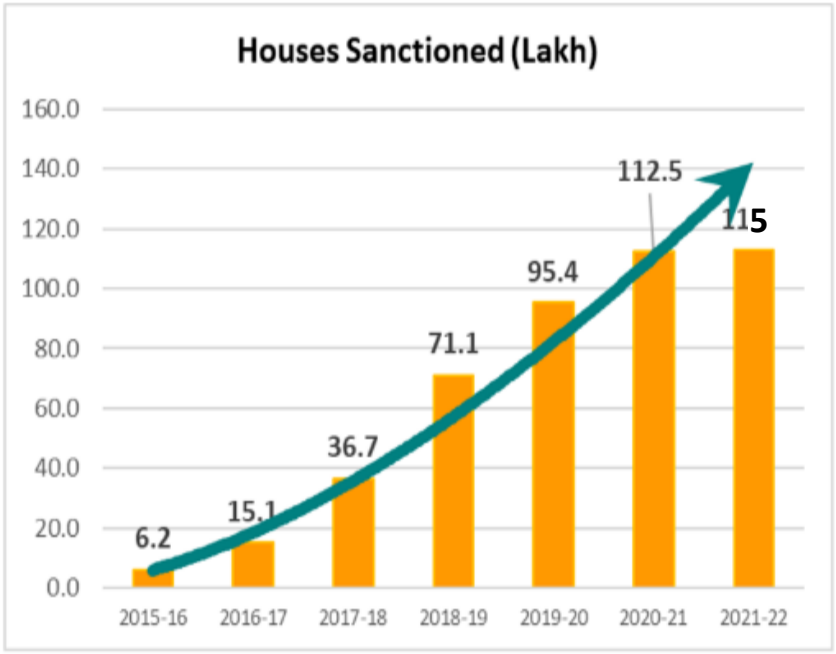
PMAY(Urban) Mission

Verticals

4 Mission verticals suiting the needs of individuals based on the geographical conditions, topography, economic conditions, availability of land, infrastructure etc



PMAY(U)
Achievements at a Glance



Houses under PMAY(U)

1.12 Cr	Assessed Demand	102.23 Lakh	Grounded for Construction
1.22Cr	Sanctioned	57.01L akh	Completed/ Delivered
20.63 Lakh	CLSS Beneficiaries	16 Lakh	New technology houses

Total Investment
₹ 8.25 Lakh Cr

Central Assistance Approved
₹ 2.01 Lakh Cr

Central Assistance Released
₹ 1.20 Lakh Cr

BLC Houses
72.36 Lakh

AHP Houses
20.63 Lakh

ISSR Houses
2.91 Lakh

CLSS Houses
2.76 Lakh

RESOURCE VS. CONSTRAINTS >>BASIC

Conventional Construction Practices have so far served well the construction industry

Can it face the present challenges now ?

Challenges

- **Depleting natural resources** threatening the **environment.**
- **Energy intensive** and polluting manufacturing practices
- Massive construction in a short time requiring **speed , quality and durability.**
- **Rising cost** of building materials
- **Shortage** of construction workers in urban areas
- Requirement of **Fast construction** in stipulated time
- Need for **thermal comfort** and sustainability
- **Dust Free** site condition
- **Quality & Durability**
- **Disaster resilience**

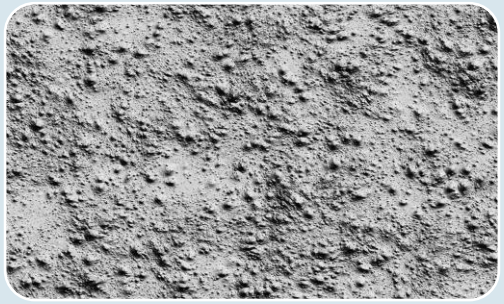
Challenges

The Ratification of the Paris Agreement on Climate Change brings Country's Commitment to reduce greenhouse gas emission intensity of its GDP by 33-35% below 2005 levels by 2030

