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 Projects : LIVE LABORATORIES

WEBINAR SERIES: Volume 3 – International Perspective

e-Learning sessions on innovative techniques in new age construction

Aug – Sep 2023

Volume 3 -Session #01 on Light House Project Rajkot, Gujarat

Theme – International Perspective Innovative Technologies and Practices in LHPs

Date: 18.08.2023, Friday | Time: 15:00 – 17:00

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Light House Projects : Live Laboratories
Webinar Series

Emerging Construction Systems for Mass Housing

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Building Materials & Technology Promotion Council
Ministry of Housing & Urban Affairs
Government of India

PMAY (U) Achievement (provisional)

[as on 14th August, 2023]

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आज़ादी का अमृत महोत्सव

G20 भारत 2023 INDIA

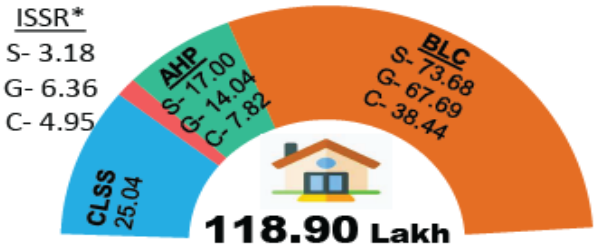
Overall Sanctions for 1.19 crore Houses

Construction of Houses (Nos in lakh)

Demand	Sanctioned	Grounded*	Completed*
112.24	118.90	113.13	76.25

Financial Progress (₹ in Cr)

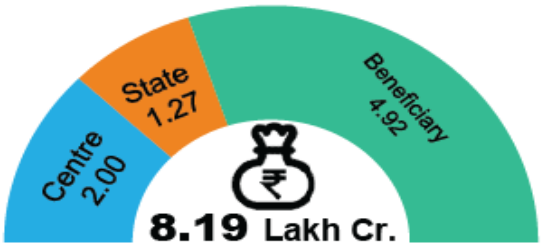
Committed	Released	Expenditure	UC Received
1,99,943	1,48,956	1,42,533	1,42,333



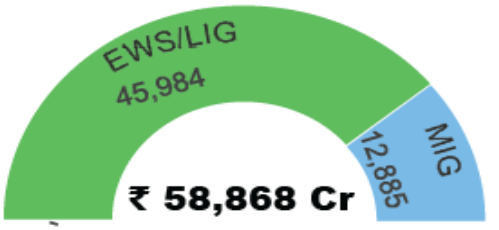
Houses in verticals (Nos in Lakh)

S- Sanctioned G- Grounded C- Completed

Beneficiaries under CLSS (in lakh)



Investment Approved (Rs in Lakh Cr.)



Interest Subsidy under CLSS (Rs in Cr.)

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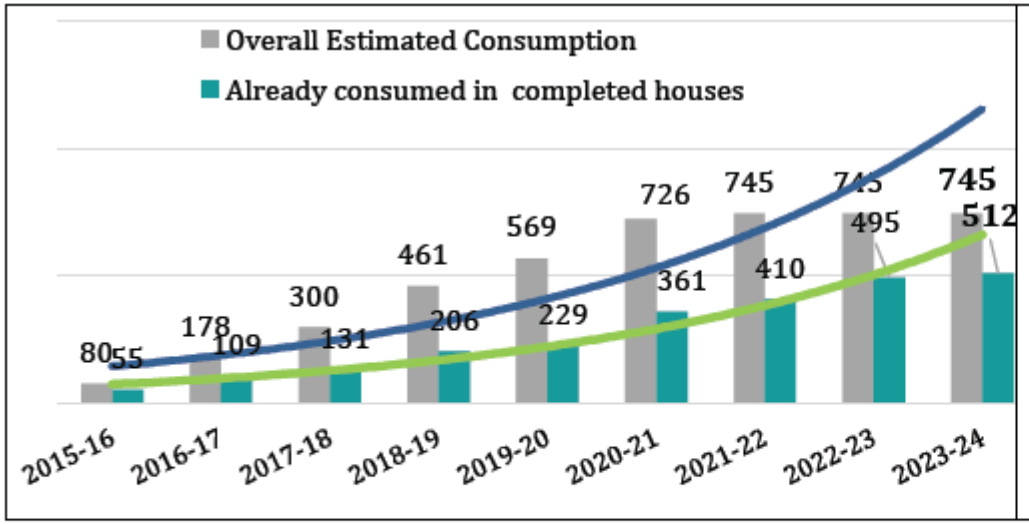
16 lakh houses are being constructed using New Technologies

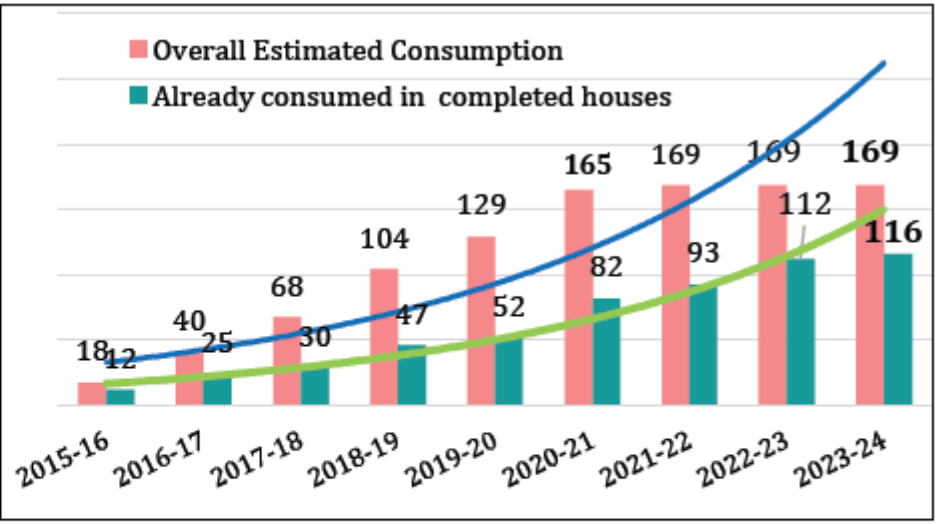
Generation of Employment

Details	Direct	Indirect	Total
Person days (Nos in Cr.)	259	587	**846**
Jobs (in lakh)	93	210	**303**

Cement Consumption (Lakh MT)



Steel Consumption (Lakh MT)

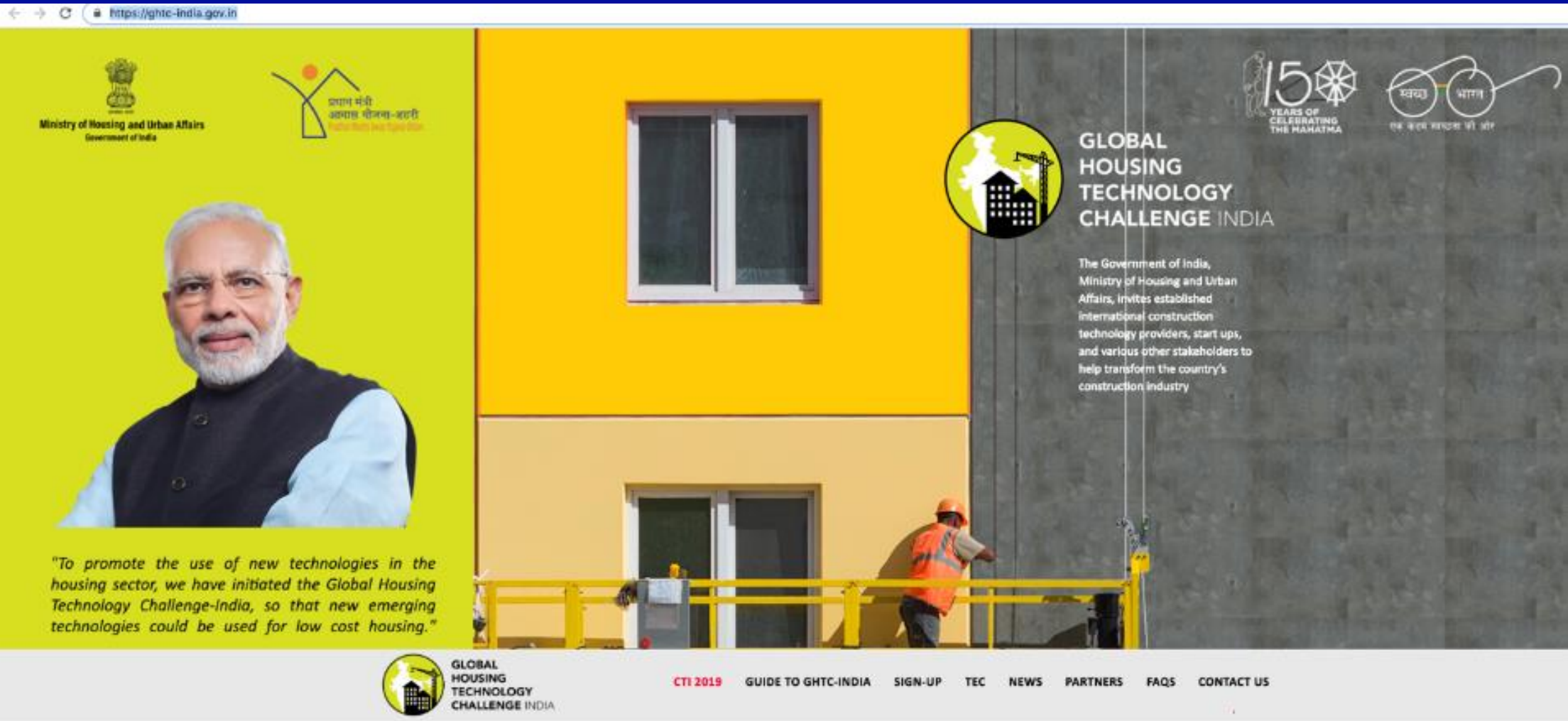


* *includes incomplete works of earlier NURM.*

सबका सपना, घर हो अपना

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Global Housing Technology Challenge - India (GHTC-I)



https://ghtc-india.gov.in/

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**

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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

bmtpc

Conventional Construction Systems

business as usual approach

The prevalent construction systems in India are:

Load bearing Structure

In this system, walls are constructed using bricks/stone/block masonry and floor/roof slabs are of RCC/stone/composite or truss. It is cast in-situ system and called load bearing system as load of structure is transferred to foundation and then to ground through walls.

RCC Framed Structure

In this cast in-situ system, the skeleton of a structure is of RCC column and beam with RCC slab. The infill walls can be of bricks/blocks/stone /panels. The load of the structure is transferred through beam and column to the foundation.

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

Emerging construction systems help to build

SAFER structures

Sustainable Buildings

- 30%-50% reduction in energy use
- 40% reduction in water use
- 35% reduction in GHG emission
- 75% reduction in waste

E Economical - low life cycle cost, better quality

R Resilient - disaster-resistant, structurally superior

3D Precast Volumetric Construction

- Replacing cast in situ RCC structural frame with factory made structural components – 3D
- Customized factory made volumetric construction i.e. the entire module (room)

3D MONOLITHIC VOLUMETRIC Construction

Courtesy :

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Global Housing Technology Challenge - India (GHTC-I)

1 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,

Light House Project (LHP) at Ranchi, Jharkhand

(Technology: Precast Concrete Construction – 3D Volumetric Construction)

No. of Dwelling Units : 1008 Nos. (G+8)
No. of Block / Tower : 7 Blocks
Units in each Block / Tower : 144 Nos.

Light House Project: Ranchi, Jharkhand

Construction Agency	M/s SGC Magicrete LLP
Technology Used	Precast Concrete Construction System – 3D Volumetric
No. of Houses	1,008
No. of Towers	07 (G+8)
Technology brief	• A latest technology where precast concrete **structural modules** like room, toilet, kitchen, bathroom, stairs etc. & any combination of these are cast monolithically in casting yard under controlled condition. • These Modules are **transported and installed** using cranes & push-pull jacks and integrated together at site to form a complete building unit.

Construction Process

1 **Casting of structural modules & slabs in the casting yard**

2 **Placement of modules at site** using cranes

3 **Placement of pre cast floors on already erected structured modules**

4 **Step 2 & 3 are repeated like Lego Blocks to complete a Tower**

2D Precast Concrete Construction

- Replacing cast in situ RCC structural frame with factory made structural components – 2D planar elements
- Customized Factory made beams, columns, wall panels, slab/floors, staircases etc.

Concrete components prefabricated in precast yard or site and installed in the building during construction

Global Housing Technology Challenge - India (GHTC-I)

2

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 interlocking concrete block	William Ling,

Light House Project (LHP) at Chennai, Tamil Nadu

(Technology: Precast Concrete Construction System-Precast Components)

No. of Dwelling Units : 1152 Nos. (G+5)
No. of Block / Tower : 12 Blocks
Units in each Block / Tower : 96 Nos.

Light House Project: Chennai, Tamil Nadu

Construction Agency	M/s B.G. Shirke Constriction Private Ltd.
Technology Used	Precast Concrete Construction System - Precast Components Assembled at Site
No. of Houses	1,152
No. of Towers	12 (G+5)
Technology Brief	• Individual **precast building components** (columns & beams, slabs, stairs etc.) are manufactured in the **casting yard** under controlled conditions. • Finished components are then transported to site, erected & assembled through in-situ concreting **(wet jointing).**

Construction Process

1 **Manufacturing** of Pre-cast building components (columns & beams, slabs, stairs etc.) in casting yard

2 **Transportation & Erection** of Pre- cast beams & columns at site

3 **Placement** of pre-cast slabs & **Assembly** through in-situ concreting (wet jointing) with beam and columns

4 **Infill walls** constructed using Autoclaved Aerated Concrete (AAC) Block masonry along with **services** (electricity, plumbing) followed by plastering

PRE-ENGINEERED STEEL STRUCTURAL SYSTEM

- Replacing cast in situ RCC structural frame with factory made steel (hot rolled) structural system

Steel skeleton with Aerocon panel infills

LIGHT GAUGE STEEL STRUCTURAL SYSTEMS

- Replacing cast in situ RCC structural frame with factory made light gauge steel (cold rolled) structural system

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Global Housing Technology Challenge - India (GHTC-I)

3

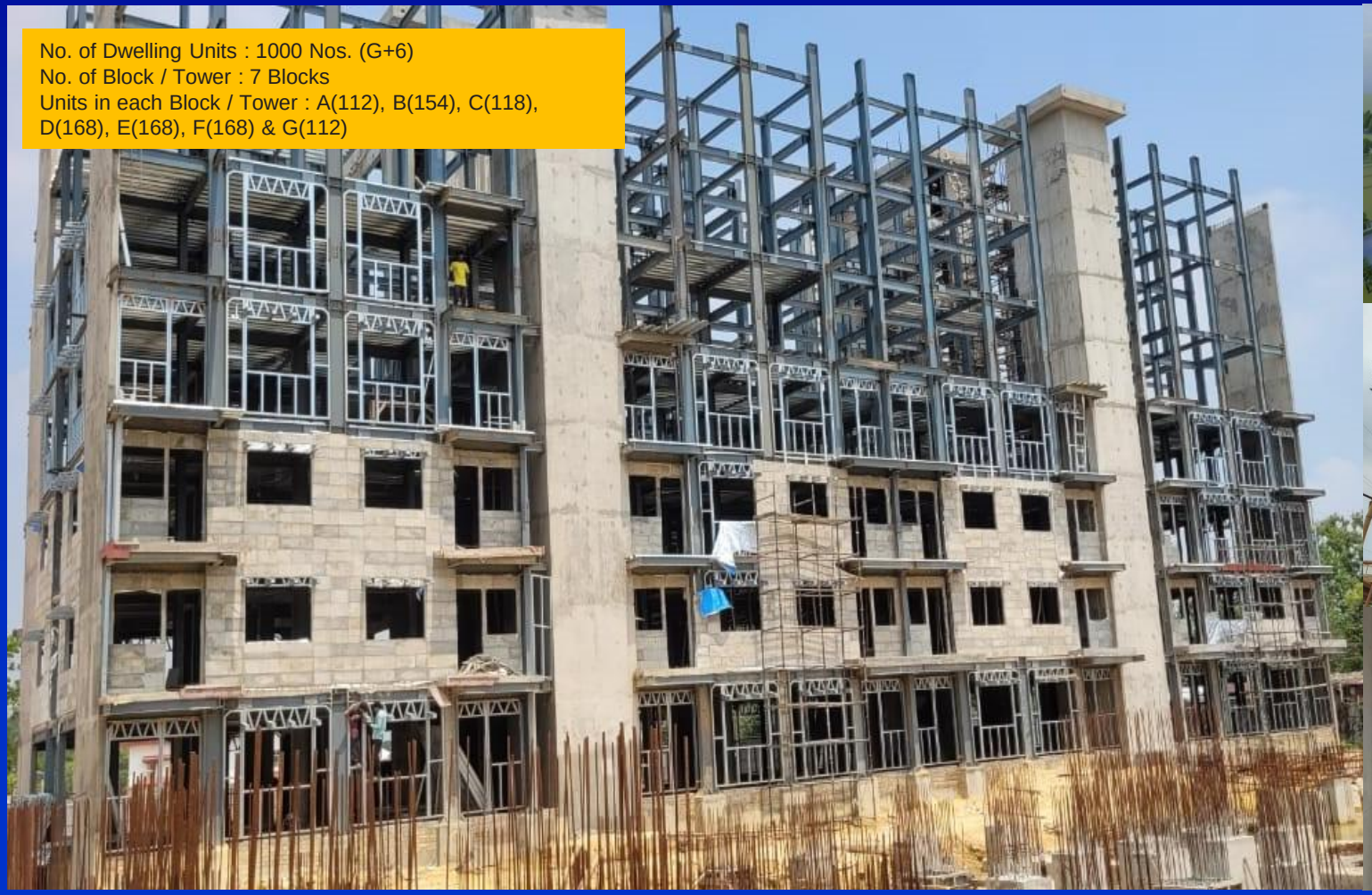
Light Gauge Steel Structural System & Pre-engineered Steel Structural System

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

Light House Project (LHP) at Agartala, Tripura

(Technology: Light Gauge Steel Structural System & Pre-Engineered Steel Structural System)

No. of Dwelling Units : 1000 Nos. (G+6)
No. of Block / Tower : 7 Blocks
Units in each Block / Tower : A(112), B(154), C(118), D(168), E(168), F(168) & G(112)



Light House Project: Agartala, Tripura

Construction Agency	M/s Mitsumi Housing Pvt. Ltd
Technology Used	Light Gauge Steel Framed (LGSF) System with Pre-engineered Steel Structural System
No. of Houses	1,000
No. of Towers	07 (G+6)
Technology brief	• This system uses factory made galvanized **Light Gauge Steel** wall components in combination with pre-engineered steel structural system for structure • The light gauge steel wall sections are **assembled at site** which are then cladded with concrete panels on both sides and filled with light weight concrete.

