NAVARITIH

New Affordable Validated Research Innovation Technologies for Indian Housing

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INTRODUCTION

- **There is a requirement of 11.2 million Dwelling units in urban areas and 29.5 million Dwelling units in rural areas in India by 2022.**
- **Construction sector is emerging to be the third largest sector to take India towards a $5 trillion economy.**
- **Conventionally Houses are built with materials like burnt clay bricks, cement, sand, aggregates, stones, timber and steel.**
- **Do we have sufficient supply of these materials & resources?**

Burnt Clay Bricks	Sand, aggregate & stones	Cement & steel	Timber
• Uses top fertile layer of soil as raw material. • Burnt using fossil fuels ,polluting environment	• Are available in short supply. • Banned in many states of India due to irrational mining.	• Are Energy Intensive and produced from natural resources (i.e. Limestone rock and iron ore).	• Deforestation is a major concern for production of timber.

FACTS AND FIGURES

- Construction industry poses a major challenge to the environment. As per UN Environment programme (UNEP), more than 30% of the greenhouse gas emission are building related and this could double by 2050.
- As per GRIHA, buildings consume about 40% of energy, 25% of water and 40% of resources. Further building activities cause 50% of the world's air pollution, 50% of all water pollution and generates of 48% of solid waste.
- In today's context, a few more terms like 'Sustainability', 'climate responsiveness' and 'disaster resilience' have become significant and are needed to be dovetailed with future construction practices.


Pollution from Kilns


Energy Intensive Production


Water Pollution

MAJOR CONSTRUCTION TYPES- WORLD OVER

- There are various types of building materials and construction practices being practiced world over since time immemorial for constructing houses.
- As per World Housing Encyclopaedia, these can be classified as:-

1. Adobe Construction.
2. Wood Houses.
3. Stone Buildings.
4. Brick- Unreinforced brick masonry construction.
5. Confined masonry construction.
6. Reinforced concrete frame construction.
7. Reinforced concrete shear wall.
8. Structural steel frame buildings.
9. Precast concrete buildings.

Most Prevalent construction systems in India

- Beyond these there are umpteen number of vernacular techniques too.

ADOBE CONSTRUCTION

- The bricks/blocks made up of local soil/mud and dried in sun are known as adobe.
- It is an age-old construction material being used world-wide. Around 30-50% of world's population lives/works in earthen buildings.
- Rammed construction is another form of mud houses where the walls are cast by compacting (ramming) layers of mud.
- A typical house is normally one or two storey high having thick walls.
- Still in India, mostly in rural India, people make houses using adobe construction despite of its high vulnerability to earthquake & other hazards.


Adobe House Exterior


Adobe House Interior

WOOD HOUSES

- In areas where wood is locally available & can be crafted for building construction using local skills.
- There are variety of wooden houses that can be
  - Bamboo frame & walls.
  - Wooden planks, post & beams.
  - Dhajji-Dewari (Small wooden frame with stone/brick masonry).
  - Ikara houses (Light wood panelling made of reed).
  - Wattle and daub.
  - Engineered timber houses.
- Thatch construction is one of the most primitive wood construction.


Dhajji-Dewari


Ikara houses

STONE BUILDINGS

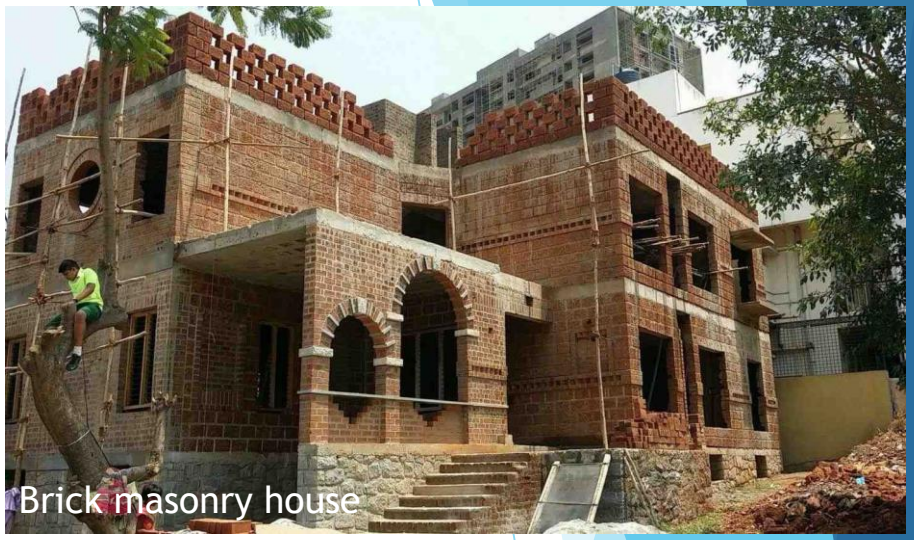
- It is cheaper & convenient to construct houses using stones where it is locally available.
- Stones used in construction can either be dressed or roughly dressed, hammered dressed or undressed.
- Some popular variety of stones that are used are slate, sandstone, granite, marble, limestone etc.
- In India Kota stone, dholpur stone, Jaisalmer stone, Kadapa are quite prevalent in different regions.
- Stone pieces can be used to construct structures with or without mortar.
- Stone buildings are heavy and vulnerable to earthquakes & hazards.
- Stone buildings are not designed for lateral loads.


