







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 #04 on Light House Project Lucknow, Uttar Pradesh

Theme – International Perspective Innovative Technologies and Practices in LHPs Date: 18.09.2023, Monday| Time: 15:00 – 17:00











Light House Projects : Live Laboratories Webinar Series

Emerging Construction Systems for Mass Housing



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





[as on 28th August, 2023]

Overall Sanctions for 1.19 crore Houses







Global Housing Technology Challenge - India (GHTC-I)

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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









Light House Projects under GHTC-India

Location	Technology	Houses
Indore	Prefabricated Sandwich Panel System	1,024
Rajkot	Monolithic Concrete Construction System	1,144
Chennai	Precast Concrete Construction System-Precast Components Assembled at Site	1,152
Ranchi	Precast Concrete Construction System-3D Pre-Cast Volumetric	1,008
Agartala	Light Gauge Steel Structural System & Pre-Engineered Steel Structural System	1,000
Lucknow	Stay in-place Formwork System	1,040

- GHTC-India was launched to identify and mainstream innovative proven construction technologies from across the globe which are Costeffective, Climate & Disaster Resilient, Sustainable and Green.
- Shortlisted Technologies will showcase 6 Light House Projects (LHPs) in 6 States through challenge process as Live Laboratories.
- □ **3S** Mantra of Skill, Scale & Speed for superior quality of construction











Light House Projects



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



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 insitu 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.





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



Light House Project (LHP) at Ranchi, Jharkhand

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





Light House Project: Ranchi, Jharkhand

Construction Agency	M/s SGC Magicrete LLP
Technology	Precast Concrete Construction
Usea	System – 5D Volumetric
No. of Houses	1,008
No. of Towers	07 (G+8)
Technology	A latest technology where
brief	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

Casting of structural modules & slabs in the casting yard



Placement of pre cast floors on already erected structured modules





Placement of modules at site using cranes





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



Advantages

- Upto 90% of the building work including finishing is complete in plant/casting yard leading to significant reduction in construction & occupancy time
- The controlled factory environment brings resource optimization, improved quality, precision & finish
- The required concrete can be designed using industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resources. In this project Ground granulated blast furnace slag has been used in concrete.
- With smooth surface it eliminates use of plaster
- The monolithic casting of walls & floor of a building module reduces the chances of leakage
- The system has minimal material wastage (saving in material cost), helps in keeping neat & clean construction site and dust free environment
- Use of optimum quantity of water through recycling
- Use of shuttering & scaffolding materials is minimal
- All weather construction & better site organization

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





Light House Project (LHP) at Chennai, Tamil Nadu

(Technology: Precast Concrete Construction System-Precast Components)





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).

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



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



Construction Process



4

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



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



Advantages

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

PRE-ENGINEERED STEEL STRUCTURAL SYSTEM

Replacing cast 0 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



Light House Project (LHP) at Agartala, Tripura

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





Light House Project: Agartala, Tripura

1

Construction Agency Technology Used	M/s Mitsumi Housing Pvt. Ltd 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 preengineered 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. 	

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



Filling of light weight concrete between the wall panels



Construction Process

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





4

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



Advantages:

Light Gauge Steel Frame (LGSF):

- 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.

Advantages:

(Hot Rolled Steel):

- The building system offers flexible design option with diverse layout possibilities/ architecture.
- Helps achieve very fast installation with various dry wall options
- Steel structures are pre-fabricated, manufactured under controlled factory environments. This ensures quality and durability of the component.
- All steel structures are 100% recyclable
- It is highly advantageous in building and infrastructure projects with long spans

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













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

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





Light House Project: Indore, Madhya Pradesh

Construction Agency	M/s KPR Construction Pvt. Ltd	1
Technology Used	Prefabricated Sandwich Panel System with Pre-Engineered Steel Structural System	
No. of Houses	1,024	1.I.L.
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. 	3

Construction Process

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



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



2 Deck slab installation in already erected steel structure





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 now plants are operational in Pune & Nagpur.



Advantages

- The system is dry walling system, brings speed in construction, water conservation (no use of water for curing of walling components at site).
- The sandwich panels have light weight material as core material, which brings resource efficiency, better thermal insulation, acoustics & energy efficiency
- Being light in weight, results in lower dead load of building & foundation size.

