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

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

सत्यमेव जयते
Ministry of Housing & Urban Affairs
Government of India

आत्मनिर्भर भारत

स्वच्छ भारत
एक कदम स्वच्छता की ओर

LIGHT HOUSE PROJECT
AT AGARTALA, TRIPURA

3D View of the Project

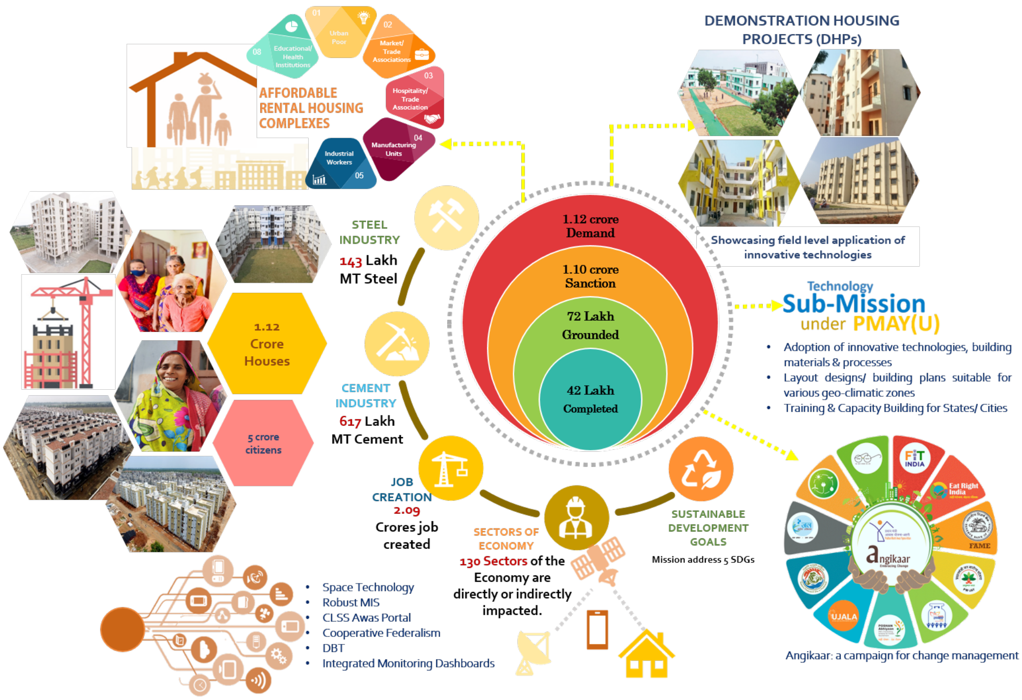
“The country is going to get a new technology to build houses for the poor and the middle class. In technical parlance, you call it the Light House Project. I believe these six projects are really like light towers. These six light house projects would give a new direction to the housing construction in the country. The coming together of states from the east-west, north-south and every region of the country is further strengthening our sense of cooperative federalism. These light house projects will be constructed through modern technology and innovative processes. This will reduce the construction time and prepare the more resilient, affordable and comfortable homes for the poor. In a way, these projects will be incubation centres and our planners, architects, engineers and students will be able to learn and experiment with new technology.”

Narendra Modi
Prime Minister of India
1.1.2021

1. Background

The Ministry of Housing and Urban Affairs (MoHUA) is implementing Pradhan Mantri Awas Yojana-Urban (PMAY-U) Mission, one of the largest public housing programs in the world, with a goal of providing all weather pucca houses to all eligible urban families by 2022. Against an assessed demand of 1.12 crore houses, so far over 1.08 crore have been sanctioned; out of this over 72 lakh have been grounded for construction and nearly 42 lakh have been completed and delivered to the beneficiaries.

Under PMAY(U), a Technology Sub-Mission (TSM) has been set up with an aim to provide sustainable technological solutions for faster & cost-effective construction of houses suiting to geo-climatic and hazard conditions of the country". TSM promotes adoption of modern, innovative & green technologies and building material for faster and quality construction of houses. It also facilitates for preparation and adoption of layout designs and building plans suitable for various geo-climatic zones.



The Country being in development phase, massive construction activities are undergoing and planned in all the States/UTs for creating affordable shelters & related infrastructures. Traditionally, houses in the country are constructed using conventional technology as in-situ reinforced cement concrete (RCC) frame & burnt clay brick masonry. With the massive construction requirement & taking into consideration the important factors such as fast depleting natural resources, achieving Sustainable Development Goals (SDGs) & international commitments to reduce Carbon Dioxide emissions, there is urgent need to find alternate, sustainable and resource efficient solutions.

Globally, there has been technological advancement in the area of building materials and fast track prefabricated/pre-engineered construction practices. However, the use of alternate construction technologies in our country is in a limited extent so far. Hence, there was a need to look for new emerging, disaster-resilient, environment-friendly, cost-effective and speedy construction technologies which would form the basis of housing construction in India. Hon'ble Prime Minister envisaged a paradigm shift through technology transition using large scale construction under PMAY(U) as an opportunity to get the best available construction technologies across the globe.

In the light of above, MoHUA initiated Global Housing Technology Challenge India (GHTC-India) in January, 2019 which aimed to identify and mainstream globally best available proven construction technologies that are sustainable, green and disaster resilient through a challenge process which could bring a paradigm shift in construction practices for housing sector.

2. Construction Scenario in India

Housing for All by 2022 is the firm resolve of the Government to provide pucca shelter to each household of India and is a humble beginning towards building New India. The number of housing units that need to be constructed are huge. There is a requirement of 11.2 million dwelling units in urban areas by 2022. Also, construction sector is emerging as third largest sector globally to take India towards $5 trillion economy.

Conventionally, houses are built with traditional materials, i.e., burnt clay bricks, cement, sand, aggregates, stones, timber & steel. Sand and aggregates are already in short supply and due to irrational mining, it is banned in number of states in India. Burnt clay bricks use top fertile soil as raw material and also, its production makes use of coal, a fossil fuel. Cement and steel are also energy intensive materials and produced from natural resource, i.e., limestone rock and iron ores respectively. Further, the construction requires clean drinking water which is already in short supply even for drinking.

The way out is:

i. To make use of alternate materials which are based on renewable resources & energy
ii. Optimize the use of conventional materials by bringing mechanization in the construction
iii. Utilize agricultural & industrials waste in producing building materials.

In conventional method, the materials are gathered at the site and then construction takes place by laying bricks layer by layer to construct walls and pouring concrete over steel cages (reinforcement) to make floors, vertical members, i.e., columns and horizontal members i.e. beams through a labour intensive process with little control on quality of finished product. Also, this construction process is slow paced. Further, in being cast in situ construction, there is ample wastage of materials and precious resources and at the same time there is enormous dust generated polluting the air. Therefore, there is need to bring construction methodologies which impart speed to the construction, bring in optimum use of materials, cut down wastages and produce quality product.

