National Seminar on Green Affordable Housing
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Alternate and Emerging Technologies for Housing & Building Construction

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

bmtpc

established in

1990

to bridge the gap between lab & land and facilitate environment-friendly, energy-efficient, cost – effective and safer constructions

Focus Areas

- **Building Materials & Construction Technologies**

  To promote development of alternate/ new materials / & technologies, standardisation, mechanisation and large scale field application

- **Disaster Mitigation & Management**

  To promote methodologies and technologies for disaster mitigation and management.

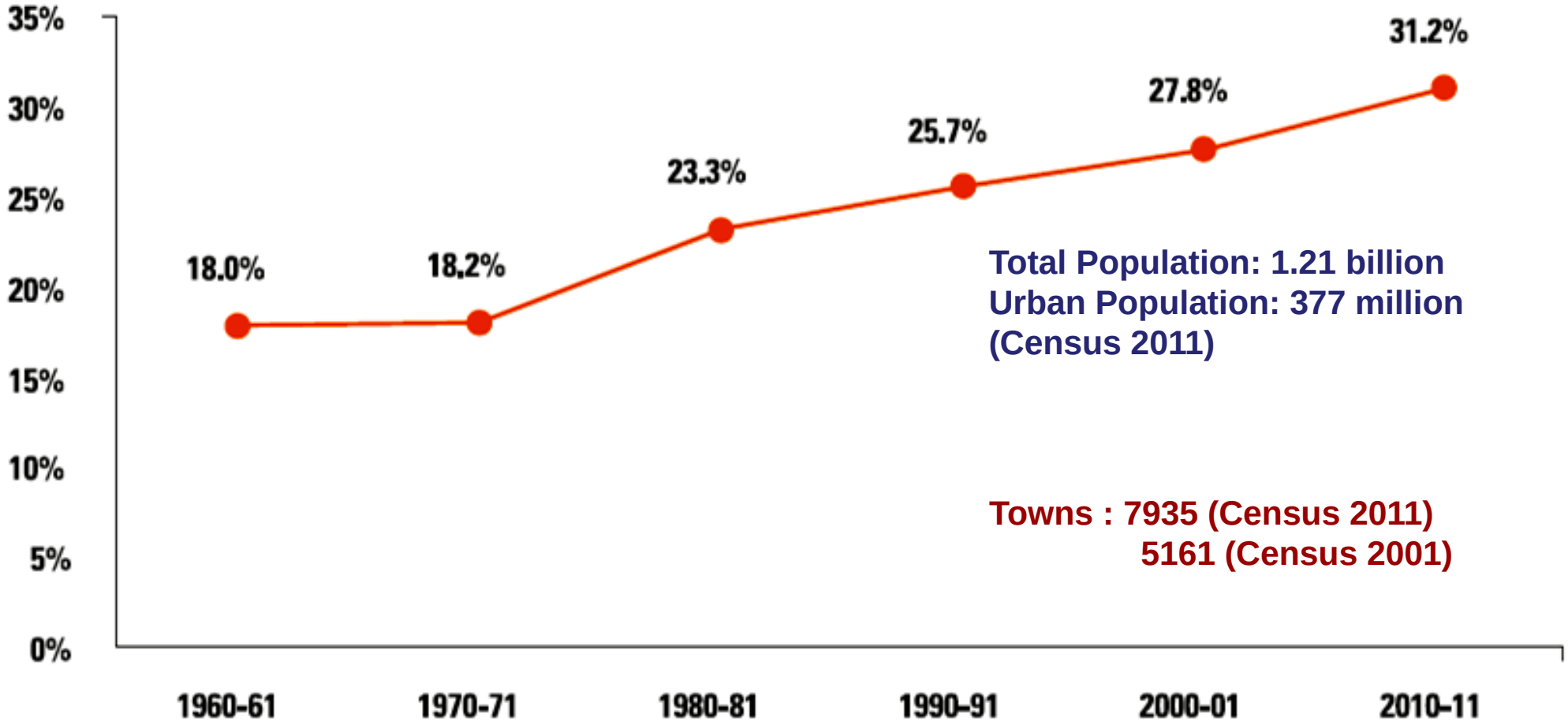
- **Capacity Building and Skill Development**

  To work as a Training Resource Centre for capacity building and promotion of good construction practices.

- **Project Management & Consultancy**

  To undertake project management and consultancy services.

Urbanization Growth in India



Source: Census of India 2011

Housing Scenario and Urbanization : India

- **32% urban population (Census 2011).**
- **40% by 2020 (Vision 2020 – Planning Commission).**
- **50% by 2041 (draft Urban India Report).**
- **Growing urbanisation has led to :**
  - **a) pressure on the availability of land and infrastructure**
  - **b) deterioration of housing conditions of the weaker sections of society**
  - **c) increased number of slums and squatter settlements.**

(27.9 million in 1981 to 61.8 million in 2001 to 93 million persons residing in slums in 2011).

Current Housing Stock (2001 and 2011)

INDIA					
Wall / Roof		2001 Census Houses		2011 Census Houses	
		No. of Houses	%	No. of Houses	%
WALL					
A - Mud / Unburnt Brick Wall with mortar	Rural	6,58,07,212	26.4	6,60,82,280	21.7
	Urban	79,91,950	3.2	1,08,08,689	3.5
Total - Category - A		**7,37,99,162**	**30**	**7,68,90,969**	**25**
B - Burnt Bricks + Stone packed with mortar	Rural	8,30,63,818	33.3	10,45,52,560	34.3
	Urban	5,43,09,628	21.8	7,50,35,035	24.6
Total - Category - B		**13,73,73,446**	**55**	**17,95,87,595**	**59**
C1 - Wood + Concrete	Rural	46,17,179	1.9	58,31,438	1.9
	Urban	51,20,151	2.1	79,33,512	2.6
Total - Category - C		**97,37,330**	**4**	**1,37,64,950**	**5**
X - Other Materials	Rural	2,40,49,304	9.7	3,00,97,412	9.9
	Urban	41,36,627	1.7	45,41,522	1.5
Total - Category - X		**2,81,85,931**	**11**	**3,46,38,934**	**11**
TOTAL BUILDINGS		24,90,95,869		30,48,82,448	
ROOF					
R1 - Light Weight Sloping Roof	Rural	6,93,42,567	27.8	7,94,30,355	26.1
	Urban	1,73,50,091	7.0	2,12,69,826	7.0
	Total	**8,66,92,658**	**34.8**	**10,07,00,181**	**33.1**
R2 - Heavy Weight Sloping Roof	Rural	6,52,99,492	26.2	7,40,34,404	24.3
	Urban	1,30,36,138	5.2	1,96,49,099	6.4
	Total	**7,83,35,630**	**31.4**	**9,36,83,503**	**30.7**
R3 - Flat Roof	Rural	4,28,95,454	17.2	5,30,98,931	17.4
	Urban	4,11,72,127	16.5	5,73,99,833	18.8
	Total	**8,40,67,581**	**33.7**	**11,04,98,764**	**36**
TOTAL BUILDINGS		24,90,95,869		30,48,82,448	