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





Light House Project (LHP) at Rajkot, Gujarat

(Technology: Monolithic Concrete Construction System)





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 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

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



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



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





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



Advantages

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







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

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





Light House Project: Lucknow, Uttar Pradesh

Construction Agency	M/s Jam Sustainable LLP
Technology Used No. of Houses	Stay in Place PVC Formwork with Pre-Engineered Steel Structural System 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

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



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



Construction Process

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





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.





Advantages

- Having formwork already as part of system, the construction of building is faster as compared to conventional buildings. The formwork needs some support only for alignment purpose.
- The formwork consists of rigid PVC components, which do not corrode, chip or stain & resistant to UV, bacteria, fungi etc., thus ensuring long life of the structure.
- The polymer content used in manufacturing of formwork is up to 55% recycled content and are further recyclable, making it an eco-friendly material.
- The form work system has specific advantage for use in coastal areas as due to polymer encasement it offers higher durability.
- With concrete as filling material, the curing requirement of concrete is significantly reduced, thus saving in precious water resources.
- The formwork system does not have plastering requirement & gives a aesthetic finished surface in different color options.
- The system provides advantages in terms of structural strength, durability enhancement, weather resistance, flexural strength, thermal insulation and ease of construction.

Conventional Construction Systems Alternate Construction Systems Slow Fast Maximum Use of Natural Resources **Optimum use of Resources Minimum Waste** Waste Generation **Air/Land/Water Pollution Minimum Pollution** Labour Intensive **Industrialized System Prescriptive Design Cost-effective Design Better health & Productivity Unhealthy Indoor Quality 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



- 40% reduction in water use
- ✤ 35% reduction in GHG emission

✤ 75% reduction in waste

Resilient - disaster-resistant, structurally superior



Looking Back / Rear view

Levels of Construction Technology







You can reach us at ska@bmtpc.org; info@bmtpc.org; info@bmtpc.org;





"Creating Enabling Environment for Affordable Housing for All"







Azadi _{Ka} Amrit Mahotsav



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WEBINAR SERIES: Volume 3 – International Perspective e-Learning sessions on innovative techniques in new age construction

Aug - Sep 2023

Volume 3 - Session #04 on Light House Project Lucknow, UP

Date: 18.09.2023, Monday| Time: 15:00 – 17:00











Ministry of Housing and Urban Affairs Government of India

LIGHT HOUSE PROJECT AT LUCKNOW

GHTC-India Category

Stay in Place Formwork System

Technology:

Stay In Place Formwork System with Pre-Engineered Steel Structural System

CONTENTS

- Six Light House Projects
- LHP at Lucknow
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- Structural Elements
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 - Structural System
 - Floor/ Roof Slab
 - Wall Panels
- Stay in Place PVC Formwork System

- Design Basis
- Construction Sequence
 - Foundation
 - Structural System
 - Floor/ Roof Slab
 - Wall Panels
 - MEP
 - Finishing
- Other Infrastructure Items

Summary of Six Light House Projects (LHPs)

LHP Location			Chennai	Rajkot	Indore	Ranchi	Agartala	Lucknow	
Sl. No	Particulars	Units	(Tamil Nadu)	(Gujarat)	(Madhya Pradesh)	(Jharkhand)	(Tripura)	(Uttar Pradesh)	
1	Name of Technology	Name	Precast Concrete Construction System- Precast Components	Monolithic Concrete Constructio n 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	F) 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	

- There are 4 blocks in Stilt + 13 configuration with 1040 houses along with basic and social infrastructure.
- Ground coverage of the project is 23% and FAR achieved is 2.41.
- Organized green space is 13%.





OTHERS PROPERTY / 5 / GH-05

I6 dwelling units at each floor of building block C &D with provision of lifts and staircases.

Typical Dwelling Unit plan



Each dwelling unit consists of one living, one bed room, a kitchen, a toilet and a balcony. The carpet area of each unit is 34.51 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

Steel Frame Structure

Stay In Place PVC Formwork System



RCC Framed Structure









The stay in place form work system is unlike the temporary shuttering adopted in conventional systems, as it stays permanently as an integral part of the structure.

In order to meet structural requirements, Hybrid system comprising of **Stay In Place PVC Formwork System with Pre-Engineered Steel Structural System** has been adopted in the present project.