In today's context, a few more terms have become significant with construction and need to be dovetailed with future construction practices. These are sustainability, climate responsiveness and disaster resilience. The construction industry poses a major challenge to the environment. As per the UN Environment Programme (UNEP), more than 30% of global greenhouse gas emissions are building related and emissions could double by 2050 on a business-as-usual scenario. As per report of the Green Rating for Integrated Habit Assessment (GRIHA), globally, buildings consume about 40% of energy, 25% of water and 40% of resources. In addition, building activities contribute an estimated 50% of the world's air pollution, 42% of its greenhouse gases, 50% of all water pollution, 48% of all solid wastes and 50% of all CFCs (chlorofluorocarbons) to the environment.

Further, disasters due to natural hazards i.e. earthquakes, cyclones, floods, tsunamis and landslides have been happening with ascending frequency and effects. Every year due to faulty construction practices and bad performance of built environment during disasters, there are not only heavy economic losses but also losses of precious lives of humans leaving irrevocable impact on human settlements and therefore, disaster-resilient construction is also paramount.

In view of the above, it is obvious that construction sector requires a paradigm shift from traditional construction systems by bringing innovative construction systems which are resource-efficient, environmentally responsible, climate responsive, sustainable, disaster-resilient, faster, structurally & functionally superior. These kinds of systems are being practiced world over successfully and have shown their versatility through the passage of time.

3. Innovative Construction Technologies: Salient Features

i. Resource Efficiency

A conventional building tends to focus on the use of basic materials namely cement, bricks, sand, aggregates, steel which are based on natural resources. Also, there is over dependence on fossil fuels for production & transportation. These natural resources are finite and cannot be replenished quickly. Also, their extraction and manufacturing have direct and indirect consequences on environment & energy requirements and pose danger to our planet in terms of greenhouse gas emissions, land & air pollution etc. Therefore, natural resources are to be used efficiently which is one of the key features of alternate construction systems as they employ industrial techniques to produces building components and use cement, steel and other aggregates optimally. The other feature of alternate construction systems is to make use of renewable resources.

ii. Structural Design Efficiency

The alternate systems follow the path of optimization. Right from the concept & design stage, the building components, including structural configuration, is designed in a manner to optimize the performance. The performance-based design instead of prescriptive design philosophy is the key for design efficiency while dealing with these alternate construction systems.

iii. Disaster Resilience

The alternate construction systems are designed to be resilient in terms of natural hazards as it entails performance-based design of buildings.

iv. Cost & Payoff

The most criticized issue about alternate construction systems is the price. The stigma is between the knowledge of up-front cost vis-à-vis life cycle cost. The cost of a building is defined as follows:

Total Cost = Initial construction cost + Running cost during life of building + disposal cost
(This is also known as life-cycle cost)

Most of the time, the criterion in selection of technology is cost per m^2, which is initial cost and can be incongruous if green aspects are to be considered. The buildings with alternate systems may cost 10-15% higher initially as of now (It can also be questioned as today these systems require initial push but once mainstreamed the initial cost will also be equivalent to cost of conventional construction) but will be less by couple of times over the entire life of the building. During the life span of a building, the financial payback will exceed the additional initial cost of using alternate systems several times. And broader benefits, such as reductions in greenhouse gases (GHGs) and other pollutants have large positive impacts on surrounding communities and on the planet.

v. Energy Efficiency

Alternate construction systems often include measures to reduce energy consumption, i.e., the embodied energy required to extract, process, transport and install building materials and the operating energy to provide services such as heating and power for equipment. The buildings with alternate systems use less operating energy, embodied energy. These buildings will have a lower embodied energy than those built primarily with brick, mortar, concrete, or steel.

vi. Water Efficiency

The conventional construction systems primarily are cast-in-situ reinforced concrete systems which require large quantity of potable water for curing and most of the time, the water of curing go waste. The new systems employ better techniques of curing such as pressurized curing, chemical curing etc. which help in conserving the water during construction.

vii. Material Efficiency

Building materials are typically considered to be sustainable if they are based on renewable/waste resources and can be reusable and recyclable. Most of the alternate construction systems either make use of industrial waste, renewable resources, energy efficient building materials or optimize the use of basic raw materials, i.e., cement, sand, aggregates, steel consumption. For example, The Glass Fiber Reinforced Gypsum (GFRG) panels make use of phospho-gypsum which is a by-product of fertilizer plant, sandwich panels make use of EPS beads which are energy efficient.

viii. Indoor Environmental Quality Enhancement

The Indoor Environmental Quality refers to providing comfort, well-being, and productivity of occupants. Indoor Air Quality seeks to reduce volatile organic compounds, or VOCs, and other air impurities such as microbial contaminants. The alternate systems employ construction materials and interior finish products with zero or low VOC emissions during the design and construction process which enhance indoor air quality. Also, well- insulated and tightly sealed envelope reduce moisture problems which often leads to dampness.

ix. Operation & Maintenance Optimization

The construction systems identified are based on factory made building components which are manufactured with high precision under strict quality control and therefore, more durable, requiring no or minimum maintenance. The alternate technologies are industrial products having SOPs for building's Operations and Maintenance (O&M).

x. Waste Reduction

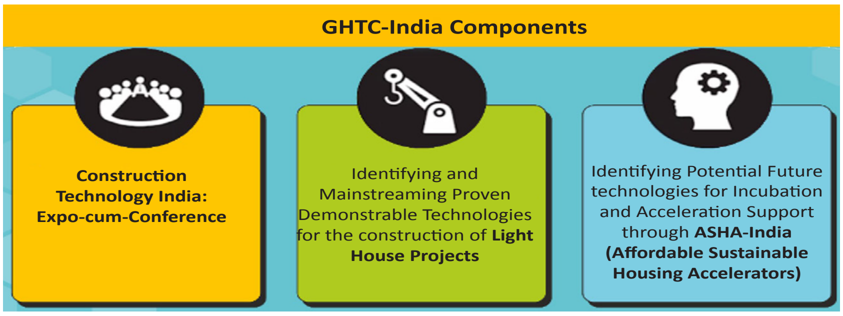
Alternate construction systems not only seek to reduce waste of energy, water and materials used during construction but also generate less construction & demolition waste after completion of the building. Well-designed buildings also help reduce the amount of waste generated by the occupants. When buildings reach the end of their useful life, they are typically demolished and disposed to landfills. In case of alternate systems, most of the deconstructed components can be reclaimed into useful building materials.