MODULE 2: RESOURCE VS. CONSTRAINTS

Basic materials Used

Burnt Clay Bricks

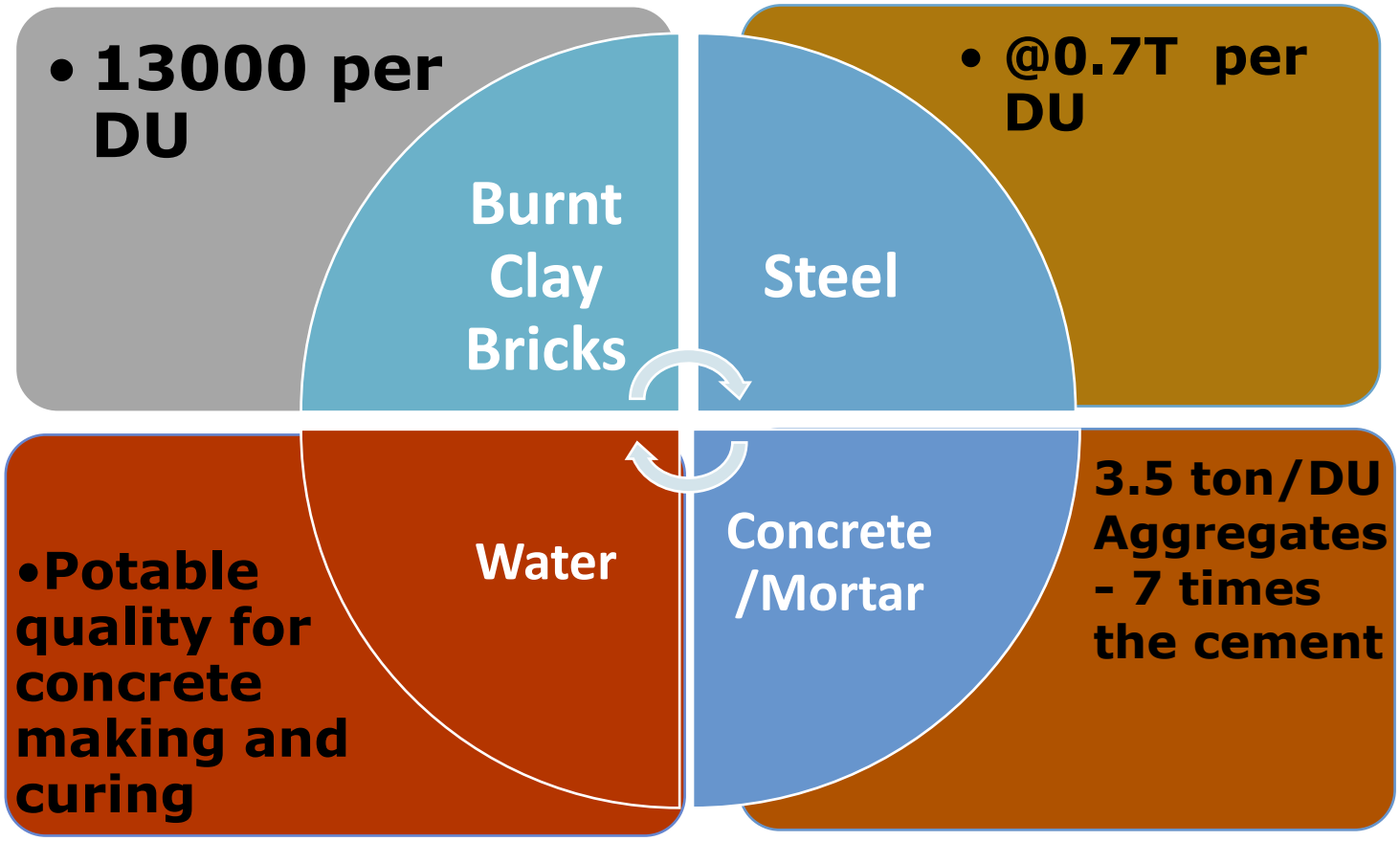


Cement + Mortar + Concrete

Steel reinforcement

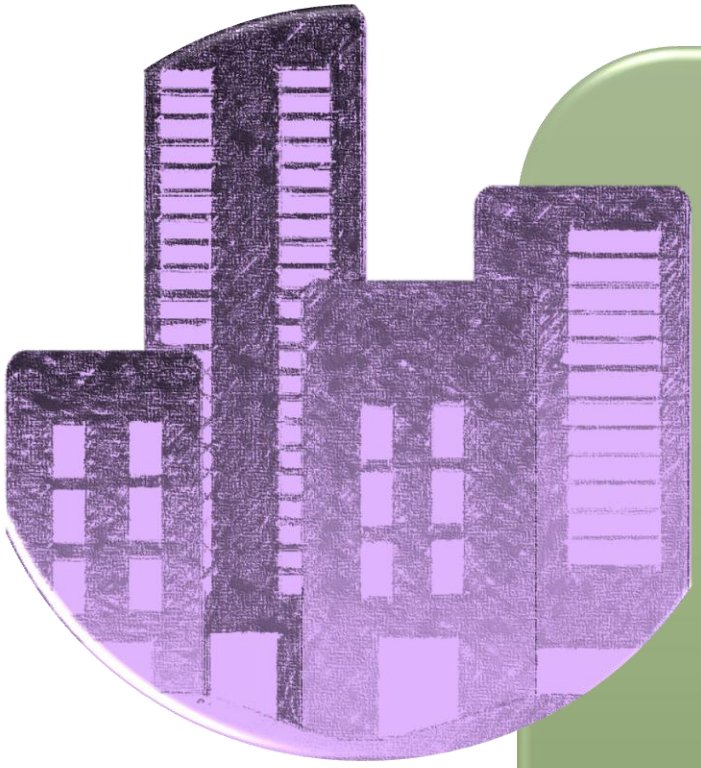
MODULE 2: RESOURCE VS.

RESOURCE REQUIREMENT FOR CONSTRUCTION OF HOUSES (average carpet area 25 sqm/du)



Environmental Issues associated with Conventional Materials

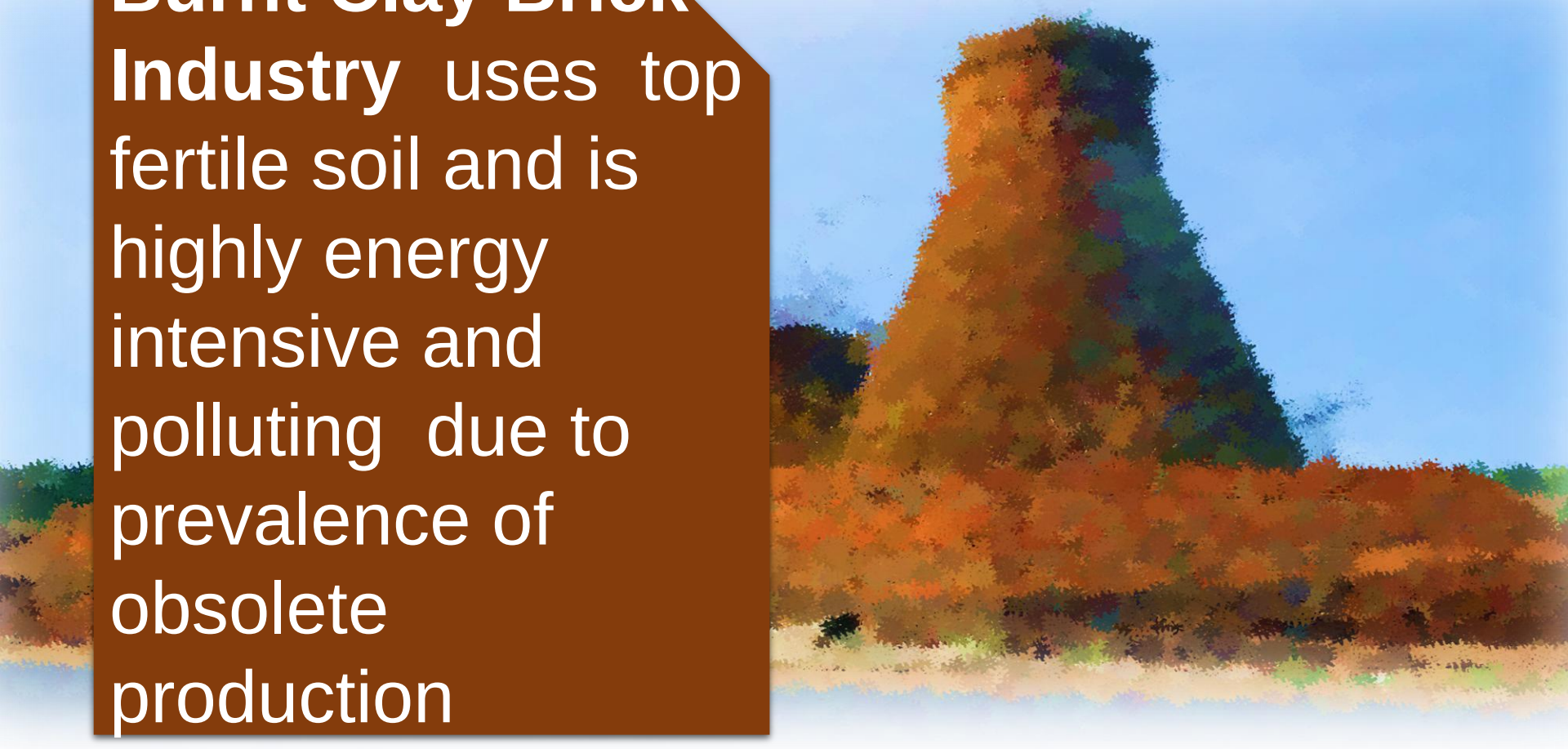
MODULE 2: RESOURCE GENERATION VS. CONSTRAINTS



Conventional building materials are naturally derived, over dependence on them can be hazardous to environment.

- They can not be depended upon for regular supply

Burnt Clay Brick Industry uses top fertile soil and is highly energy intensive and polluting due to prevalence of obsolete production



MODULE 2: RESOURCE VS. CONSTRAINTS >> BURN

BRICK PRODUCTION

2ND LARGEST PRODUCER AFTER CHINA [BTRs 74% ; Clamps 21%]	
Brick making enterprises	1,40,000
Brick making fuel used	Coal & biomass
Annual Brick production	240 – 260 billion
Coal / biomass Consumption	35-40 million ton
CO_2 emission	66 million ton
Clay Consumption	500 million m^3

Energy intensive

Coal consumption is 8% of the total consumption (third largest consumer after power & steel)