Random rubble masonry


Ashler masonry

BRICK- UNREINFORCED BRICK MASONRY

- It is the most common housing form used widely around the world.
- Made in standard sizes (230mmX115mmX75mm) using top fertile layer of soil, essentially clay.
- The bricks are fired up in a kiln to remove moisture present in the soil.
- Bricks were used to construct magnificent structures like the roman aqueducts, Great wall of China, Islamic domes and monuments.
- As per Census 2011, based on predominant construction materials of walls, about 58% of the buildings used brick for walling.
- It has high vulnerability to earthquakes & hazards.


Brick masonry house


Brick masonry By Architect Laurie Baker

CONFINED MASONRY CONSTRUCTION

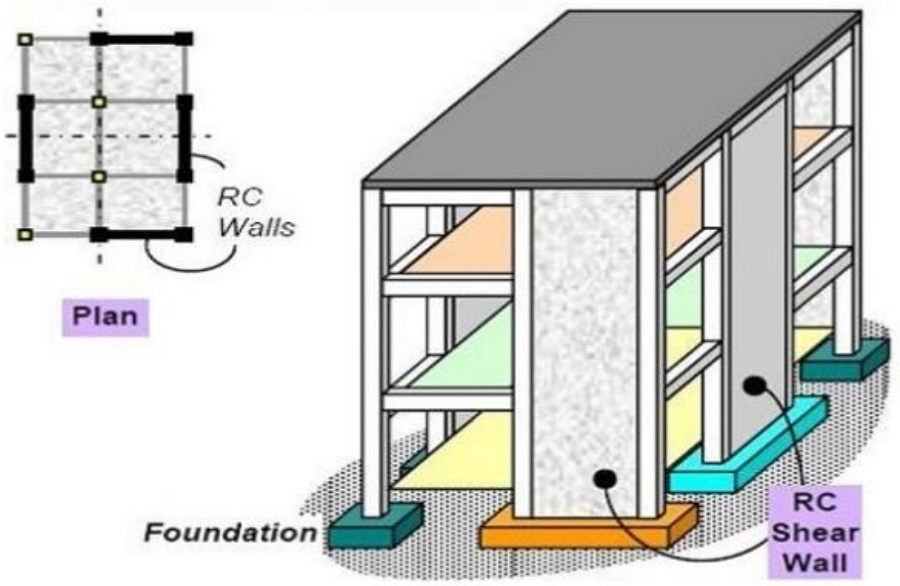
- It is a reinforced masonry construction where masonry wall is reinforced from all sides with concrete confining members.
- The vertical confining members are called tie columns while the horizontal confining members are called tie beams.
- Since unreinforced brick walls are poor in tension and cannot counter horizontal loads, reinforcement is required to withstand disasters.
- This type of construction has been very popular in South American countries which are prone to earthquakes.
- Such construction requires cement, steel as well.

REINFORCED CONCRETE FRAMED CONSTRUCTION

- Ever since Portland cement came into existence in the 19th century, concrete structures started replacing the old load bearing structures.
- A mix (called concrete mix) is prepared using cement, coarse aggregate, fine aggregate, water, in fixed proportion. Steel is used as skeleton for structures and the mix is poured over it.
- After setting, the concrete gains strength and RCC structure obtains its desired state.
- Concrete structures can be formed in any form and it expanded the horizons of construction.
- RCC structures are presumed to be superior in case of resisting earthquakes & other hazards.