End-User Benefits
• Improved structural & functional performance
• Safer and disaster resilient house
• Better quality of construction
• Low maintenance, minimum life cycle cost
• Speedy construction resulting in early occupancy
• Cost-effective and environment-friendly
• Better fire resistance & thermal efficiency
• Less air pollution and waste generation

4. Global Housing Technology Challenge-India

MoHUA has initiated the Global Housing Technology Challenge-India (GHTC-India) which aims to identify and mainstream a basket of innovative construction technologies from across the globe for housing construction sector that are sustainable, eco-friendly and disaster-resilient. They are to be cost effective and speedier while enabling the quality construction of houses, meeting diverse geoclimatic conditions and desired functional needs. Future technologies will also be supported to foster an environment of research and development in the country. GHTC-India aspires to develop an eco-system to deliver on the technological challenges of the housing construction sector in a holistic manner.

Construction Technology India (CTI) – 2019: 1st Biennial Expo-cum-Conference was inaugurated by Hon'ble Prime Minister on 2nd March 2019. He also declared the year 2019-20 as the 'Construction Technology Year' to promote new and alternate technologies at a large scale in the country. The Expo brought together multiple stakeholders from across the world involved in innovative and alternative housing technologies for exchange of knowledge and business opportunities and master classes.



MoHUA, through a Technical Evaluation Committee (TEC), shortlisted 54 innovative proven technologies suiting different geo-climatic conditions that could be considered for demonstration through actual ground implementation of six Light House Projects (LHP) in six different States/UTs of PMAY(U) regions across the country. These 54 technologies were further categorized into following six broad categories:

1. Precast Concrete Construction System - 3D Precast volumetric

2.Precast Concrete Construction System - Precast components assembled at site

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

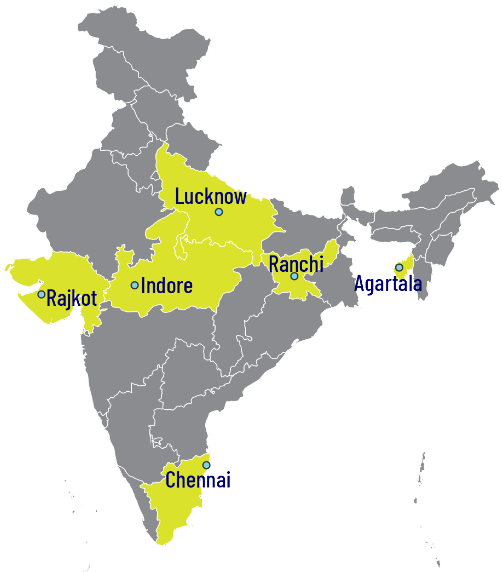
4.Prefabricated Sandwich Panel System

5.Monolithic Concrete Construction

6.Stay In Place Formwork System

The details of the shortlisted 54 technologies are available at https://ghtc-india.gov.in.

5. Light House Projects



Six distinct innovative technologies have been selected from among 54 globally best technologies that participated in GHTC-India for constructing six Light House Projects (LHPs) of about 1,000 houses each with allied infrastructure at Indore, Rajkot, Chennai, Ranchi, Agartala and Lucknow.

Hon'ble Prime Minister Shri Narendra Modi laid the foundation stone of these LHPs on January 1, 2021 and Hon'ble Governors, Hon'ble Chief Ministers of six states along with State Ministers joined the event from the LHP sites through video conference. The LHPs are model housing projects comprising of nearly 1,000 houses at each location with allied services are being constructed for showcasing use of the best of new-age technologies, materials and processes in the construction sector.

The houses are being constructed using the innovative technologies shortlisted under GHTC-India suitable to the geo-climatic and hazard conditions of the region and will be completed in challenges mode within 12 months time. LHPs will pave the way for a new eco-system where globally proven technologies will be adopted for cost effective, environment-friendly and speedier construction.

LHPs will serve as Live Laboratories for different aspects of transfer of technologies to field application, such as planning, design, production of components, construction practices, testing, etc., for both faculty and students, builders, professionals of private and public sectors and other stakeholders involved in such construction.

Details of six Light House Projects are as given below:

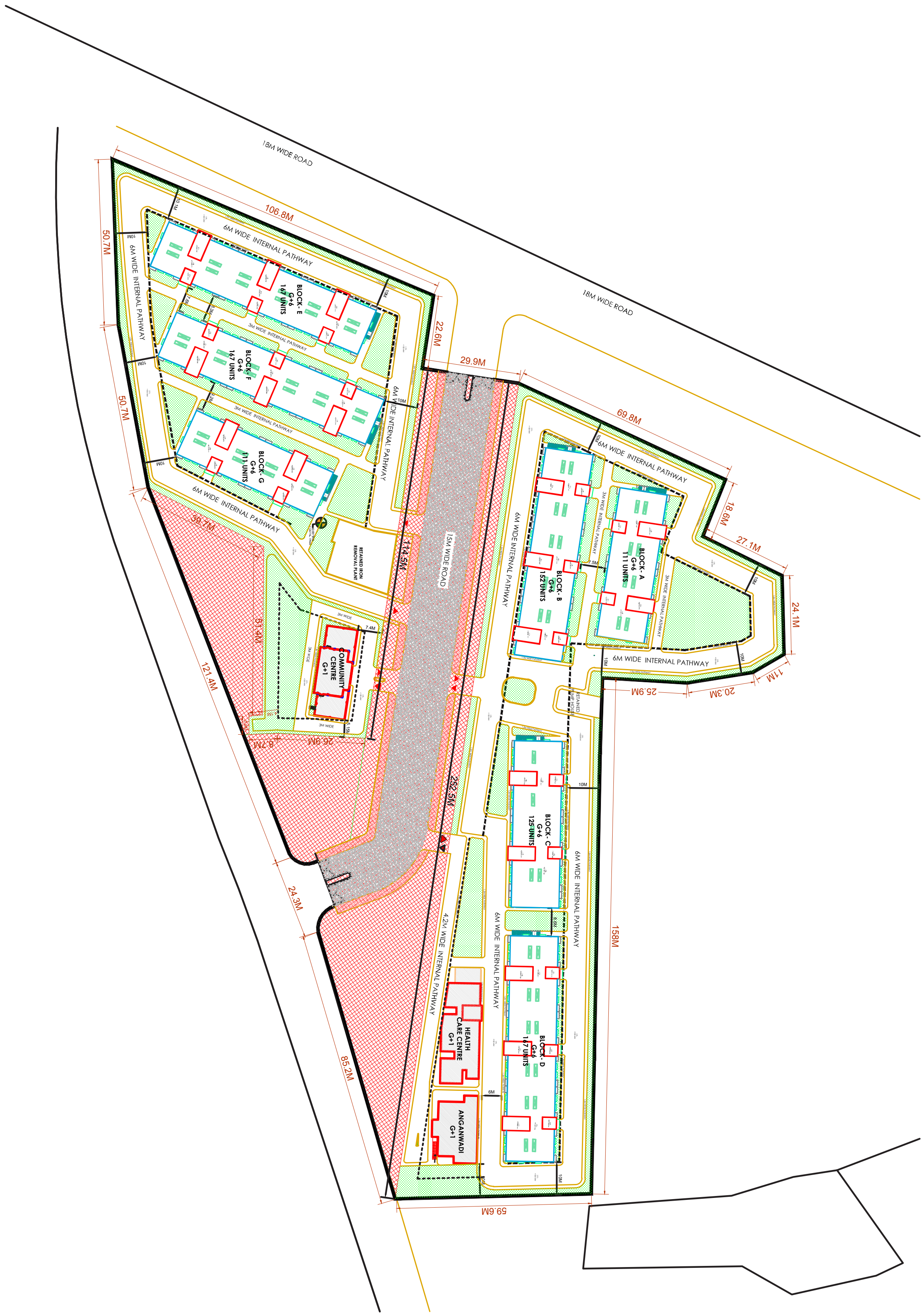
Location	DUs (Storeys)	Technology	Construction Agency
1. Indore, Madhya Pradesh	1,024 (S+8)	Prefabricated Sandwich Panel System	M/s KPR Projectcon Private Limited
2. Rajkot, Gujarat	1,144 (S+13)	Monolithic Concrete Construction using Tunnel Formwork	M/s Malani Construction Co.
3. Chennai, Tamil Nadu	1,152 (G+5)	Precast Concrete Construction System – Precast Components Assembled at Site	M/s B. G. Shirke Construction Technology Pvt. Ltd.
4. Ranchi, Jharkhand	1,008 (G+8)	Precast Concrete Construction System – 3D Volumetric	M/s SGC Magicrete LLP
5. Agartala, Tripura	1,000 (G+6)	Light Gauge Steel Structural System & Pre-engineered Steel Structural System	M/s Mitsumi Housing Pvt. Ltd.
6. Lucknow, Uttar Pradesh	1,040 (S+13)	PVC Stay In Place Formwork System	M/s JAM Sustainable Housing LLP

