Special Issue

# निर्माण सारिका

A Newsletter of BMTPC

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## World Habitat Day

**5th October, 2020**

## Housing For All:
## A Better Urban Future

October 5 World Habitat Day 2020

bmtpc

निर्माण सामग्री एवं प्रौद्योगिकी संवर्द्धन परिषद्
आवासन और शहरी कार्य मंत्रालय, भारत सरकार
BUILDING MATERIALS & TECHNOLOGY PROMOTION COUNCIL
Ministry of Housing & Urban Affairs, Government of India

*"Creating Enabling Environment for Affordable Housing for All"*

## CONTENTS



# From the Desk of
# Executive Director

In the backdrop of Global Pandemic Covid-19, this year's World Habitat Day is being celebrated on virtual platform by the entire world. Despite of more than 33 million confirmed cases of Covid-19 including more than 1 million deaths worldwide as on 28.09.2020, our spirits to show our commitment towards resilient and sustainable habitat have not ebbed and this year theme of "Housing for All: A Better Urban Feature" stands testimony to this resolve. It is more pertinent in the Indian context, where there was mass exodus of urban migrants due to Covid-19 for the want of not only livelihood but also better living conditions. This prompted Govt. of India to immediately launch Affordable Rental Housing Complexes Scheme (ARHCs) under Pradhan Mantri Awas Yojna (Urban) to provide ease of living to millions of migrants working in urban areas. India's commitment towards Housing for All is also unprecedented and is one of the biggest in the world. As against the validated demand of 11.2 million houses in urban areas, 10.8 million houses have already been sanctions and 6.7 million houses have already been grounded. Housing for All by 2022, the 75$^{th}$ year of our Independence looked a distant dream when we started our journey in 2015, but looking at the figures, it is going to be achieved much before the target year of 2022. Thanks to present govt's pro-poor commitments and reforms coupled with plethora of urban renewal schemes. Govt's mantra of 3S i.e. Skill, Scale and Speed further trigerred massive public investment, robust private consumption and structural reforms leading to rapid growth of economy. With US $3 trillion GDP, India is aspiring to be largest and fastest growing economy of the world. Urban cities of India being engines of growth will contribute more than 50% to GDP in coming years and therefore cities need to be receptive, innovative and productive to foster sustainable growth and ensure better quality of living.

It is not only at policy forefront that the present Govt. is playing a pro active role but also at the technological intervention level, we are committed for sustainable development of construction sector using building materials and construction technologies which are resources efficient, climate resilient, cost effective and disaster reselient. The first of its kind initiative was taken by Govt. of India to organize Global Housing Technology Challenges – India (GHTC-I) through which 54 new construction systems were identified for speedy construction of livable and affordable houses for urban poor. At present, six Light House Projects (LHP's) using these shortlisted technologies are being implemented in six regions of India to showcase the efficacy of these systems and mainstreaming them in the construction sector. These Light House Projects (LHP's) will be live laboratories to transfer the technology at the field level and to understand different aspects of construction including planning, design, disaster resilience, sustainability, structural and functional performance and other parameters required for field level application. With these niche technologies, India is also going to be a global leader in the area of construction technologies.

India is cruising to become US $ 5 trillion economy and recently the clarion call given by Hon'ble Prime Minister of India of 'आत्म निर्भर भारत' to make use of our local resource of raw materials to produce global products and technology will make India the biggest hub of manufacturing. It is time for all of us to contribute towards self-reliant India so as to build new Young India. It is also an opportune time to promote our vernacular construction practice and materials amalgamated with global know how to produce cutting edge innovations in the building sector. There have been spurt of startups in the sector with new and innovative ideas which will certainly help India to be a global leader in the housing sector as well to provide sustainable & holistic solution.

It is my proud privilege to publish BMTPC's Special E-newsletter "निर्माण सारिका" comprising of papers, articles on this year theme of Housing for All. It is being published since 1990 without fail and in this Covid-19 trying times, this year's publication holds a special place in my heart. The help and support of Shri Dalip Kumar, SFO(DC&E), BMTPC and the contributors for bringing out this publication is gratefully acknowledged.

*Let us perform reform and transform.*

(Dr. Shailesh Kr. Agrawal)

**ANTÓNIO GUTERRES**
***Secretary - General***
***UNITED NATIONS***

## Message

Each year World Habitat Day focuses attention on the state of the world's towns and cities. This year's observance highlights the centrality of housing as a driver for sustainable urban development.

Currently, 1 billion people live in overcrowded settlements with inadequate housing. By 2030, that number will rise to 1.6 billion. Action is needed now to provide low-income families and vulnerable populations with affordable housing with security of tenure and easy access to water, sanitation, transport and other basic services. To meet global demand, more than 96,000 housing units will need to be completed every day – and they must be part of the green transition.

The urgency of improving living conditions has been brought to the fore by COVID-19, which has devastated the lives of millions in cities. Access to clean water and sanitation, along with social distancing, are key responses to the pandemic. Yet in slums it has proved difficult to implement these measures. This means an increased risk of infection, not only within slums, but in whole cities, many of which are largely serviced by low-income informal sector workers living in informal settlements.

On World Habitat Day, in this crucial Decade of Action to achieve the Sustainable Development Goals, I call for heightened efforts to promote the partnerships, pro-poor policies, and regulations needed to improve housing in cities. As we strive to overcome the pandemic, address the fragilities and inequalities it has exposed, and combat climate change, now is the time to harness the transformative potential of urbanization for the benefit of people and planet.