Housing Scenario in India

Urban Housing - Estimation by Technical Group

Housing shortage at the beginning of 11th Five Year Plan (1.4.2007).	**24.71 million** dwelling units
Additional Housing Requirement for the 11th Plan	**1.82 million** dwelling units
Total housing requirement during 11th Plan Period including the carried over housing shortage	~~**26.53 Million**~~ dwelling units **18.78 Million (2012)**

Rural Housing - Estimation

Housing shortage	**43.67 million** dwelling units
Housing Shortage for BPL Families (90%)	**39.30 million** dwelling units

Housing Shortage – BREAK-UP

- **Urban Housing** - More than 95% shortage is for EWS/LIG segments
- **Rural Housing** - 90% housing shortage for BPL Families

Government's Initiative in Housing Sector

Ministry of Housing & Urban Poverty Alleviation

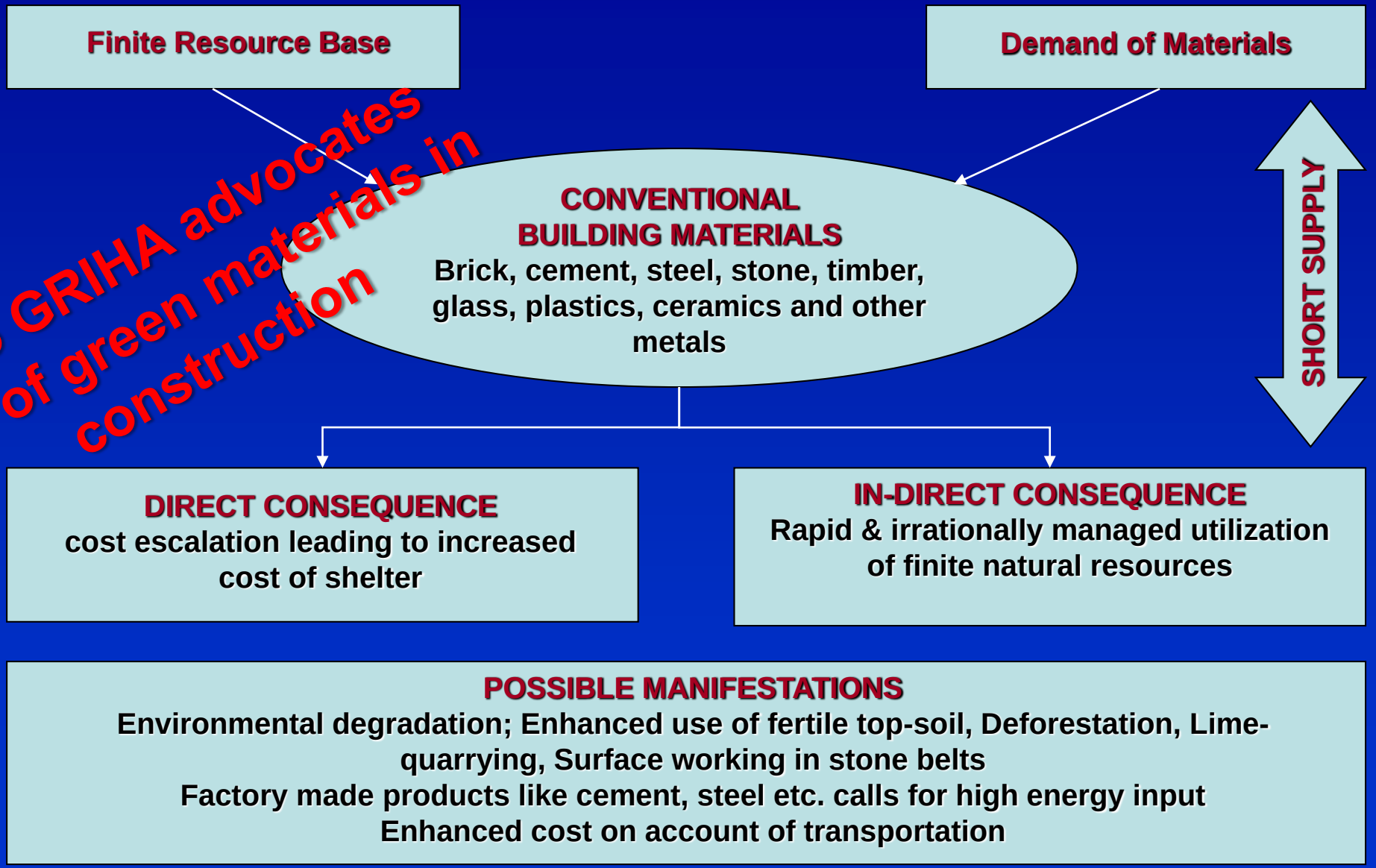
- National Urban Housing & Habitat Policy 2007.
- Jawaharlal Nehru National Urban Renewal Mission (JNNURM)

  ⟹ *(1.5 million houses with basic services from 2007-14)*
- Rajiv Awas Yojna (RAY) ⟹ *(towards slum free India)*
- Affordable Housing in PPP : Subsumed in RAY

Ministry of Rural Development

- Indira Awaas Yojana

Conventional Building Materials



Need of the Hour

- Use of renewable resources f building materials
- Efficient use of existing conv tional materials by producing factory made (prec t) building components
- Use of raw materials resources based on waste products
- Affordability and sustainability
- Industrialization of housing sector

Alternate Housing Systems

Aims to reduce the cost of construction and at the same time not sacrifice any element of safety or serviceability of the house over the life cycle.