Light House Projects : Salient Features

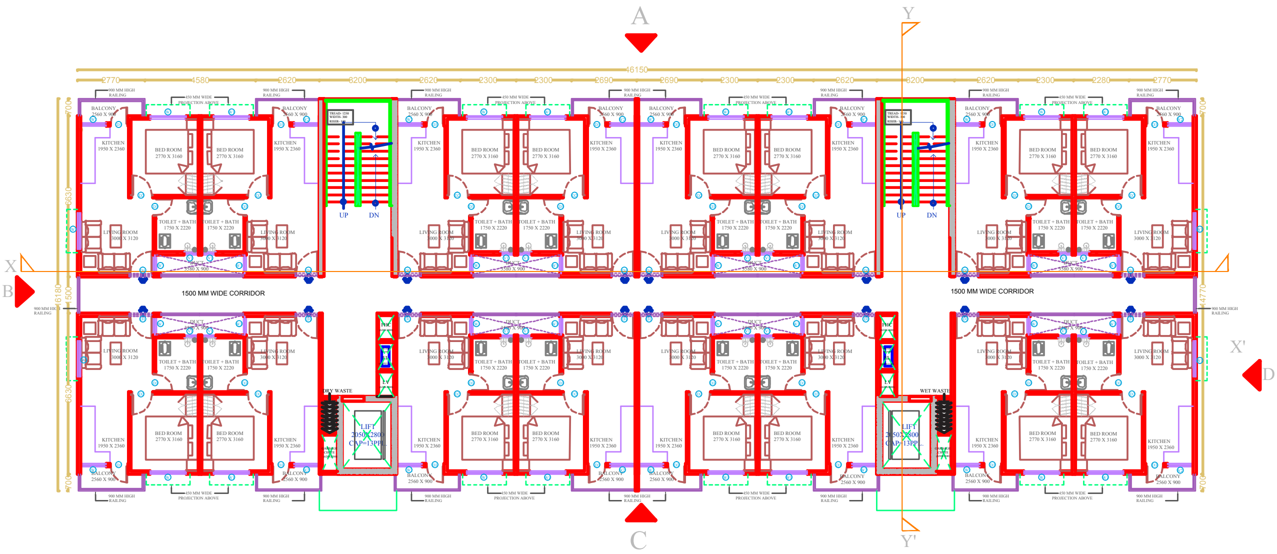
- LHPs are model housing project with approximately 1,000 houses built at each location with shortlisted alternate technology suitable to the geo-climatic and hazard conditions of the region.
- Constructed houses under LHPs will include on site infrastructure development such as internal roads, pathways, common green area, boundary wall, water supply, sewerage, drainage, rainwater harvesting, solar lighting, external electrification, etc.
- Houses under LHPs are designed keeping in view the dimensional requirements laid down in National Building Code (NBC) 2016 with good aesthetics, proper ventilation, orientation, as required to suit the climatic conditions of the location and adequate storage space, etc.
- Convergence with other existing centrally-sponsored Schemes and Missions such as Smart Cities, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Swachh Bharat (Urban), National Urban Livelihood Mission (NULM), Ujjwala, Ujala, Make in India were ensured during the designing of LHPs at each site.
- The structural details were designed to meet the durability and safety requirements of applicable loads including earthquakes, cyclone, and flood as applicable in accordance with the applicable Indian/International standards.
- Cluster design may include innovative system of water supply, drainage and rainwater harvesting, renewable energy sources with special focus on solar energy.
- The period of construction will be maximum 12 months. Approvals were accorded through a fast track process by the concerned State/UT Government.
- For the subsequent allotment of constructed houses under LHPs to the eligible beneficiaries in States/ UTs, procedures of existing guidelines of PMAY (U) will be followed.