*António Guterres*

# Key Messages by UN-HABITAT


KEY MESSAGES
SEPTEMBER 2020

## **Housing For All:** A Better Urban Future

Having an adequate home is now, more than ever, a matter of life and death. As COVID-19 continues to spread, people have been told to stay at home, but this simple measure is impossible for people who do not have adequate housing.

At the same time, COVID-19 has reminded us that home is much more than just a roof. To make us feel safe and enable us to continue living, working and learning, a home needs to be secure, to allow us to access basic services and infrastructure for hygiene measures and to have enough room for physical distancing. It should also be located in a place that enables residents to access public green and open spaces, employment opportunities, health-care services, schools, childcare centres and other social facilities.

An estimated 1.8 billion people were already living in slums and informal settlements, inadequate housing or in homelessness in our cities worldwide before the pandemic began. Some 3 billion people lack basic hand-washing facilities. This means millions of people worldwide are more likely to experience poor health due to the absence of basic services and exposure to multiple socio-economic and environmental hazards.

Structural inequalities have been highlighted by the COVID-19 pandemic, showing how people from minorities, indigenous peoples and migrants are disproportionally affected by housing precarity, overcrowding and homelessness.

COVID-19 has spread in areas where people lack adequate housing, and are faced with inequalities and poverty. Residents in these areas are also often not recognized by the authorities or protected and face the risk of being evicted and relocated, particularly in times of crisis. According to ILO, 55 per cent of the world's population – about 4 billion people – do not benefit from any form of social protection.

Housing is a human right and a catalyst for all other fundamental rights. It is the only way to ensure the "***Right to the City for All***".

Inclusive, affordable and adequate housing is the key to the sustainable transformation of our cities and communities. Sustainable Development Goal 11 aims for resilient, inclusive, safe, diverse cities by 2030 and one of the targets is access to adequate, safe and affordable housing and basic services for all by 2030 and the upgrading of slums.

The COVID-19 crisis is showing how success comes from collaboration and is giving new momentum to the idea that ensuring housing rights for all is a shared responsibility.

The COVID-19 crisis has demonstrated the power of communities and people's ability to adapt and find local and innovative solutions. It has also shown that it is possible to quickly address housing emergencies as local and national governments provide temporary solutions including:

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*Source: https://urbanoctober.unhabitat.org/whd*

- Short term and emergency accommodation for people without secure housing through underutilized spaces and repurposing of buildings.
- Moratoriums on evictions due to rental and mortgage arrears or forced evictions of informal settlements and slums along with suspension of utility costs and surcharges for the duration of the pandemic.
- Access to buildings, land and open space for essential small businesses, food security, emergency health care and other vital functions needed while people stay at home.

While these steps are timely and important, they need to become sustainable long-term changes enshrined in policy and legislation. The pandemic has demonstrated the importance of a people-centred approach as housing is as vital for the character, shape and socio-economic vibrancy of cities as it is to public health outcomes.

## Housing is the building block of people's health, dignity, safety, well-being and inclusion.

**Health:** Adequate housing is a first line of defence against a number of health risks. It helps reduce the spread of diseases and enables people to follow sanitary protocols.

**Dignity:** Having an adequate house is an essential condition for living in dignity. Accessibility of housing is key particularly, for people with disabilities, older persons or people with other cultural, social or healthrelated needs.

**Well-being:** Adequate housing provides the basis for belonging and the well-being of people enabling them to grow, engage, live, work and learn together. Community spaces and shared facilities for diverse population groups, needs and cultural activities must be considered when designing houses and settlements and planning for a better urban future.

**Safety:** An adequate physical shelter protects people against multiple safety risks. With the increase of extreme weather events, housing for all contributes to building the resilience of communities and cities to climate change.

**Inclusion:** The stability of a safe home is essential to ensure social and economic inclusion as part of a neighbourhood and community and to access jobs and livelihoods. Building better homes with people ensures that neighbourhoods are vibrant and integrated with diverse housing solutions and use which meet the needs of everyone.

## Housing is a shared responsibility.

Adequate housing for all will depend on strengthened and coordinated efforts including from national and local governments. Local authorities are key actors in ensuring that all citizens stay safe and protected. National governments are critical for supporting local decision-makers by empowering them to take preventative action and make effective decisions.

Other partners include civil society organizations building partnerships with residents, private sector mobilizing resources for options including rentals, housing preservation and rehabilitation and the international community mobilizing support for housing.

People must be empowered and equipped to contribute to and shape the housing where they live. We need to facilitate the right framing and incentives for unlocking long-term political commitment, creativity, investment and local ownership for housing all in our future cities.

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*Source: https://urbanoctober.unhabitat.org/whd*

# Post Covid-19 Construction Trends

*Dr. Shailesh Kr. Agrawal*[1]

In the backdrop of global pandemic COVID-19, the construction sector will also transit to new normal. To keep pace with the rapid urbanization coupled with globalization and economic development, construction sector has already been in the process of shifting to automation, industrialization and internet of things but the transition has been rather slow and lagging. The covid-19 has triggered this shift and accelerated disruptions which will define the future and next normal for the construction sector.

The fundamental changes are primarily catalyzed by changes in market characteristics, such as scarcity of skilled labour, persistent cost pressure from infrastructure and affordable housing, stricter regulations on work-site, sustainability and safety, and evolving sophistication and needs of customers and owners. Therefore, the emerging disruptions, construction industry is grappled with can be listed as follows:

## Owner & customer sophistication along with sustainability requirements

Client demands will evolve regarding performance, TCO, and sustainability: smart buildings, energy and operational efficiency, and flexibility and adaptability of structures will be given higher priorities. Expectations will also rise among customers, who want simple, digital interactions as well as more adaptable structures.