Construction Process

1 **Customised steel columns & beams** manufactured in the factory are erected at site

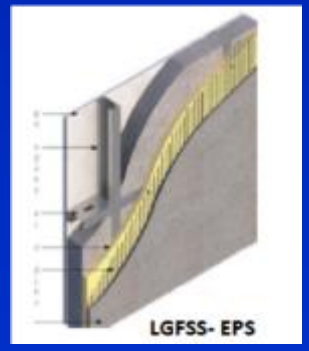
2 **Erection** of factory made **LGSF panels** and **Fixing** of Precast concrete panels for walling

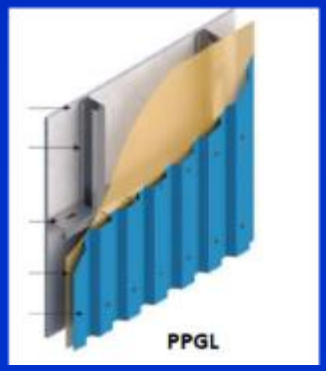
3 **Filling of light weight concrete** between the wall panels

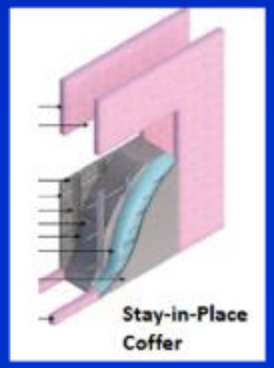
4 **Deck slab installation** in already erected steel structure & **Concreting with services**

PREFABRICATED SANDWICH PANEL SYSTEMS

- **EPS Core Panel Systems**
- **Other Sandwich Panel Systems**
  - **Fibre cement board**
  - **MgO Board**
  - **AAC panels**







- **Replacing brick and mortar walls with dry customized walls made in factory**

SINGLE

DOUBLE

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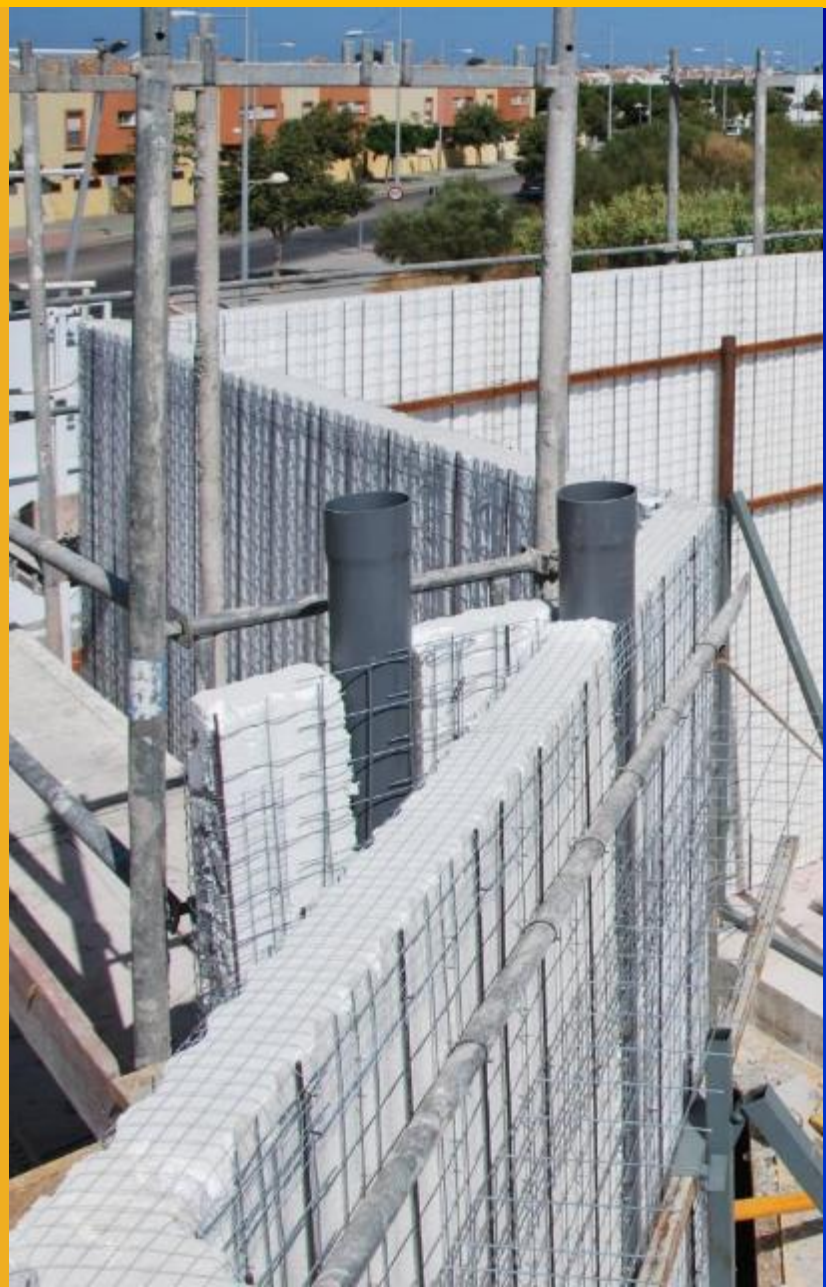
4

Prefabricated Sandwich Panel System

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



Light House Project (LHP) at Indore, M.P.

(Technology: Prefabricated Sandwich Panel System & Pre-Engineered Steel Structural System)

No. of Dwelling Units : 1024 Nos. (S+8)
No. of Block / Tower : 8 Blocks
Units in each Block / Tower : 128 Nos.

Light House Project: Indore, Madhya Pradesh

Construction Agency	M/s KPR Construction Pvt. Ltd
Technology Used	Prefabricated Sandwich Panel System with Pre-Engineered Steel Structural System
No. of Houses	1,024
No of Towers	08 (S+8)
Technology brief	• The **factory-made Prefabricated Sandwich Panel System** comprises of core cement mortar with EPS granules balls sandwiched between calcium silicate boards on both sides. • These panels are being used in combination with **pre-engineered steel structural system as a dry wall construction** in this project.

Construction Process

1 **Customised steel columns & beams** manufactured in the factory are erected at site

2 **Deck slab installation in already erected steel structure**

3 **Concreting** of deck slabs with reinforcement along with **services**

4 **Factory made Prefabricated sandwich panels** are installed as infilled walls along with services

Rising EPS (Beads) Cement Panels

- Rising EPS (Beads) Cement Panels are patented panels from M/s Rising Japan Infra Pvt. Ltd. These are lightweight composite wall, floor and roof sandwich panels made of thin fiber cement/calcium silicate board as outer and inner faces with a core of EPS granule balls, adhesive, cement, sand, fly ash and other bonding materials in mortar form.
- The core material in slurry state is pushed under pressure into preset molds. Once set, it shall be moved for curing and ready for use with RCC or steel framed structure.
- These panels are presently manufactured by the firm in China and shortly a plant will be installed in India.

MONOLITHIC CONCRETE CONSTRUCTION

- Replacing cast-in-situ Formwork with factory made customized formwork systems
- Formwork material is Aluminium / composites / steel having 100 to 500 repetitions
- Assembly line construction i.e. placing the formwork, pouring the concrete, moving the formwork to upper level

5

Monolithic Concrete Construction

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

Light House Project (LHP) at Rajkot, Gujarat

(Technology: Monolithic Concrete Construction System)

No. of Dwelling Units : 1144 Nos. (S+13)
No. of Block / Tower : 11 Blocks
Units in each Block / Tower : 104 Nos.

Light House Project: Rajkot, Gujarat

Construction Agency	M/s Malani Construction Co.
Technology Used	Monolithic Concrete Construction using Tunnel Formwork
No. of Houses	1,144
No. of Towers	11 (S+13)
Technology brief	• **Reinforced Concrete walls and slabs** are cast monolithically in single pour (one go) using Tunnel Form work. • It is a 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 a house.

Construction Process

1 **Customised Tunnel Formwork** (mould) of steel manufactured in the factory

2 **Placement of Tunnel formwork** in already erected reinforcement cage for walls at site

3 **Placement of slab reinforcement & Concreting** of walls & slabs together in one go along with **services** (electricity,

4 **Infill walls** constructed using Autoclaved Aerated Concrete (AAC) Block followed by plastering

Modular Tunnel form

- Tunnel formwork is a mechanized system for cellular structures. It is based on two half shells which are placed together to form a room or cell. Several cells make an apartment. With tunnel forms, walls and slab are cast in a single day.
- The formwork is set up for the day's pour in the morning. The reinforcement and services are positioned and concrete is poured in the afternoon. Once reinforcement is placed, concrete for walls and Slabs shall be poured in one single operation. The formwork is stripped the early morning and positioned for the subsequent phase.
- Here the walls and slabs are cast in a form of a tunnel leaving two sides open whereas in monolithic concrete construction the entire room is cast in a single pour..

STAY-IN-PLACE FORMWORK SYSTEM

- Replacing cast-in-situ Formwork with factory made formwork systems
- It is sacrificial formwork or lost formwork means formwork is left in the structural system to later act as insulation or reinforcement cage

Global Housing Technology Challenge - India (GHTC-I)

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 insitu 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

Light House Project (LHP) at Lucknow, U.P.

(Technology: Stay in-place Formwork System & Pre-Engineered Steel Structural System)

No. of Dwelling Units : 1040 Nos. (S+13)
No. of Block / Tower : 4 Blocks
Units in each Block / Tower : A(494), B(130), C(208) & D(208)

Light House Project: Lucknow, Uttar Pradesh

Construction Agency	M/s Jam Sustainable LLP
Technology Used	Stay in Place PVC Formwork with Pre-Engineered Steel Structural System
No. of Houses	1,040
No. of Towers	04 (S+13)
Technology brief	• Poly-vinyl Chloride (PVC) based permanent stay-in-place form work acting as pre finished walls filled with concrete which requires no plaster and paint • These pre finished walls are used in combination with Pre-Engineered Steel Structural System

Construction Process

1 **Customised steel columns & beams** manufactured in the factory are erected at site

2 **Deck slab installation** in already erected steel structure & **Concreting with services**

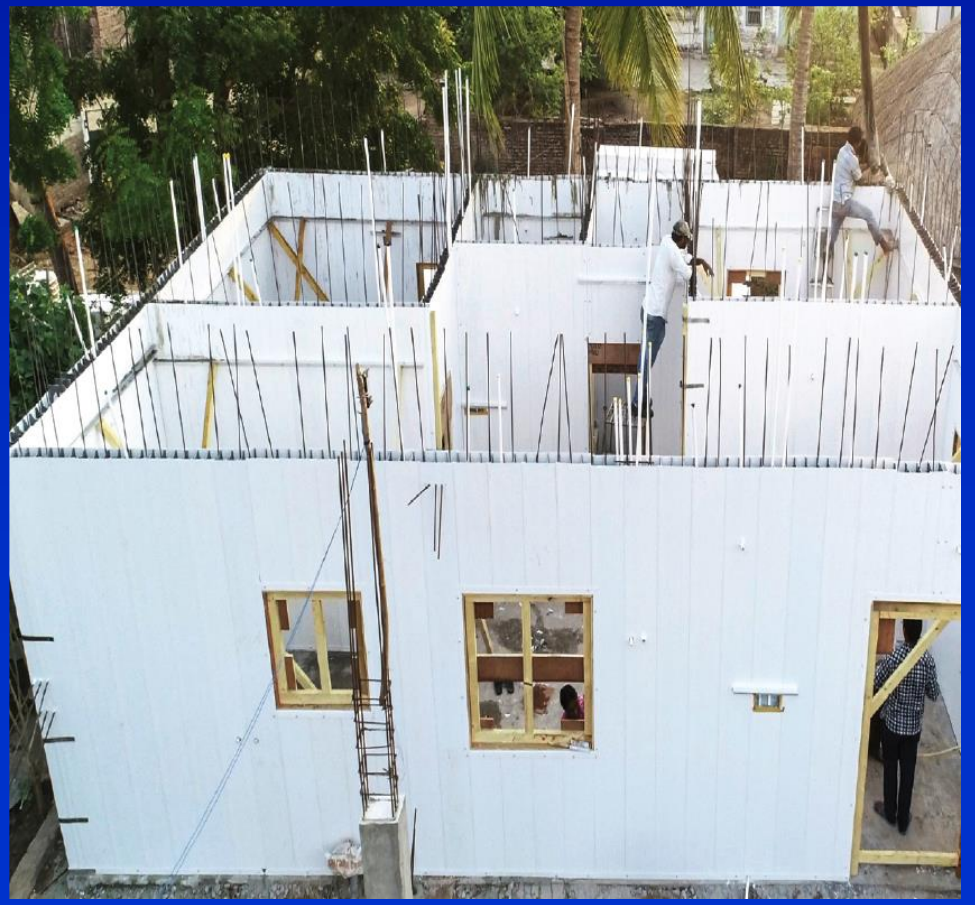
3 **Factory made prefinished PVC Wall forms** are installed as infilled walls along with services

4 **Filling of infill walls with concrete**

Stay-In-Place PVC Wall Forms

- The extruded components slide and interlock together to create continuous formwork with the two faces of the wall connected together by continuous web members forming hollow rectangular components. The web members are punched with oval-shaped cores to allow easy flow of the poured concrete between the components.
- The hollow Novel Wall components are erected and filled with concrete, in situ, to provide a monolithic concrete wall.

- This is a prefinished wall formwork from M/s Novel Assembler Pvt. Ltd. comprising of rigid Poly-Vinyl Chloride (PVC) based polymer components that serve as a permanent stay-in-place durable finished form-work for concrete walls.



Adoption of New Technologies by States

AHP houses in Pune, Maharashtra using Precast Construction Technology

- Around **16 Lakh houses** are being built using innovative technologies under PMAY(U) & other state schemes.