There is need for adoption of :

- strong,
- durable,
- functional,
- aesthetic,
- environment friendly,
- ecologically appropriate,
- energy efficient
- affordable and adaptable
- cost-effective materials
- appropriate technologies in construction.

- # Foundations
  - Foundations with different materials such as over burnt bricks, stone masonry
  - Pile foundations
- # Walls
  - Rat-trap Bond
  - Mortar less masonry
  - Bricks & Blocks from different materials including agro-industrial wastes
- # Roofs / slabs
  - Precast technologies such as RC Planks & Joists system, Brick panels, RC Channels, waffle slabs
  - Filler slabs
  - Micro concrete roofing tiles
  - Bamboo Mat Corrugated Roofing Sheets and ridge cap
- # Door frames and panels
  - RCC doors & window frames
  - Doors & shutters from plantation timber and composites

Alternative Systems : Miscellaneous

- RCC lintels and lintel cum chajjas
- Precast thin lintels and lintel cum chajjas
- Arches
- Corbelled openings
- Sand stone slabs
- Ferrocement precast staircase steps
- Ferrocement shelves
- Ferrocement panels
- Precast ferrocement tanks and drains

Building Materials and Technologies
IDENTIFIED, ASSESSED AND PROMOTED by BMTPC

- Working specifications on 22 Items prepared by BMTPC and covered by Indian Standards.
- Helped CPWD in incorporating them in their Schedule of Specifications.
- All these technologies have been tested for their performance and after successful use in many projects have been adopted for cost effective housing.
- Where Indian Standards are available on many material and product, quality control is maintained voluntarily by manufacturers through BIS Certificate Mark, operated by BIS.
- Where Indian Standards are not available, Performance Appraisal Certification being operated by BMTPC is applicable.

Standardization of Technology

bmtpc

Working Specifications formulated on Innovative and Cost-effective Materials and Techniques

BUILDING MATERIALS		**BIS CODE**
BM01	Specifications for Calcium Silicate Bricks	IS:4139-1989
BM02	Specifications for Fly ash-Lime Bricks	IS:12894-1990
BM03	Specifications for Clay-Fly ash Bricks	IS:13757-1993
BM04	Specifications for Clay Flooring Tiles	IS:1478-1992
BM05	Specifications for Burnt Clay Flat Terracing Tiles	IS:2690-1993
BM06	Specifications for Fibrous Gypsum Plaster Boards	IS:8273-1984
BM07	Specifications for Bamboo Mat Corrugated Roofing Sheets	IS:15476-2004
BUILDING COMPONENTS		
BC01	Specifications for Precast Solid Cement Concrete Blocks	IS:2185-1979 (Part I)
BC02	Specifications for Precast Concrete Stone Masonry Blocks	IS:14213-1994
BC03	Specifications for Hollow & Solid Light Weight Concrete Masonry Units	IS:2185-1983 (Part II)
BC04	Specifications for Precast Reinforced Concrete Door and Window Frames	IS:6523-1983
BC05	Specifications for Ferrocement Door Shutters	-
BC06	Specifications for Precast Ferrocement Water Tanks	IS:13356-1992
BC07	Specifications for Precast Concrete Manhole Covers & Frames	IS:12592-1988 (Part I) IS:12592-1991 (Part II)

Working Specifications formulated on Innovative and Cost-effective Materials and Techniques

CONSTRUCTION TECHNIQUES		BIS CODE
CT01	Specifications for Precast Channel Unit for Flooring/Roofing	IS :14201-1994 IS:14215 –1994
CT02	Specifications for Precast Reinforced Concrete Plank Flooring/Roofing	IS:13990-1994 IS:13994-1994
CT03	Specifications for Thin R.C. Ribbed Slab for Floors and Roofs -	
CT04	Specifications for Construction of Floors and Roofs using Precast Concrete Waffle Units	IS:10505-1983
CT05	Specifications for Prefabricated Reinforced Concrete L Pans for Roofs	IS:14241-1994 IS:14242-1995
CT06	Specifications for Precast Doubly-Curved Shell Units for Construction of Floors and Roofs	IS:6332-1984
CT07	Specifications for Precast Reinforced/Prestressed Concrete Ribbed or Cored Slab Units for Floors & Roofs	IS:10297-1982
CT08	Specifications for Reinforced Brick and Reinforced Brick Concrete Slabs for Floors and Roofs	IS:10440-1983
CT09	Specifications for Prefabricated Brick Panel for Floors/ Roofs	IS:14142-1994 IS:14143-1994

Note: With the efforts of the Council all these items have been inducted in the CPWD schedule of specifications of CPWD, and housing agencies in Orissa, Tamil Nadu, Kerala and Andhra Pradesh.

More than
30 machines are available for producing cost-effective, energy-efficient, environment-friendly building components which are easy to operate.

Employment generation varies from 4 to 14 per machine.