## Unending shortage of skilled labour resources

Skilled-labour shortages have become a major issue in several markets and therefore industrialized modular construction is going to be in thing.

## New site regulations in view of climate change mitigation, sustainability & safety

The global conversation about climate change puts increasing pressure on the industry to reduce carbon emissions. Requirements for sustainability and work-site safety are increasing which require new set of health and safety procedures. Also, standardize building codes or provide type certificates and approvals for factory-built products.

## Modern methods of construction enabling off-site production and industrialization of construction methods

Modularization, off-site production automation, and on-site assembly automation will enable industrialization and an off-site, product-based approach. The shift will be towards a more controlled environment. The transition to efficient off-site manufacturing with integrated automated production systems more like automotive manufacturing is new normal.

1 Executive Director, Building Materials & Technology Promotion Council, New Delhi

## Newer materials and innovative products

Sustainable building materials, use of local skills & local materials, waste-based building products, Innovations in traditional basic materials like cement enabling reduction of carbon footprints, Emerging lighter-weight materials such as light-gauge steel frames, prefinished volumetric construction, plug & play kind pods are new trends with a focus on factory production of modules.

## Introduction of internet of things such as BIM, smart infrastructure, digital solutions

Smart buildings and infrastructure that integrate the Internet of Things (IoT) will enable more efficient operations. Building-information modelling (BIM) to create a full digital three-dimensional model (a "digital twin") with time & cost as parameters is already being incorporated in construction.

## New entrants

There are host of new people knocking the sector. Start-ups, venture capitalists and private equity will replace the current business models.

The above disruptions along with global dynamics have already enabled new normal in the construction sector and further global pandemic will bring perceptible changes. These new normal are as follows:

## Product-based approach

An increasing share of structures and surrounding services will be delivered and marketed as standardized products similar to automotive industry. The future will be promotion of branded offerings, with standardized but customizable designs that can improve from one product generation to the next, and delivery using modularized elements and standardized components produced in factories. The modules and elements will be shipped and assembled on site. Production will consist of assembly line–like processes in safe, sustainable environment with a large degree of repeatability.

BIM Model (Source: https://mlp-consulting.com/autodesk-revit)

## Specialization

Agencies will start to specialize in target niches and segments (such as luxury single-family housing, multi-storey residential buildings, hospitals, or processing plants) in which they can build competitive advantages. And they will specialize in using different materials, subsegments, or methods of construction. The shift toward specialization will also require companies to develop and retain knowledge and capabilities to maintain their competitive advantages. Obviously, players will need to weigh carefully the effectiveness, efficiency, and brand positioning that greater specialization enables against the potential risk or cyclicality benefits of a more diversified portfolio. DFMA (design for manufacturie & assembly) is the new normal for construction.

## Value-chain control and integration with industrial-grade supply chains

Companies will move to own or control important activities along the value chain, such as design and engineering, select-component manufacturing, supply-chain management, and on-site assembly. Companies will be able to achieve this goal through vertical integration or strategic alliances and partnerships by using collaborative contracting and more closely aligned incentives. Digital technology will change the interaction model: BIM models will lead to more decision making early on in the process, distribution will move toward online platforms and advanced logistics management, and end-to-end software platforms will allow companies to better control and integrate value and supply chains. Value-chain control or integration

will reduce interface frictions and make innovation more agile.

## Consolidation

Growing needs for specialization and investments in innovation-including the use of new materials, digitalization, technology and facilities, and human resources-will require significantly larger scale than is common today. As product-based approaches, with higher standardization and repeatability, further increase the importance of gaining scale, the industry is likely to increasingly see a significant degree of consolidation, both within specific parts of the value chain and across the value chain.

## Customer-centricity and branding

With productization-that is, turning development, engineering, or construction services into easy-to-market products or solutions-and specialization in the industry, having a compelling brand that represents an organization's distinctive attributes and values will take on added importance. As in traditional consumer industries, a strong brand can tie customers more closely to the construction company's or supplier's products and help to build and maintain relationships and attract new customers. Similar to brands in other manufacturing industries, such construction brands will encompass, among other aspects, product and service quality, value, timing of delivery, reliability, service offerings, and warranties.

## Investment in technology and facilities

Productization implies a need to build off-site factories, which requires investments in plants, manufacturing machinery and equipment (such as robotics to automate manufacturing), and technology. Where modular is not used, the construction site also will likely become more capital intensive, using advanced automation equipment and drones, among other technologies. R&D investment will become more important for specialized or more productized companies, so companies are likely to increase spending to develop new, innovative products and technologies.

## Investment in human resources

Innovation, digitalization, value-chain control, technology use, and specialization in end-use segments all increase the importance of developing and retaining in-house expertise, which will compel players to invest more in human resources. The importance of risk management and other current capabilities will decrease and be replaced by an emphasis on others, such as supply-chain management. To build the necessary capabilities, companies will need to further invest in their workforces. This becomes even more important in light of the transition to the future of work. Most incumbents struggle to attract the digital talent they need, and will need to raise excitement about their future business models.

## Internationalization

Greater standardization will lower the barriers to operating across geographies. As scale becomes increasingly important to gaining competitive advantages, players will increase their global footprints-both for low-volume projects in high-value segments such as infrastructure, as well as for winning repeatable products that will be in demand across the world. The COVID-19 pandemic might slow down this development.