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



Source: M/s B.G.Shirke

Foundation

- Conventional as per geo-technical investigations, bearing capacity, soil strata, water table, etc.
- Raft foundation with RCC column upto plinth height.
- RCC plinth beam and grade slab at plinth level.



Structural system

 Pre-Engineered Building 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



Wall Panels - Stay in Place PVC formwork System

- The formwork components are manufactured from extruded polyvinyl chloride (PVC).
- The extrusions consist of two layers, the substrate (inner) and Modifier (outer).
- The two layers are co-extruded during the manufacturing process to create a solid profile.









Stay in Place PVC formwork System



 Typical manufacturing plant for production of PVC formwork



• Typical Wall Panel Dimensions

Application	Novel	Wall Th	Weight of Panel with	
		Overall (Nominal)	Concrete Core	concrete
External Wall	N126	126 mm	120 mm	8.5 kN/m
Internal Wall	N64	64 mm	60 mm	4.25 kN/m

- Width of the individual panel components = 300 / 250 mm.
- Height is as per the requirement. In LHP at Lucknow, it is full storey height about 3 mtr.



PROFILES	110MM, 150	MM, 200MM	AND 250MM	PANEL WIDTH	300 MM				
PVC THICKNESS	2.6 MM			PVC DENSITY	1,300 KG/ M ³				
LIFE EXPECTANCY	MINIMUM 5	O YEARS	-	FINISH	GLOSS WHITE, WATER RESISTANT				
HEIGHT	ALL PANELS O CUSTOM HEI MAXIMUM 8	CAN BE ORDE GHTS MINIM	RED TO UM 1.0M -	UV STABILITY	NOT AFFECTED BY EXPOSURE TO SUNLIGHT EITHER IN STORAGE OR AS FINISHED PRODUCT				
	STOCK HEIGH 3.8M, 4.0M,	1TS: 2.8M, 3N 4.6M, 5M, 6N	1, 3.3M, 3.6M, 1.	SPECIFIC PPE	NONE REQUIRED. GLOVES ARE NOT ESSENTIAL, BUT ON SITES WHERE MANDATORY, GLOVES WITH RUBBER FINGERS AND PALM INFILL WILL				
	CONCRETE VOLUME (M ³ /M ²)	PRODUCT WEIGHT (KG/ M ²)	FIRE RATING (MINUTES MINIMUM)	MSDS	READILY AVAILABLE				
110MM PROFILE	0.101	14.7	90	ORDERING LEAD	STOCK HEIGHTS DELIVERED TO MAJO CAPITAL CITIES WITHIN SEVEN DAYS				
155MM PROFILE	0.145	15.8	180		FROM ORDER, CUSTOM HEIGHT PANELS				
200MM PROFILE	0.188	16.8	≥ 240	SHIPPING AND	WE OFFER DELIVERY AT COST, OR YOU CAN ARRANGE YOUR OWN				
250MM PROFILE	PROFILE 0.2404 17.8 ≥ 240		PAYMENT	COD OR 30-DAY ACCOUNT UPON APPLICATION					

Stay in Place PVC formwork System

CODE, SPECIFICATION OR STANDARD	CERTIFIED BY
AS1530.3 - IGNITABILITY, FLAME PROPAGATION, HEAT RELEASE AND SMOKE RELEASE	CSIRO
AS/NZ3837:1998 - HEAT & SMOKE RELEASE RATES	CSIRO
BCA PARTS AZ & C1 - HEAT & SMOKE RELEASE REQUIREMENTS	CSIRO; SGS-CSTC; MURTAGH BOND
	STRUCTURAL ENGINEERS
BCA PART F5 - ACOUSTIC PERFORMANCE, SOUND TRANSMISSION AND INSULATION	RUDDS CONSULTING ENGINEERS
GREEN BUILDING COUNCIL OF AUSTRALIA - GREEN STAR OFFICE DESIGN	CETEC

- The rigid poly-vinyl chloride (PVC) based form work system serve as a permanent stay-inplace durable finished form-work for concrete walls.
- 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.



Performance Appraisal Certificate No.: 1044-S/2019 has been issued to M/s Novel Assembler Pvt. Ltd, Mumbai by BMTPC.