Mechanization of Technologies

Alternate Station Hydraulic Brick Press

Solid/Hollow Concrete Block Machine (Egg laying Type)

RCC Plank Casting Machine (Rotating Type)

RCC Joist Casting Machine (Egg laying Type)

Precast L-Panel Machine

Precast Rcc Plank Machine

Ferrocement Roofing Channel Machine

Combination Machine

Bi-Directional Vibro Press

Bi-Directional Vibro Press

Bi-Directional Vibro Press

C–Brick Machine

Solid/Hollow Concrete Block Machine

Compressed Earth Block Machine (Balram)

Concrete Block Machine (Sakar)

Compressed Earth Block Machine (Hydraform)

Multipurpose Stone Processing Machine

Solid/Hollow Concrete Block Machine (Handheld Type)

Precast concrete Door/ Window Frame Machine

Stone/Coal Dis-integrator

Bar and Pipe Cutting Machine

Micro Concrete Roofing Tile Machine

Ferrocement C-Beam Machine

Precast RCC Joist Machine

Terrazo/Chequered Tile Machine

Stationary Block Machine

Compressed Earth Block Machine (Mardini)

TNG Rural Housing Kit

MCR Tile making Machine (Manual)

Field Level Application of cost effective technologies

Development & Promotion of Cost Effective Technologies

Demonstration Construction

Laggere, Karnataka – 252 houses

Nagpur, Maharashtra – 70 houses

Dehradun, Uttarakhand – 100 houses

Kudalu, Karnataka – 70 houses

Development & Promotion of Cost Effective Technologies

Demonstration Construction

Trichi, Tamil Nadu – 100 houses

Technologies used:

- RR masonry in foundation and plinth
- Concrete block masonry using Flyash bricks in superstructure
- Filler slabs
- RCC door frames

Technologies used:

- Flyash Bricks for walling
- Precast RCC Beam and curved planks for roofing.
- Ferrocement Stair Case
- RCC Door Frames
- Precast RCC chajjas etc.

Bilaspur, Chhattisgarh – 100 houses

Development & Promotion of Cost Effective Technologies

Raipur Phulwari, Amethi, Distt.Sultanpur (UP)

Demonstration Construction

Cost with Alternate Technologies: Rs.710/sqft.
With Conventional Technologies: Rs.871/sqft.

No. of Houses : 24 (G+1)
Built up area of each unit: 38.22 sq.mt.
Each unit with one living room, one bedroom, kitchen, one separate bath and WC.

TECHNOLOGIES USED:
Rat-trap bond in bricks for walling
Filler Slabs with bricks for roofing
RCC door/window frames, precast sunshades, staircases, lintels etc.

2010-2011

Development & Promotion of Cost Effective Technologies

Demonstration Construction

Community Centre at Village Khojkipur-Naggal, Ambala, Haryana

Cost with Alternate Technologies: Rs.670/sqft.
With Conventional Technologies: Rs.850/sqft.

2010-2011

- **Covered Area : 728 sq.mt (approx) – G+1**
- **Provision of a Multi-Purpose Hall with male/female toilets and greenrooms, two Multi-Purpose Rooms, crèche with toilets, Library-cum-Reading Room, Office, Colony Health Centre.**

TECHNOLOGIES USED:

- **Rat trap bond in bricks; interlocking type compressed earth blocks; flyash bricks; modular bricks for walling; RCC planks and joists; prefabricated panels; prefab brick arch panels; RCC filler slab; doubly curved shell for roofing; precast concrete door/window frames; precast sunshades, lintels, staircases, etc.**

Development & Promotion of Cost Effective Technologies

Bitna Road, Pinjore, Distt.Panchkula, Haryana

Demonstration Construction

Cost with Alternate Technologies: Rs.760/sqft.
With Conventional Technologies: Rs.971/sqft.

No. of Houses : 24 (G+1)
Built up area of each unit: 38.22 sq.mt.
Each unit with one living room, one bedroom, kitchen, one separate bath and WC.

TECHNOLOGIES USED:

- Rat-trap bond in bricks for walling
- RCC Filler Slabs with bricks for roofing
- RCC door/window frames, precast sunshades, staircases, lintels etc.

Project includes :
Onsite infrastructure facilities like pathways, septic tank, electrical works, Boundary wall etc.

Other Features :
Provision of community work centre, multi-purpose meditation room. Houses includes Earthquake Resistant Features.

2012

Development & Promotion of Cost Effective Technologies

Demonstration Construction

Informal Markets at Visakhapatnam, Andhra Pradesh

Cost with Alternate Technologies: Rs.516/sqft.
With Conventional Technologies: Rs.650/sqft.

2010-2011

- Area of Market : 14150 sq.ft.
- Facilities : Plateform for vendors, Activity rooms, creche, Reading Area, Health Centre, Toilets, Amphitheatre, Park, etc.

TECHNOLOGIES USED:

- Stone Masonry/Flyash bricks, RCC lintel band and roof level band
- Filler Slab, Concrete pavers
- Pre-cast RCC door/window frames, Wood substitute door/window shutters.

Development & Promotion of Cost Effective Technologies

New Initiative – Demonstration Houses at Rae Bareli, Uttar Pradesh

Demonstration Construction

No. of Houses : 24 (G+1)
Built up area of each unit: 38.14 sq.mt.
Each unit with one living room, one bedroom, kitchen, one separate bath and WC.

TECHNOLOGIES BEING USED:

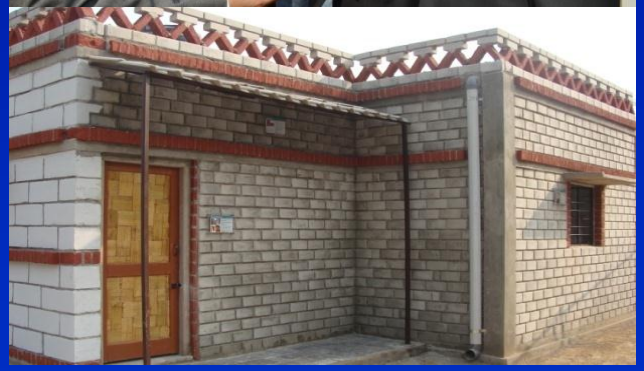
- **Rat-trap bond in bricks for walling**
- **RCC Filler Slabs with bricks for roofing**
- **RCC door/window frames, precast sunshades, staircases, lintels etc.**

Estimated Cost with Alternate Technologies: Rs.796/sqft.
With Conventional Technologies: Rs.1050-1100/sqft.

Development & Promotion of Cost Effective Technologies

Demonstration House during BMTPCexpo'12 at NSIC from 6-8 Nov., 2012

Demonstration Construction



Built up area of each unit: 39.34 sq.mt.
Each unit with one living room, one bedroom, kitchen, one separate bath and WC.

TECHNOLOGIES USED:

- Rat trap bond in bricks; interlocking type compressed earth blocks; flyash bricks; concrete bricks; RCC planks and joists; RCC filler slab; precast concrete door/window frames; precast sunshades, lintels, BMCS, MCR Tiles, GRC Jallies, Bamboo mat door, etc.