## Sustainability

While sustainability is an important decision factor already, we are only at the very beginning of an increasingly rapid development. Beyond the carbon-abatement discussions, physical climate risks are already growing and require a response.8 Companies will need to consider the environmental impact when sourcing materials, manufacturing will become more sustainable (for example, using electric machinery), and supply chains will be optimized for sustainability as well as resilience. In addition, the working environments will need to radically change from hostile to non-hostile, making construction safer. Water consumption, dust, noise, and waste are also critical factors.

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Ministry of Housing and Urban Affairs
Government of India

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

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

School of Planning and Architecture, New Delhi

Building Materials & Technology Promotion Council, New Delhi

Fee slashed to Rs.1000/- (Rs.500 for students)

# e-Course on Vulnerability Atlas of India

Registration open at www.spa.ac.in

The e-course on Vulnerability Atlas of India has been launched by Shri Hardeep S Puri, Hon'ble Minister of State (I/C) for Housing and Urban Affairs, Government of India on August 29, 2019. The e-Course is being offered jointly by the School of Planning & Architecture, New Delhi and Building Materials & Technology Promotion Council (BMTPC), New Delhi.

It is a basic e-learning course that offers awareness and understanding about natural hazards, helps identify regions with high vulnerability with respect to various hazards (earthquakes, cyclones, landslides, floods, etc.) and specifies district-wise level of damage risks to the existing housing stock.

The e-course will be a tool for effective & efficient disaster mitigation & management in the field of Architecture, Civil Engineering, Urban & Regional Planning, Housing & Infrastructure Planning, Construction Engineering & Management and Building & Materials Research.

**COURSE FEE**

Rs.3000/- per person
Fee slashed to
Rs.1000/- per person (Rs.500/- for Student) for limited period upto 30.9.2021
One-time, Non-refundable


## Who can Benefit

- Students/ Faculty/ Practitioners/ Researchers/ Individuals
- Defence/ Central Armed Police Forces
- National/ State Disaster Management Authorities
- Central/ State/ Local Government Officials
- Public/ Private Professionals
- Consulting Organisations, Civil Society Organisations
- Construction Agencies/ Organisations

## Course Contents

**Module 1:** Concept of Vulnerability Atlas of India

**Module 2:** Earthquake Hazard and Vulnerability to Housing

**Module 3:** Wind / Cyclone Hazard and Vulnerability to Housing

**Module 4:** Flood Hazard and Vulnerability to Housing

**Module 5:** Landslides, Thunderstorm and Tsunami Hazards

**Module 6:** Housing Vulnerability Risk Table

**Module 7:** Using Vulnerability Atlas of India

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# Pradhan Mantri Awas Yojana (Urban) - Present Status & Achievements

*C. N. Jha*[1]
*Pankaj Gupta*[2]

Housing is one of the most basic needs of all human beings. The analysis of the housing scenario in the Country indicates the housing shortage predominantly lies with economically weaker / lower income section of the society. While according due importance to the subject, the Government of India has launched a comprehensive mission "Housing for All by 2022" the time by which the Nation completes 75 years of its Independence. In order to achieve this objective in urban areas, as by now we are all aware that one of the most ambitious social housing schemes in the world namely Pradhan Mantri Awas Yojana –Urban (PMAY-U) is presently under advanced level of implementation in our Country. The scheme takes holistic approach for uplifting & mainstreaming the urban poor by way of making provision for decent pucca house with water connection, toilet facilities, 24x7 electricity supply and access. The PMAY (U) is under implementation since June 17, 2015 with mission period upto March 31, 2022.

The Country has had its share of social housing schemes earlier also in the form of Jawaharlal Nehru Urban Renewal Mission (JNNURM), Rajiv Awas Yojana (RAY), Valmiki Ambedkar Awas Yojana ( VAMBAY) etc. with varying degrees of success, however none of these schemes match PMAY in terms of scale & coverage.

Considering the ambitious target, deliberations were held with all the States/Union Territories, experts from Academic/ Technical Institutions, financial Institutions & other Stakeholders. The experiences with earlier social housing schemes were reviewed & strategies were worked out. Based on the same, the erstwhile Ministry of Housing & Urban Poverty Alleviation came out with Scheme Guidelines for Housing for All (Urban), which gives broad provisions of the scheme & stipulates the important requirements such as minimum size of house to be in conformance to National Building Code (NBC), meeting the structural safety against earthquake & other natural hazards conforming to NBC and to have all basic infrastructure facilities associated with house such as water, sanitation, sewerage, electricity, road etc. The strategies for implementation of the mission have also been included. The strategies formulated under four verticals, significance of the same & important achievements so far are given below, as per the following details;

## In-situ" Slum Redevelopment using land as Resource

"In-situ" slum rehabilitation using land as a resource with private participation for providing houses to eligible slum dwellers is an important component of the "Housing for All" mission. This approach aims to leverage the locked potential of land under slums to provide houses to the eligible slum dwellers bringing them into the formal urban settlement.

Private partner for Slum Redevelopment under this vertical is to be selected through open bidding process. State Governments and cities as per the requirement may provide additional Floor Area Ratio (FAR)/Floor Space Index (FSI)/ Transferable Development Rights (TDR) for making slum redevelopment projects financially viable. Slum rehabilitation grant of Rs. 1 lakh per house, on an average,

1 Dy.Chief (S&PD), Building Materials & Technology Promotion Council, New Delhi
2 Dy.Chief (I&D), Building Materials & Technology Promotion Council, New Delhi

would be admissible for all houses built for eligible slum dwellers in all such projects.

This strategy by virtue of providing decent accommodation at the same place of accommodation of slum households ensures continuity in their employment & other important facilities such as schooling of their children, nearby health facilities, social welfare schemes etc.

