





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

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GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Global Housing Technology Challenge - India (GHTC-I)

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

Summary of Six Light House Projects (LHPs)

LHP Location		Chennai	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	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.
- Proposed organized green space is 13%.





OTHERS PROPERTY / 5 / GH-05

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OTHERS PROPERTY / 5 / GH-03

• 16 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

Stay In Place PVC

Load bearing Structure



RCC Framed Structure



Steel Frame 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	
	OverallConcret(Nominal)Core		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.

PRODUCT SPECIFIC	ATIONS				
PROFILES	110MM, 150MM, 200MM AND 250MM		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 (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,	115: 2.8M, 3N 4.6M, 5M, 6N	2.8M, 3M, 3.3M, 3.6M, SPECIFIC PPE M, 5M, 6M.		NONE REQUIRED. GLOVES ARE NOT ESSENTIAL, BUT ON SITES WHERE MANDATORY, GLOVES WITH RUBBER FINGERS AND PALM INFILL WILL REMOVE RISK OF SLIPPING.
	CONCRETE VOLUME (M ⁵ /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 MAJOR CAPITAL CITIES WITHIN SEVEN DAYS
155MM PROFILE	0.146	15.8	180		FROM ORDER. CUSTOM HEIGHT PANELS WITHIN FIVE WEEKS.
200MM PROFILE	0.188	16.8	≥ 240	SHIPPING AND	WE OFFER DELIVERY AT COST, OR YOU CAN ARRANGE YOUR OWN
250MM PROFILE	0.2404	17.8	≥ 240	PAYMENT	COD OR 30-DAY ACCOUNT UPON APPLICATION

Stay in Place PVC formwork System

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STRUCTURAL ENGINEERS
RUDDS CONSULTING ENGINEERS
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.



⁽ITPC: V. mendoliji Altas: 3ed Enticity Presi Group, McHilli, Map in Banad on righted stars of EQL GDE Entic Wed Speed Map National Builting Code: 2016; Cyclose Bate, 169-2016; MiC, MC GL Housen/Population as per Centure 2011; Phonese Installing exact & folded in sume. Of chainer: The maps are adely for financial 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=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 <u>+</u>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

Structural Drawings



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.

Concrete mix design (IIT Delhi)

Cement	Conc.	Water	Ceme	Fly	Sand	Coarse	•	Plastici	Slump		Comp.		Fly	Water/				
Name	Grade		nt	Ash		Aggreg	jate	zer			Strengt	th	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.

Batching Plant

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



Concrete Testing

Quality control and quality assurance is essential for a project and therefore a quality control lab has been established at site for testing of raw materials and finished products.







QA Testing Laboratories Pvt. Ltd.

JAS-ANZ

M5400913IN

(Govt. Approved Testing Laboratories)

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	An	ISO 9001:20	15, 14001:2	015 & 45001:2018 Accredited	Laboratory	
		(This Co	TEST (artificate is	CERTIFICATE	ım)	9.
Test Repor	rt No.	QAL/BMI210507	00109	Report Date		14/05/2021
Sample Na	mut	TMT Bars		Sample Received	Date	EUE/2021
Sample Gra	ade	Fe-500D		Sampling Quantit	y	1 set of
Date of Tes	st Start.	7/5/2021		Date of Completin	e	14/05/2021
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1. Physical &	Chamical Discipline					
Α.	PHYSICAL PARAMETERS					
S.Na.	a. Test Parameter		Units	Specifications as per 15: 1786-2008 (Grade-Fe-500 D)	Results	Test Mathod
1	Mass per meter		Kg/m	0.365 ± 7%	0.399	15:11658(P-1):2005
2	Tertaile Strength		N/mm ¹	545 Min.	635.0	IS 1608(P-1) 2005
3	Vield Stress		Polymon P	SCC Min.	548	15:1608(P-1) 2005
4	Rate of tensile Strongth of the test piece(TS/VS)	of Yield Stress		greater than 1.10	1.16	IS : 1608(P-1) 2005
5	Elongation		35	15 Min.	23.5	15 : 1005/P-11 2000
6	Bend Test			The Specimen should be considered to be passed the test if there is no rupture or no cracks on the bant portion.	passes the burt	IS : 1589-2008
<u>x</u>	7 Rebend Tast		2	The Specimen should be considered to be paraled the test if there is no supture or no crocks on the repert portion	parses the test	IS : 1788-2008
8,	CHEMICAL COMPOSITION	Q.				
1	CARBON		St. by mans	max. 0.25	6.21	18: 228
2	MICN .		% by mass	-	97.98	IS 228
3	MANGAMERE		% by mass	max 0.3	0.08	IS 228
4	ZINC		% by mees	max 0.3	0.11	IS 228
5	TELANIUM		% by mass	max. 0.02	0.005	5:228
6	PROSPHORIDUS		% by mane	max. 0.04	0.025	IS : 228
7	SULPHUR		% by mass	max. 0.04	0.021	IS: 228
- 6	CHROMUM		% by mass	max. 0.01	0.003	15:328

Reinforcement Testing

Remarks- The sample conform to IS : 1788-2008 of Grade Fe-800 D with respect to above texts

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• The project starts with layout and excavation.

 After the layout at site, the excavation of each block is done using mechanical excavators up to the required depth of foundation which is 2.5 m for blocks.



• The foundation work starts with the PCC of 100 mm thickness (M10 Grade)



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.





- Back filling with soil and water in layers of 200 mm with proper compaction.



- 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.

Casting of plinth beam



- 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

CAUTION





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 beams

Erection of steel columns & beams

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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

the second

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

EXTERNAL 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





FINISHING ITEMS

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



OTHER INFRASTRUCTURE ITEMS

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











A view of block (A) with Prefabricated wall Panels





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

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