Advantages

- Having formwork already as part of system, the construction of building is faster as compared to conventional buildings. The formwork needs some support only for alignment purpose.
- The formwork consists of rigid PVC components, which do not corrode, chip or stain & resistant to UV, bacteria, fungi etc., thus ensuring long life of the structure.
- The polymer content used in manufacturing of formwork is up to 55% recycled content and are further recyclable, making it an eco-friendly material.
- The form work system has specific advantage for use in coastal areas as due to polymer encasement it offers higher durability.
- With concrete as filling material, the curing requirement of concrete is significantly reduced, thus saving in precious water resources.
- The formwork system does not have plastering requirement & gives a aesthetic finished surface in different color options.
- The system provides advantages in terms of structural strength, durability enhancement, weather resistance, flexural strength, thermal insulation and ease of construction.

Limitations

- Stay in Place PVC Forms Walls need pre-planned & installed MEP/Services for concealed network.
- Door and Window position shall not be changed after pouring of concrete.
- Erection of panels shall be under supervision of trained staff.



Being first time mass scale field implementation of new technology the Light House Project at Lucknow is on **Design & Build Basis**

Agency: M/s JAM Sustainable Housing LLP, Ahmedabad

Technology Provider: M/s Novel Assemblers, Mumbai

Design Basis

- Structural Frame as RC Steel Hybrid structure
 - Sub-structure up to the plinth level in RCC
 - Superstructure is using HR Steel built-up I sections with lift wells in RCC Shear wall
- Safe Bearing capacity: 13.3 T/m², depth of foundation 2.5 m
- Raft foundation as per IS:2950 (Part-1)-1981 (reaffirmed 2008)
- Wind speed: Very High damage risk zone with basic wind speed (V $_{\rm b}{=}50 \text{m/sec})$
- Design wind speed:
 - $V_z = V_b.k_1.k_2.k_3.k_4$
 - k₁ (Risk Coefficient)=1
 - k_2 (Size factor)=as per height
 - k_3 (topography factor)=1
 - k_4 (importance factor)=1
- Wind Pressure $(P_z) = 0.6.Vz^2$
- Wind pressure is converted into design wind pressure and then distributed at each storey as wind force.



Design Basis

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

 $A_{h} = (Z/2).(S_{a}/g).(I/R)$

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

Design Lateral Force (V_B)

 $V_B = A_h.W$

W is seismic weight of building

- Linear dynamic analysis shall be done to obtain the design lateral forces with steel columns as fixed for SMRF frames and pinned for ordinary frames.
- Rigid diaphragms in horizontal direction at floor levels as per Cl.7.6.4 of IS:1893(Part-1):2016.
- Expansion joints as per Cl.3.10.3.2 of IS:800-2007 to cater for thermal and seismic forces.
- Design has been carried out as per IS 456-2000, IS 800-2007 and NBC-2016.



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<u>+</u>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



Construction Sequence

Foundation

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

FOUNDATION

Structural Drawings



FOUNDATION

Concrete & Reinforcement Steel Specifications

Item	Concrete Grade
Raft foundation, Plinth beam, Grade slab, Column upto Plinth level	M25
Shear walls, Water tank, Sewage Treatment Plant (STP)	M30

- 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 are to be TMT bars of Fe 500 as per IS 1786-2008.

FOUNDATION

Concrete mix design (IIT Delhi)

Cement	Conc.	Water	Ceme	Fly	Sand	Coarse	•	Plastici	Slump		Comp.		Fly	Water/
Name	Grade		nt	Ash		Aggregate zer		zer			Strength		Ash/	Cement
											(MPa)		Cement	ratio
						10	20		Initial	After	7 Day	28	itious	
						mm	mm			l hour		days	Materia	
													1	
јк	M-30	160	319	137	692	415	623	0.65%	145	110	32.5	39.4	30%	0.35
	M-25	160	287	154	694	416	625	0.60%	160	140	24.7	32.2	35%	0.36
Ultra	M-30	160	319	137	692	415	623	0.65%	135	120	33.1	42.0	30%	0.35
Tech	M-25	160	287	154	694	416	625	0.60%	160	150	23.2	33.5	35%	0.36

28 days Target Strength: M30 38.25 MPa

28 days Target Strength: M25 31.65 MPa

Design Slump range for the above mix:

100 – 150 (Pumpable)

Fly Ash content of 30% as a proportion of Cementitious Material in case of M30 Grade Concrete and 35% in case of M25 Grade Concrete is being used in the project, making the concrete **green and sustainable**, therefore, conserving natural resources i.e. lime stone.