BMTPC has transferred the technology to an entrepreneur for setting up a Bamboo Mat Corrugated Sheet and Bamboo Particle Board Manufacturing Unit at Byrnihat, Meghalaya

with production capacity of 3000 sheets per month

Providing livelihood and employment to nearly 10000 workers (mostly women).

Construction of demonstration structures using bamboo materials in Mizoram and Tripura

Salient Features of the Structures

- Bamboo posts
- Bamboo grid ferrocement walls
- Bamboo trusses and purlins
- Bamboo Mat Corrugated Sheet Roofing

Construction of Demonstration Buildings using Bamboo Based Technologies in Mizoram

Type II house at Lunglei. - COMPLETED

School Building at Aizawl. - COMPLETED

Picnic Hut at Tiangnuam, Aizawl - COMPLETED

Type II house at Luangmual, Aizawl - COMPLETED

Construction of Demonstration Buildings using Bamboo Based Technologies in Tripura

Type II house at Rajbhawan Agartala - COMPLETED

Type II house at Circuit House Agartala - COMPLETED

Picnic Hut at Nehru Park, Agartala- COMPLETED

Type II house at Circuit House Udaipur - COMPLETED

Construction of Demonstration School Building using Bamboo based Technologies in Tripura

Development & Promotion of Cost Effective Technologies

Construction of Post Office at Majuli, Assam

- **Bamboo based technologies being used are:**
  - **bamboo truss, bamboocrete, bamboo as structural members, etc.**
  - **During the construction, training was provided to the construction workers in bamboo based technologies.**

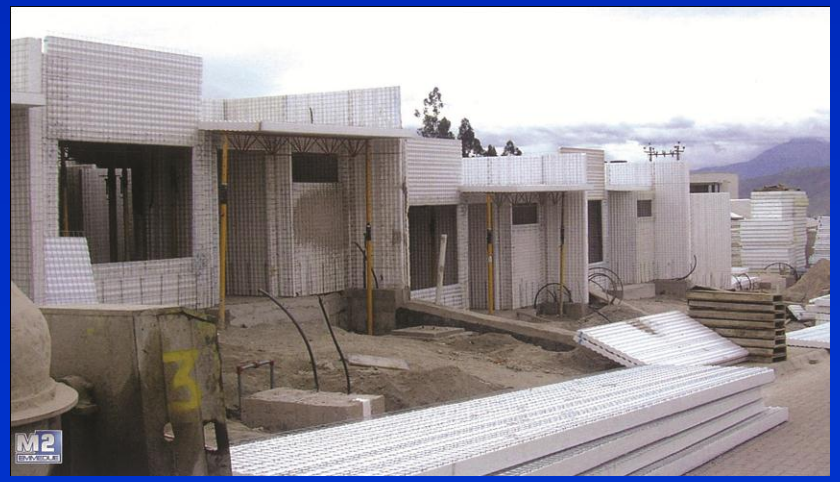
Emerging Technologies for Social Mass Housing

Broad Parameters for evaluation of technologies

- Structural stability
- Material specification and its durability
- Green concept
- Joints and connections specially for prefabricated system
- Cost effectiveness of the emerging technologies vis-à-vis conventional construction system (RCC and masonry construction)
- Speed of construction and quality
- Sanitation
- Suitability to Indian climatic and hazard conditions
- Scale of minimum number of houses
- Adoptability of Services.
- Expected life span of the proposed system
- Maintenance scheme for the system
- Resistance of the system against fire, blast, etc.
- Users' feedback and certification, wherever possible.
- Compatibility and adherence of the system to BIS
- Any shortcoming of the system

Panel Building System using Steel Mesh, Polystyrene Core and Chipping Concrete

- Panel Building system is a load bearing wall construction which is seismic resistant and thermally insulated.
- Buildings of any typology or architectural structure, ranging from most simple to the most complex one, could be constructed.
- The base element of the building system is a modular panel composed of two electro-welded galvanized steel meshes, reciprocally joined by connectors , in the middle of which is a suitably shaped foam polystyrene plate.
- High resistance steel meshes composed of bars having dia. 2.5 to 5 mm. are made in factory. Panels could be supplied with meshes having different dia. and different geometrical characteristics.



Panel Building System using Steel Mesh, Polystyrene Core and Chipping Concrete…contd.

- Materials used: Meshes manufactured using high resistance steel bars of dia. 2.5 – 5mm, Self - extinguishing Polystyrene core (min density 15 kg / m3), Chipping Concrete having characteristic strength 30 Mpa
- Salient features: Good heat and sound insulation properties, versatility in construction, lightweight but strong, resistance to seismic, hurricane/tornado forces including blast explosion of 50 psi, fire rating of 60 min, cost effective building system utilizing local raw materials and labour force, speed of construction (30% less than conventional construction system), environment friendly being, CFC free and non-toxic, energy efficient
- Evaluation: Wind projectile resistance test – Wind Science and engineering, Texas Tech University, Texas; Fire resistance test - Centro Technologico De La Madera, spain; Dynamic Tests – RITAM-ISRIM-Universita Di Perugia- CSM; Sound insulation test- SIRIM QAS International Sdn. Bhd, Malaysia

Panel Building System using Steel Mesh, Polystyrene Core and Chipping Concrete…contd.

- Details of construction of buildings using the technologies:
  - Construction of 1820 units in 6 storey at Bangi, Selangor, 89.2 crore
  - Construction of 50 units at Hulu Langar Distt. Selangor, Malaysia. 17.8 crore
  - Construction of 6 storey private hospital with 3 basement car park at Jalan Tun Razak, Kuala Lumpur, Malaysia, 220.5 crore
  - Construction of 1002 units in 4 storey at Selangor, 11.75 crore
  - Constructing houses near Kolkata for Government of west Bengal

Panel Building System using Steel Mesh, Polystyrene Core and Chipping Concrete…contd.