Pollution and health issues

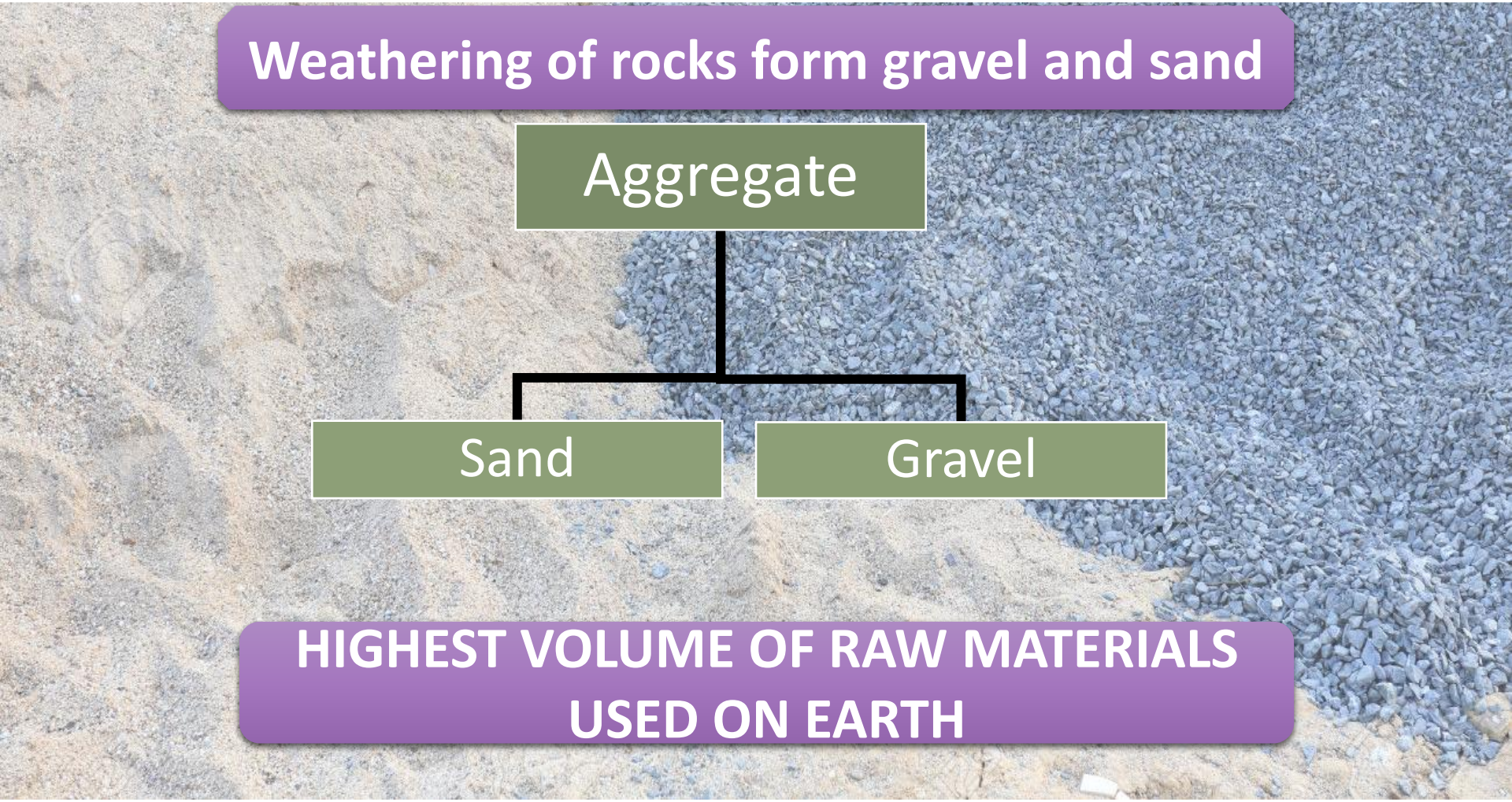
Bottom ash in kiln causes health problems

Pollution and health issues

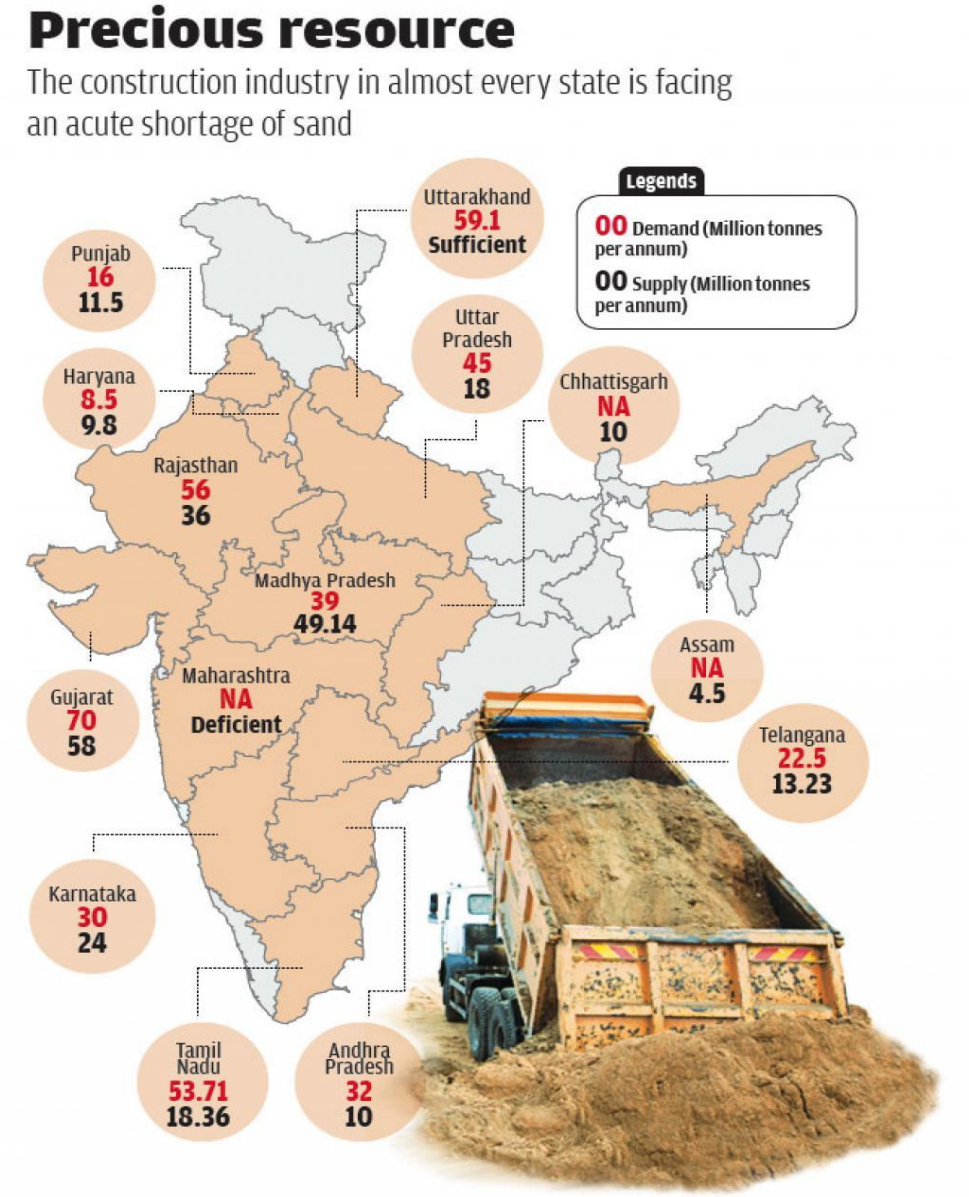
City Pollution

Large brick clusters around Indian cities cause air pollution and affects air quality