REINFORCED CONCRETE SHEAR WALL

- The RCC concrete walls act as shear walls when placed in the specific bays in the plan of the RCC framed buildings.
- Shear walls are very effective in resisting lateral forces (that of earthquake, wind etc.)
- These shear walls are regular in plan and elevation however its design and construction requires expert inputs.
- This structural system is very effective in case of high rise buildings & skyscrapers.
- In earthquake prone areas, India being one, this system coupled with RCC framed construction is the new norm of construction.



STRUCTURAL STEEL FRAMED BUILDINGS

- Use of steel framed buildings dates back to the 19th century when the production of steel became more efficient in the US.
- The steel framed structures are made of columns and beams which are rolled steel sections.
- These sections are ‘I’ shaped, channel section, angle section, tubular (square/rectangular/circular)
- Indian standards provide hot-rolled structural steel shapes such as wide-flange beams, columns etc.
- Cold rolled steel also known as light gauge steel is a good option for low rise buildings
- These sections make construction durable, reliable, cost effective, fast for all building types.

PRECAST CONCRETE BUILDINGS

- After the second world war (1945), the precast concrete buildings were constructed in the former USSR & some eastern European countries for social mass housing. Later it was picked by others.
- The concept is very simple, manufacturing building units in controlled environment, taking it to the site, erect & assemble.
- The production in factory is of two types:
  1. 2D Planar structural elements. (walls etc.)
  2. 3d Volumetric construction (entire room/unit).
- The end product is quality & durable house delivered in short time.
- At present, its scope is limited in India.


2D Planar Precast


3D Volumetric Precast

CONVENTIONAL V/S ALTERNATE CONSTRUCTION SYSTEM

Conventional construction systems	Alternate construction systems
• Slow	• Fast
• Maximum use of Natural Resources	• Optimum use of resources
• Waste generation	• Minimum waste
• Air/Land/Water Pollution	• Minimum pollution
• Labour Intensive	• Industrialized systems
• Prescriptive Design	• Cost-effective design
• Unhealthy indoor quality	• Better health & productivity
• Regular maintenance	• Low life cycle cost
• Energy Intensive	• Energy efficient
• Cast-in-situ (poor quality)	• Factory made (Quality product)
• High green house gas Emission	• Low green house gas emission
• Unsustainable	• Sustainable

ALTERNATE CONSTRUCTION SYSTEM

- With the global buzz about sustainability, reduction of carbon emissions, climate change mitigation strategies, the use of greener good practices in the construction has gained importance & has become relevant today.
- BMTPC identified new potential technologies under 7 system typologies for mass housing assessed for their sustainability in different geo-climatic regions of the country. These 7 systems are:-

1. **Engineered formwork system-** 3 systems
2. **Lost formwork system-** 7 systems
3. **Precast sandwich panel systems-** 20 systems
4. **Light gauge steel structural systems-** 2 systems
5. **Steel structural systems-** 3 systems
6. **Precast concrete construction systems-** 11 systems
7. **Metal structural systems-** 1 system

About 1.4 million houses are being constructed with alternate construction systems under PMAY-U & other state run schemes

MARKET TRANSFORMATION THROUGH TECHNOLOGY TRANSITION

Technology Providers
- Enhanced business opportunity
- Better Productivity
- Upskilling of human resources

Developers/contractors
- Reduction in construction cost
- Faster delivery of houses
- Quality & durable product

End-user
- Improved structural performance
- Better thermal, indoor air quality, acoustics
- Less maintenance/ low life-cycle cost

Nation
- Less air/land/water pollution
- Low green house gas emission
- Sustainable development

GLOBAL HOUSING TECHNOLOGY CHALLENGE (GHTC-INDIA)

- Ministry of housing and urban affairs (MoHUA) conceptualized the Global Housing Technology Challenge (GHTC-India).
- This was done to provide a platform with which a holistic eco-system can be facilitated so that appropriate technologies from around the world can be catalysed towards transition in housing & const. sector.
- The challenge has 3 components, which are:-
  1. Conduct of a biennial construction technology, India, Expo-Cum-Conference, to provide a platform for all stakeholders to exchanging knowledge and business.
  2. Identifying proven demonstrable technologies from across the world, and mainstream them through field level application in 'Light House Projects (LHPs)' across India.
  3. Promoting potential future technologies through the establishment of Affordable Sustainable Housing Accelerators (ASHA-India) for incubation & accelerator support.