State	Technology
Andhra Pradesh	EPS, Monolithic and Steel Technology
Chhattisgarh	Monolithic and Precast Technology
Gujarat	Monolithic, Precast (Waffle-crete)
Kerala	Glass Fibre Reinforced Gypsum (GFRG)
Maharashtra	Precast (3S) & Monolithic Technology
Odisha	Precast concrete construction
Jharkhand	Global Tender floated
Tamil Nadu	Precast Concrete Technology
States like Assam, Karnataka, Madhya Pradesh, Telangana & Uttarakhand have also expressed interest in Technology neutral bidding process	

54

Alternate technologies Identified

54

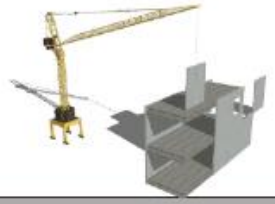
technologies approved by CPWD

34

SoRs issued for alternate technologies by CPWD (27+7)

Looking Back / Rear view

Levels of Construction Technology

Level 0	Level 1	Level 2	Level 3	Level 4
				
MATERIAL	COMPONENTS	ELEMENTAL OR PLANAR SYSTEMS	VOLUMETRIC SYSTEM	COMPLETE BUILDING SYSTEMS
Basic materials for site-intensive construction ✓ Involves more Labour ✓ Time consuming	Manufactured components ✓ Fabricated in Factory ✓ Can't be build On-site ✓ Assist in construction speed & quality	Linear or 2D components ✓ Series of Pre fabricated elements assembled to form the shell ✓ Requires on-site work	3D components in the form of modules ✓ Volumetric, forms a completed part of the building ✓ Involves more than one trade in the factory	Modular components - fully finished and delivered to site ✓ Finished interior & exterior surfaces ✓ Less on-site work

Source: Gibb., A.G.F., *Off-site Fabrication—Pre-Assembly, Pre-Fabrication, and Modularization*

Courtesy : hoMission Abode All

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"Creating Enabling Environment for Affordable Housing for All"

Light House Projects : LIVE LABORATORIES

WEBINAR SERIES: Volume 3 – International Perspective

e-Learning sessions on innovative techniques in new age construction

Aug – Sep 2023

Volume 3 - Session #01 on Light House Project Rajkot, Gujarat

Date: 18.08.2023, Friday | Time: 15:00 – 17:00

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 RAJKOT

GHTC-I Category:

Monolithic Concrete Construction System

Technology:

Monolithic Concrete Construction using Tunnel Formwork

CONTENTS

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Global Housing Technology Challenge - India (GHTC-I)

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

Summary of Light House Project (LHP)

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

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

Typical floor plan

Block Plan

At each floor there are 08 dwelling units

Project Layout Plan

Typical Dwelling Unit Plan

Unit Plan

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

Unit 3D VIew

Prevalent Construction Systems → **Technology being Used**

Load bearing Structure

RCC Framed Structure

Monolithic Concrete Construction using Tunnel Formwork

Tunnel formwork
- Customized formwork

Assembly of Formwork

Concreting after Placing formwork

Structure after removal of formwork
- Shear Wall Construction

Structural Elements

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

FOUNDATION

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

Foundation

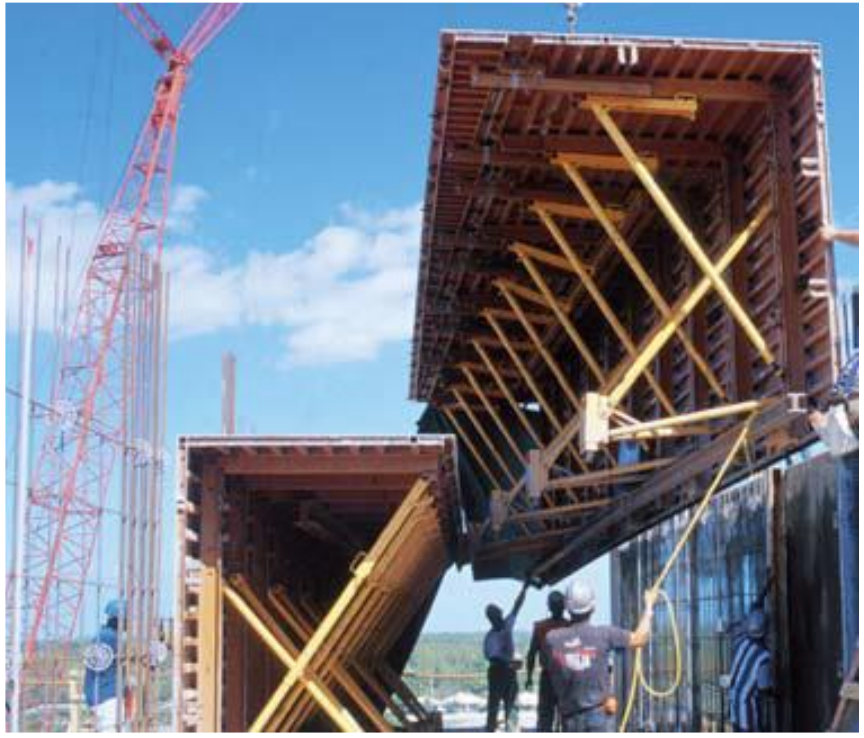
- As per geo-technical investigations, bearing capacity, soil strata, water table, etc.
- Typical raft foundation of varying sizes depending on the load.

Foundation

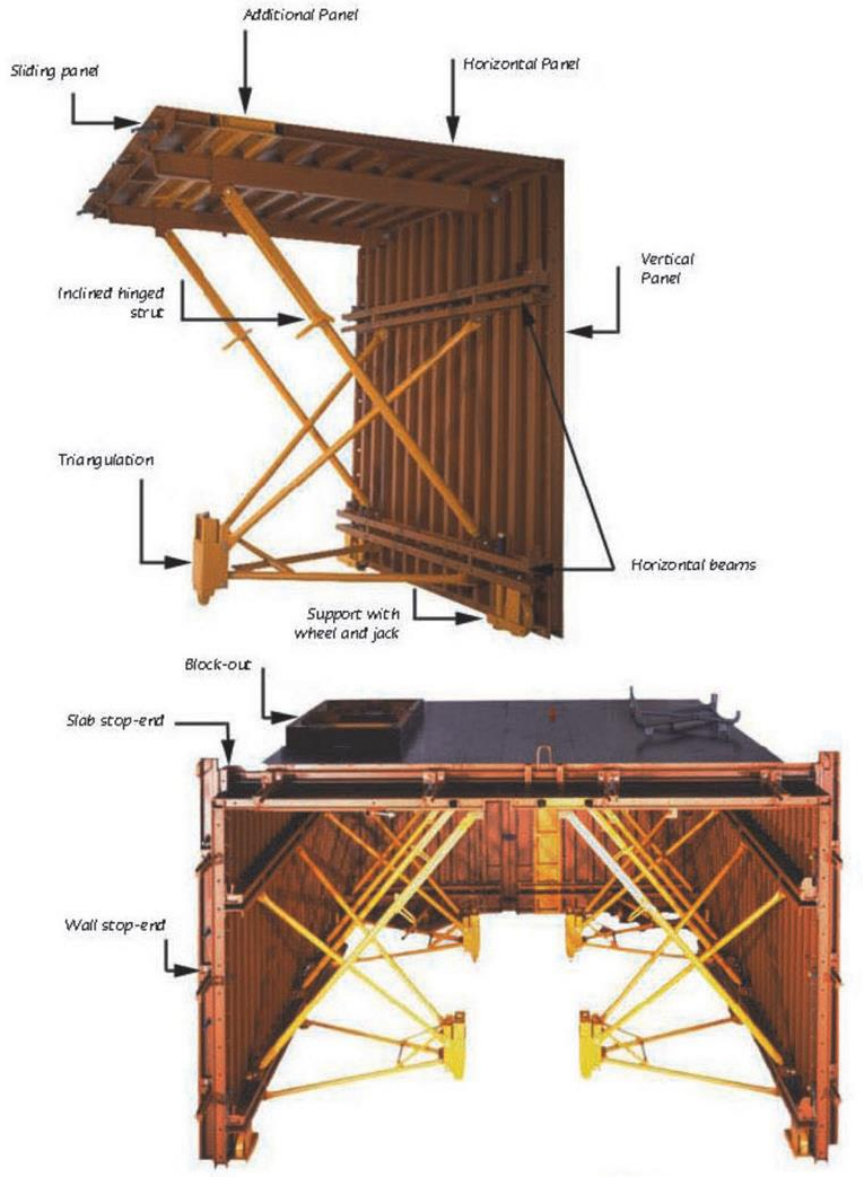
- Concreting of raft footing with M25 concrete as per Structural Drawing.
- Formwork for shear walls up to plinth beam.

Structural System

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



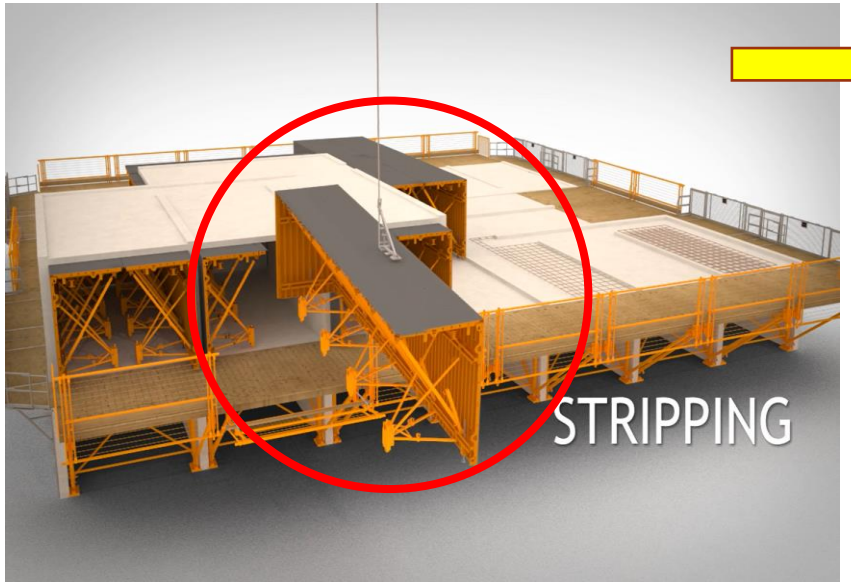
Assembly of Tunnel Formwork

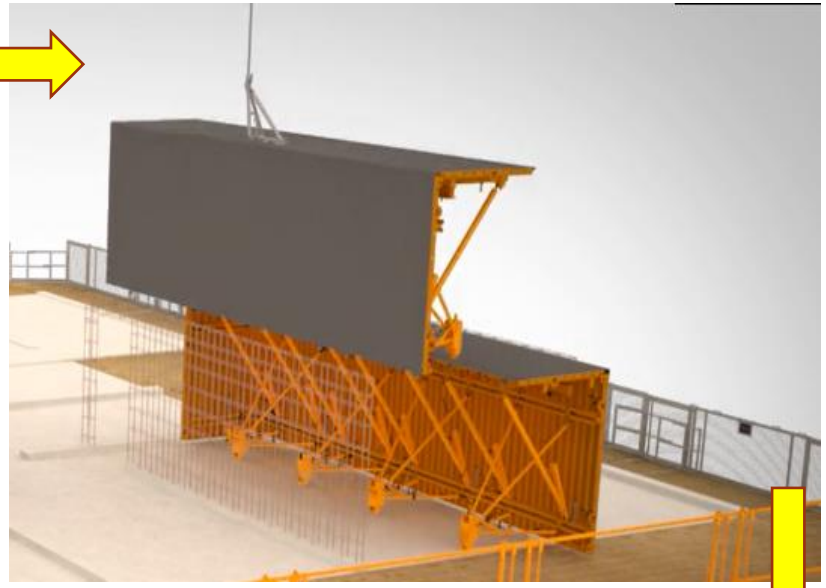


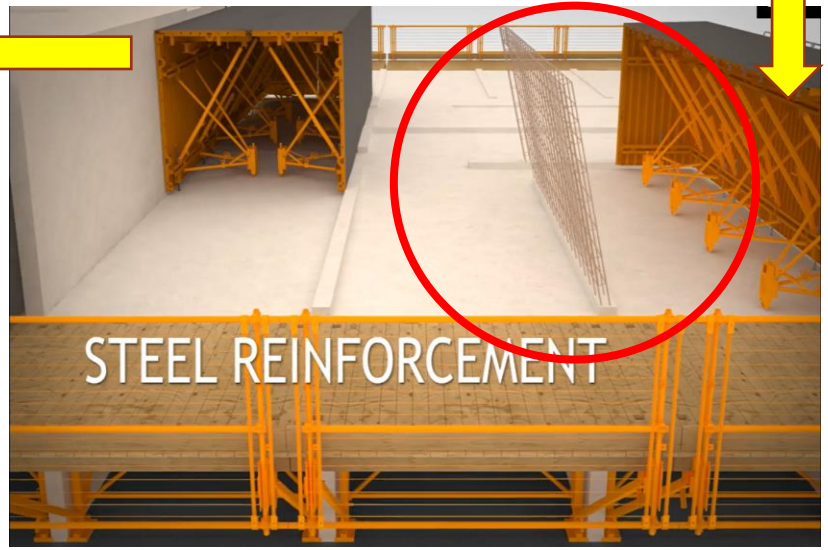
Work Cycle with Tunnel Formwork

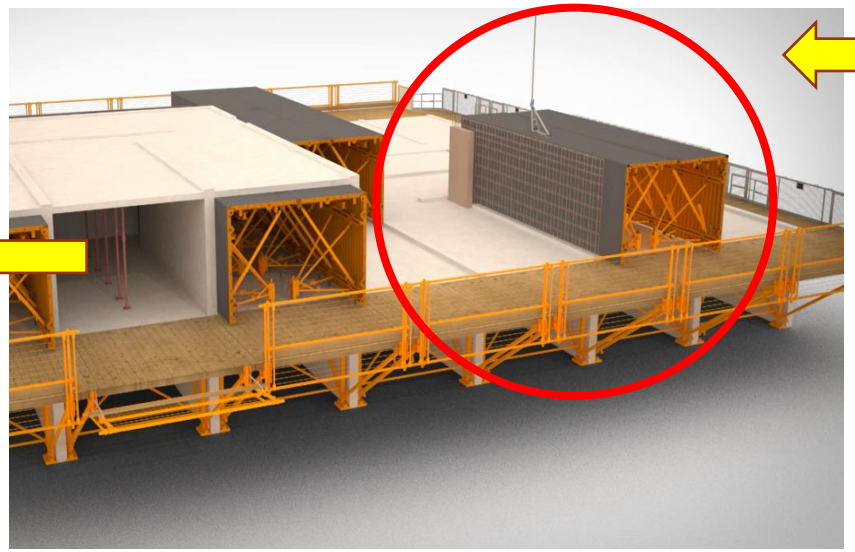
The on-site implementation of 24 hour cycle is divided into following operations.

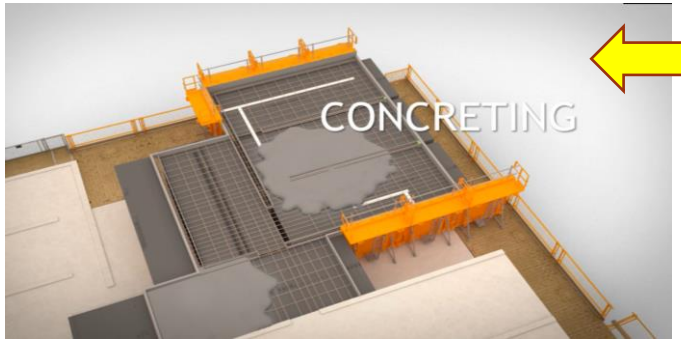
1. Stripping of the formwork from the previous day.
2. Positioning of the formwork for the current day's phase, with the installation of mechanical, electrical and plumbing services.
3. Installation of reinforcement in the walls and slabs.
4. Concreting.











Structural System

- Placement of tunnel formwork for slab and wall

- Concreting after placement of reinforcement on slab and wall.

Structural System

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

Placement and leveling of concrete

Structural Elements

- Finished Monolithic structure with shear wall and slab

Autoclaved Aerated Concrete (AAC) Blocks for Wall

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

Mass Scale Field Implementation of New Technology

Light House Project at Rajkot

on

Design & Build Basis

Agency:

M/s Malani Construction Company, Rajkot

Technology Provider:

M/s Outinord Formwork Pvt. Ltd., Pune

Design Basis

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

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

  k_1 (Risk Coefficient)=1

  k_2 (Size factor)=Category 4

  k_3 (topography factor)=1

  k_4 (importance factor)=1

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

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

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

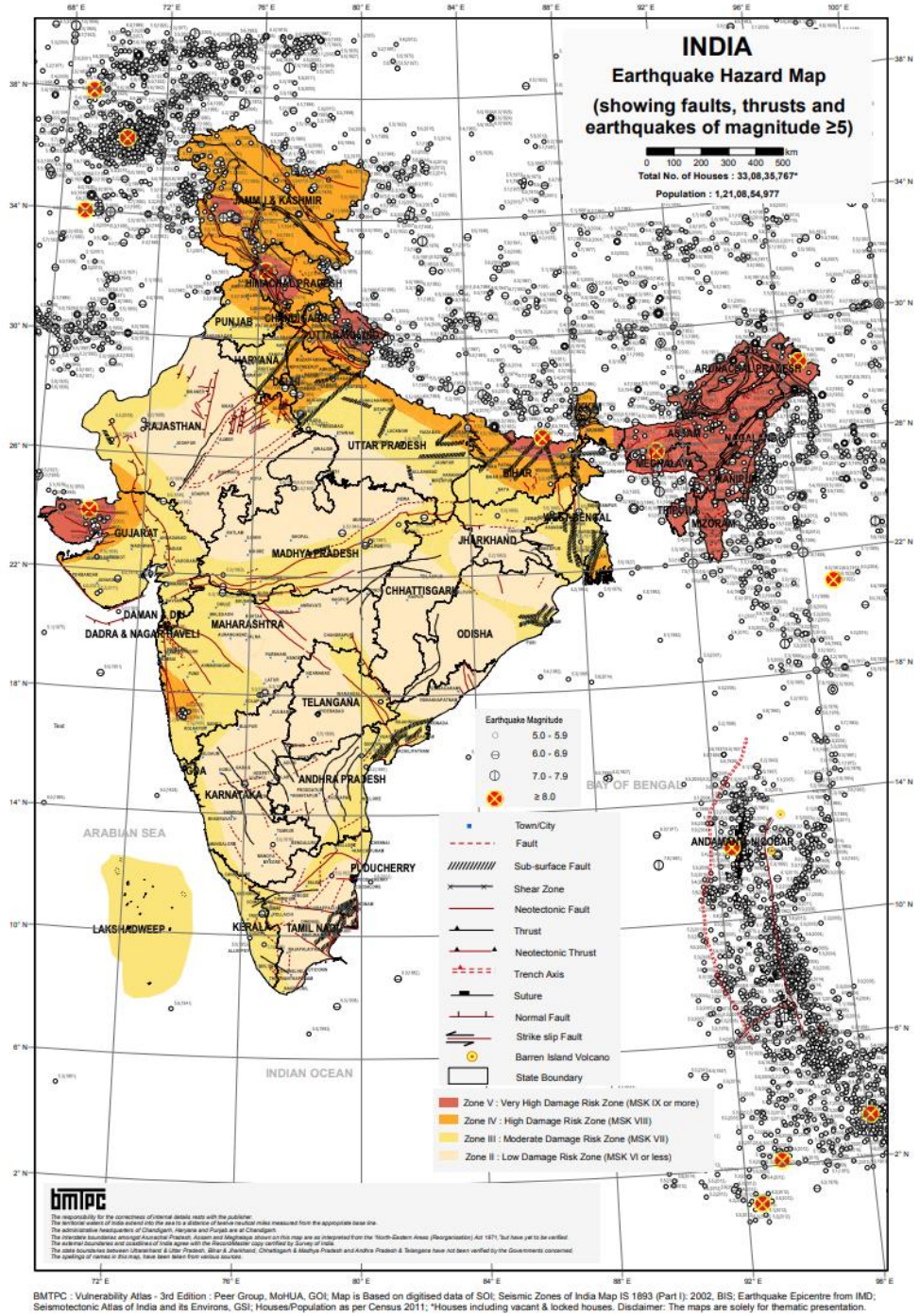
S_a/g is design acceleration coefficient for different soil types corresponding to natural period (T) of building