Technology Using Expanded Steel Mesh Panels, Polystyrene Beads & Alleviated Concrete

- The system is entirely a “on-site” construction process.
- The houses are entirely, including the roof, made up of structure panels assembled with Beams.
- Alleviated concrete, a special mix of concrete and expanded polystyrene beads, hence incorporating both the thermal and the sound insulation, is injected into a steel structure made of panels reinforced with beams (galvanized steel wire studs / steel rods).
- The Concrete base and the foundations of the houses are prepared in a conventional manner. The panels are tied to the soldered wire mesh and to the iron rods in the base and in the foundations and assembled in accordance with the design of the house.

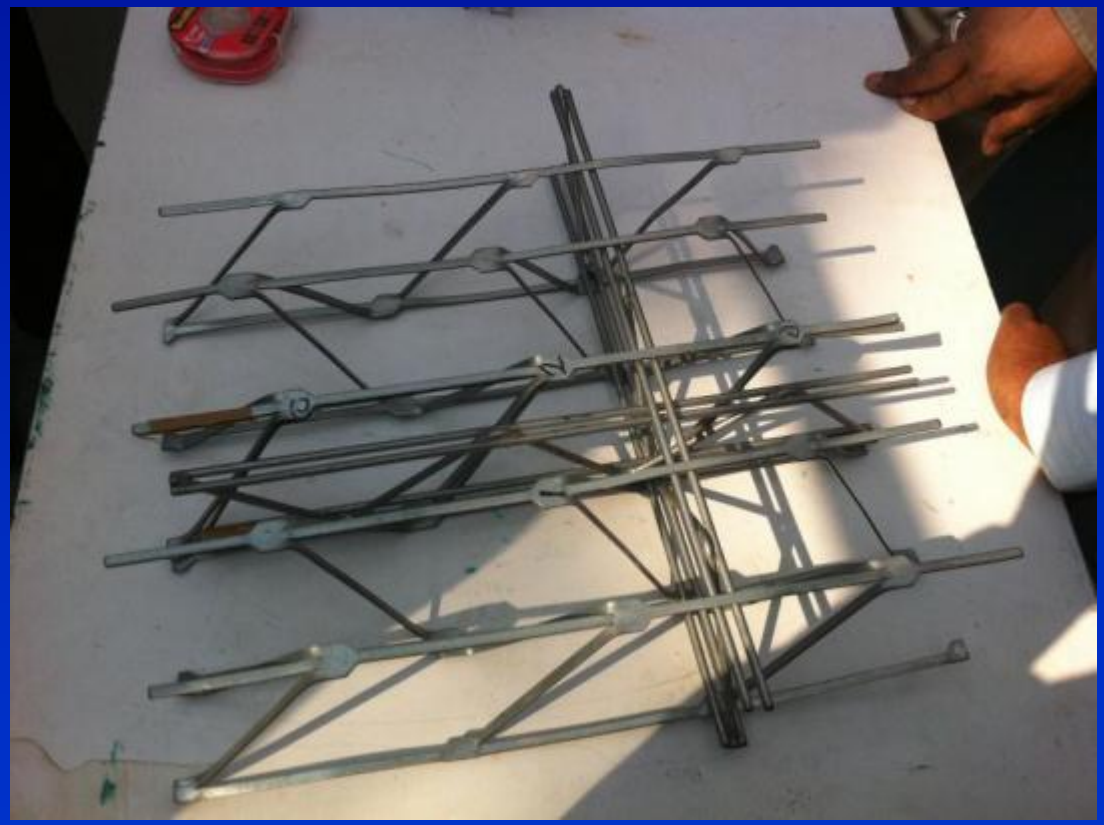
Technology Using Expanded Steel Mesh Panels, Polystyrene Beads & Alleviated Concrete…contd.

- Materials used: Expanded steel type of galvanized steel mesh panels, cast and expanded in continuous process from a 1.6 mm thick and 30 cm wide galvanized steel sheet coil and Alleviated concrete made up of cement; fiber; sand and expanded polystyrene beads(1-4 mm).
- Salient Features: Well insulated, earthquake/hurricane/tornado resistant, fire and termite resistant, built on site in less time, minimal manpower, equipment and logistics, high quality and durability, cost effective, sound, safe, healthy, energy efficient, environment friendly, architectural flexibility, higher strength of walls and roof, wires and pipes embedded in the walls, no forms, shuttering frames or casings. The system is composed of tri-dimensional panels, realized without welding in one piece, without any loss of materials by special cutting process and using galvanized steel plates. It is made of two sides of longitudinal ribs which are linked together at the knots by jambs. The layout of jambs in relation to the ribs defines the sides.
- Evaluation: Thermal, sound and structural certification by GINGER-CEBTP, France; fire resistance certification by EFECTIS, France; Certification by CSTB, SOCOTEC, VERITAS

Technology Using Expanded Steel Mesh Panels, Polystyrene Beads & Alleviated Concrete…contd.

- Details of construction of buildings using the technologies:
  - Houses in Paris,Toulon, French Riviera, Morocco, Peru, New Caledonia, Vietnam, Rambouillet-Clairefontaine.
  - Buildings in Disneyland-Paris, Japan tower in Paris.
  - Besides the above, the reinforcement of damaged walls and houses, construction of special purpose walls, construction of roads, Tunnels, conduits, vaults, arches, bridges and stabilization of soils have been carried out using the technology in various parts of the world.
  - Constructing houses near Mumbai for private organisation
  - Constructing houses near Kolkata for Government of west Bengal

Technology Using Expanded Steel Mesh Panels, Polystyrene Beads & Alleviated Concrete…contd.



Pre-stressed Precast Prefab Technology Using Hollow Core Slab, Beams, Columns, Solid Walls, Stairs, etc.

- Pre-stressed precast RCC technology using hollow core slabs, beams, columns, solid walls, stairs etc. are designed and manufactured in factory, shipped and erected at site.
- Multi-storey precast concrete frames are constructed with columns and beams of different shapes and sizes, stair and elevator shafts and floor slabs.
- The joints between the floors elements are executed in such a way that concentrated loads are distributed over the whole floor. This system is widely used for multi storey buildings.
- The structural frame is commonly composed of rectangular columns of one or more storeys height. The beams are normally rectangular, L-shaped or inverted T-beams. They are single span or cantilever beams, simply supported and pin-connected to the columns. Hollow core floor slabs are by far the most common type of floor slabs in this type of structure.