Maharashtra & Gujarat are two leading States in the implementation of this strategy with total number of houses sanctioned as 2,23,237 & 92,568 respectively as on September 28, 2020.

## Credit-Linked Subsidy Scheme

In order to expand institutional credit flow to the housing needs of urban poor credit linked subsidy component has been included as a demand side intervention. Credit linked subsidy are provided on home loans taken by eligible urban poor (EWS/LIG) for both acquisition & construction of house.

Beneficiaries of Economically Weaker section (EWS) and Low Income Group (LIG) seeking housing loans from Banks, Housing Finance Companies and other such institutions are eligible for an interest subsidy at the rate of 6.5 % for tenure of 15 years or during tenure of loan whichever is lower. The credit linked subsidy is available only for loan amounts upto Rs 6 lakhs and additional loans beyond Rs. 6 lakhs, if any, will be at nonsubsidized rate.

This vertical gives option & flexibility to beneficiary households for acquiring any completed or under-construction houses by any Public or Private Developers. This option also helps Public/Private Developers in giving impetus to sell of its inventories.

Here again, Gujarat & Maharastra are way ahead of other States/UTs in the implementation of this strategy with total number of houses sanctioned as 2,98,678 & 2,94,239 respectively as on September 28, 2020.

## Affordable Housing in Partnership (AHP)

The third component of the mission is affordable housing in partnership as a supply side intervention. The mission provides financial assistance to EWS houses being built with different partnerships by States/UTs/Cities.

Under this component, to increase availability of houses for EWS category at an affordable rate, States/UTs, either through its agencies or in partnership with private sector including industries, can plan affordable housing projects. Central Assistance at the rate of Rs. 1.5 Lakh per EWS house would be available for all EWS houses in such projects.

The States/UTs decide on an upper ceiling on the sale price of EWS houses in rupees per square meter of carpet area in such projects with an objective to make them affordable and accessible to the intended beneficiaries. For that purpose, State and cities considers extending other concessions such as their State subsidy, land at affordable cost, stamp duty exemption etc.

This component primarily covers the EWS households living in poor conditions in rented accommodations. Maharashtra, Karnataka & Andhra Pradesh are three leading States in implementation of this strategy with total number of houses sanctioned as 5,25,880, 3,56,165 & 3,11,186 respectively as on September 28, 2020.

## Beneficiary-led individual house construction or enhancement

This is fourth component of the mission, which provides assistance to individual eligible families belonging to EWS categories to either construct new houses or enhance existing houses on their own to cover the beneficiaries who are not able to take advantage of other components of the mission. Such families may avail of central assistance of Rs. 1.5 lakh for construction of new houses under the mission.

A beneficiary desirous of availing this assistance is to approach the ULB with adequate documentation regarding availability of land owned by it. Such beneficiaries may be residing either in slums or outside the slums. Beneficiaries in slums which are not being redeveloped can be covered under this component if beneficiaries have a Kutcha house.

As one of the important technological interventions for effective monitoring of construction process, these individual houses are to be tracked through geo-tagged photographs, for which States/UTs are implementing suitable systems.

This vertical targets the EWS beneficiaries having land with legal ownership & living in kuccha houses. The three leading States in implementation of this strategy are Andhra Pradesh, Uttar Pradesh & Madhya Pradesh with total number

of houses sanctioned as 16,74,815, 15,28,741 & 5,82,712 respectively as on September 28, 2020.

As one of the important social measures, the preference in selection or allotment is to be given to physically handicapped persons, senior citizens, Scheduled Castes, Scheduled Tribes, Other Backward Classes, minority, single women, transgender and other weaker and vulnerable sections of the society. While making the allotment in multi-storied apartments, the families with differently-abled persons and senior citizens may be allotted house preferably on the ground floor or lower floors.

## Progress in terms of sanction, grounding & completion of Houses

Against the validated demand of 1.12 Cr houses by the States/ UTs, a significant progress has been achieved in terms of sanction, grounding & completion of houses so far. The State/UT wise physical as well as financial progress as on September 14, 2020 is given Table-1.

## Technology Sub-Mission

Technology Sub-mission under the PMAY(U) is functioning to facilitate adoption of modern innovative and green technologies and building material for faster and quality construction of houses. Technology Sub-Mission is to facilitate preparation and adoption of layout designs and building plans suitable for various geo-climatic zones & also assist States/Cities in deploying disaster resistant and environment friendly technologies. The major activities /achievements so far under Technology Sub Mission are as below;

### i. Identification, Evaluation and Certification of Emerging Technologies

BMTPC an autonomous organization under MoHUA is mandated to identify, evaluate and promote emerging construction systems suiting to different geo-climatic conditions of the country, which are safe, sustainable and environment-friendly and ensure faster delivery of quality houses. The Government of India has authorized BMTPC to certify such new systems through Performance Appraisal Certification Scheme (PACS) (vide Gazette Notification No. I-16011/5/99 H-II Vol 49 dated 5th November, 1999). The third edition of Compendium of Prospective Emerging Technologies for Mass Housing has been published and can be downloaded from www.bmtpc.org. With 12 new Housing Systems/ Technologies as certified under PACS till date, there are 36 evaluated & certified Technologies under PACS as on date in Six broad categories.

### ii. Adoption of New Technologies by Government Agencies & National Building Code of BIS

Ministry of Housing and Urban Affairs has issued an Office Memorandum dated 20.03.2018 in which it has been decided that CPWD, DDA & NBCC may adopt the technologies, which have been validated by Building Materials and Technology Promotion Council (BMTPC) under the Ministry of Housing and Urban Affairs in all their projects irrespective of location and project cost.

