

Emerging Technologies for Housing & Building Construction



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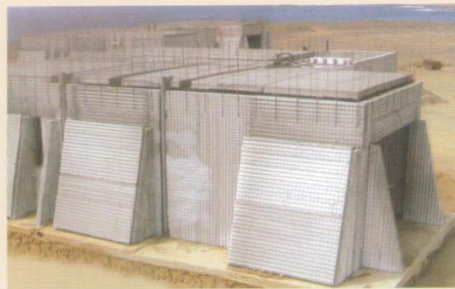
Building Materials & Technology Promotion Council
Ministry of Housing & Urban Poverty Alleviation
Government of India

BMTPC has been promoting cost-effective, environment-friendly, energy-efficient and disaster resistant technologies developed in India. With fast depleting natural resources; need for environment protection to protect greenhouse gas effect; need for bringing more speed, durability and quality in construction; it is prudent to widen the horizon to look for alternate cost effective technologies within and outside the country. With this in mind, BMTPC floated a Global Expression of Interest (EOI) for introducing emerging and alternate cost effective housing technologies suitable to Indian geo-climatic and hazard conditions through construction of demonstration houses at various parts of the country. A Technology Advisory Group (TAG) was constituted to evaluate the offers received.

Based on the parameters identified by the Technology Advisory Group (TAG) following technologies/systems have been short listed for further evaluation/study:

Panel building system using steel mesh, polystyrene core and chipping concrete

The panel Building system is a load bearing wall construction which is seismic resistant and thermally insulated. It is reported that 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. Polystyrene is self-extinguishing foam polystyrene suitably shaped, used both as a disposable form and as an insulating layer. The EPS is made of carbon, hydrogen and for 98% air. Thickness, shape and density of the polystyrene core may change according to specific requirements. The minimum density normally used is equal to 15 kg / m³.



Once the panels are installed, they are anchored and finished with the application of light concrete on both of their sides. Thus, buildings with load bearing walls consisting of two reinforced concrete plates are made integral by a thick network of connectors, with an insulating core. Single panel is finished, by applying on each a layer of chipping concrete having characteristic resistance of 30 Mpa at least. As load bearing element, the double panel and the floors are finished during the installation with concrete of suitable grade placed into the slab ribs as well. Should the panels carry out a non load bearing function, a concrete plaster, even a pre mixed one, is applied for a thickness of at least 25 mm.



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

Technology using expanded steel mesh panels, polystyrene beads & alleviated concrete

The system is entirely a “on-site” construction process, not based on prefabricated, pre cast or preassembled elements and is a most spectacular, versatile and efficient construction system. 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. They can be made from regular, poured, heavy concrete, but more generally the use of alleviated concrete or at least of one more layer of alleviated concrete, will provide good thermal insulation and good comfort from the ground also. Prior to the pouring of the concrete of the base, 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. They are then, held together by special made galvanized steel wire studs, which fit one into the other, horizontally and vertically, to form the complete skeleton of the construction, roof included.

The assembled panels form a rigid, extremely robust, self-supporting steel skeleton, comprising the outside walls and all other bearing walls and partitions, the floors and ceilings, including the roof. Doors and walls are then simply “cut out”, using steel scissors or other steel cutters. Cut-offs is recovered and re-used. Templates of doors and windows are positioned. Instead of using framework, both sides of each panels are then simply covered with a galvanized wire mesh/fencing mesh/Chicken mesh, which is clipped to the panels, and will serve as a frame when the alleviated concrete injected.

“Alleviated” or “light” concrete is then injected with a special concrete pump. This pump can operate from a distance of 60 meters and to a height of up to 60 meters (almost 20 floors). The alleviated concrete is a custom-made mixture of cement, fiber, sand and Expanded Polystyrene (EPS) beads (1 to 4 mm), resulting in a low-density concrete (50-700 kg/m³) and hence incorporating thermal and sound insulation. The injected walls are then finished / leveled / smoothed from both sides. The concrete-injected then forms a true and quasi-homogeneous composite with incomparably better properties than plain steel reinforced concrete; Offers excellent thermal and phonic insulation; has walls that breathe; is completely resistant to fire; Offer complete protection against earthquakes and hurricanes and; is immune to termites and other insects.

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.

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.

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. This results in huge financial savings.
- **Material Savings:** Precast pre-stressed technology results in 40% reduction in slab weight. This reduces in building weight, material & foundation cost resulting in direct cost savings.
- **Savings in Exterior Painting & Finishing:** All exterior surfaces can be provided with aggregate or other such colored finishes which require no additional painting over the life time of the building. Alternatively the walls are made with a very smooth mirror like finish saving in plastering costs.
- **Increased Carpet Area:** Because of the high strength of the concrete structure small sized walls can be used in lieu of thicker ones. This results in the increased carper area for a similar construction of in-situ buildings.
- **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.