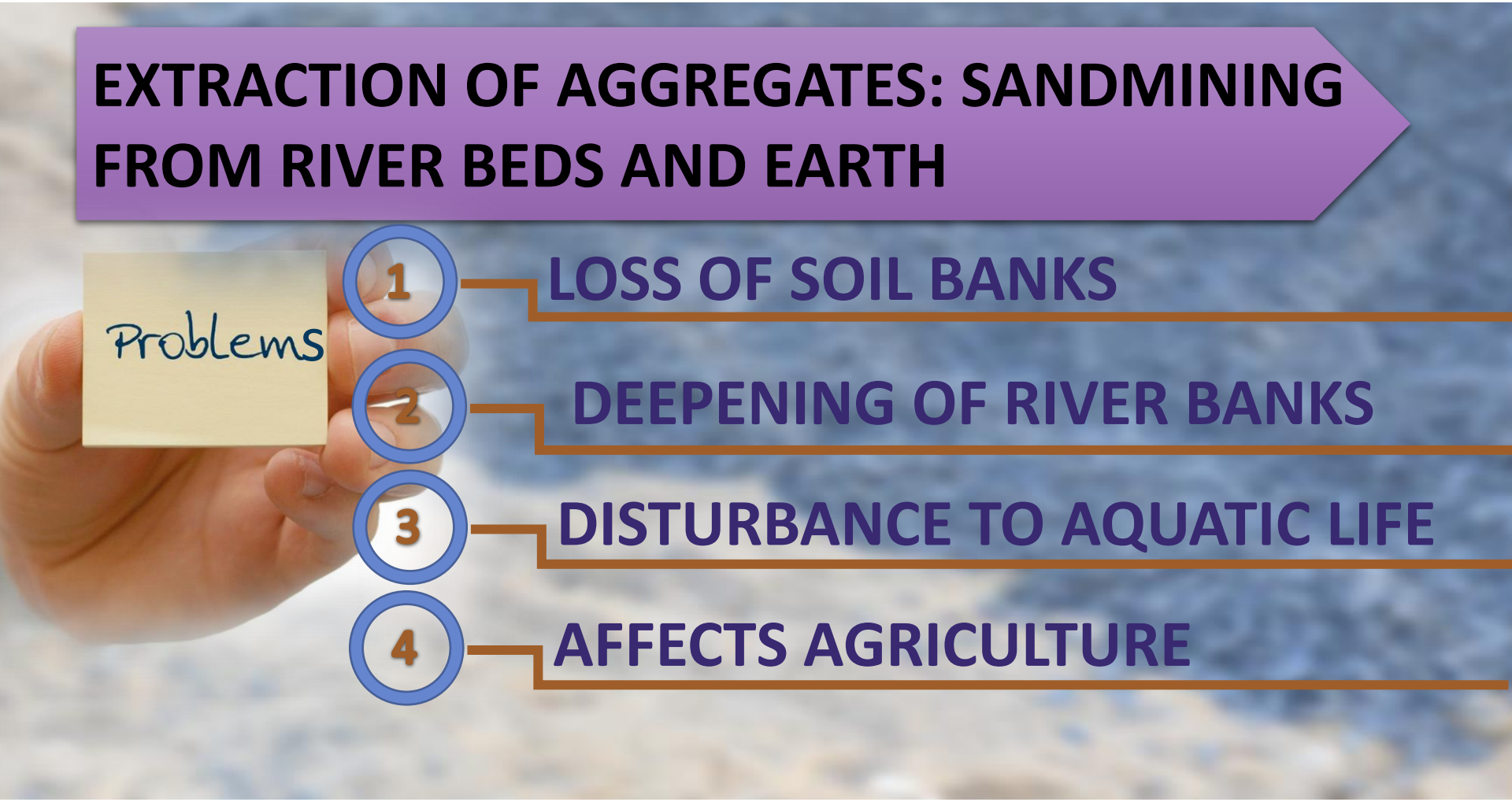
MODULE 2: RESOURCE GENERATION VS.



State-wise demand of Sand for construction

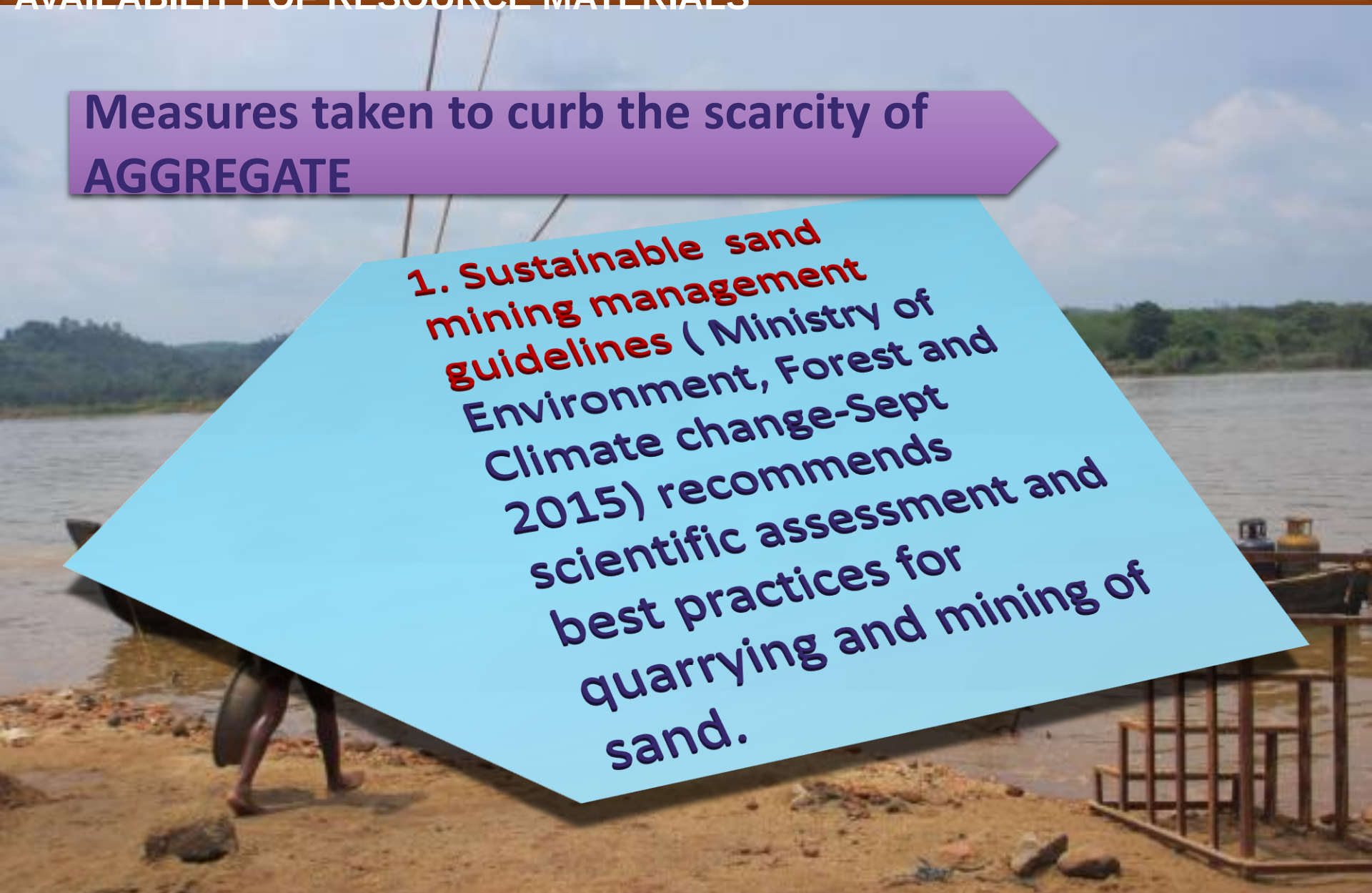


MODULE 2: RESOURCE GENERATION VS. CONSTRAINT >>AGGREGATES



The mining of aggregates has reached a level of threatening the environment ecosystem besides reaching a level of scarcity that would threaten the economy.