SHORTLISTED ENTRIES IN GHTC-INDIA (2019)

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

- **54 entries were selected under 6 system typologies. These typologies were:-**

A. **Precast concrete construction systems- 3D-Volumetric Precast.-** (4)

Mass production of entire units as modules in factories (minimum wastage)

B. **Precast concrete construction systems- Precast components assembled at site.-** (8)

Mass production of structural components in factories (minimum wastage)

C. **Light gauge steel structural system & pre-engineered steel structural systems.-** (16)

Cold rolled steel & pre-engineered sections that is not energy intensive to produce.

D. **Prefabricated sandwich panel system.-** (9)

Alternative for brick walls as filler walls in case of framed structures.

E. **Monolithic Concrete Construction systems.-** (9)

All walls/openings/floors are casted monolithically on site using modular formwork.

F. **Stay in place formwork systems.-** (8)

Formwork that acts as structural support/ insulation that remains with the building.

SIX LIGHT HOUSE PROJECTS UNDER GHTC (INDIA)

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

- **The shortlisted global technology providers are invited to plan & construct Light House Projects (LHPs) within the framework of PMAY-(U) on pre selected site across 6 regions.**
- **These light house projects shall serve as open laboratories for different aspect.**

S.No.	Location	DUs, storeys	Technology
1	Indore, Madhya Pradesh	1024 DUs S+8	Precast sandwich panel system (precast RCC beams and columns, hollow core slabs, EPS Sandwich panel walls)
2	Rajkot, Gujarat	1144 DUs S+13	Monolithic concrete construction (tunnel form)
3	Chennai, Tamil Nadu	1152 DUs G+5	Precast concrete construction (precast components assembled at site)
4	Ranchi, Jharkhand	1008 DUs G+8	Precast concrete construction (3D Volumetric construction)
5	Agartala, Tripura	1000 DUs G+6	Light gauge steel structure system & pre-engineered steel structural system
6	Lucknow, Uttar Pradesh	1040 DUs G+13	Stay in place form work system (steel structural system, composite decking floor)

WHY ALTERNATE CONSTRUCTION SYSTEMS ARE NEEDED?

Aspect	Description
Resource Efficiency	Conventional construction practices are based on natural resources which are finite and cannot be replenished quickly. Therefore these resources are to be used efficiently.
Structural Design Efficiency	The performance based design instead of perspective based design is the key to design efficiency. Alternate construction techniques follow the path of optimization right from the start to the end.
Disaster Resilience	Designed to be in resilient against natural hazards as it entails performance based design.
Cost & payoff	When we compare price we often compare only 'initial construction cost' which seems high for alternate construction practices. If we talk about the 'life cycle cost' = initial cost + Running cost + disposal cost, then it is less.
Energy Efficiency	The embodies energy required to extract, process, transport & install building and the operating energy to provide services is less.

WHY ALTERNATE CONSTRUCTION SYSTEMS ARE NEEDED?

Aspect	Description
Water Efficiency	Construction systems like cast-in-situ concrete requires large amount of potable water for curing which goes waste. Alternate construction system employs better techniques which ensures minimum wastage.
Material Efficiency	Most of the alternate construction systems use industrial waste, C&D waste , renewable resources that can even be reused and recycled.
Indoor Environmental quality enhancement	Material used in alternate construction systems have zero or low volatile organic compounds (VOCs) and other microbial contaminants. Also well insulated and tightly sealed envelope reduces moisture problems.
Operation and maintenance optimization	Many components in alternate construction systems are factory made which are made with high precision and perfection. These components and their assembly requires low maintenance in their lifetime.
Waste reduction	Waste generated during production, operation and demolition is either very low or in most cases is reusable for further projects.

END-USER BENEFITS OF ALTERNATE CONSTRUCTION SYSTEMS

- Improved structural and functional performance
- Safer and disaster resilient houses
- Better quality of construction
- Low maintenance, minimum life cycle cost
- Speedy construction resulting in early occupancy
- Cost effective and environment friendly
- Better fire resistance and thermal efficiency
- Less air pollution and waste generation.
- Emerging construction systems help to build:-

Precast concrete construction (precast components assembled at site)

2BHK in 24 Hours **Bharat City, Ghaziabad.**

THANK YOU