Reinforcement and shuttering for raft foundation



 All building blocks have Raft foundation with 500 mm thick M-25 Concrete. An additional thickness of 400 mm has been constructed around staircase and lift well.



• Columns of M25 Grade Concrete are being cast upto plinth height over already laid cured raft.



- Plinth beam shuttering work along with reinforcement cage
- Fixing of anchor bolts with templates over which factory made built up columns with base plate will be erected.



- Anchor bolts have been cast with concrete at plinth level over which factory made built up columns with base plate will be erected.
- The reinforcement laying & shuttering work is in progress for shear wall construction of lift & staircase portion.

Plinth beam and shear wall casting

DANOED





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

• 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
20	500	100	100
24	600	100	150
27	700	100	150
30	800	100	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

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

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



Erection of steel columns

Erection of steel columns & beams

The same start the start the ye

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.



Placing of deck slab and reinforcement

COLLAR

Concrete on deck slab

Wall Panels

Construction & Installation Process with Stay in Place PVC formwork System in the LHP

Construction is done in a following sequential manner:

- 1. Transportation of Prefabricated PVC Wall panels 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. Fixing of PVC wall panels on decking floor, once the structural frame and floor is installed and aligned.
- 5. Putting the reinforcement as per requirement on the already fixed PVC wall panels and filling the cavities with concrete.
- 6. The wall panels have provisions of holes for services conduits where services such as water supply, electricity are laid before filling the cavities.
- 7. Upon installment of wall panels, flooring and ceiling, the finishing work is executed.



Wall Panels

PVC Wall to Steel Frame Connection

Structural integrity and monolithic behavior of wall and structural frame is achieved in this technology through dowel bars.



INTERNAL WALL REINFORCEMENT DETAIL

Wall Panels

Typical view of PVC wall panels and steel frame construction



Fixing of Wall Profiles

Concreting in Wall Profiles

Services, Doors, Windows



DOORS, WINDOWS AND CONCRETING

- Capping panels are fixed on edges of doors & windows before fixing wooden frames to gain strength for concrete pour. The frames are removed once concrete is set. No gaps to be left in between panels.
- Water proofing/hydrophilic sealant installed to cover all gaps and prevent concrete leak
- All corners, doors, windows, stop ends are adequately braced
- Metal strip on external wall corners and aluminum angles on top third of walls
- Screws on window panels and bottom connectors

Services lines are fixed

inside the wall panels

Openings are cut in the

walls for electrical and

prior to concrete pour

plumbing interfaces

- Self Compacting Concrete shall be poured by boom pump with a 50mm dia. end hose
 - Pour shall not be done more than 1 mt. at any point to ensure panels can withstand concrete pressure



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





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.























Status of the Project in terms of important components of Building work,

As on September 17, 2023

S. No.	Components of Building work	Completed/Total Requirement
1.	Erection of Steel Structural Framing comprising of Built-up columns and beams	For 1004 DUs/1040 DUs (About 96% of total requirement of about 3600 Tons)
2.	Construction of Shear wall concrete (Staircase & Liftwells)	About 98% of the total requirement
3.	Installation of PVC Wall forms in number of DUs	968 DUs/1040 DUs

Live status of LHP site can be accessed at <u>https://ghtc-india.gov.in</u>

CONTACT US:

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Webinar Series

LIGHT HOUSE PROJECT AT LUCKNOW

GHTC - India Category: Stay in Place Formwork System

Technology:

Stay in Place Formwork System with Pre-Engineered Steel Structural System



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.