MODULE 2: RESOURCE GENERATION VS. CONSTRAINTS >>NON AVAILABILITY OF RESOURCE MATERIALS



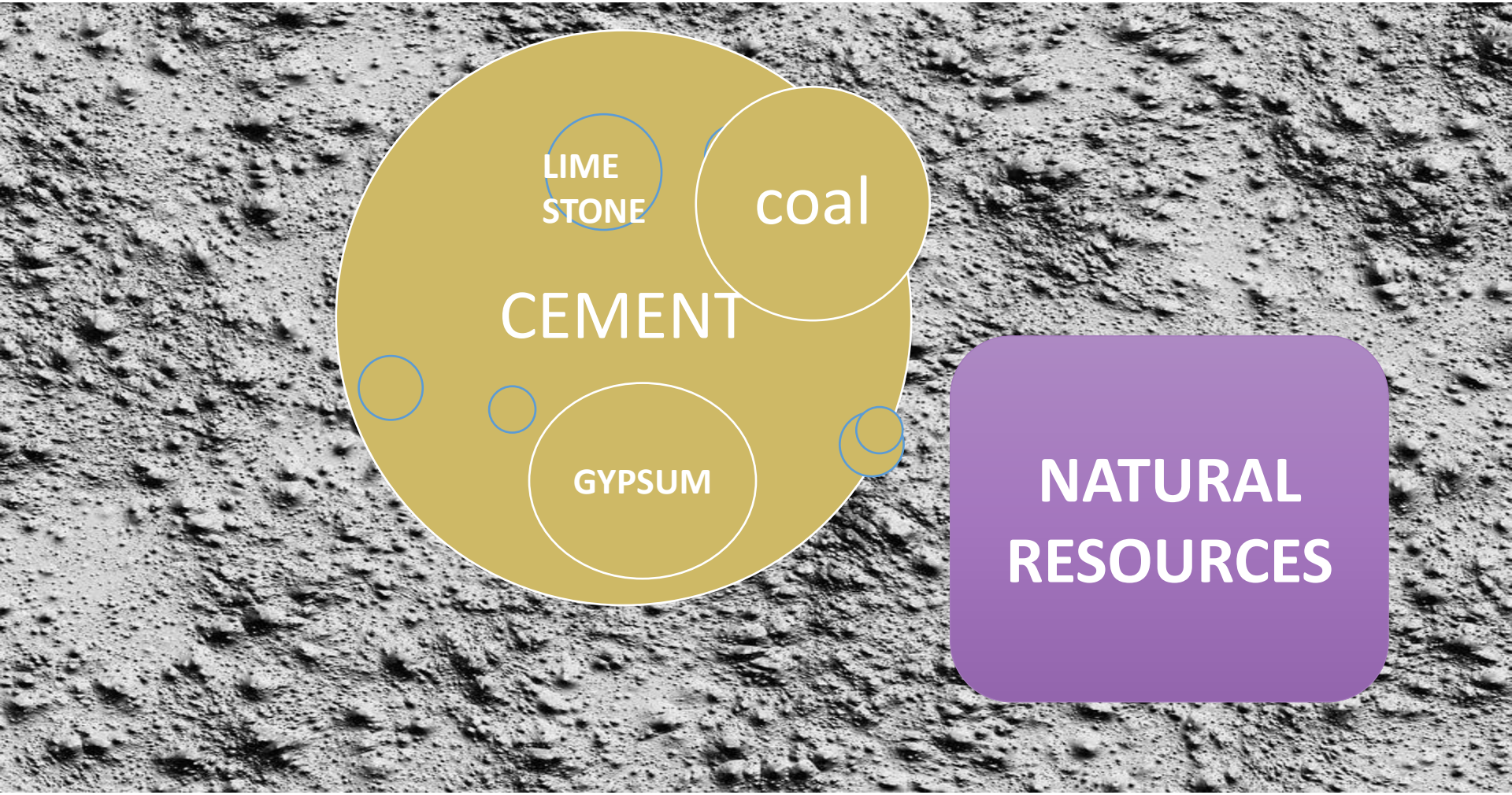
Measures taken to curb the scarcity of AGGREGATE

1. Sustainable sand mining management guidelines (Ministry of Environment, Forest and Climate change-Sept 2015) recommends scientific assessment and best practices for quarrying and mining of sand.

RESOURCE MATERIALS

Measures taken to curb the scarcity of AGGREGATE

MODULE 2: RESOURCE VS. CONSTRAINTS >>



MODULE 2: RESOURCE GENERATION VS. CONSTRAINTS

Challenges and Problems

1. **CONSERVATION OF LIMESTONE:** Total cement grade limestone reserve available to meet industry requirement - 89,862 MT. Current limestone resources expected to last for 35-41 years!

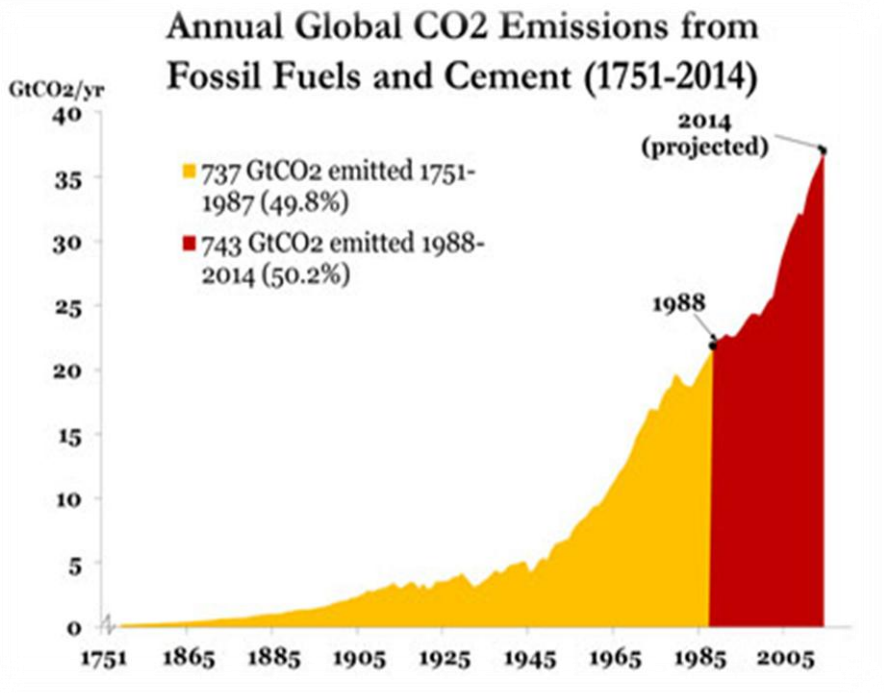
2. Highly energy intensive 5-8 MJ/kg

Challenges and Problems

3

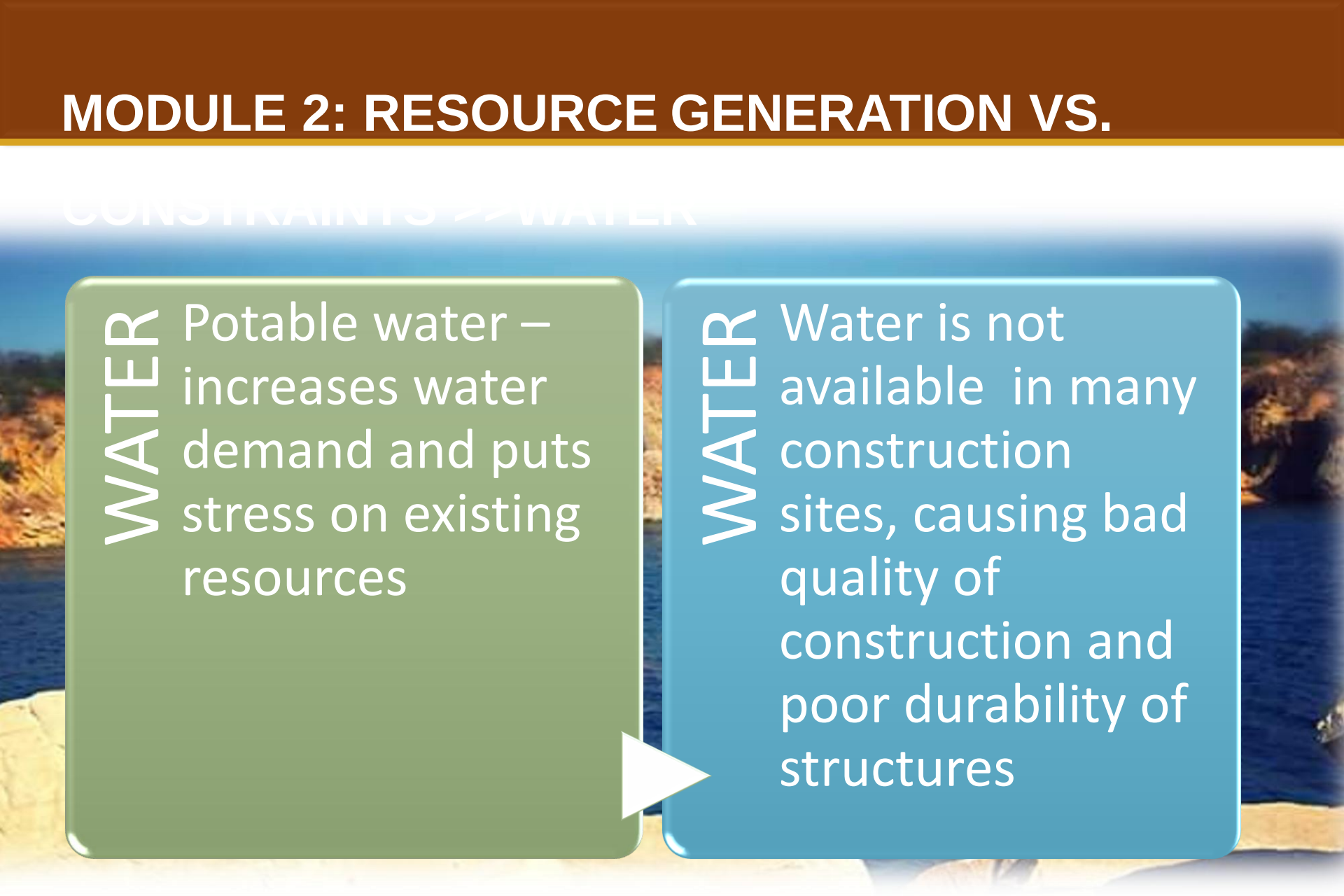
AIR Pollution:

CO_2 release of 258.366 MT per year (National avg: 0.85 of CO_2 per 1Tonne of cement)



MODULE 2: RESOURCE GENERATION VS.

CONSTRAINTS >> WATER



WATER Potable water – increases water demand and puts stress on existing resources

WATER Water is not available in many construction sites, causing bad quality of construction and poor durability of structures

Shortage of Skilled and Unskilled Manpower

Acute shortage of labour in urban areas.

The shortage or low productivity of labour directly affects the project time and brings cost overrun

Quality and S

Weather

Weather also affects conventional construction progress and material storage.

Pollution and Waste

Site construction practices generate dust and waste which affect the local environment.

Cost

Bricks, cement and mild steel share major cost of the building

Cost

Bricks, cement and mild steel share major cost of the buildin

About 51.5% of cost of construction is for building materials like bricks, cement and steel and 25% of cost of construction is for labour charges.

ng cost

62.5

MODULE 2: RESOURCE GENERATION VS. CONSTRAINTS >>OTHER CRITICAL CHALLENGES

Necessity to find alternate building materials and technologies

- minimize or replace
  - use of OPC
  - natural aggregates
  - water
  - burnt clay bricks
  - in-situ construction as far as possible
  - less polluting and energy efficient technology
- bring speed
- quality
- Durability
- Resource Efficiency
- Disaster Resilience
- cost effectiveness

Background

For constructing dwelling units Judicious selection of technologies is required

Reduces Carbon Footprint

Structurally Safe

Save Energy

Bring Speed

Quality &Durability

Improved site environment

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Technology Sub-mission - GHTC India, IHTM

Promoting use of rapid, resource efficient, disaster resilient construction technologies

https://ghtc-india.gov.in

Ministry of Housing and Urban Affairs
Government of India

"To promote the use of new technologies in the housing sector, we have initiated the Global Housing Technology Challenge-India, so that new emerging technologies could be used for low cost housing."

150 YEARS OF CELEBRATING THE MAHATMA

स्वच्छ भारत

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

The Government of India, Ministry of Housing and Urban Affairs, invites established international construction technology providers, start ups, and various other stakeholders to help transform the country's construction industry

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

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Construction Technologies

Global Housing Technology Challenge - India (GHTC-I)

Categories	Technology	Tech. Providers
1	*Precast Concrete Construction System - 3D Precast volumetric*	4
2	*Precast Concrete Construction System – Precast components assembled at site*	8
3	*Light Gauge Steel Structural System & Pre-engineered Steel Structural System*	16
4	*Prefabricated Sandwich Panel System*	9
5	*Monolithic Concrete Construction*	9
6	*Stay In Place Formwork System*	8
	Total	**54**

Conventional Construction Systems	Alternate Construction Systems
Slow	Fast
Maximum Use of Natural Resources	Optimum use of Resources
Waste Generation	Minimum Waste
Air/Land/Water Pollution	Minimum Pollution
Labour Intensive	Industrialized System
Prescriptive Design	Cost-effective Design
Unhealthy Indoor Quality	Better health & Productivity
Regular Maintenance	Low Life Cycle Cost
Energy Intensive	Energy Efficient
Cast-in-situ Poor Quality	Factory Made Quality Products
High GHG Emissions	Low GHG Emissions
Unsustainable	Sustainable

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GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Light House Projects

Hon'ble Prime Minister laid the foundation stone of six LHPs on 01.01.2021

Technologies Evaluated & Recommended>> Precast Prefab Concrete Construction

Precast Prefab Concrete Construction- Components assembled at site

- Based on factory mass manufactured standardized structural prefab components conforming to relevant Indian Standards.
- Modular, prefabricated industrialized system best suited for mass housing.

Precast Prefab Concrete Construction>> Factory Set-up

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Global Housing Technology Challenge - India (GHTC-I)

1

Precast Concrete Construction System – Precast components assembled at site

1	Precast Large Concrete Panel (PLCP) System with structural members (wall, slab etc.) cast in a factory/ casting yard and brought to the building site for erection & assembling	Larsen & Toubro
2	Pre-cast Concrete Structural system comprising of pre-cast column, beam, precast concrete / light weight slab, AAC blocks/ infill concrete walls.	B.G. Shirke Construction Technology Pvt. Ltd
3	Optimal Pre-cast concrete System through structural Analysis, design & equipment support	Elematic India,
4	Precast concrete construction system using precast walls with precast plank floor	PG Setty Construction Technology Pvt Ltd,
5	Precast components comprising of beams, coloumns, staircase, slab, hollow core slab etc. manufactured in plant & erected on site	Teemage
6	Pre-cast sandwich panel system & Light weight Pre cast Light Weight concrete slab	Nordicflex
7	Prefabricated Interlocking Technology (without mortar) with Roofing as Mechnized Precast R.C. Plank & Joist system	Adalakha Associates Pvt. Ltd
8	Large Hollow wall prefab concrete Panel (lightweight, interlocking, concrete panel) using factory produced large standard hollow	William Ling,

PRECAST CONCRETE-3D MONOLITHIC VOLUMETRIC

Global Housing Technology Challenge - India (GHTC-I)

2 Precast Concrete Construction System – 3D Volumetric

1	Pre-cast concrete system with columns, beams, walls, slabs, hollow core slabs & also 3D Volumetric components	Katerra
2	Vertical structural modules cast in Plant/Casting yard are assembled together through casting of floor panel. The unit is transported & installed at site.	Moducast Pvt. Ltd
3	3D Modular casting using steel mould and high performance concrete of building modules in factory. These pods are transported to the construction site & assembled	Magicrete Building Solutions,
4	Modules with 3D Volumetric Precast concrete unit, various units make on house	Ultratech Cement Ltd,

Technologies Evaluated & Recommended>> Monolithic Concrete Construction using modular Aluminum or Tunnel formwork

Monolithic Concrete Construction using modular Aluminum orTunnel formwork system

A typical plan of one of the mass housing projects

- Tailor-made Modular formwork made of Aluminum with about 100 repetition potential

Or

- Tailor made Tunnel formwork system made of steel with about 1000 repetition potential

- Walls constructed as shear wall in monolithic way with slabs.