  - Design Lateral Force (V_B)

$$V_B=A_h.W$$

W is seismic weight of building

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



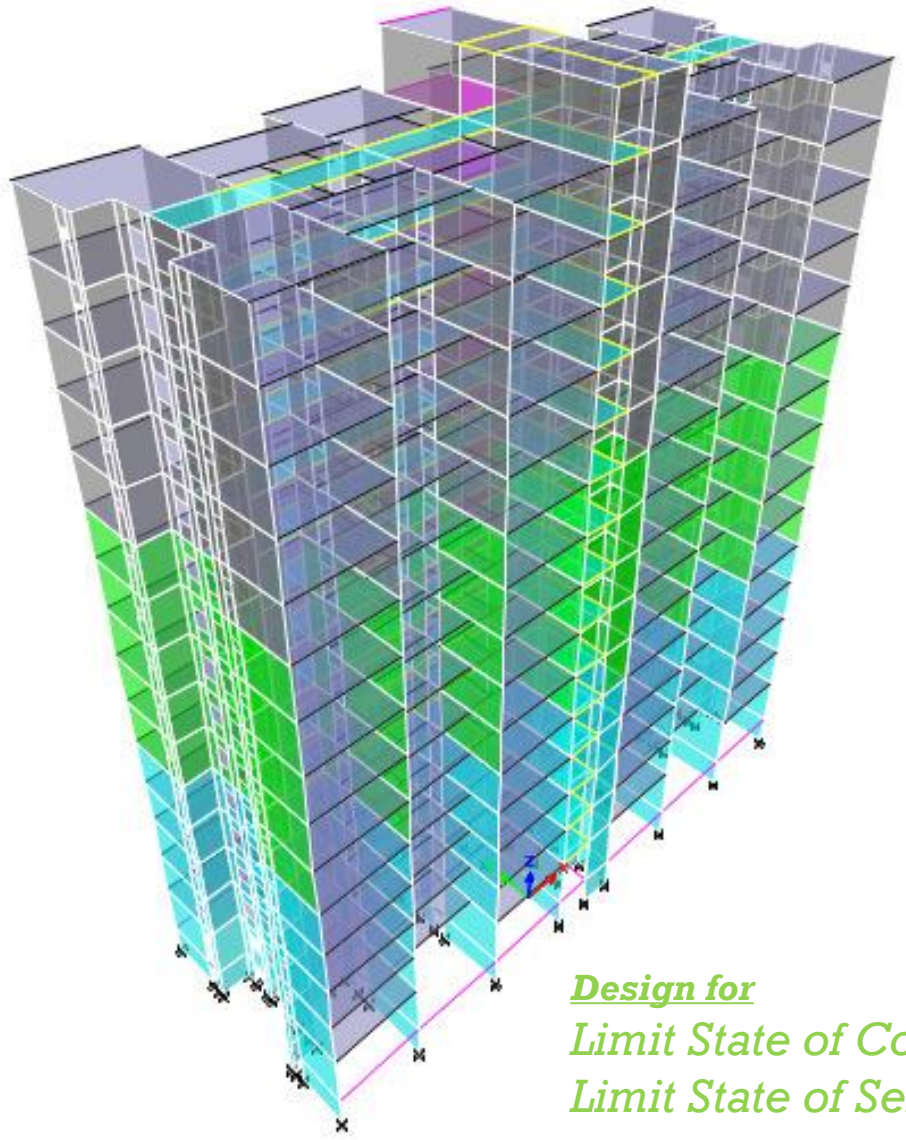
BMTPC : Vulnerability Atlas - 3rd Edition : Peer Group, MoHUA, GOI; Map is Based on digitised data of SOI; Seismic Zones of India Map IS 1893 (Part I): 2002, BIS; Earthquake Epicentre from IMD; Seismotectonic Atlas of India and its Environs, GSI; Houses/Population as per Census 2011; *Houses including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

STRUCTURAL ANALYSIS & DESIGN

- 2D and 3D Modeling

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

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



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

Design for

Limit State of Collapse

Limit State of Serviceability

Construction Sequence

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

Salient features of technology implementation of the project

- **Development of concrete mix:**

  Strength criteria of 8 Mpa after 10-12 hrs – concrete mix design grade M40.

MIX DESIGN BY NCCBM, AHMEDABAD

FINAL RECOMMENDATIONS FOR THE CONCRETE MIX DESIGN

M40 (MSA20) Grade, Workability: 180 mm (After 60 Minutes), Exposure Condition:

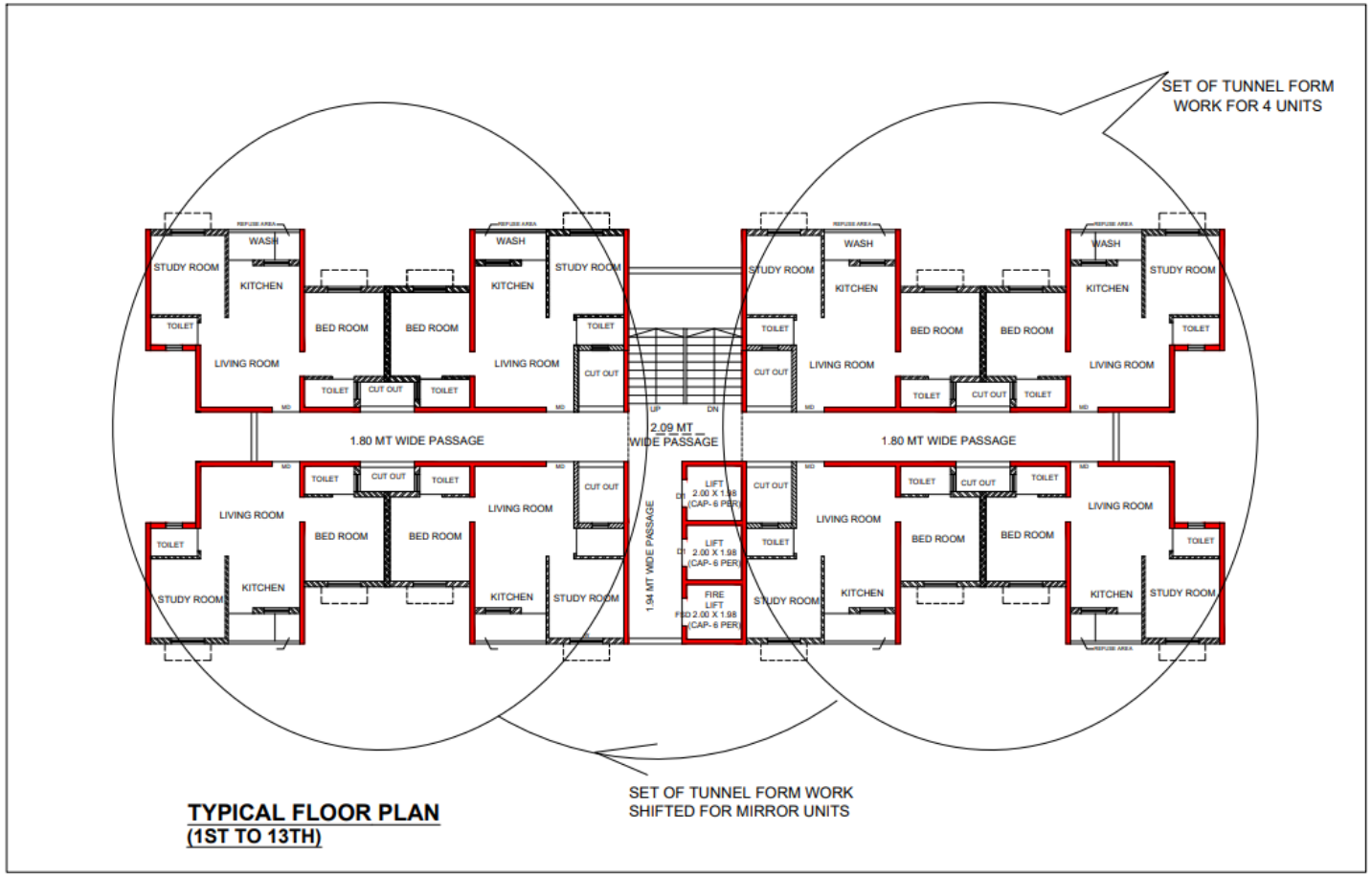
As per IS:456-2000, Minimum Cement Content: As per IS:456-2000Kg/m^3.

The recommendations for M40 MSA20 grade of concrete on the basis of data generated from Table1 and for the target average 28-day compressive strength of 48.25 N/mm^2 are as follows:

Mix Constituents (kg)	For One Cubic Metre
Cement	325 Kg
GGBS	150 Kg
Alco fine	25 Kg
Water	165 Kg
Fine Aggregate Mix Material Sand (75 %) Stone Dust (25 %)	731 Kg 548.2 Kg 182.8 Kg
Coarse Aggregate 10-20mm (50 %) < 10mm (50 %)	 563 Kg 563 Kg
Admixture @ 0.9 % by wt. of (Cementitious Material Content)	4.50 Kg
Water – Cement Ratio	**0.33**

SALIENT FEATURES contd.

- Two tower cranes with capacity of 6T load each were installed at the project site for placing two sets of Tunnel form (each for four DUs) separately on two towers.
- The tunnel formwork installation sequence adopted at site;



SALIENT FEATURES contd.

- A set of formwork for 4 Units were put on one side of Staircase/ lift well, and after casting of the units, it was shifted to its other side. After completion of the opposite side, it was again brought to upper side of already cast Units.
- The average time taken for casting of two Towers of 208 DUs (Each Tower with 104 DUs) was 45 Days with two sets of Tunnel forms. Accordingly, 8 DUs were constructed in about 1.75 Days & an average Cycle time of 1.75 Days (for 8 DUs) was achieved in the project. In few instances, particularly in summer days when concrete gained initial strength fast (allowing early deshuttering) a Cycle time of less than 36Hrs (1.5 Days) was also achieved.
- A typical cycle time achieved at site using this particular formwork system comprise of following:

  (i) De-shuttering of Tunnel form & placing it inside portion/ upper storey – Time taken about 4-6 hrs,

  (ii) Putting of reinforcement cage in wall & slab portion along with electrical & plumbing conduits – Time taken about 6-8 hrs,

  (iii) Pouring of concrete in the slab & wall portion - Time taken 4-6hrs, and

  (iv) De-shuttering (after 16-20 hrs).

  (Before de-shuttering of tunnel form, it was ensured that strength of casted cube in the mould, while pouring the concrete in that portion, achieved a minimum strength of 8 N/mm2.)

SALIENT FEATURES contd.

- The completion of all 11 building blocks took one year (June 2021 to June 2022),

- The project suffered disruptions due to COVID-19, high wind affecting the operation of Tower Cranes with Tunnel form (during July to August, 2021), inclement weather leading to heavy rainfalls, batching plant O&M issues, disruption of supply of aggregates in the State for few weeks in the month of May, 2022, etc.

- A total of 143 repetitions of Tunnel form (Set of 8 DUs) were achieved in the project for construction of entire 1144 DUs. As per agency, the high carbon tunnel formwork can be used for more than 500 repetitions.

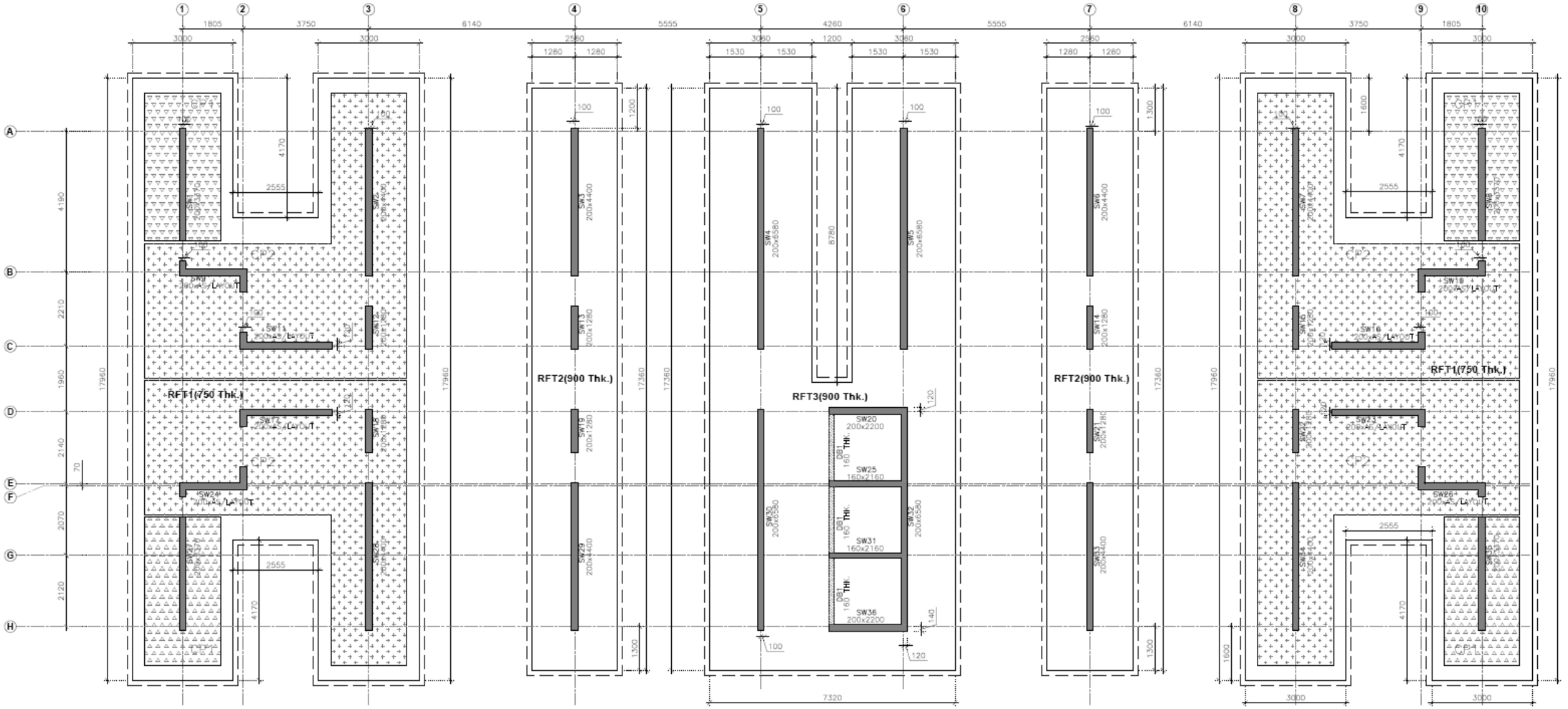
SALIENT FEATURES contd.

- Had it been three sets of formwork (for 12 DUs), all building structures could have been completed in about 8 months time, but again with higher resources requirements on the part of construction agency.

- On account of primarily AAC masonry wall on external face, the building system has been evaluated as 3 - 4% more comfortable than the conventional building by GIZ, with the peak temperature difference in a summer season as 1.1°C better than the conventional building. Other sustainable parameters included the embodied energy reduction by 25% due to use of GGBS in cement concrete mix, significant reduction in use of water, etc.

FOUNDATION

Structural Drawings



STRUCTURAL LAYOUT AT FOUNDATION LEVEL.

ALL CENTER LINE & DIMENSION REFER AS PER ARCH DRG.

—THUS MARKED 450 THK.CAP ABOVE RAFT

—THUS MARKED 900 THK.CAP ABOVE RAFT

FOUNDATION

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

FOUNDATION

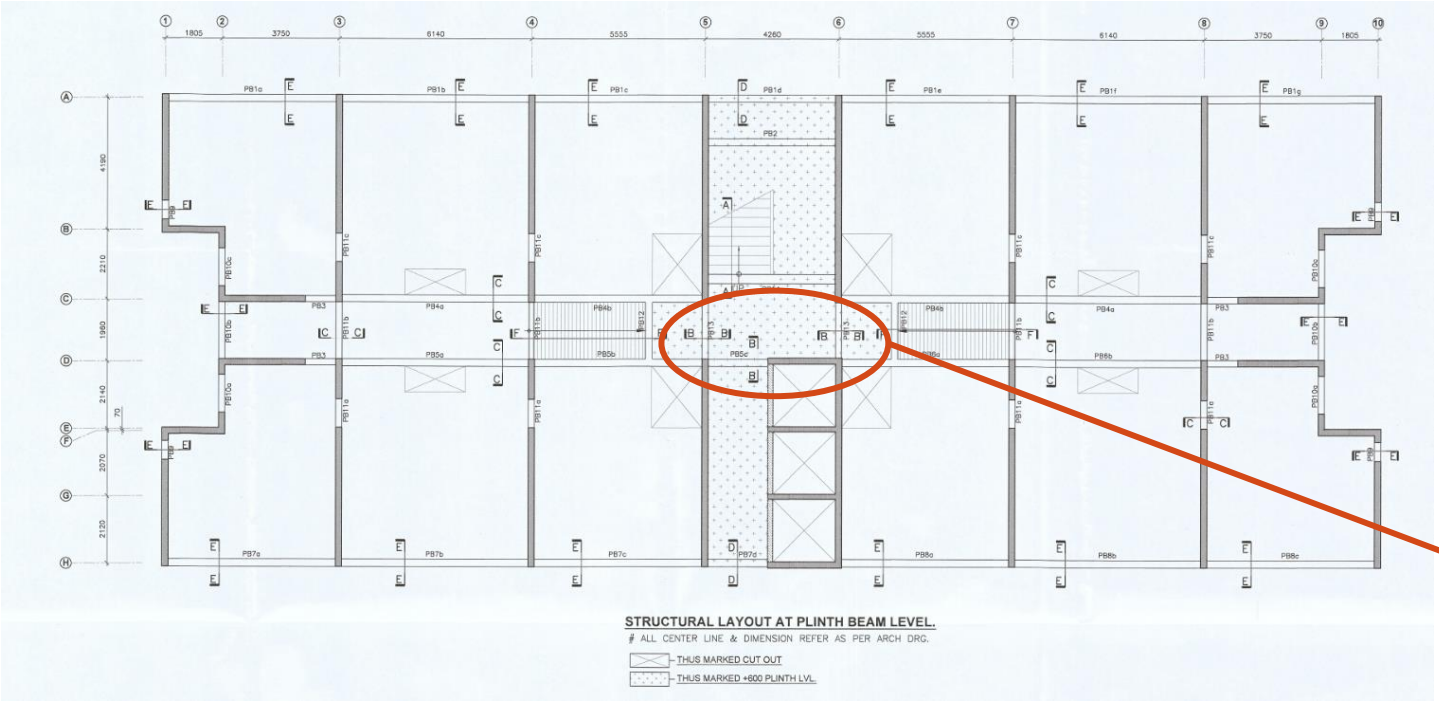
- After PCC, laying of reinforcement and shuttering for raft foundation is done.