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

Fraunhofer

- Artificial Intelligence
- Electromobility

IBP

Clean Tech and Sustainability



Fraunhofer Institute For Building Physics IBP





Departments Today





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://bmtpc.org/LatestTopicsDetails.aspx ?mid=196



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







Location And Climate: Lucknow

- Altitude: 125 m
- 26,76 ° North 80,89 ° East



- Mean temperature:
- Mean rel. Humidity:
- Normal-rain-sum:

25,0 °C

67,4 %





Structural System

- Pre-Engineered steel skeleton structural system
- Stay in Place PVC (Polyvinyl Chloride) Formwork System
 - Formwork for pouring the concrete
 - > Filler walls plaster finish
- Reinforced Concrete Slabs







ANALYSIS AND RESEARCH







HEAT TRANSFER – U-VALUE CALCULATION





Heat Transfer

The parameter which characterizes the heat transfer through the building envelope is the U-value.

The U-value states the steady-state density of heat transfer rate **per temperature difference** between the environmental temperatures on each side.

Factors affecting the U-value of opaque areas:

- Thickness and heat conductivity
- Air cavities
- Thermal bridges

$$U = \frac{H_T}{A \cdot \Delta \theta} \left[\frac{W}{m^2 K} \right]$$

 $\begin{array}{ll} U & \text{U-value [W/m^2K]} \\ H_T & \text{Heat flux } \binom{d_i}{\lambda_i} \text{ [W]} \end{array}$

A Area [m²]

 $\Delta \theta$ Temperature difference [K]



Material	λ [W/mK]
Reinforced concrete	2,5
Brickwall	0,8
Straw	0,055
Foamglass	0,045
Mineral Wool	0,035



Calculation Example For U-Value

$$U = \frac{1}{R_{se} + \sum_{n} \frac{d_n}{\lambda_n} + R_{si}} \left[\frac{W}{m^2 K}\right]$$

$$U = \frac{1}{0,04 + \frac{0,2}{2,5} + \frac{0,05}{0,045} + 0,13} \left[\frac{W}{m^2 K} \right]$$
$$U = 0,10 \left[\frac{W}{m^2 K} \right]$$

$$d_{1} = 0.2 m$$

$$d_{2} = 0.05 m$$

$$\lambda_{1} = 2.5 \left[\frac{W}{mK}\right]$$

$$\lambda_{2} = 0.045 \left[\frac{W}{mK}\right]$$

$$R_{se} = 0.04 \left[\frac{m^{2}K}{W}\right]$$

$$R_{si} = 0.13 \left[\frac{m^{2}K}{W}\right]$$



U-Value Calculation For Lucknow (Stay In Place Formwork System)

Material	Thickness	Thermal conductivity
PVC	3 mm	0,2 [W/Km]
Light Concrete	120 mm	0,14 [W/Km]
PVC	3 mm	0,2 [W/Km]

$$U = \frac{1}{0,04 + \frac{0,003}{0,2} + \frac{0,12}{0,14} + \frac{0,003}{0,2} + 0,13} \left[\frac{W}{m^2 K}\right]$$

$$U = 0,95 \quad \left[\frac{W}{m^2 K}\right]$$



Material	Thickness	Thermal conductivity
PVC	3 mm	0,2 [W/Km]
Concrete	120 mm	1,6 [W/Km]
PVC	3 mm	0,2 [W/Km]

$$U = \frac{1}{0,04 + \frac{0,003}{0,2} + \frac{0,12}{1,6} + \frac{0,003}{0,2} + 0,13} \left[\frac{W}{m^2 K}\right]$$

 $U = 3,63 \quad \left[\frac{W}{m^2 K}\right]$





DURABILITY OF STAY IN PLACE FORMWORK





Stay in Place Panel Systems in Lucknow

- Structural design: Stay in place PVC formwork system, filled with reinforced concrete
- Conditions:

IBP

At times very strong UV radiation on the outside

What could happen if the structure can't withstand this radiation in the long-term?











Stay in Place Panel Systems in Lucknow Calculation of heat and moisture transfer in construction

PVC without any leaks



PVC with leaks





Influences Of Moistness On Thermal Conductivity - general Influence





Influences Of Moistness On Thermal Conductivity – Lucknow Example

Application	Building Moisture Content [Vol.% λ]			Calculation Values [U-Value H_T]				
	Vol.%	λ	Vol.%	λ	U-Value dry	H _⊤ dry	U-Value moist	H _T moist
Lightweight concrete	0	0,14	20	0,22	0,94	53,6	1,3	69,8
concrete	0	1,7	8	2,2	3,6	173,3	3,8	182,6