Pre-stressed Precast Prefab Technology Using Hollow Core Slab, Beams, Columns, Solid Walls, Stairs, etc…contd.

- Materials used: Cement concrete, steel strands, reinforcing steel.
- Salient features:
- Saving in Cost: Precast Prefab buildings can be constructed in less than half the time it takes to construct using conventional construction.
- Material Savings: Precast pre-stressed technology results in 40% reduction in slab weight.
- Savings in Exterior Painting & Finishing: All exterior surfaces can be provided with aggregate or other such colored finishes which require no additional painting.
- Increased Carpet Area: Because of the high strength of the concrete structure small sized walls can be used in lieu of thicker ones.

Pre-stressed Precast Prefab Technology Using Hollow Core Slab, Beams, Columns, Solid Walls, Stairs, etc…contd.

- Salient features contd.
- Energy Savings: Hollow core slabs act as a natural insulator & thereby result in savings in air conditioning cost. Additionally, walls can have in-built foam insulation resulting in increased savings.
- Environmental Benefits: Prefab concrete can have fly ash as a ingredient in the concrete mix. This results in higher strength concrete while at the same time utilizing an otherwise waste product.
- Long Life Cycles: As buildings components are manufactured & cured in controlled conditions the resulting elements have better strength & durability. This results in buildings having much longer life cycles than conventional in-Situ construction
- Water Savings: Water requirement for curing of elements is minimal as compared to in- situ construction. Also in the factory the water is recycled thereby saving this precious commodity.

Pre-stressed Precast Prefab Technology Using Hollow Core Slab, Beams, Columns, Solid Walls, Stairs, etc…contd.

- Details of construction of buildings using the technologies:
  - Multi story residential housing in Finland
  - 4 works in Finland and Sweden are in hand having value 1739 lakhs.
  - No construction work undertaken in India.
  - Established a complete manufacturing plant in Khapoli, near Mumbai

Pre-stressed Precast Prefab Technology Using Hollow Core Slab, Beams, Columns, Solid Walls, Stairs, etc…contd.

Monolithic Concrete Technology Using Plastic / Aluminium Composite Formwork

- Walls and slabs are cast in one operation in specially designed light weight form/ moulds in concrete.
- Concrete is poured in the forms & forms are removed after the setting of concrete takes place, resulting in box like cubical structure of required architectural design.
- The pre-designed formwork also acts some sort of assembly line production and enables rapid construction of multiple units of repetitive type.

Monolithic Concrete Technology Using Plastic / Aluminium Composite Formwork…contd.

- Materials used: Primarily M20 grade concrete walls, slabs & HYSD reinforcement of Fe 415/ Fe500 grade.
- Specification:
- Foundation : Strip footing based on SBC of soil. Foundation & plinth wall to be 150 mm thick.
- Work above Plinth: load bearing cement concrete of M20 Grade walls with single layer of vertical & horizontal reinforcement.
- Slab & Staircases: 100 mm thick M20 Grade concrete slabs. Plain soffit staircase with concrete/masonry riser.
- Reinforcement: HYSD reinforcement of Fe 415/ Fe500 grade
- Shuttering/Form works : PVC-Aluminium Formwork with minimum propping
- In addition, IPS/Ceramic Tile flooring in rooms, dado in WC & bath. Metal doors for main & internal walls, PVC doors for bath & WC etc.
- As indicated, the specifications/items are indicative & can be changed to suit the needs of users as per local conditions/practices.
- Evaluation: CEPT University, Ahmadabad

Monolithic Concrete Technology Using Plastic / Aluminium Composite Formwork…contd.

- Details of construction of buildings using the technologies:
  - Construction of 5008 houses at Kanjhawala, Narela, Ghoga in Delhi (2008-09) for DSIIDC
  - 512 houses in Bawana industrial complex, Delhi (2008-09) for DSIIDC
  - Construction of 6745 houses in Ahmedabad Gujarat for AUDA
  - 6 projects with Monolithic Construction Technology System have been reported to be under execution in various parts of the country.

Monolithic Concrete Technology Using Plastic / Aluminium Composite Formwork…contd.






Monolithic Concrete Construction using Aluminium Formwork

- In the Monolithic concrete construction with aluminium forms system, Concrete walls and slabs are cast monolithically at one pour.
- The system allows reduction in thickness of concrete members below the minimum value than the conventional construction, thus reducing the consumption of natural resources.
- Single floor with built up area of about 300 sqm. can be completed in two days using the aluminium formwork system.
- The technology reduces the cost of repair and maintenance compared to conventional system.

USA

Monolithic Concrete Construction using Aluminium Formwork…contd.

- Materials used: Cement, aggregate, sand, steel and aluminium formwork
- Salient features: Structurally sound, safe, durable against earthquakes, cost effective technology, resistant to fire etc.
- Evaluation: Wind Engineering Research Deptt., Texas Technical University, USA

- Details of construction of buildings using the technologies:
  - Construction of houses using monolithic construction technology for slum renewal projects for KSCB at Bangalore and Mysore under JNNURM.

Monolithic Concrete Construction using Aluminium Formwork…contd.

Precast Concrete Panels Using Concrete, Welded Mesh And Plates, Polystyrene Core

- Pre-cast concrete load bearing panels are made of reinforced concrete with a polystyrene insulated core that varies in size from 40mm to 200mm depending upon the insulation requirements.
- The reinforced concrete panels are moulded in specially designed steel moulds under controlled factory conditions.
- The buildings and houses can be designed to suit any geographical position or environment and can withstand wind speed in excess of 285km/hr.
- The system does not impose any design restrictions Due to cohesive structural design, the system requires only strip foundation for most buildings.

Precast Concrete Panels Using Concrete, Welded Mesh And Plates, Polystyrene Core…contd.