In order to facilitate adoption of alternate and emerging technologies by the State Governments, Ministry of Housing & Urban Affairs has pursued CPWD, BIS and State departments to come out with notifications, Circulars, SORs, specifications etc. which will authorize State governments to use these new construction technologies in housing projects

CPWD has already issued SoRs on 29 new technologies & materials so far.

In the recently published National Building Code 2016 by BIS, provisions have been updated to ensure utilization of number of new/alternative building materials and technologies to provide for innovation in the field of building construction.

### iii. Demonstration Housing Projects using New Technologies

In order to showcase the field application of new emerging technologies & to create confidence about new technologies, MoHUA has taken an initiative to construct Demonstration Houses through BMTPC. States were invited to participate in the “Demonstration Housing Project (DHPs)”.

***Completed Projects:***

5 DHPs namely Construction of 36 Units using GFRG system (Glass Fibre Reinforced Gypsum Panel) and a community building at Nellore District, Andhra Pradesh, 32 DUs (G+3) using Expanded Polystyrene Sheet Core (EPS) technology at Bhubaneshwar, Odisha, 36 DUs (G+2) using Structural Stay in Place Formwork System (Coffer) at Bihar Shariff, Bihar, 32 (G+3) using Structural Stay in Place Formwork System (Coffer) - 16 DUs and Light Gauge Steel Frame structure (LGSF) -16 DUs at Gachibowli, Hyderabad, Telangana & 40 (G+1) DUs using Stay in Place EPS based double walled panel System (Sismo) at Aurangabad Jagir, Lucknow, have been completed.

## Table-1: State/UT wise physical and financial progress as on September 14, 2020

| Sr. No. | | Name of the State/ UT | Project Proposal Considered | Physical Progress (Nos.) | | | Financial Progress (Rs. in Crore) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | House Sanctined | Houses Grounded* | House Completed* | Investment | Central Assistance | |
| | | | | | | | | Sanctioned^ | Released^ |
| 1 | | Andhra Pradesh | 1,023 | 20,20,335 | 5,77,712 | 3,46,699 | 87,569.79 | 30,540.14 | 8,013.65 |
| 2 | | Bihar | 505 | 3,59,896 | 1,71,955 | 73,171 | 19,325.54 | 5,592.61 | 1,963.58 |
| 3 | | Chhattisgarh | 1,639 | 2,59,237 | 2,01,936 | 1,00,782 | 11,007.22 | 3,961.06 | 1,930.77 |
| 4 | | Goa | 10 | 1,590 | 1,532 | 1,531 | 338.52 | 35.80 | 35.26 |
| 5 | | Gujarat | 1,351 | 7,20,616 | 6,31,417 | 4,50,380 | 65,523.68 | 13,141.97 | 8,920.22 |
| 6 | | Haryana | 538 | 2,75,985 | 56,701 | 29,756 | 27,426.46 | 4,443.75 | 978.79 |
| 7 | | Himachal Pradesh | 159 | 10,766 | 8,805 | 3,908 | 616.80 | 190.89 | 98.50 |
| 8 | | Jharkhand | 389 | 2,02,528 | 1,50,908 | 82,757 | 12,920.22 | 3,083.90 | 1,778.87 |
| 9 | | Karnataka | 2,603 | 6,63,193 | 4,14,428 | 1,94,481 | 43,702.30 | 10,601.35 | 3,957.72 |
| 10 | | Kerala | 510 | 1,21,897 | 1,05,772 | 79,339 | 5,889.53 | 1,956.04 | 1,313.95 |
| 11 | | Madhya Pradesh | 1,464 | 8,06,655 | 7,03,871 | 3,46,246 | 41,701.60 | 12,710.14 | 7,218.89 |
| 12 | | Maharashtra | 1,014 | 12,59,390 | 5,85,553 | 3,73,421 | 1,20,333.59 | 20,229.21 | 7,627.92 |
| 13 | | Odisha | 616 | 1,56,671 | 1,11,226 | 73,165 | 6,084.03 | 2,460.53 | 1,201.58 |
| 14 | | Punjab | 885 | 98,817 | 56,223 | 31,177 | 5,178.59 | 1,587.40 | 626.55 |
| 15 | | Rajasthan | 404 | 2,19,685 | 1,33,512 | 1,08,373 | 15,107.04 | 3,770.80 | 1,803.45 |
| 16 | | Tamil Nadu | 3,455 | 6,88,135 | 6,25,950 | 3,18,457 | 40,604.07 | 10,760.34 | 5,519.97 |
| 17 | | Telangana | 286 | 2,02,541 | 1,97,468 | 1,33,243 | 21,660.67 | 3,382.03 | 2,237.36 |
| 18 | | Uttar Pradesh | 4,287 | 17,55,476 | 12,36,917 | 6,15,696 | 77,340.18 | 27,064.96 | 10,979.07 |
| 19 | | Uttarakhand | 195 | 39,679 | 23,231 | 16,739 | 2,967.66 | 739.53 | 425.61 |
| 20 | | West Bengal | 466 | 4,69,773 | 3,53,548 | 2,14,089 | 23,396.09 | 7,327.79 | 3,708.77 |
| **Sub- total (States) :-** | | | **21,799** | **1,03,32,865** | **63,48,665** | **35,93,410** | **6,28,693.60** | **1,63,580.24** | **70,340.46** |
| 21 | North East States | Arunachal Pradesh | 48 | 7,274 | 7,226 | 2,874 | 422.39 | 163.79 | 110.20 |
| 22 | | Assam | 340 | 1,22,326 | 63,476 | 20,928 | 3,771.43 | 1,843.73 | 944.89 |
| 23 | | Manipur | 37 | 50,159 | 32,818 | 4,369 | 1,280.33 | 752.77 | 237.15 |
| 24 | | Meghalaya | 36 | 4,703 | 1,607 | 1,026 | 181.44 | 70.99 | 7.09 |
| 25 | | Mizoram | 44 | 35,227 | 11,820 | 3,453 | 761.91 | 538.38 | 119.47 |
| 26 | | Nagaland | 64 | 32,003 | 21,291 | 4,194 | 935.19 | 505.98 | 166.39 |
| 27 | | Sikkim | 11 | 563 | 535 | 270 | 18.60 | 8.74 | 3.88 |
| 28 | | Tripura | 83 | 85,638 | 57,374 | 43,002 | 2,566.56 | 1,373.15 | 811.65 |
| **Sub- total (N.E. States) :-** | | | **663** | **3,37,893** | **1,96,147** | **80,116** | **9,937.84** | **5,257.54** | **2,400.73** |
| 29 | Union Territories | A&N Island (UT) | 2 | 598 | 38 | 22 | 151.23 | 8.97 | 0.47 |
| 30 | | Chandigarh (UT) | - | 716 | 5,676 | 5,676 | 159.35 | 15.95 | 15.95 |
| 31 | | UT of DNH & DD | 9 | 6,724 | 6,255 | 4,141 | 484.26 | 129.78 | 107.83 |
| 32 | | Delhi (NCR) | - | 21,508 | 62,088 | 45,488 | 4,112.52 | 483.77 | 483.77 |
| 33 | | J&K (UT) | 332 | 55,134 | 29,749 | 8,615 | 2,996.34 | 832.84 | 193.02 |
| 34 | | Ladakh (UT) | 8 | 1,777 | 910 | 370 | 84.85 | 36.67 | 17.28 |
| 35 | | Lakshadweep (UT) | - | - | - | - | - | - | - |
| 36 | | Puducherry (UT) | 30 | 13,698 | 14,451 | 3,846 | 653.24 | 209.22 | 116.12 |
| **Sub- total (UT) :-** | | | **381** | **1,00,155** | **1,19,167** | **68,158** | **8,641.79** | **1,717.20** | **934.45** |
| **Grand Total^ :-** | | | **22,843** | **1.08 Cr.** | **66.64 Lakh** | **37.42 Lakh** | **6.47 Lakh Cr.** | **1.72 Lakh Cr.** | **74,856 Cr.** |