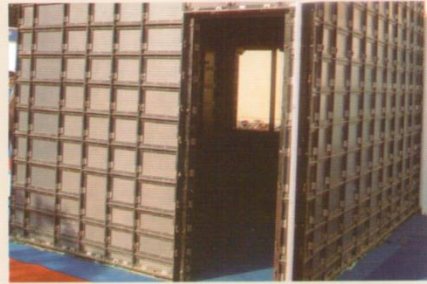
Monolithic concrete technology using plastic/ aluminium composite formwork

In the monolithic concrete technology, 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.

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.



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.

Materials used: Cement, aggregate, sand, steel and aluminium formwork

Salient features: structurally sound, safe, durable against earthquakes, cost effective technology, resistant to fire etc.



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. Then the panels are removed from the moulds and stacked vertically for curing. Power and water conduits are installed in the panels during production. 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 and can be used for any kind of architectural and aesthetic design as these panels are custom designed and manufactured. The panels have smooth surfaces. However, any kind of texture can be added on to the panel surface. Due to cohesive structural design, the system requires only strip foundation for most buildings.



Concrete panels can be designed with strength of 5000 psi. These results in stronger panels than concrete blocks or most poured concrete walls but are thinner and light weight. The panels are of good quality and uniformity as they are cast and cured in controlled factory environment. The panels can be installed in fraction of time. The foundation takes two hours to prepare and the panels are set in three hours.

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.

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 behavior.



Materials used: Concrete, Cellular light weight concrete Slabs, Precast column

Specification: 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.

GFRG/ Rapidwall Building System Technology

Glass Fibre Reinforced Gypsum (GFRG)/ Rapidwall is a building panel product, made essentially of gypsum plaster, reinforced with glass fibres. This product, suitable for rapid mass-scale buildings construction, was originally developed and used since 1990 in Australia. The product is not only eco-friendly or green, but also resistant to water and fire. GFRG panels are presently manufactured to a thickness of 124 mm under carefully controlled conditions to a length of 12 m and a height of 3 m. The panel can be cut to required size. 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 panel contains cavities that may be filled with concrete and reinforced with steel bars to impart additional strength and provide ductility. The panels may be unfilled, partially filled or fully filled with reinforced concrete as per the structural requirement. Experimental studies and research have shown that GFRG panels, suitably filled with plain reinforced concrete, possess substantial strength to act not only as load-bearing elements, but also as shear walls, capable of resisting lateral loads due to earthquake and wind. It is possible to design such buildings up to ten storeys in low seismic zones (and to lesser height in high seismic zones). Manufacture of GFRG panels with increased thickness (150 mm, 200 mm) with suitable flange thickness can facilitate construction of taller building.



GFRG panels can be unfilled when used as partition walls, but when used as external walls, need to be suitably designed (with reinforced concrete filling) in order to resist the design wind pressures. For single-storey construction (suitable for mass low-cost housing), unfilled GFRG panels can be used for walls as well as roof (which may be pitched suitably), with local reinforced concrete filling at the joints between walls and between the roof and walls. It is mandatory to provide embedded RCC horizontal tie beam over all the walls below the floor slab/roof slab.

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 CO₂ 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.

GFRG building systems can be constructed only with technical support or supervision by qualified engineers and constructors, based on structural designs carried out in detail to comply to prevailing standards; this is applicable even for low-rise and affordable mass housing, to provide for safety against natural disasters (such as earthquakes and cyclones).

ABOUT BMTPC

Building Materials & Technology Promotion Council (BMTPC) is an autonomous body under the aegis of the Ministry of Housing & Urban Poverty Alleviation, Government of India established in 1990. Since its inception, BMTPC has been working towards smooth transfer of home grown cost effective, energy-efficient, environment-friendly and disaster resistant building materials and construction technologies from lab to field.

Major Areas of Work:

- **Building Materials & Construction Technologies :**
To promote development, standardization, mechanization and large scale field application of proven innovative and emerging building materials and technologies in the construction sector.
- **Disaster Mitigation & Management :**
Mainstreaming disaster risk reduction in housing, existing and developmental projects.
- **Capacity Building and Skill Development :**
To work as a Training Resource Centre for capacity building and promotion of good construction practices to professionals, construction agencies, artisans and marketing of building technologies from lab to land.
- **Project Management & Consultancy :**
To undertake project management and consultancy services encompassing DPR preparation, innovative design consultancy and vetting, appraisal, monitoring, quality assurance and third party inspection of housing projects under the various Central/State Schemes.

For further details please contact:



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**For Technology Show Visit
BMTPC
at Hall No.5
from 14-27 November, 2011 during
India International Trade Fair at
Pragati Maidan, New Delhi.**