- Materials used: Cement, aggregates, sand with additives, Welded mesh and plates, polystyrene core
- Salient features: Reduced labour cost due to quicker/easier assembly, in some cases no mason is required; tornado/hurricane damage resistance, fire, termite and dry rot resistance; requires less insulation; low maintenance and improved sound proofing; can be erected in cold temperature, preventing concrete pour delays; buildings constructed using the system are resistant to earthquakes measuring up to 6 on Richter Scale; save air conditioning energy; higher upfront cost, requires on-site crane including certified installer sometimes; offers a 10 year warranty on the structure using the technology.
- Evaluation: Building Research Association of New Zeeland (Fire Rated and structural load testing), Structural Engineering Research centre, Chennai and Jawaharlal Nehru Technological University, Hyderabad.

Precast Concrete Panels Using Concrete, Welded Mesh And Plates, Polystyrene Core…contd.

- Details of construction of buildings using the technologies:
  - Construction of houses New Zealand, Maryland, Delaware
  - Construction of demonstration houses in Hyderabad for APSHCL
  - Constructing houses in different parts of Andhra Pradesh for APSHCL under INDIRAMA Scheme
  - Established a full-fledged manufacturing unit in Hyderabad

Precast Concrete Panels Using Concrete, Welded Mesh And Plates, Polystyrene Core…contd.

Industrialized 3-S System Using Cellular Light Weight Concrete Slabs & Precast Columns

- The industrialized total open prefab construction technology is based on factory mass manufactured structural prefab components conforming to norms of IS standards and BIS Certification mark.
- In this system Dense Concrete hollow column shell of appropriate size are used in combination with pre -cast dense concrete rectangular T Shape/L shape beams and lightweight reinforced autoclaved cellular concrete slabs for floors and roofs.
- The hollow columns are grouted with appropriate grade of in–situ concrete. All the connections and jointing of various structures are accomplished through in situ concreting along with secured embedded reinforcement of appropriate size, length and configuration to ensure monolithic continuous resilient ductile behaviour.

Industrialized 3-S System Using Cellular Light Weight Concrete Slabs & Precast Columns…contd.

- Materials used: Concrete, Cellular light weight concrete Slabs, Precast column
- Salient features: As per relevant Indian Standards; IS 2185-Part 3 specification for autoclaved cellular concrete blocks, IS 6041 construction of autoclaved cellular concrete block masonry, IS 6072SP autoclaved reinforced cellular concrete wall slab, IS 6073 autoclaved reinforced cellular concrete floors and roof slab.
- Evaluation: Stanford University, USA; IIT, Mumbai; CBRI, Roorkee; SERC, Chennai; TSRF, Bangalore. It is mentioned that all the above Institutions have concluded that the 3 S prefab System satisfies all the technical parameters, codal requirements and most suitable for mass housing projects.

Industrialized 3-S System Using Cellular Light Weight Concrete Slabs & Precast Columns…contd.

- Details of construction of buildings using the technologies:
  - Construction of Transit/sale tenements at Goregaon, Mumbai using Prefab technology, 78.73 crore
  - Construction of 56 MIG, 1624 HIG, 98 Row houses, 40 shops at Dindoshi, Mumbai using Prefab technology, 168.5 crore
  - Construction of 1255 transit tenements at Pratiksha Nagar, Mumbai using Prefab technology, 21.77 crore
  - Construction of 200 transit, 407 LIG, 588MIG houses at Jogeshwari, Mumbai using Prefab technology, 43.75 crore
  - Construction of 62LIG, 8 MIG, Kannaamwar Nagar, Mumbai using Prefab technology, 10.83 crore.
  - Construction of 640 transit, 564 LIG, 217 LIG -1, 714 MIG, 196 HIG houses, 10 shops at Sion, Mumbai using Prefab technology, 76.5crore.
  - Construction of Transit, LIG, MIG, RIG houses, at Chembur, Mumbai using Prefab technology, 63.00 crore
  - Construction of 1210 transit tenements at Malad, Mumbai using Prefab technology, 47.62 crore
  - Construction of 2768 transit tenements at Dharavi, Mumbai using Prefab technology, 60.48 crore
  - Construction of 1088 HIG tenements at Andheri, Mumbai using Prefab technology, 108.70 crore
  - Construction of 1405 transit, 620 LIG, 784 MIG, 504 HIG houses at Sion, Mumbai using Prefab technology, 126.24 crore.
  - Constructing 28068 houses in Mumbai using 3 S prefab system, 1609.3 crore.
  - Constructing 3488 houses in Navi Mumbai using 3 S prefab system, 263.61 crore
  - Constructing 6216 houses in Hyderabad using 3 S prefab system, 786.27 crore
  - Constructing Houses for DDA at Dwarka

Industrialized 3-S System Using Cellular Light Weight Concrete Slabs & Precast Columns…contd.

Glass Fibre Reinforced Gypsum (GFRG)/ Rapidwall Building System Technology (evaluated through PACS)

- Glass Fibre Reinforced Gypsum (GFRG)/ Rapidwall is a building panel product, made essentially of gypsum plaster, reinforced with glass fibres.
- Used since 1990 in Australia. Although its main application is in the construction of walls, it can also be used in floor and roof slabs in combination with reinforced concrete.
- The panels may be unfilled, partially filled or fully filled with reinforced concrete as per the structural requirement.


Australia

Glass Fibre Reinforced Gypsum (GFRG)/ Rapidwall Building System Technology (evaluated through PACS)..contd.

- Materials used: Gypsum plaster reinforced with glass fibres.
- Salient features: Substantial reduction in the structural weight of the building, no plastering requirement for walls and ceiling, increased speed of construction with less manpower, saving of cement, steel, river sand, burnt clay bricks/concrete blocks and hence saving of energy and reduced CO_2 emissions, contributing to environment protection and mitigate climate change, use of reprocessed/recycled industrial by product, waste gypsum, to manufacture GFRG panel, helping to abate pollution and protect the environment.
- Evaluation: IIT Madras and SERC Chennai, Building Materials & Technology Promotion Council (BMTPC), New Delhi. Detailed design manual has been developed for construction of buildings using GFRG panel.

Glass Fibre Reinforced Gypsum (GFRG)/ Rapidwall Building System Technology (evaluated through PACS)..contd.

Thank you for your kind attention

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