FOUNDATION

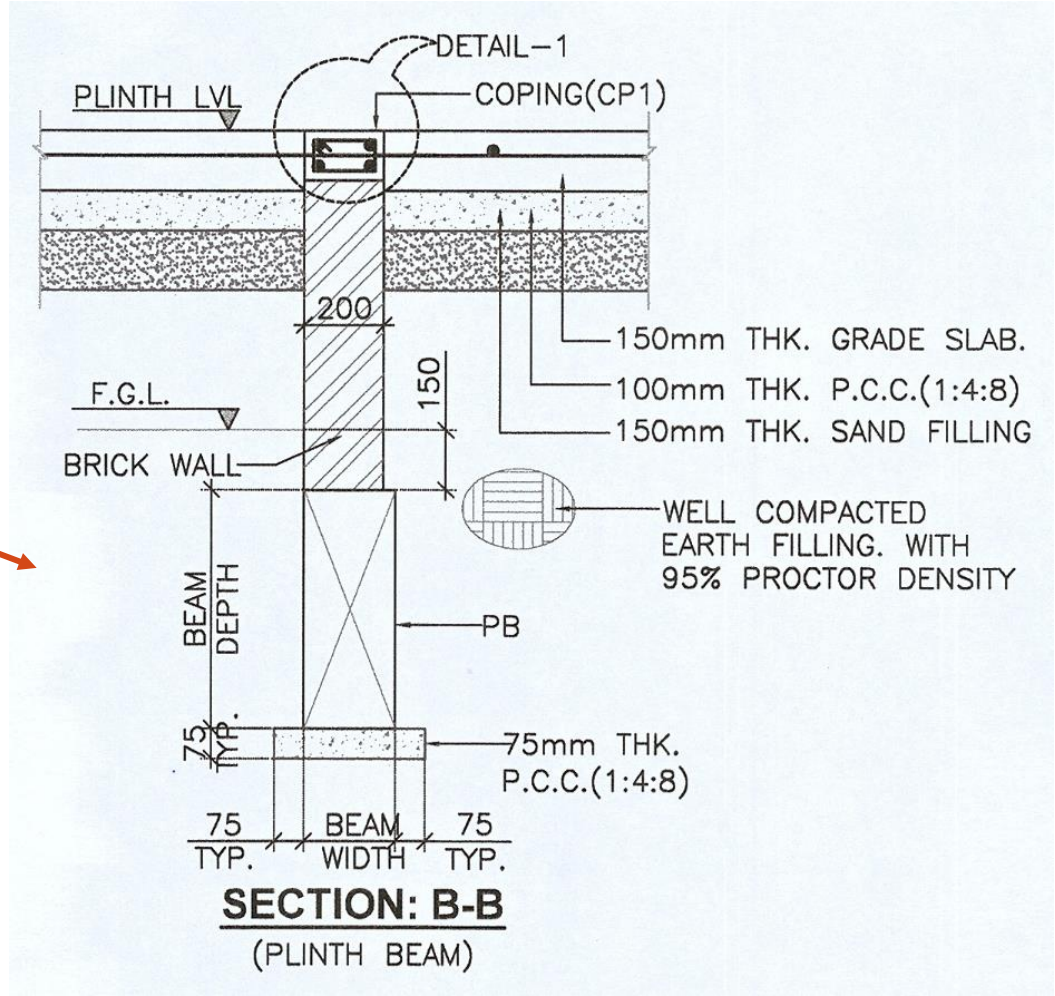
- Concreting of raft footing with M25 concrete was done as per Structural Drawing

STRUCTURAL SYSTEM

Structural Layout at Plinth Beam Level



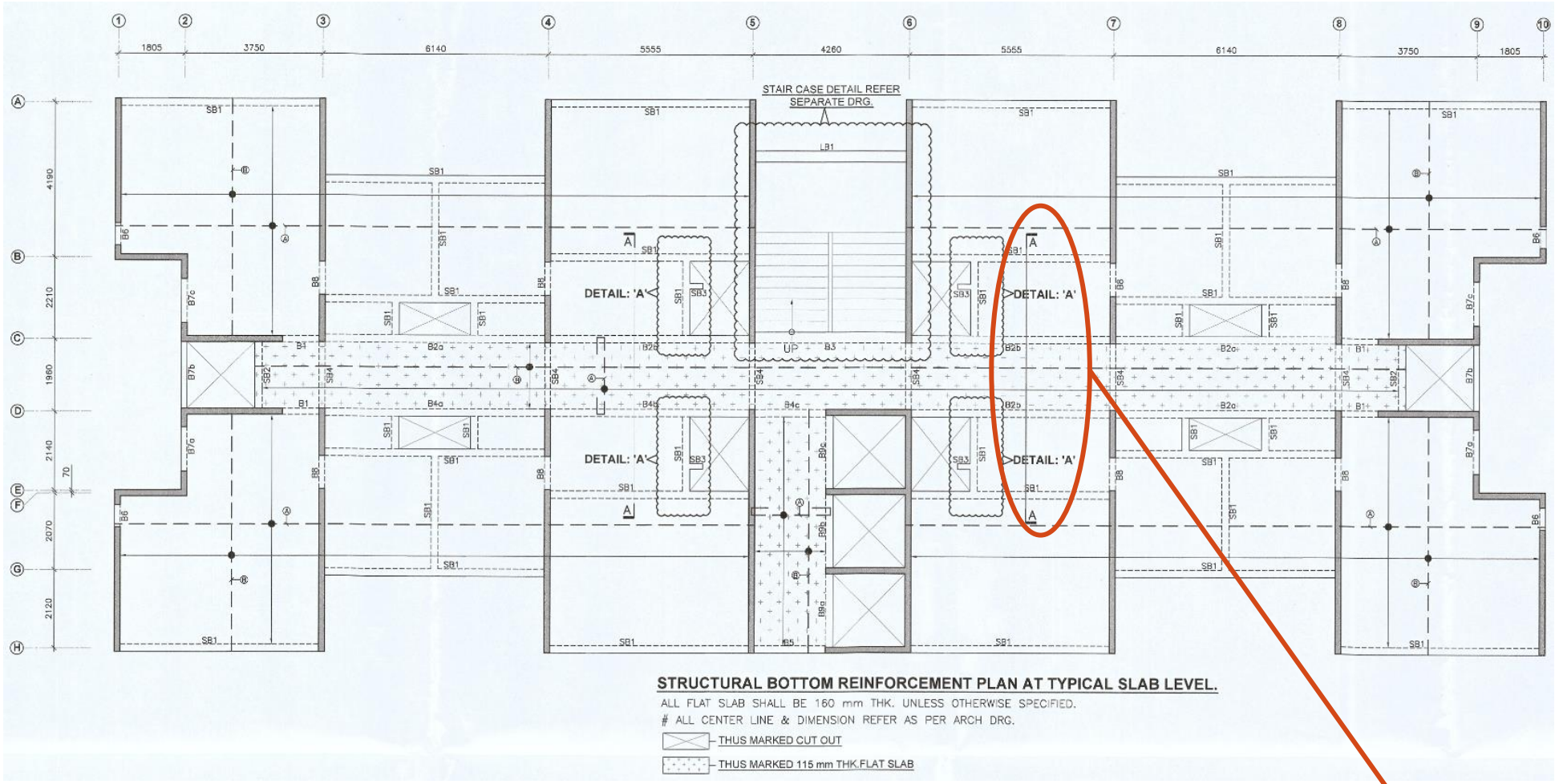
SCHEDULE OF BEAM SIZE		
SR.NO.	BEAM SIZE	BEAM NUMBER
1	230 X 600	PB1,PB2,PB4,PB5,
		PB6,PB7,PB8,PB12.
2	200 X 600	PB3,PB9,PB10,PB11,PB13.
3	300 X 600	PB14.



STRUCTURAL SYSTEM

Typical Reinforcement Details of Shear Wall

STRUCTURAL SYSTEM

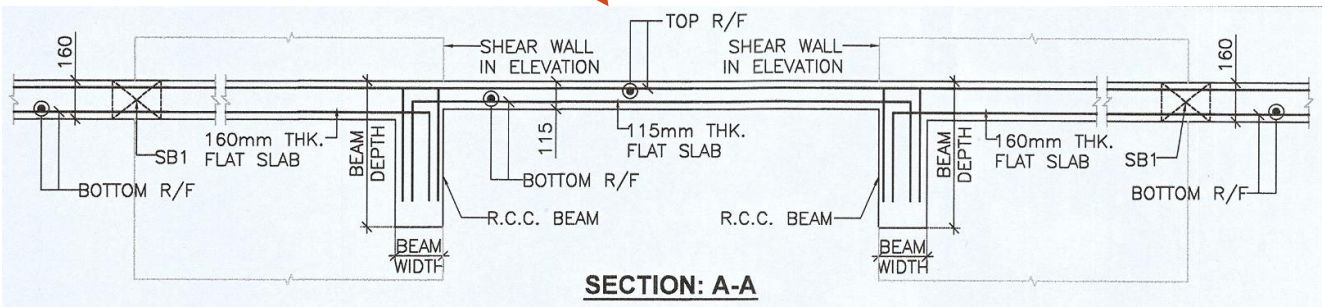


SCHEDULE OF BEAM SIZE		
SR.NO.	BEAM SIZE	BEAM NUMBER
1	160 X 600	B1.
2	200 X 600	B2,B4,B5,B9.
3	300 X 600	B3,LB1.
4	160 X AS/LS	B6,B7,B8.

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

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

Structural Reinforcement Plan at Typical Slab level



STRUCTURAL SYSTEM

Typical Reinforcement at Slab level

STRUCTURAL SYSTEM

Concreting of Slab

AAC BLOCK MASONRY

Autoclaved Aerated Concrete (AAC) Blocks for Wall

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

FINISHING ITEMS

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

INFRASTRUCTURE ITEMS

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

Towers in Progress Photographs

Towers in Progress Photographs

Onsite Photographs

Tower 9

Tower 10

Photographs after completion

Houses occupied by beneficiaries – Recent photographs

Houses occupied by beneficiaries – Recent photographs

The details of LHP can be accessed at

https://ghtc-india.gov.in

Project is completed & handed over to the beneficiaries in October, 2022.

CONTACT US:

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New Delhi - 110011
E-Mail: ghtc-mhua@gov.in /
ska@bmtpc.org
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प्रधान मंत्री आवास योजना-शहरी
Pradhan Mantri Awas Yojana-Urban

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Ministry of Housing and Urban Affairs
Government of India

आज़ादी का अमृत महोत्सव

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Webinar Series

LIGHT HOUSE PROJECT AT RAJKOT

GHTC - India Category:

Monolithic Concrete Construction System

Technology:

Monolithic Concrete Construction using Tunnel Formwork

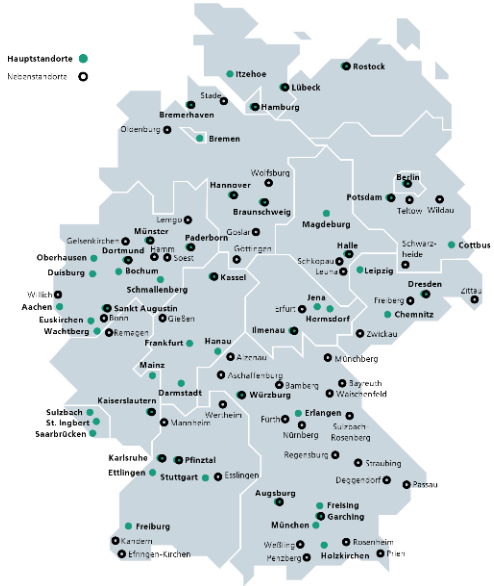
Fraunhofer IBP

INTRODUCTION

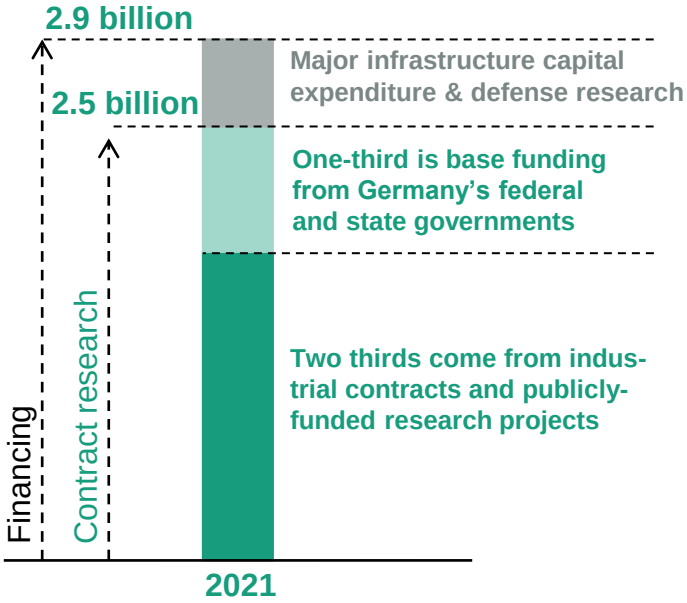
Fraunhofer Society On Applied Science

Applied research with a focus on key future-relevant technologies and the commercialization of findings in business and industry. A trailblazer and trendsetter in innovative developments.

> 30,000 employees



76 institutes and research units



Fraunhofer IBP

giz

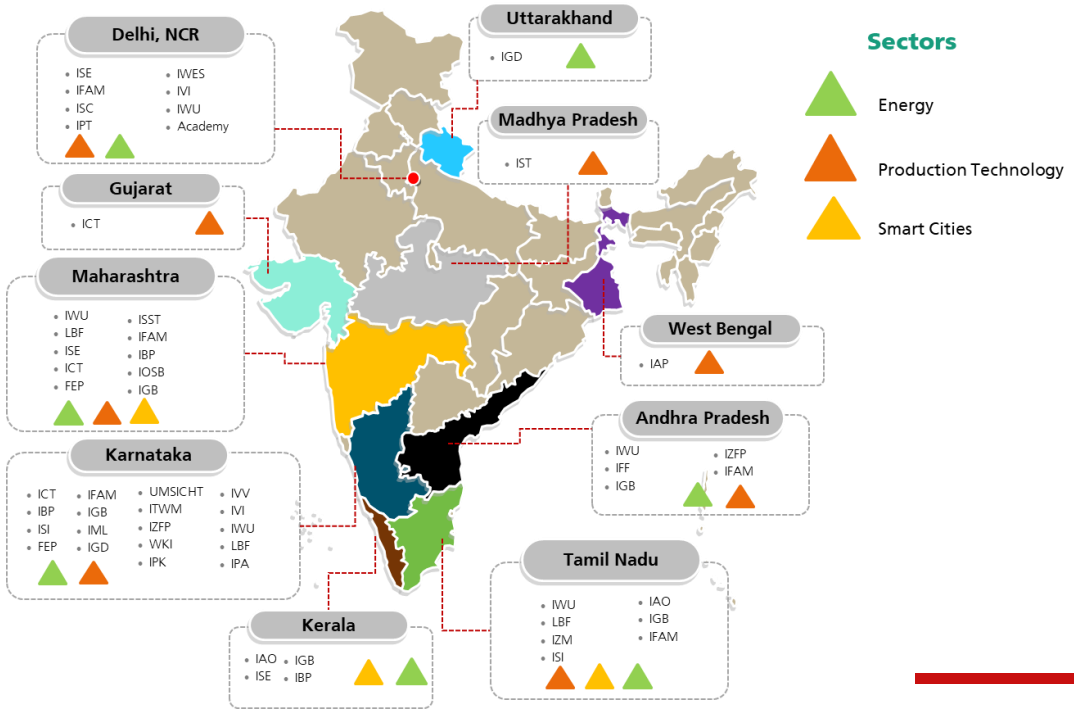
Fraunhofer Society – Presence in India

Present since 15 years

- 56 Institutes
- Revenue € 50 M in last 10 years

Focus areas:

- Production Technology
- Renewable Energy
- Smart Cities
- Artificial Intelligence
- Electromobility
- Clean Tech and Sustainability