Light House Project at Agartala, Tripura

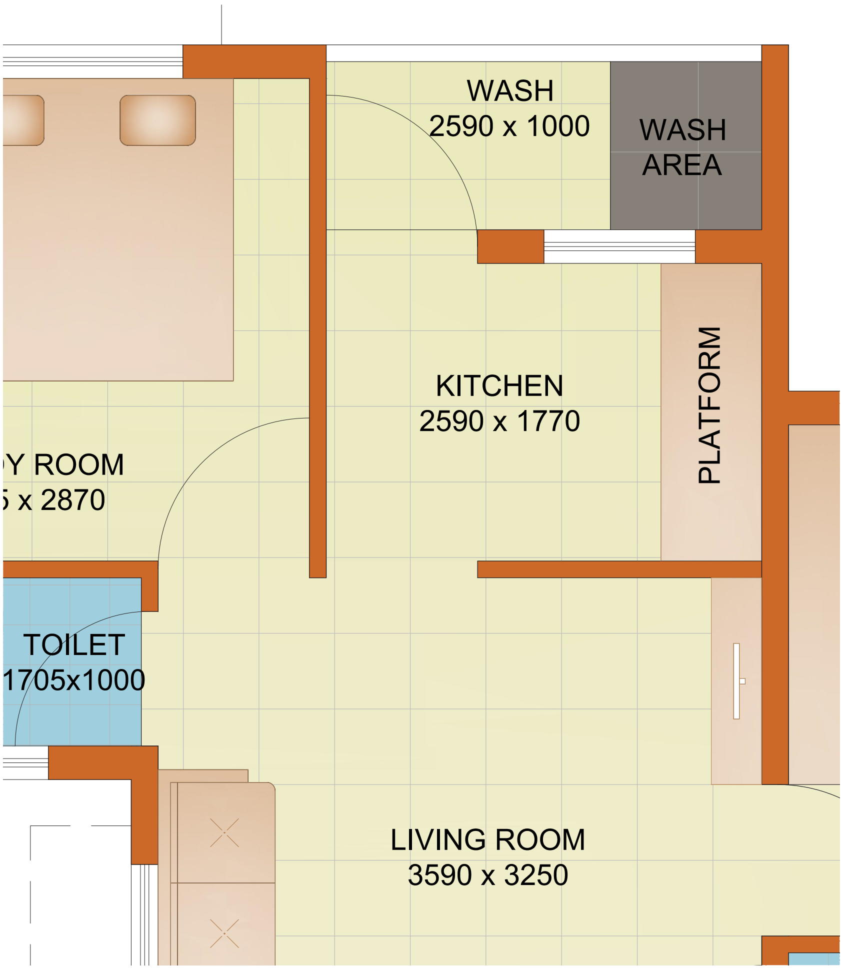
Project Brief	
Location of Project	Akhura Road, Agartala, Tripura
No. of DUs	1,000 (G+6)
Plot area	24,168 sq.mt.
Carpet area of each DU	30.03 sq.mt.
Total built up area	45,273 sq.mt. including social infrastructure
Technology being used	Light Gauge Steel Structural System with pre-engineered steel structural system
Other provisions	Anganwadi, Health Centre, Community Centre
Broad Specifications	
Foundation	RCC pile foundation
Structural Frame	Pre-engineered steel structural frame
Walling	Light gauge steel structural system with cement concrete panels and light weight concrete as infill
Floor Slabs/Roofing	High tensile galvanized deck sheet with required reinforcement and 50 mm Concrete
Joinery & Finishing	Door Frame/Shutters: • Pressed steel door frame with flush shutters • PVC door frame with PVC Shutters in toilets. Window Frame/ Shutter: • uPVC frame with glazed panel and wire mesh shutters. Flooring: • Vitrified tile flooring in Rooms & Kitchen • Anti-skid ceramic tiles in bath & WC • Kota stone Flooring in Common area. • Kota stone on Staircase steps. Wall Finishes: • Weather Proof Acrylic Emulsion paint on external walls • Oil Bound distemper over POP on internal walls
Infrastructure	Internal Water Supply, Laying of Sewerage Pipe Line, RCC storm water drain, Provisions for Fire Fighting, Internal Electrification, Internal Road & Pathway (CC Road and Bituminous Road), Providing Lifts in building blocks, Landscaping of site, Street light with LED lights, Solar Street Light System, Sewerage Treatment Plant, External Electrification, Water Supply System including underground water reservoir, Compound wall with Boundary Gates, Horticulture facilities, Rain Water Harvesting, Solid Waste Management.


18M WIDE ROAD
18M WIDE ROAD
106.8M
50.7M
50.7M
22.6M
29.9M
69.8M
18.6M
27.1M
24.1M
11M
20.3M
25.9M
39.7M
51.4M
121.4M
114.5M
252.5M
158M
24.3M
85.2M
59.6M
26.9M
6M WIDE INTERNAL PATHWAY
BLOCK- E
G+6
167 UNITS
BLOCK- F
G+6
167 UNITS
BLOCK- G
G+6
111 UNITS
BLOCK- A
G+6
111 UNITS
BLOCK- B
G+6
152 UNITS
BLOCK- C
G+6
125 UNITS
BLOCK- D
G+6
167 UNITS
15M WIDE ROAD
COMMUNITY CENTRE
G+1
HEALTH CARE CENTRE
G+1
ANGANWADI
G+1
4.2M WIDE INTERNAL PATHWAY
3M WIDE INTERNAL PATHWAY
RETAINED IRON REMOVAL PLANT

Layout Plan



Block Plan



Unit Plan

Technology Details

A. INTRODUCTION

Light Gauge Steel Framed Structure with Infill Concrete Panels (LGSFS-ICP) Technology is an innovative emerging building and construction technology using factory made Light Gauge Steel Framed Structure (LGSFS), light weight concrete and precast panels. The LGS frame is a "C" cross-section with built in notch, dimpling, slots, service holes etc. produced by computerized roll forming machine. These frames are assembled using metal screws to form into LGSF wall and roof structures of a building. Provisions for doors, windows, ventilators and other cutouts as required are incorporated in the LGSFS.