Energy Balance – Using Dry, Moist, Light And Heavy Materials









THERMAL COMFORT IN BUILDINGS





Temperature Ranges





Olgyay's Bioclimatic Chart





Olgyay's Bioclimatic Chart





Thermal Comfort In Lucknow





Thermal Comfort In Lucknow – With Light Concrete





MEASUREMENT OF SOLAR RADIATION – DURABILITY OPTIMISATION



Solar Radiation Measurements

Standard tests

- notched impact strength
- weather resistance
- thermal stability
- fire behavior

Aging tests

- in the field
- in the laboratory











Recap: Stay in Place Formwork System In Lucknow

The Stay in Place Formwork System used in Lucknow is a system which can be used to build new homes fast, providing good solutions in terms of energy efficiency and thermal comfort.





Further Reads, Links



LIGHT HOUSE PROJECTS

Pursuing the vision of Honbile Prime Minister to transform housing construction sector, Ministry of Housing and Urban Affairs initiated a Global Housing Technology Challenge to identify and mainstream the best available construction technologies from across the globe.

Out of the identified 54 technologies, Six Light House Projects using six distinct technologies were finalised to showcase use of these technologies for further mainstreaming in the country. The Honble Prime Minister laid the foundation stone of Six Light House Projects on 1st January 2021.

Light House Project Chennal, Tamil Nadu comprising of 1,152 houses with all basic and social infrastructure facilities has been completed in record 12 months Honbile Prime Minister dedicated the Light House Project Chennal to the Nation on 26th May 2022. Funder, Light House Project Rajkor, Gujaret was also completed with was inaugurated by Honbile Prime Minister on 19th October 2022. These two Projects have been successfully completed nail respective departed the washer conditions.

LHPs are model housing projects with houses being built with shortlisted alternate technology suitable to the geo-climatic and hazard conditions of the region. This projects are demonstrating construction of ready to live houses with maximum speed, economy and with better quality of construction in a sustainable manner.

The LHPs are functional as LL-boratories to promote widespread learning on the use of innovative construction technologies/ systems on ground and mainstreaming in Indian context. For propagation on use of innovative technologies, a drive for free online enrolment of Eachly & Students of ITSI NTSI Engineering collegat Planning & Architecture Colleges, Technical Protestonia Ingged in Privater Public sectors; Central/StateULB Collegis, Star-upli notarostic Timpreprenet, and other concentration stakeholders as TECHNOGRHVS as institutes. Soft more than 83000 Defonguinh have been enrolled.

LHP LOCATION	TECHNOLOGY SELECTED	NUMBER OF HOUSES TO BE CONSTRUCTED	STATUS
Chennai Tamii Nadu	Precast Concrete Construction System - Precast Components Assembled at Sile	1152	Completed
Rajkot Gujarat	Monolithic Concrete Construction using Tunnel Formwork	1144	Completed
Indore Madhya Pradesh	Prefabricated Sandwich Panel System	1024	In-progress
Lucknow Uttar Pradesh	PVC Stay. In Elico. Formwork System	1040	In-progress
Ranchi Jharkhand	Precast Concrete Construction System – 30 Volumetric	1008	In-progress
Agartala Tripura	Light Gauge Steel Structural System & Pre-angineered Steel Structural System	1000	In-progress

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Technograhi Platform



Click on respective LHP site on map to

know more about particular LHP site

OTHER RELEVANT INFORMATION

- Setting up of Project Committee (PMC) to oversee the entire progress of construction of LHPs at six locations in six States under GHTC-India
- Pictures of Pre-bid meeting on RFP for construction of Light House Projects/LHPs) at Six location on 29th July, 2019
- Association of BMTPC as Technical Partner of the Ministry of Housing and Urban Affairs -GHTC India
- Operational Guidelines for Implementation of Light House Projects (LHPs)
- Tender Evaluation Committee to finalize the selection of agency(les) for Light House Projects(LHPs). Office Order







Ministry of Housing and Urban Affairs Government of India







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B

Pradhan Mantri Awas Yojana (Urban) Nirman Bhawan, New Delhi – 110 011 INDIA Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

> Climate Smart Buildings (IGEN-CSB) B5/5, Safdarjung Enclave New Delhi – 110 029 INDIA