Fraunhofer IBP

giz

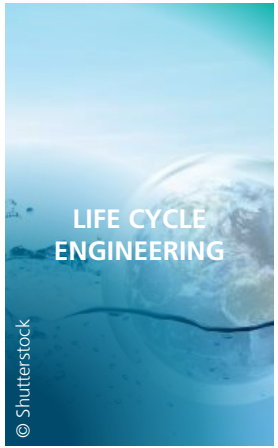
Fraunhofer Institute For Building Physics IBP

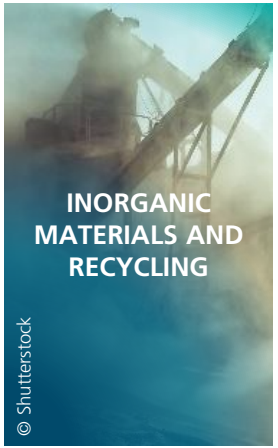
€ 20.5 M
External income

SOURCES OF FUNDS

- 45% Industry / trade associations
- 38% Federal / state governments
- 17% EU / Other

Departments Today





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Light House Projects And Technograhi Programme

Development of short video E-modules on LHP technologies

- field application
- merits and limitations
- thermal comfort
- energy efficiency parameters
- durability

Technograhi Platform
https://ghtc-india.gov.in/Content/LHP.html

Sharing of International knowledge, experience and best practices on the LHP construction technologies

- Expert Lectures
- Video tutorials
- **Webinars**/in-person conference virtual/real* site visits

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Light House Projects And Technograhi Programme

Technograhi Platform
https://ghtc-india.gov.in/Content/LHP.html

Chennai
Precast Concrete Construction System – Precast components assembled at site

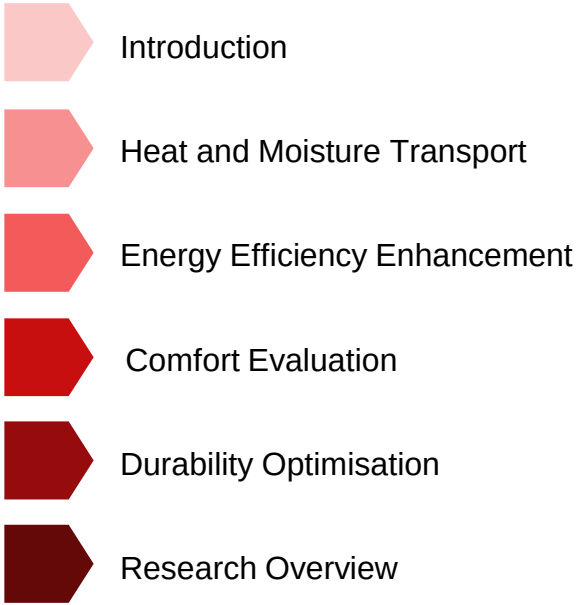
Rajkot
Tunnel Formwork for Monolithic Construction

Lucknow
Stay in Place Fromwork System

Indore
Prefabricated Sandwich Panel System

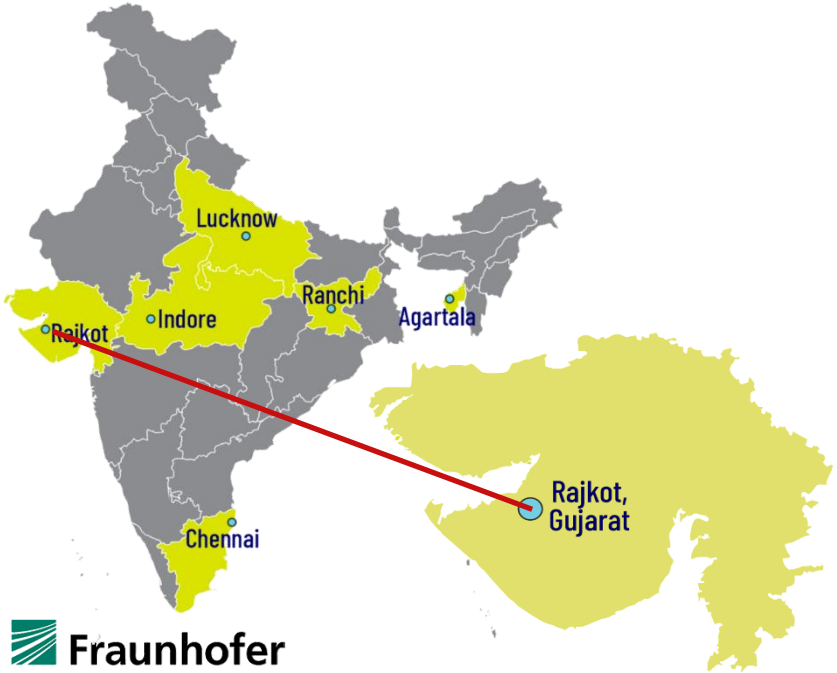
Ranchi
Precast Concrete Construction – 3D Volumetric

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

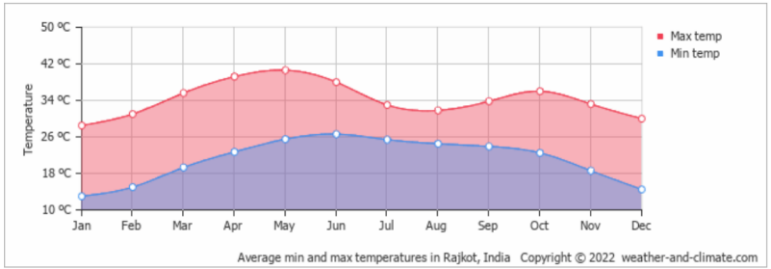


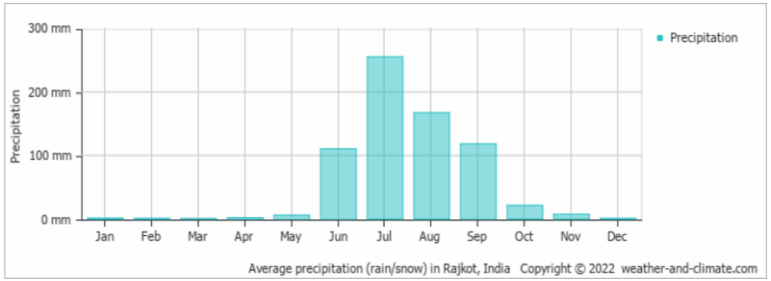
Location And Climate: Rajkot

- Altitude: 134 m
- 22,31 ° North 70,78 ° East



- Mean temperature: 27,2 °C
- Normal-rain-sum: 676,0 mm/a





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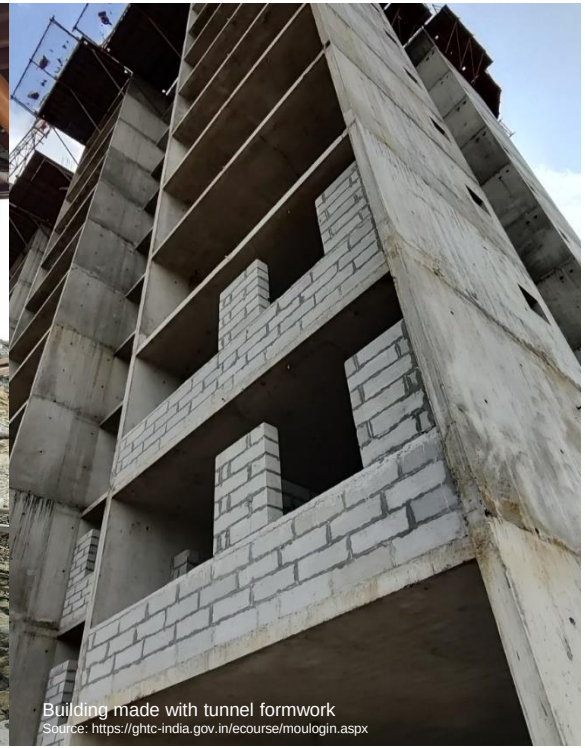
Structural System Rajkot

- Tunnel-shaped formwork
- Walls & slabs are cast simultaneously:
  - No joints
  - Faster construction
  - Monolithic concrete construction
- The filler walls are made of AAC blocks

Building made with tunnel formwork
Source: https://ghtc-india.gov.in/ecourse/moulogin.aspx



Building made with tunnel formwork
Source: https://ghtc-india.gov.in/ecourse/moulogin.aspx

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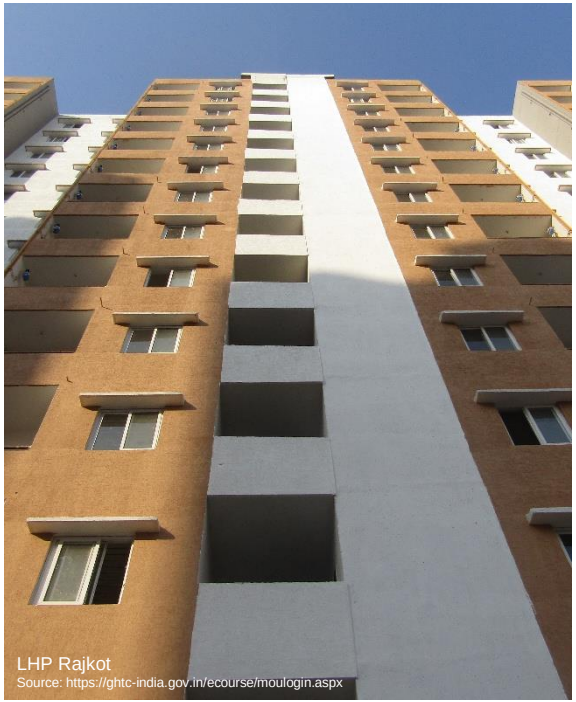
Light-House-Project Rajkot


LHP Rajkot
Source: https://ghtc-india.gov.in/ecourse/moulogin.aspx


LHP Rajkot
Source: https://ghtc-india.gov.in/ecourse/moulogin.aspx


LHP Rajkot
Source: https://ghtc-india.gov.in/ecourse/moulogin.aspx

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International Construction Example

- “The Paramount”, Georgia, USA
- 146 m high-rise residential apartment
- 3-days floor cycle
- One of the tallest residential concrete tunnel formwork projects
- Project was set to be complete in 10 months → concluded in 9 months

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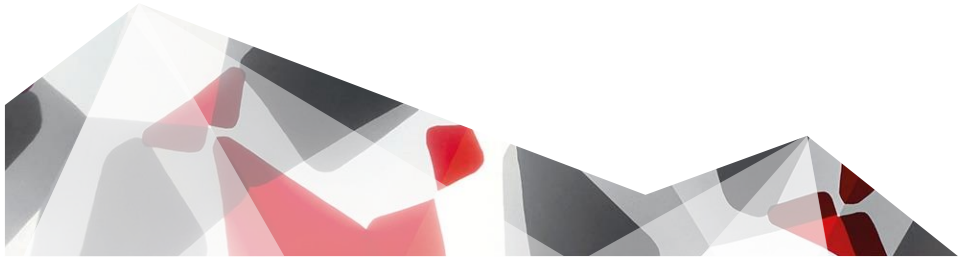
Analysis And Research

Heat and Moisture Transfer



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Solar Radiation

Solar radiation (S) on a surface is:

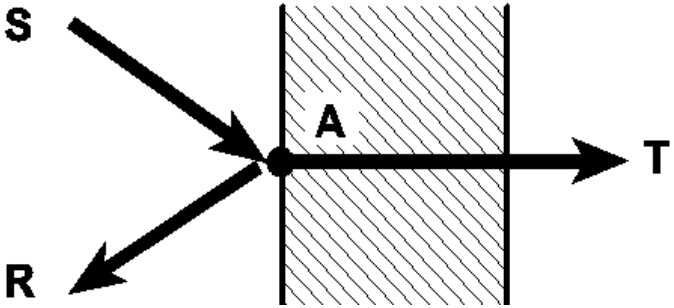
- reflected solar radiation (R)
- absorbed solar radiation (A) or
- transmitted solar radiation (T)
- (for opaque bodies there is no transmission)

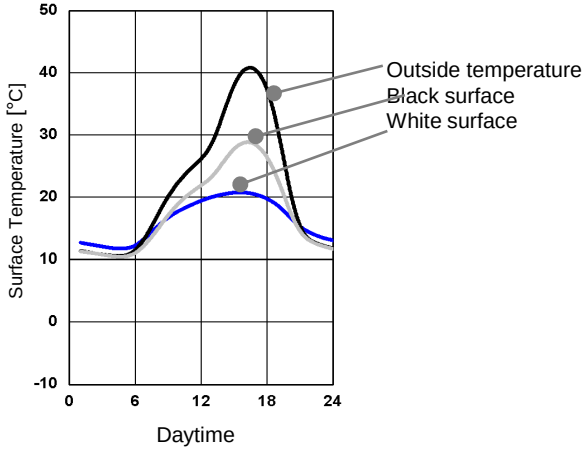
The formula for it is:

$$S = R + A + T$$

Reflectance and absorption is dependent on:

- colour and
- surface texture





Cool Colours

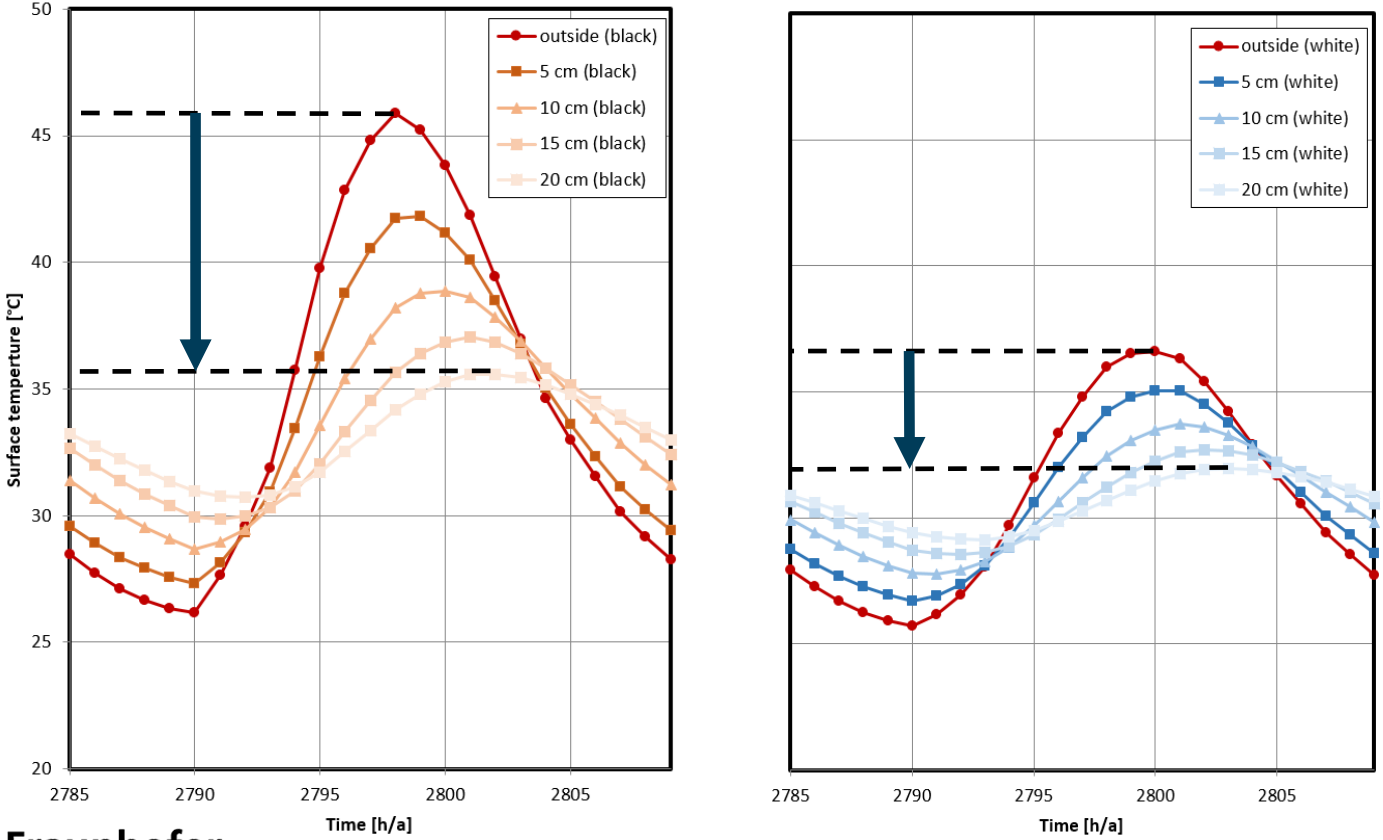
Mechanism

- Light surface colour that reflects most of the solar radiation
- Heats up less than dark surfaces
- Types:
  - Coatings
  - Membranes
  - Tiles
  - Shingles

Effects

- Reduction of the surface temperatures outside between 10 – 20 °C
- Reduction of urban-heat-island-effect (UHI)
- Reduction of indoor temperatures