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3

1	Aluminium formwork system for Monolithic Concrete construction	Maini Scaffold Systems
2	Aluminium formwork system for Monolithic Concrete construction	KumkangKind India Pvt. Ltd
3	Aluminium formwork system for Monolithic Concrete construction	S-form India Pvt. Ltd.,
4	Aluminium formwork system for Monolithic Concrete construction	ATS Infrastructure Ltd.
5	Aluminium formwork system for Monolithic Concrete construction	Innovative housing & Infrastructure Pvt. Ltd
6	Aluminium formwork system for Monolithic Concrete construction	MFS formwork Systems Pvt. Ltd.
7	Aluminium formwork system for Monolithic Concrete construction	Knest Manufacturers LLP
8	'Tunnel form' construction technology, an cast in situ RCC system, based on the use of high-precision, re- usable, room-sized, steel forms or moulds for monolithic concrete construction	Outinord Formworks Pvt. Ltd.
9	Aluminium formwork system for Monolithic Concrete construction	Brilliant Etoile

Technologies Evaluated & Recommended>>. Light Gauge Steel Structures & Pre -engineered Stel structural system

Steel Structures including Light Gauge Steel Structures

THE BASIC STRUCTURE IS FABRICATED USING

- Factory made light Gauge steel section exclusively or in combination with prefabricated hot rolled steel sections.
- Walling elements are made of fibre cement boards / EPS Panels or sandwich light weight concrete with suitable insulation

Steel Structures including Light Gauge Steel Structures

- Light Gauge structure alone are suitable upt o G+3 structures.
- In combination with hot rolled section multi storied structures can be erected.

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

...ology Challenge - India (GHTC-I)

4

Light Gauge Stee... Structural Syster... engineered Stee... Structural Syster...

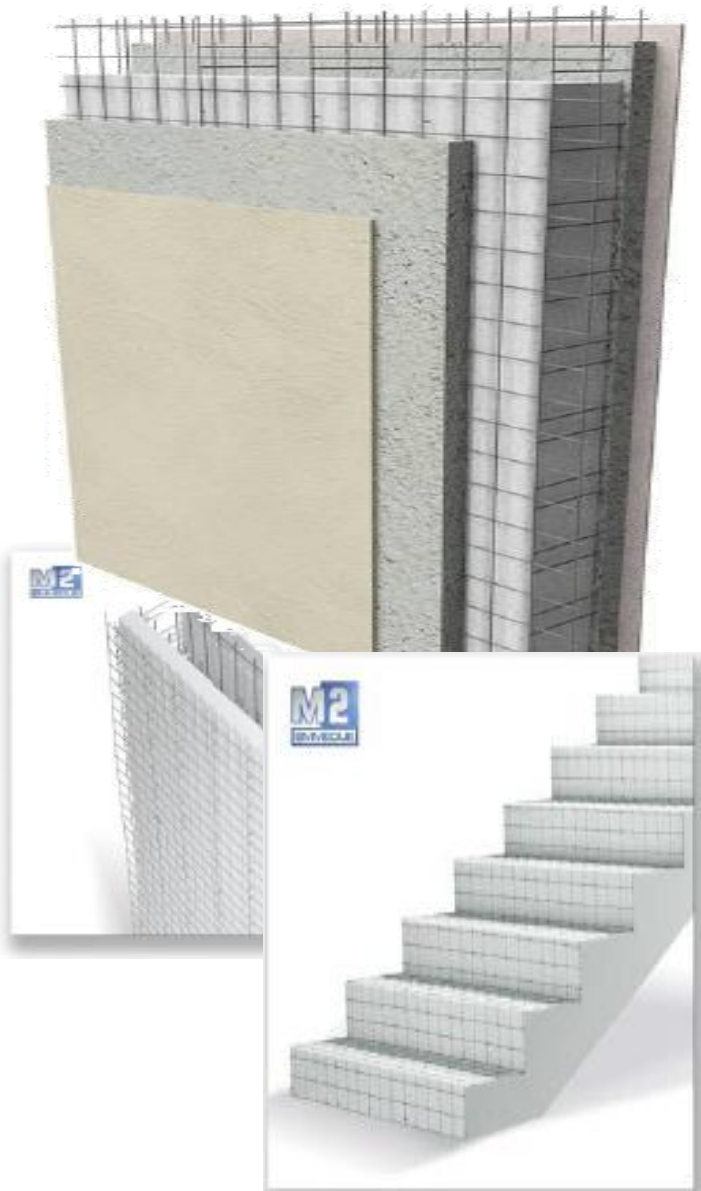
1	LGS Framing with various walling & roofing options	Mitsumi Housing Pvt. Ltd,
2	LGS Framing with various walling & roofing options	Everest Industries Ltd,
3	LGS Framing with various walling & roofing options	JSW Steel Ltd.,
4	LGS Framing with various walling & roofing options	Society for Development of Composites
5	LGS Framing with various walling & roofing options	Elemente Designer Homes
6	LGS Framing with various walling & roofing options	MGI Infra Pvt. Ltd.,
7	LGS Framing with various walling & roofing options	RCM Prefab Pvt. Ltd,
8	LGS Framing with various walling & roofing options	Nipani Infra and Industries Pvt. Ltd.,
9	LGS Framing with various walling & roofing options	Strawcture Eco
10	LGS Framing with various walling & roofing actions	Visakha Industries Ltd.
11	Prefabricated steel structural system with Dry wall system as AAC panels, PUF panels etc	RCC Infra Ventures Ltd.
12	Hot rolled steel frame with speed floor	Jindal Steel & Power Ltd.
13	Hot rolled steel section with AAC Panels as floor & slab	HIL Ltd.
14	AAC wall and roof panel system to provide integrated solution. AAC products are reinforced and used in both load and non-load bearing applications	Biltech Building Elements Ltd
15	AAC Panels are Wire mesh/ steel reinforced for use as wall & slab. Appears to be non load bearing panels to be used with structural framing.	SCG International India Pvt Ltd
16	Precast Light Weight Hollow-core wall Panel is a non-structural construction material with framed structures	Pioneer Precast Solutions Private Limited

Technologies Evaluated & Recommended>>Prefabricated Sandwich Panel system

2.

>> EPS Core Based Factory Made Panel System

- Uses combination of Expanded Polystyrene Core (EPS) and High Strength Galvanized Steel Wire Mesh.
- Successfully used in Europe, Eastern Canada, North Eastern USA, China and other Asian countries.
- UK, Ireland, USA and other Countries have also certified the system.



2.

>> EPS Core Based Factory Made Panel System

- **Panels are factory made in controlled environment.**

2.

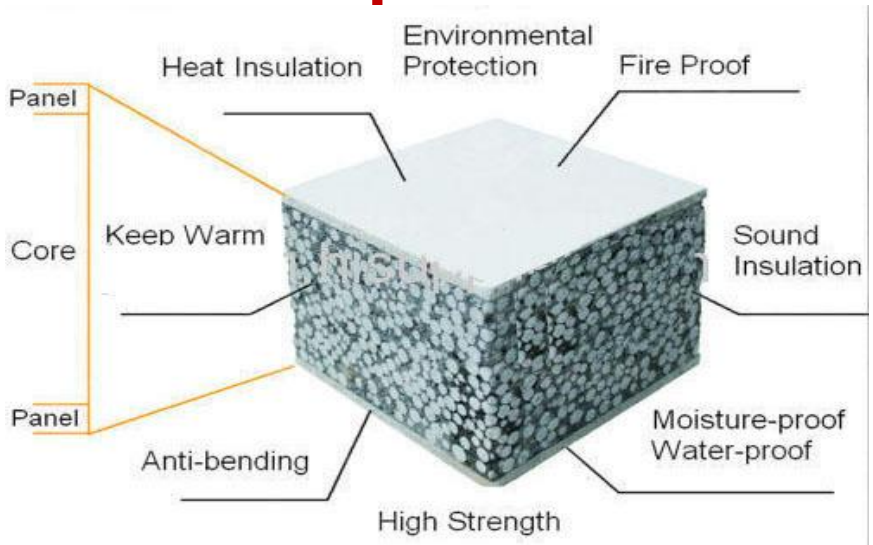
>> EPS Core Based Factory Made Panel System

Advantages

Baupanel technology
Expanded Polystyrene panels in position

- ✓ Panels are light weight and easy to erect.
- ✓ Site work is minimum requiring minimum skilled workers
- ✓ Very suitable for seismic prone areas.
- ✓ No heavy machinery required.
- ✓ Better Thermal & Acoustic behavior.
- ✓ Brings speed & quality.