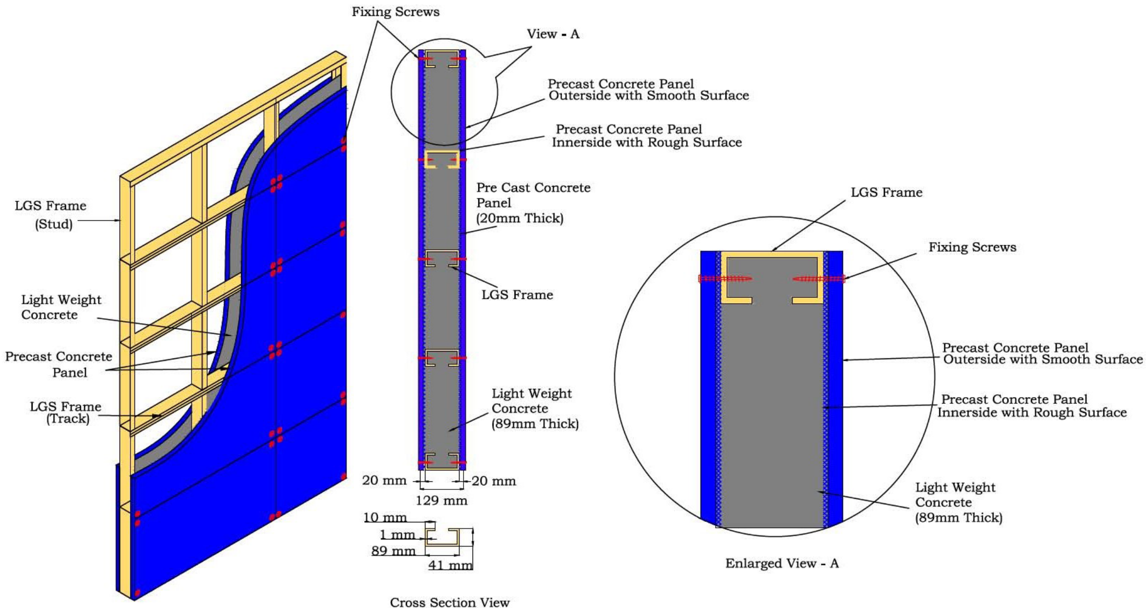


Fig.1 Structural Details of LGSFS-Infill Concrete Wall

The LGS frames are manufactured in a factory and assembled in to LGSF wall structures and then transported to the construction site and erected wall by wall on a pre-built concrete floor as per the floor plan of the building. Steel reinforced concrete panels of size 800mm X300mm X20mm thick are manufactured at factory and transported to site. These panels are fixed on either side of the LGSFS wall using self-drilling/tapping screws to act as outer and inner faces of the wall leaving a gap between them. This gap is then filled with light weight concrete using a special mixing and pumping machine. Electrical and plumbing pipes/conduits are provided in the service holes of the LGSFS before concreting is done. Self-compacting concrete is mixed and pumped into the gaps between two panels. The concrete flows and fills the gap and provides adequate cover to the LGS frames and joints. The concrete shall also adhere to the concrete panels. After curing, LGSFS with in-fill concrete and panels (LGSFS-ICP) forms a monolithic sandwich composite wall structure with thermal and sound insulation properties.

The roof structure of LGSFS-ICP building is constructed using metal/plastic formwork system with steel reinforced concrete as per structural design. Standard procedures are employed to concrete the roof slab. After curing for 96 h, the formwork is de-moulded and the wall and roof are putty finished. Door and window frames are fixed to the LGS frames and shutters fixed with necessary accessories. Finishing work such as laying floor tiles, fixing electrical and sanitary fixtures and painting is carried out using standard conventional methods.

After completion of ground floor, first, second and third floors of the building is constructed using the same procedure that of the ground floor. The staircase, chajja and parapet walls of the building are also constructed using LGSFS-ICP Technology.

B. MATERIAL REQUIREMENTS

1. Raw Materials

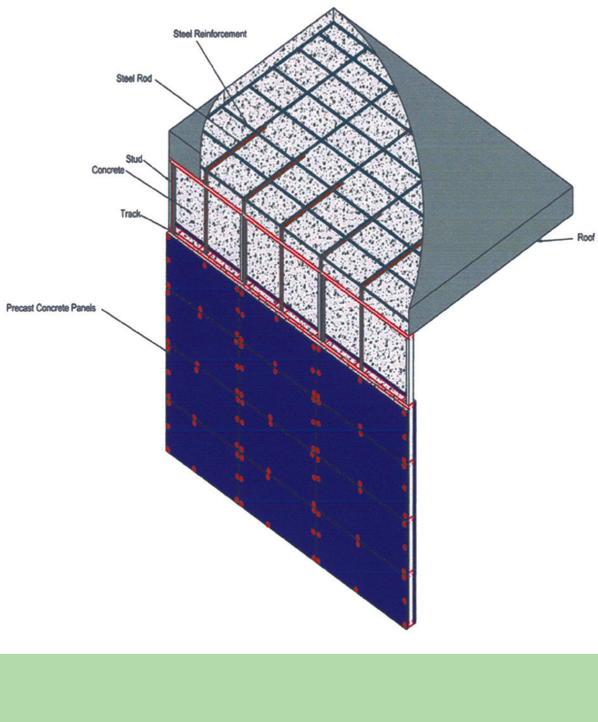
i. LSG Coil of galvanized steel shall conform to IS 277:1992.
ii. Fasteners and Connectors
   (a) Frame assembly screws: Shall be galvanized steel screws self-drilling type of size 10 x 25 mm having Truss-head and shall be as per ASTM C 1513-10.).
   (b) Wall Erection Screws: Shall be galvanized steel screws self-drilling type of size 8 x 25 mm having Hex Washer head and shall be as per ASTM C 1513-10
   (c) Precast Concrete Panels Fixing Screws: Shall be of galvanized steel screws self-drilling type of size 8 x 50 mm having CS head and shall be as per ASTM C 1513-10.
   (d) Wall and Foundation Anchor Bolt: Shall be of high tensile galvanized steel of size 10 x 100 mm/ 10 x 150 mm and 12 x 100 mm/ 12 x 150 mm and shall be as per ASTM C 1513-10.
iii. Foaming Chemicals: Shall be made from protein foam concentrate and FC-lite foaming agent
iv. Gypsum plaster board: Shall be of size 1830 mm x 1220 mm and 12.5mm to 20 mm thick and shall conform to IS 2095 (Part 1):2011
v. Water Proofing Treatment: Shall be using integral waterproofing compound as per IS 2645:2003
vi. Putty: Shall be as per IS 63:2006
vii. Ordinary Portland cement (OPC) shall be of 43/53 grade as per IS 269:2015
viii. Sand and Aggregates shall be as per IS 383:2016
ix. Reinforced Steel: Shall be as per IS 1786:2008
x. Structural steel: Shall be as per IS 800:2007
xi. Steel fiber: Shall have length of 60 mm &dia. 0.75 mm and shall be as per EN 14889-1:2006
xii. Glass fiber: Shall be made from Fiber mesh 303 E3 and shall be as per EN 14889-2:2006

2. Pre-engineered steel structural frame

The structure consists of steel pillars, modules and other components designed for worst loading conditions as per IS 800:2007 and IS 801:1975. In addition, the structure shall be designed in accordance with IS 1893(Part 1) & IS 875 for seismic and wind load considerations, both individually and in combination, as applicable. Steel pillars shall be made by welding MS plate of 16mm thickness and steel tubes of size 200mm x 200mm having wall thickness varying from 3mm to 16mm depending upon the number of floors. The smaller pillar is fixed with sub-assemblies for modules. All the columns shall be checked for their safety and computations shall be done for the same for satisfying requirements of IS 800 and IS 801.

3. Light gauge steel frame

The Light gauge steel frame structure (LGSFS) for infill walls comprises of "C "cross section studs (vertical members) and tracks (horizontal members) frames assembled together by means of mechanical screws. The joints between wall & roof junctions/wall to wall junctions are designed as rigid joints.