Influence Of Surface Colour And Wall Thickness



Temperature damping effect

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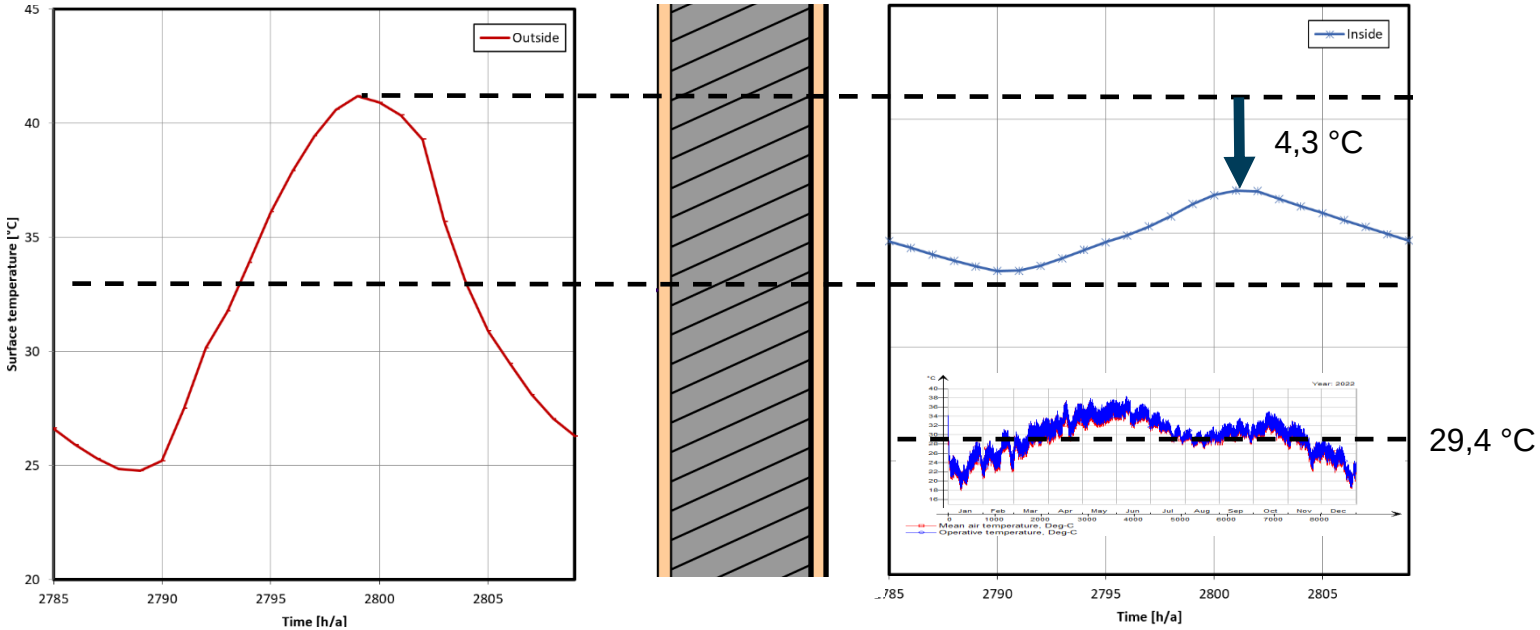
Rajkot – Basic Construction



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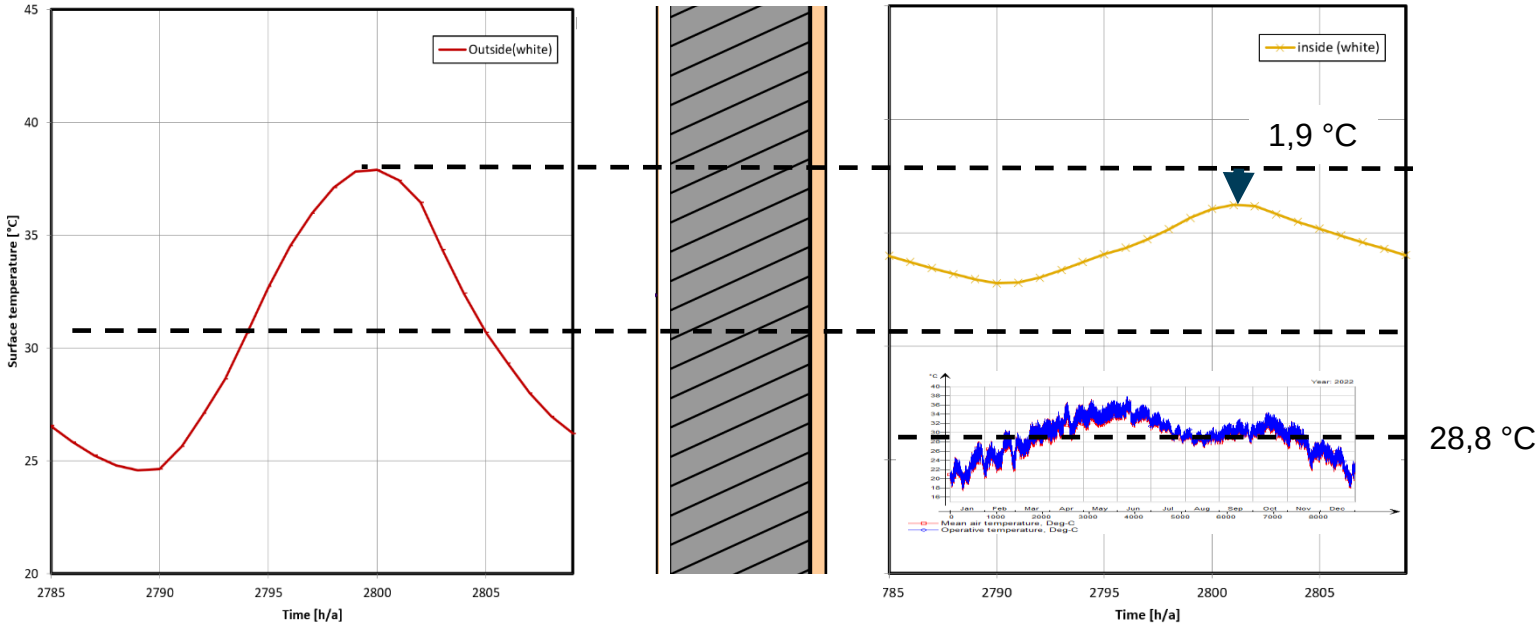
Rajkot – White Colour Surface



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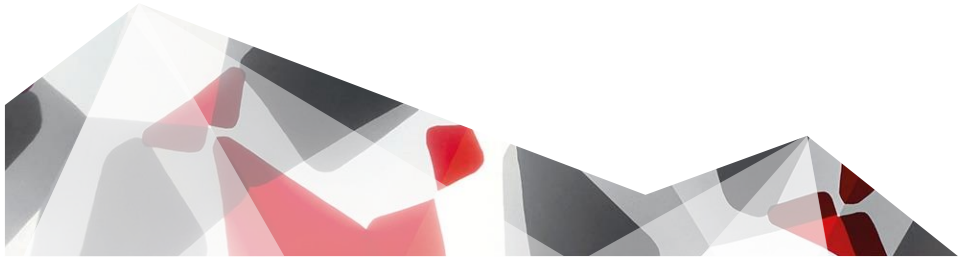
Basics of Energy Efficiency in Buildings



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“ACHIEVING THE BEST POSSIBLE BENEFIT WITH THE LEAST POSSIBLE EFFORT”

Efficiency

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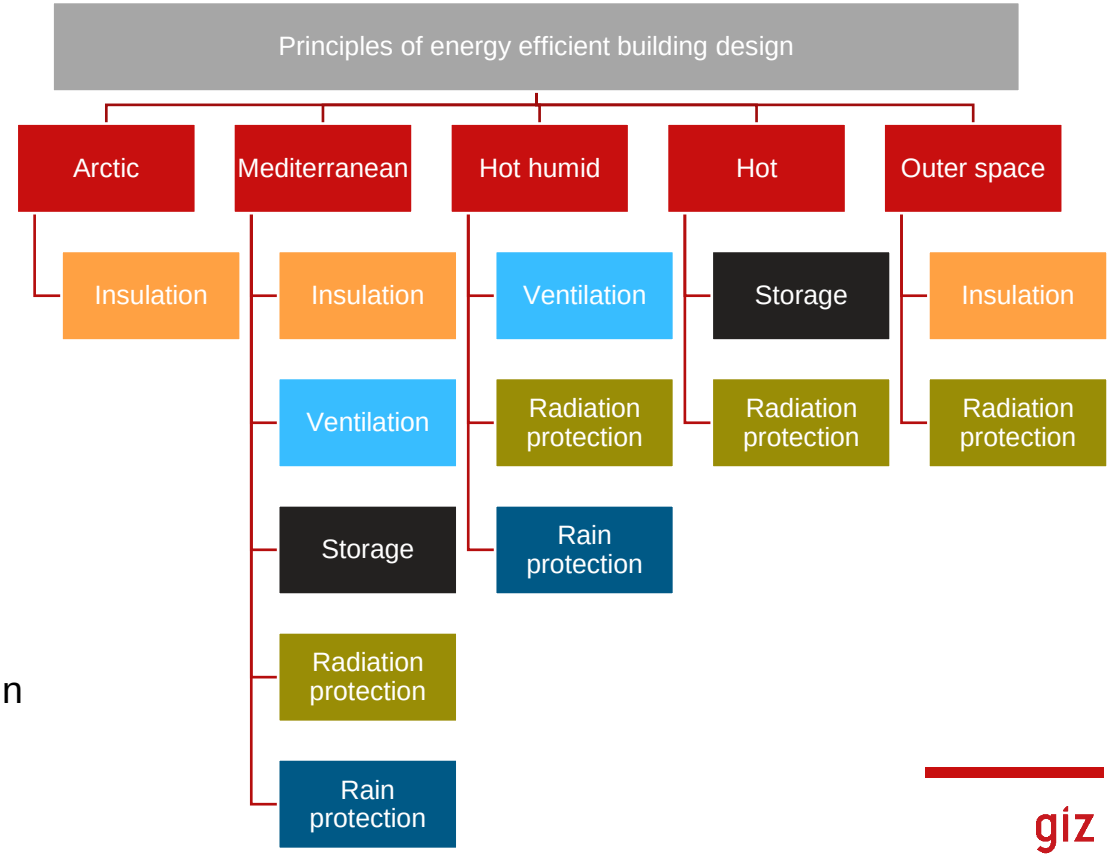
Principles Of Energy Efficient Building Design

Benefits

- Reduction of energy demand during use phase
- Reduction of damages
- Enhancement of comfort



Energy demand

Balancing the energy need to hold a certain indoor climate.

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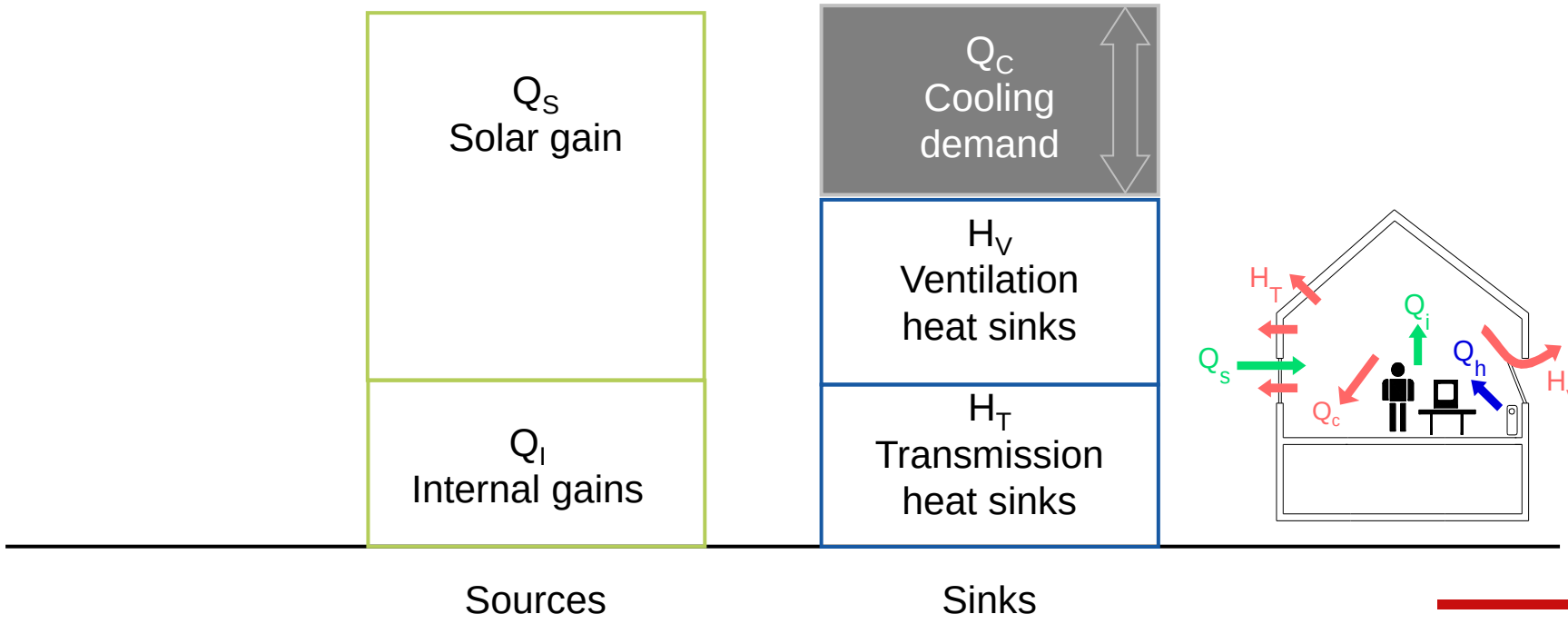
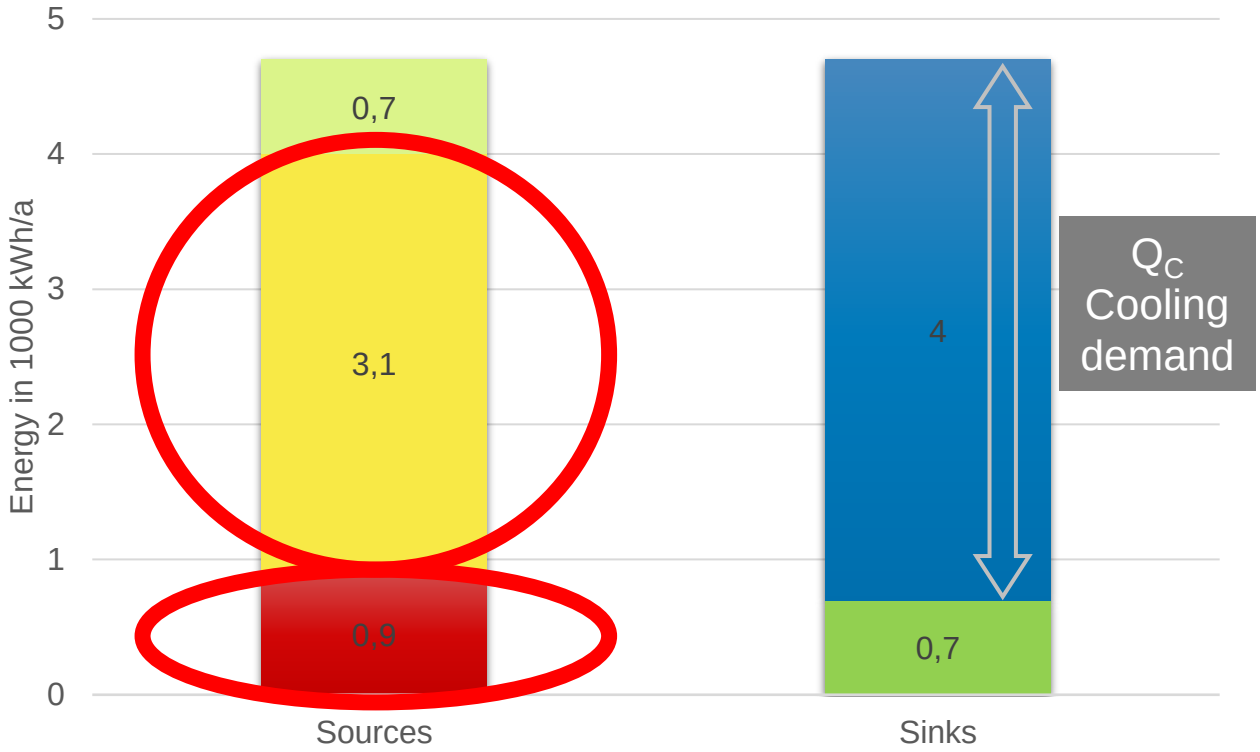
Energy Balancing Basics – Graphical Display

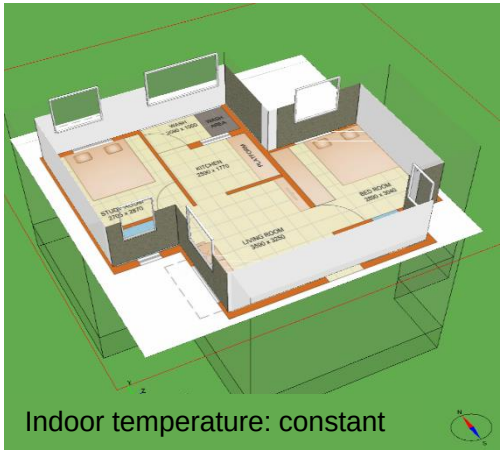
$$Q_S + Q_I = H_V + H_T + Q_C$$



Balancing Example – Actual Design

$$H_T + Q_S + Q_I = H_V + Q_C$$





Q_S	Solar gain
Q_I	Internal gain
H_T	Heat transmission
H_V	Ventilation
Q_C	Cooling demand