***The projects under Progress***

The Construction of Demonstration Housing Project (G+3) for use as Working Women Hostel using Light gauge Steel technology including on site Infrastructure Work at Panchkula, Haryana & Construction of Demonstration Housing Project (G+1) for social purpose using Stay in place structural formwork System including on site Infrastructure Work at Agartala, Tripura, are in progress.

***Recently awarded Projects***

The two projects namely Old Age home Project comprising of single & multiple sharing rooms & facilities as Activity room, prayer room, Doctor room, Dining hall etc with all necessary on-site infrastructure components , at Chimbel, Goa & Affordable Housing Project for PMAY (U) beneficiaries with 40 Dwelling Units & all necessary on-site infrastructure components, at Hathijan, Ahmedabad, Gujarat

**iv. Use of new Technology by States and other agencies:**

The Table-2 gives the uses of technologies by different states and private agencies.

**Table-2: Uses of technologies by different states and private agencies.**

| Sr. No. | State | No of houses | | | |
|---|---|---|---|---|---|
| | | PMAY(U) Including Earlier Scheme | Under State Scheme | Private Sector | Total |
| 1. | Andhra Pradesh | 7,01,517 | 2,528 | - | 7,04,045 |
| 2. | Bihar | 36 | - | - | 36 |
| 3. | Chhattisgarh | 17,801 | 192 | - | 17,993 |
| 4. | Delhi (UT) | 13,524 | 77,384 | - | 90,908 |
| 5. | Gujarat | 53,463 | 2,240 | - | 55,703 |
| 6. | Haryana | - | 700 | 24,750 | 25,450 |
| 7. | Himachal Pradesh | 249 | - | - | 249 |
| 8. | Jharkhand | 1,673 | 40,750 | - | 42,423 |
| 9. | Karnataka | 14,020 | 5,663 | 23,599 | 43,282 |
| 10. | Madhya Pradesh | 1,024 | - | - | 1,024 |
| 11. | Maharashtra | 1,40,901 | 1,67,252 | 66,424 | 3,74,577 |
| 12. | Orissa | 7,794 | - | - | 7,794 |
| 13. | Puducherry (UT) | 1,136 | - | - | 1,136 |
| 14. | TamilNadu | 24,132 | 1,492 | - | 25,624 |
| 15. | Telangana | 18,612 | - | 2,475 | 21,087 |
| 16. | Tripura | 1,000 | - | - | 1,000 |
| 17. | Uttar Pradesh | 1,080 | 2,658 | 71,696 | 75,434 |
| 18. | Uttrakhand | 2,187 | - | - | 2,187 |
| 19. | West Bengal | - | - | 12,659 | 12,659 |
| **Total** | | **10,00,149** | **3,00,859** | **2,01,603** | **15,02,611** |

**v. Organization of Global Housing Technology Challenge-India**

The MoHUA organized "Global Housing Technology Challenge-India (GHTC-India)" in March 2019 with an objective to identify & mainstream innovative technology for mass housing which would bring paradigm shift to housing construction scenario that is cost-effective, fast, safe, sustainable and adaptable to suit different geo-climatic conditions of the country. Grand Expo-Cum-Conference of Global Housing Technology Challenge - India (GHTC-India) was held on 02-03 March, 2019 at Vigyan Bhavan, New Delhi. A basket of 54 proven technologies has been shortlisted under GHTC India in six broad categories by Technical Evaluation Committee (TEC) as constituted by MoHUA, GoI. In a significant step to mainstream these technology, construction work of 6 Lighthouse projects of about 1000 EWS houses have been awarded each in six identified regions of the Country in States of Madhya Pradesh, Jharkhand, Gujarat, Tamilnadu, Tripura & Uttar Pradesh using technology from each of 6 broad categories.