4. Precast concrete panels

Precast Concrete Panels are used as facing sheets for construction of walls. Self-compacting concrete of M20 grade is used. Metal modes, concrete mixing machine and vibration tables are used for manufacturing the panels. The panels are designed to withstand the concrete weight pumped in between the gap of the panels without failure and buckling.

The steel reinforced precast concrete panels (PCP), has one side rough surface and the other side smooth surface. The PCP's are fixed on either side of Light Gauge Steel Frame Structures (LGSFS)–studs and tracks using mechanical fasteners. While fixing, the rough side of the panels are facing inside and smooth side is facing outside. Each PCP is fixed with 6 screws. Light weight concrete is pumped in to the gap between two PCPs. The concrete bonds with the rough surface of the panels. Thus, the LGSFS and PCPs are firmly joined to make a monolithic steel–concrete structure.

5. Concrete/light weight concrete

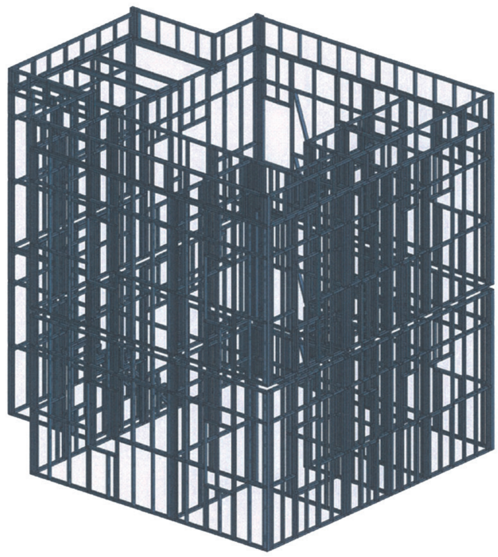
The concrete used for infill wall is light weight and free flow. The density shall be 1500-1800 Kg/m^3 after adding/mixing foam or EPS beads as per the design mix developed by the agency. The light weight concrete shall be of grade M5 to M10, as required. The light weight concrete shall be mixed and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

C. MANUFACTURING PROCESS

The manufacturing process of the constituents of LGSFS-ICP system is as follows:

1. Light Gauge Steel Frame Structure

Cold formed Light gauge steel frame super structure is manufactured out of min. 0.95 mm pre-treated factory finished hot dipped GI high tensile steel sheet (AZ 150 GSM Aluminium zinc alloy coated steel and having yield strength of 550MPA) which shall be as per IS 800:2007 and conforms to AISI specification and IBC 2009. The wind loads shall be as per IS 875 (Part 3):2015. The framing section is cold form "C' type of 0.55 mm to 1.55 mm thickness in required length as per structural design requirements, duly punched with dimple slots at required locations as per approved drawings. The slots shall be along center line of the web and shall be placed at 250 mm min. away from both edges of the member. The frame is supplied in specified dimensions and fastened with metal strip of 25 mm x 25 mm x 0.50 mm to both adjoining walls.



2. Precast Concrete Panels

Precast concrete panels are manufactured using cement, sand, aggregates, glass &steel fibers, water and admixtures using a design mix and curing cycle developed by the agency. It is steel fibre reinforced precast concrete panel. It gets strength as steel reinforced concrete.

The overall dimensions of the panel are 1220 mm x 610 mm x 20 mm thick and the weight shall be around 36 kg. The panels are designed to have smooth or textured outside surface and rough inside surface. The panels are also designed to withstand green concrete load of 200 kg without failure and deflection shall be less than 1.0 mm.

The concrete used for the panels shall be of grade M20 having water absorption less than 8%.
Mix ratio of light weight aggregate for 1.0 cu.m is as follows:

Cement	=	300 kg
Sand	=	400 kg
Flyash	=	300 kg
6mm-8mm Aggregate	=	1350 kg
PPfibre + steel fibre	=	4.14 kg
Water	=	150 kg
Admixtures	=	150 ml

3. Concrete/Light Weight Concrete

The wall or the roof is constructed using M20 grade concrete and M5 –M10 grade light weight concrete. The concrete used is light weight and free flow. The light weight concrete is mixed and used at site. The concrete/ light weight concrete is pumped into the gap between the panels.

4. Assembly/Connecting Screws and Anchoring Bolts

LGS frames are assembled together to fabricate LGSF structures using self-taping screws. The LGSF structures such as wall, roof, truss and staircase are connected by using special screws which shall conform to ASTM C 1513. The anchoring boards used for connecting LGSF wall structure to the foundation shall conform to relevant Indian/American Standards.

D. APPLICATIONS

The technology is used for construction of Low rise residential buildings up to G+3 storey – EWS, LIG & MIG houses, Schools, Health centers, Community centers, independent houses and rehabilitation buildings.

E. INSTALLATION/ CONSTRUCTION OF LGSF STRUCTURES

1. Construction of Foundation and Plinth

The foundation and plinth is constructed confirming the floor plan of the building. The foundation depth, width, steel reinforcement, grade of concrete etc. is determined by structural analysis report prepared on the basis of soil condition, height of building, number of storeys, special live load requirement, if any.

2. Assembly of LGS Frames and Construction of Wall

The LSG frames manufactured using numerically controlled roll forming machine using CAD design shall be transported to the construction site. The frames shall be assembled into wall structure. All the wall structures shall be connected together one by one as per the building plan by connecting screws. The wall position shall be marked on the floor and the wall structure placed on the marking. After completing the same, straightness, square

and the levels shall be checked by magnetic spirit level. The bottom track shall then be connected with the floor using anchor bolts at every 600 mm bolts.

3. Fixing of Pre-cast Panels

The precast concrete panels shall be fixed on the LGSF wall structure on studs and tracks by using metal screws. The panels shall be fixed first on the outer side of the LGSFS wall. Electrical/plumbing pipes/conduits shall be fixed as per the electrical and plumbing layout. After completion, the panels shall be fixed inside the LGSFS walls and allocations for electrical and plumbing cutouts shall be marked on the panel.

4. Concrete Mixing and Pumping

Self-compacting concrete of required grade/light weight concrete shall be mixed using concrete mixing machine and then pumped into the gap between two panels using a special pumping unit. Care shall be taken to pump the concrete gradually and uniformly on all the walls. Concreting shall be done till the gap is completely filled up to the top of the LGSFS wall.

5. Construction of Roof Slab

The roof slab of the building shall be constructed by using metal/plastic shuttering and conventional concreting. Necessary steel reinforcement as per design shall be provided over the formwork and concreting shall be done to required thickness. Balcony and chhajja etc., wherever required shall also be constructed using formwork. After curing the slab, shuttering shall be removed and bottom of the roof slab putty finished.