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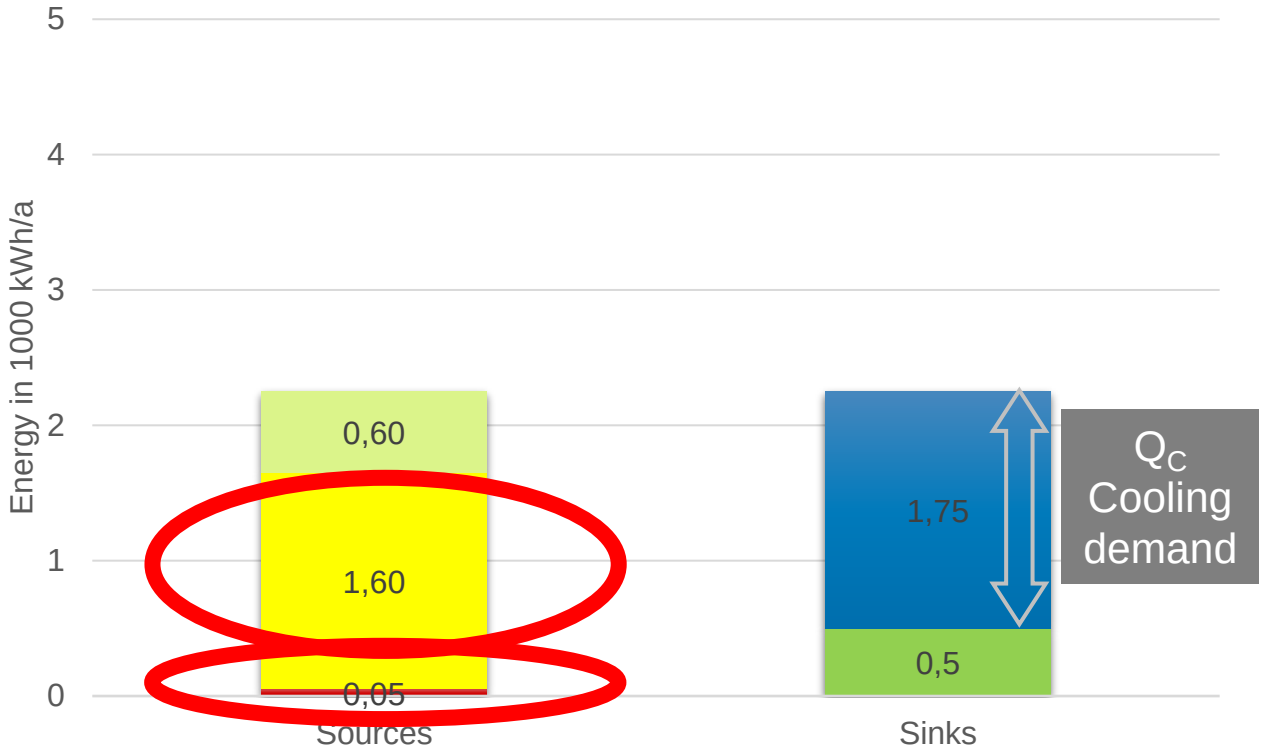
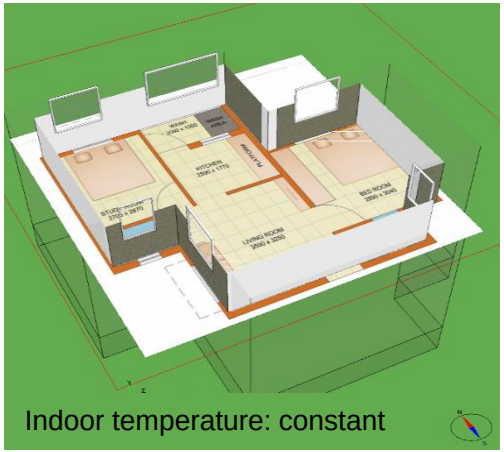
Balancing Example – With White Surface, Insulation And Sun Shading

$$H_T + Q_S + Q_I + H_V = Q_C$$





Q_S	Solar gain
Q_I	Internal gain
H_T	Heat transmission
H_V	Ventilation
Q_C	Cooling demand

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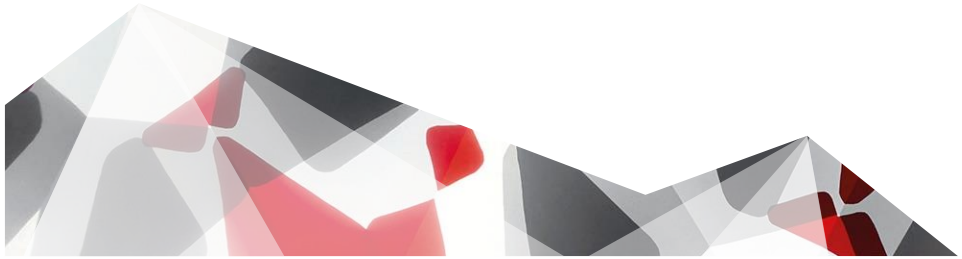
Thermal Comfort in Buildings



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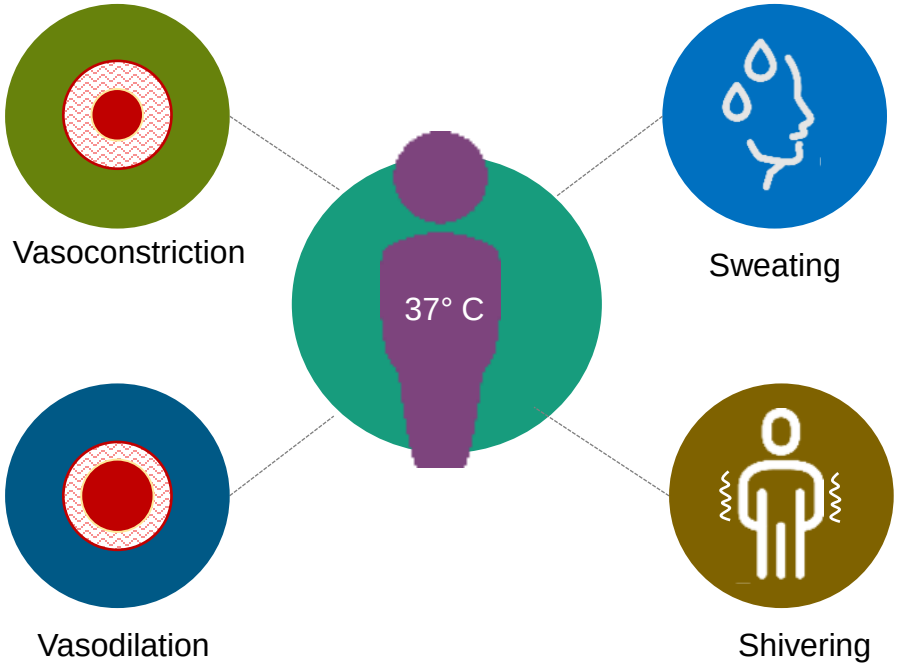
Human Energy Balance




Humidity


Air Speed


Radiant Temperature


Air Temperature


Metabolic Rate


Clothing Insulation

Measures To Improve Thermal Comfort

Active Measures

- Air conditioning

Passive Measures

- Shading
- Night Ventilation
- Insulation
- White Surface Colour

Thermal Comfort Enhancement Simulation Demonstration With

IDA ICE

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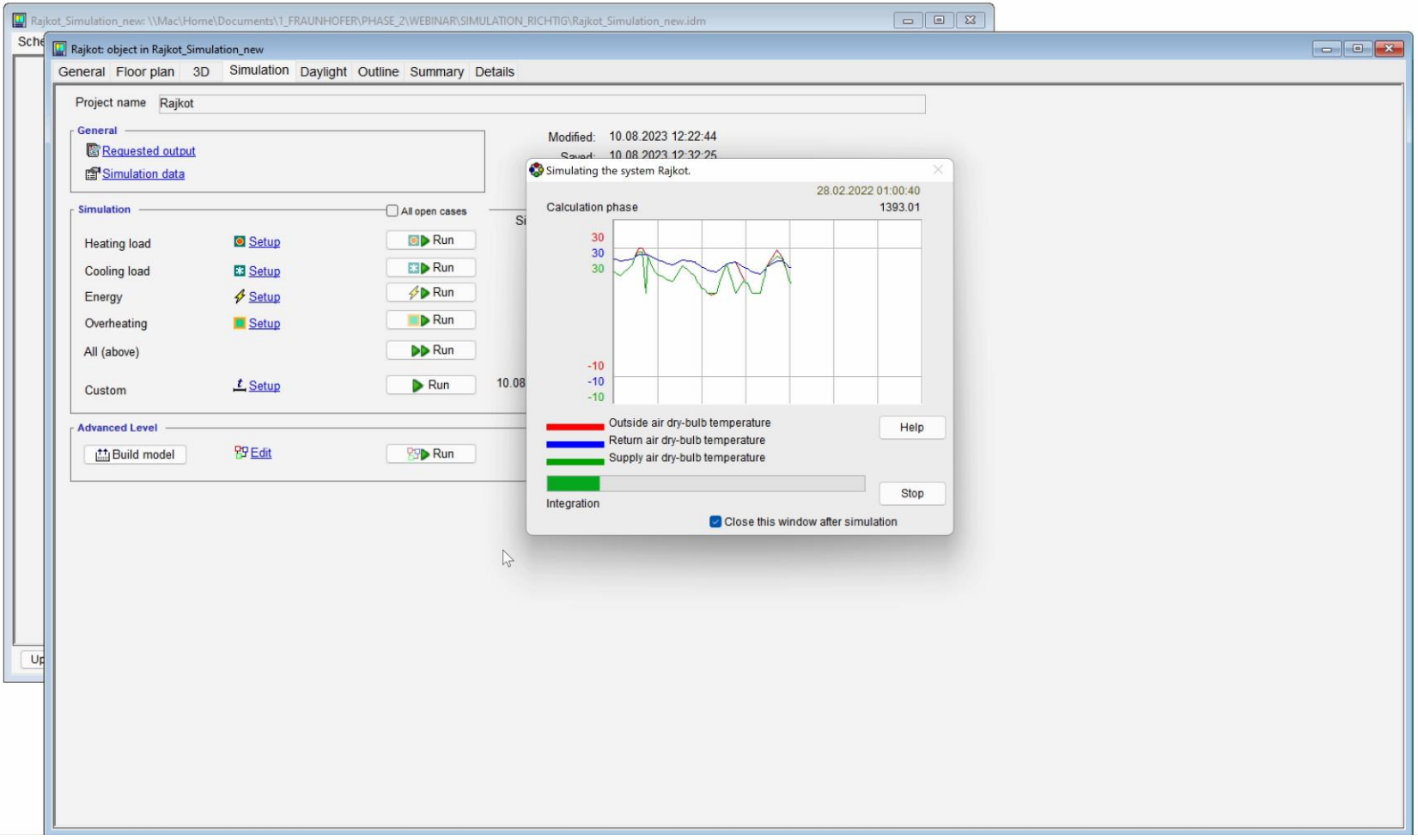
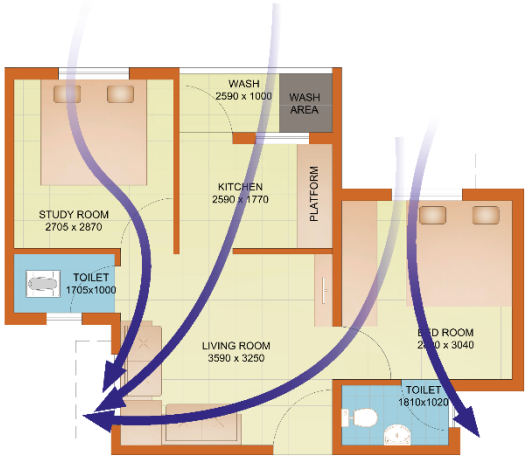

Rajkot_Simulation_new: \\Mac\Home\Documents\1_FRAUNHOFER\PHASE_2\WEBINAR\SIMULATION_RICHTIG\Rajkot_Simulation_new.idm
Rajkot: object in Rajkot_Simulation_new
General
Floor plan
3D
Simulation
Daylight
Outline
Summary
Details
Project name
Rajkot
General
Requested output
Simulation data
Modified:
10.08.2023 12:22:44
Simulation
All open cases
Heating load
Setup
Run
Cooling load
Setup
Run
Energy
Setup
Run
Overheating
Setup
Run
All (above)
Run
Custom
Setup
Run
Advanced Level
Build model
Edit
Run
Simulating the system Rajkot.
28.02.2022 01:00:40
Calculation phase
1393.01
30
30
30
-10
-10
-10
Outside air dry-bulb temperature
Return air dry-bulb temperature
Supply air dry-bulb temperature
Help
Integration
Stop
Close this window after simulation

Measures To Improve Thermal Comfort

Active Measures

- Air conditioning



Passive Measures

- Shading
- Night Ventilation
- Insulation
- White Surface Colour

Direction and placement of windows beneficial

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Development and Potential of Concrete

Relevance Of Development In Concrete Technologies

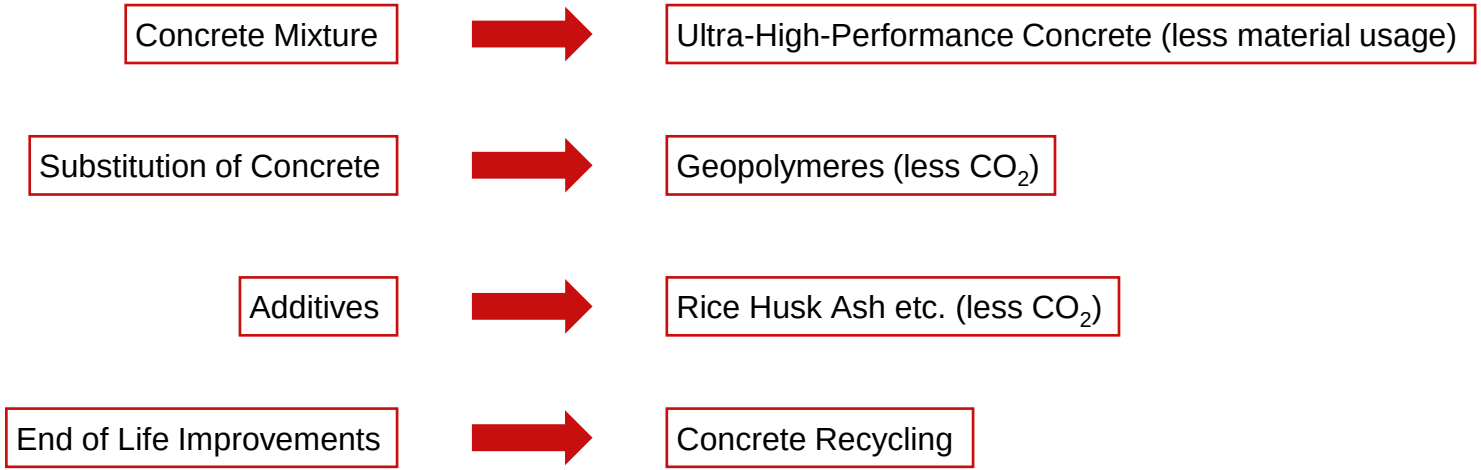
Economic problems

- Sand consumption approx. 50 billions tons/year
- Scarcity of sand and gravel

Social problems

- No real recycling in construction industry
- High CO_2 emissions in the construction industry
- Cement industry responsible for 2.8 billion tons of CO_2 annually

Potential Of Climate Friendly Concrete



Challenges Regarding Concrete Recycling

„Mechanical processing turns one big piece into lots of little ones„

Recycling problems with fresh concrete

- Secondary aggregate less mechanical strength
- Higher water consumption
- Fresh concrete difficult to work with

Selective separation instead of crushing!

ELECTRODYNAMIC FRAGMENTATION

Principles of electrodynamic fragmentation

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Principles of electrodynamic fragmentation

Application of an electrical field

- Frequency: 5 Hz
- Voltage: 200 kV
- Energy consumption: 2,3 kWh/t

Mechanical weakening

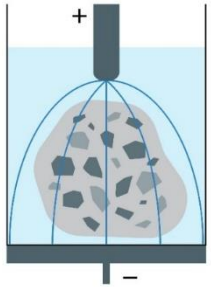
Plasma channel & shock wave

- Electrical discharges run along phase boundaries.
- Electrical breakthrough leads to a plasma channel.

Component separation

- Electrical explosion and shock wave
  seperate components selectively.

1



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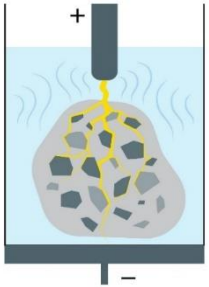

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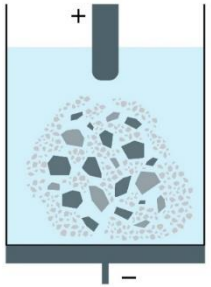

Principles of electrodynamic fragmentation

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Further Reads, Links

Technograhi Platform

Welcome To Global Housing Technology Challenge - LHP (ghtc-india.gov.in)

Tunnel Formwork

Ray, P., Bera, D.K., Rath, A.K. (2021). Comparison Between the Tunnel Form System Formwork and the MIVAN Formwork System in a Multi-unit Building Project. In: Das, B., Barbhuiya, S., Gupta, R., Saha, P. (eds) Recent Developments in Sustainable Infrastructure . Lecture Notes in Civil Engineering, vol 75. Springer, Singapore.

M. A. Fakhratov, M. S. Akbari, A. Hosaini, N. Dayoub; Comparison of the tunnel formwork system and traditional formwork system. AIP Conference Proceedings 16 August 2022; 2559 (1): 060009.

Dryvit Outsulation Chosen to Clad Tallest Tunnelform Concrete Project in North America. (2005). Retrieved 16.08.2023, from https://www.dryvit.com/fileshare/doc/in_the_news/pp0105.pdf

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Ministry of Housing and Urban Affairs
Government of India

आज़ादी का अमृत महोत्सव

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