Sand witch panel system-EPS cement panels



wall & slab with EPS Cement sandwich Panel to be used with RCC or Steel structural frame.

Load bearing upto G+1 storey

Sand witch panel-Pre-fab PIR (Poly-isocyanurate) based Dry Wall Panel System" as non-load bearing wall.

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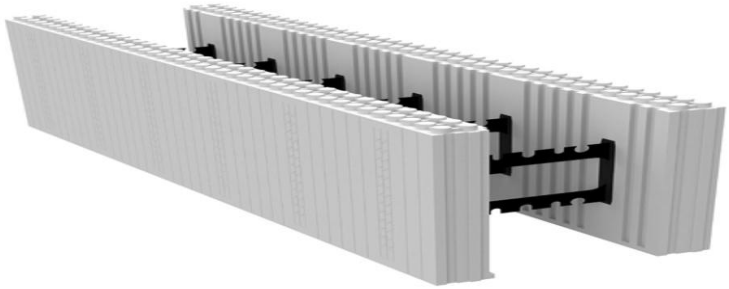
5

1	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	Worldhaus
2	EPS Cement sandwich Panel: wall & slab with EPS Cement sandwich Panel to be used with RCC or Steel structural frame. Load bearing upto G+1 storey	Bhargav Infrastructure Pvt.Ltd
3	EPS Cement sandwich Panel: wall & slab with EPS Cement sandwich Panel to be used with RCC or Steel structural frame. Load bearing upto G+1 storey	Rising Japan Infra Private Limited
4	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	Bau Panel Systems India Pvt Ltd,
5	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	BK Chemtech Engineering
6	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	MSN Construction
7	Reinforced Expanded Polystyrene sheet core Panel with sprayed concrete as wall & slab	Beardshell Ltd.
8	Pre-fab PIR (Poly-isocyanurate) based Dry Wall Panel System" as non-load bearing wall	Covestro India Pvt. Ltd.,
9	Sandwich panels as wall & slab	Project Etopia Group

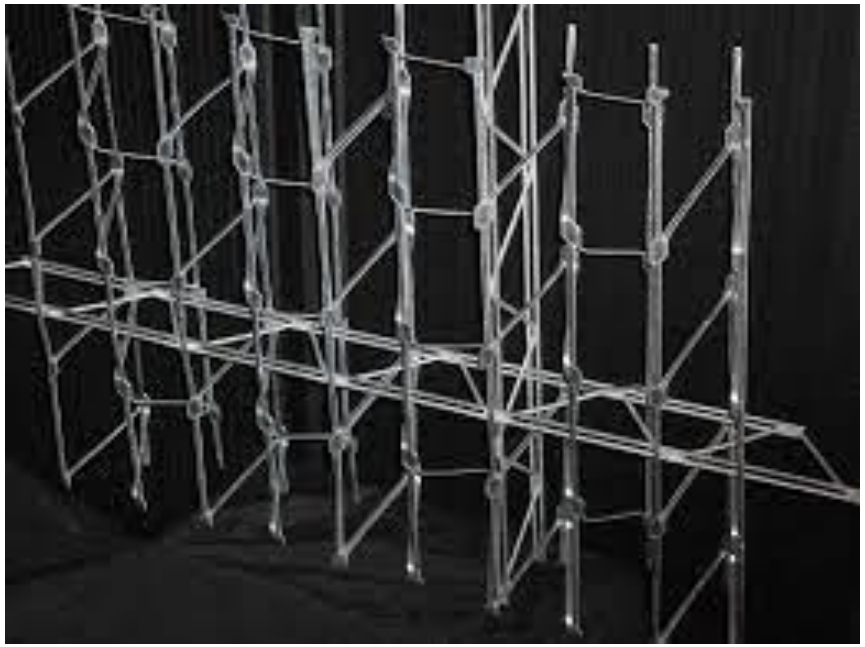
Technology Evaluated and recommended>>-Stay in Place Formwork System

PVC Stay in place formwork

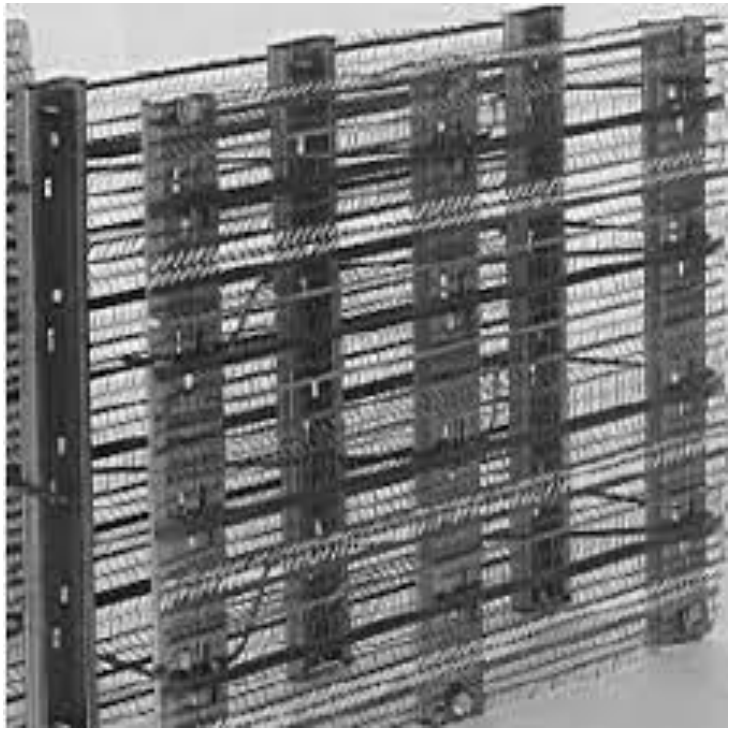


Fast ICF formwork

Stay in Place Formwork System- >>Expanded steel panel & Galvanized steel formwork system



Expanded steel panel reinforced with galvanized steel wire struts



Coffer structural stay in place formwork system

GFRG Panel system

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6 Stay In Place Formwork System

1	Expanded-Steel Panel reinforced with all- galvanised Steel Wire-Struts serving both as the load- bearing steel structure and as the stay-in-place steel formwork filled with EPS-alleviated concrete	JK Structure
2	Factory made prefab Glass fibre reinforced Gypsum cage panels suitable for wall & slab with reinforcement & concrete as infill as per the requirement	FACT-RCF Building Products Limited
3	Structural Stay In Place Galvanized Steel formwork system for walling with the same bottom single layer formwork for slabs/ in-situ slab	Coffor Construction Technology Pvt.Ltd
4	Factory produced PVC Stay in place formwork with concrete & reinforcement in walling units with cast in-situ RCC Slab	Joseph Jebastin (Novel Assembler)
5	Fully load bearing walls with 150 mm monolithic concrete core sandwiched inside two layers of EPS as walling The forms are open ended hollow polystyrene interlocking blocks which fits together to form shuttering system	Reliable Insupack
6	Ready to use Stay in place polymer formwork, light weight, with flooring slab (combination of ferro cement and natural stone) placed on RCC precast joists)	Kalzen Realty Pvt. Ltd
7	Fast Bloc, Insulated Concrete Form (ICF), acts as formwork for concrete and rebar, Co1oumn/post and beam construction, creating an strong skeleton in the walls.	Fastbloc Building Systems
8	Formwork system "Plaswall with Two fibre cement boards (FCB) & HIMI (High Impact Molded Inserts) bonded between two sheets of FCB in situ and erected to produce a straight-to- finish wall with in-situ concrete	FTS Buildtech Pvt.Ltd

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Thank You
for Your Kind
attention

Any Questions?