6. Reinforcement

Deformed steel bars of 8mm/10mm dia. as per design shall be used.

7. Staircase and Railing

Staircase and balcony railing shall be fixed using conventional methods.

8. Fixing Electrical and Plumbing Fixtures

The panels shall be cut at the marked locations for fixing electrical and plumbing fixtures.

9. Fixing of Doors, Windows & Ventilator Frames and Shutters

The doors, windows & ventilator frames shall be fixed on the cutouts provided in the LGSFS. The frames shall be made of WPC, uPVC and other materials, as required. Thereafter, the doors and windows shutters shall be fixed to the frames. The shutters shall be made of glass fibre/ HDF sandwich composite materials.

10. Fixing Floor Tiles

Floor tiles of desired quality and make shall be fixed to the floor, as required. Similarly, wall tiles of desired quality and make shall be fixed in the kitchen, bath and toilet using conventional methods, as required.

11. Surface Finishing and Painting

Cement based putty shall be applied on the outside and inside walls and then painted with desired colour.

F. SPECIAL FEATURES

1. Structural Stability

Due to low weight, significant reduction in design earthquake forces. Chance of progressive collapse are marginal due to highly ductile and load carrying nature of closely spaced studs/joists.

2. Durability

Buildings shall be designed as per codal provisions of IS 456.

3. Behavior in earthquake

The buildings shall be designed for loads in accordance with IS 875 (Part 1 to 5) and IS 1893 (Part 1).

4. Behavior in wind

The wind loads shall be as per IS 875 (Part 3).

5. Fire Safety

During fire performance oriented test, it was observed that there was some minor cracks on the surface of all the walls.

6. Rain

During the ponding on roof slab for 24 hours, no dripping or leakage of water through roof slab or drop patches were observed on underside of the roof slab.
During rain simulation of external face of the wall by jetting for 12 hours, no leakage of water, dampness or sweating were observed on inner face of the wall.

7. Thermal Performance

There was a reduction in temperature upto 4ºC inside the unit indicating that it has got a good thermal comfort.

8. Acoustic Performance

The unit has got a good acoustic comfort.

9. Light weight

Weight of the LGSFS-ICP building is about 20-30% lighter when compared to conventional building thereby resulting in material and energy savings.

10. Limitation of Use

- LGSFS-IPC Technology may be used for construction upto G+3 storey Buildings only.
- For more than G+3 storey buildings, hybrid construction methods shall be used.

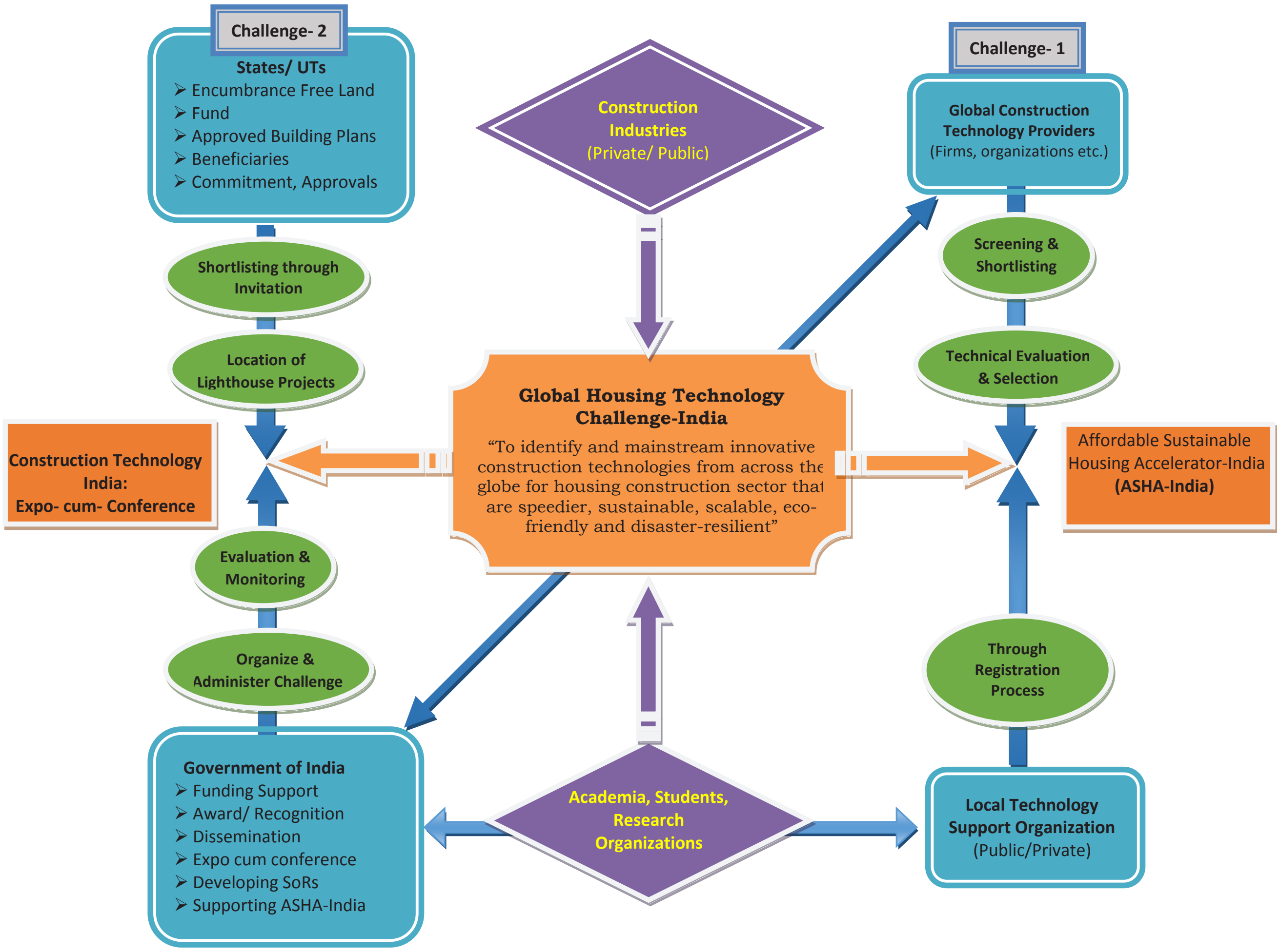
11. Critical Details

- Self coloured water repellent texture stucco.
- Guard bars and wooden/steel windows shall be provided. Aluminium sliding windows shall be avoided.
- Sun shades shall be provided for all windows/external doors as per design.

G. CERTIFICATION

Performance Appraisal Certificate No. 1028-S/2016 has been issued to M/s Society for Development of Composites, Bangalore by BMTPC.

Process Flow of GHTC-India



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सत्यमेव जयते

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