The Council has published digital version of 3rd edition of Vulnerability Atlas of India. In order to educate about the Vulnerability Atlas of India and Disaster resistant design & construction practices, the Secretary, Ministry of Housing & Urban Affairs, Govt. of India had written letters to Chief Secretaries of State/UTs, IITs, CPSUs and Central Ministries/Deptt. to organize state level one-day workshops. These workshops are designed for engineers, architects and other stakeholders dealing with housing and buildings. Six Thematic

Workshops on Vulnerability Atlas of India and Disaster resistant design & construction practices, has already been organized successfully so far.

The E-Course on Vulnerability Atlas of India was launched by Hon'ble Minister of State (I/C) for Housing and Urban Affairs on August 29, 2019. The e-course is offered by the School of Planning & Architecture (SPA), New Delhi and Building Materials & Technology Promotion Council (BMTPC), Ministry of Housing & Urban Affairs. The registration to e-Course on Vulnerability Atlas of India is through SPA's website www.spa.ac.in. It is a unique course that offers awareness and understanding about natural hazards, helps identify regions with high vulnerability with respect to various hazards (earthquakes, cyclones, landslides, floods, etc.) and specifies district-wise level of damage risks to the existing housing stock. The e-course is a tool for effective & efficient disaster mitigation & management in the field of Architecture, Civil Engineering, Urban & Regional Planning, Housing & Infrastructure Planning, Construction Engineering & Management and Building & Materials Research.

A series of activities have been envisaged by the Ministry of Housing & Urban Affairs for implementation under GHTC-India. As part of "Construction Technology Year 2019-20", it is planned to initiate a Certificate Course on Use of Innovative Construction Technologies titled "NAVARITIH" by BMTPC in collaboration with School of Planning & Architecture, New Delhi. The objectives of the Certificate Course are to (a) Familiarise the professionals with the latest materials and technologies being used worldwide for housing, (b) Provide an awareness of the state of art of materials and technologies in terms of properties, specifications, performance, design and construction methodologies so that professionals can successfully employ these in their day to day practice and (c) Provide exposure to executed projects where such materials and technologies have been implemented. The Course will be available for any person having B.E. / B.Tech (Civil) or B.Arch. (or equivalent) or Diploma in Civil with 5 years' experience. A number of meetings to conceptualize the Certificate Course were held in the Ministry with BMTPC and SPA New Delhi. The reading material for the Course is under finalization with the help and support of SPA.

In its continuing effort for creating proper eco-system for adoption of new technologies, MoHUA has published the following documents under Sub-Mission:

- Compendium of Prospective Emerging Technologies for Mass Housing (Third Edition containing 24 New Technologies).
- Best Practices: Habitat Planning & Design for the Urban Poor.
- Compendium of Best Practices in States.
- Model Expression of Interest using Alternate Technology.
- Multi-Attribute Evaluation Methodology for Selection of Emerging Housing Technologies.
- Booklet on emerging construction Systems, May 2018.
- Ready Reckoner for Utilization of Recycled Produce of C&D Waste,
- Guidebook for Concreting Artisans,
- Manual on Waterproofing of GFRG / RAPIDWALL Buildings
- Digital version of 3rd edition of Vulnerability Atlas of India -Hon'ble Prime Minister, released the digital version of Third Edition of Vulnerability Atlas of India on the occasion of Global Housing Technology Challenge - India (GHTC-India), Construction Technology India 2019 Expo-cum-Conference on 2nd March, 2019 at New Delhi.

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Demonstration Housing Project at Bhubaneshwar, Odisha

# Policy Agenda for Housing the Urban Poor

*KK Pandey*[1]

## INTRODUCTION

This document briefly brings together a brief and pointed road-map for policy agenda on housing the urban poor. We may recall that housing has multiplier effect on income, employment, quality of life and safe environment. It is equally important for poor who are an integral part of city economy. Merely the difference between households and houses does not show the magnitude of housing shortage. It is basically the requirements of urban poor that reveal housing backlog. These have serious implications on urban poor in terms of health, hygiene and their economic potential. Housing backlog of poor also indicate the multidimensional poverty in terms of shelter, services, access to income and employment. Congestion factor accounted for 80 percent of backlog (18.78 million houses) followed by 12 percent for obsolescent houses and 8 percent for non-serviceable and homeless conditions[1].

1 Pandey,KK,Pioneer ,October 28,2017:Urban Housing to Stimulate Urban Economy ,

**Table 1 : Housing backlog in Urban Areas**

| Housing Backlog | Congestion factor | Obsolescent houses | Non serviceable houses /homeless conditions |
|---|---|---|---|
| 18.78 million | 80% | 12% | 8% |

Nearly 87 percent of Housing backlog belongs to the households living in deficient areas accommodating mostly the poor. These are illegal land subdivision, slums, squatters, and congested core city areas. Most of the backlog on congestion factor (more than one married couple sharing the same roof) is caused by inadequate housing in these settlements.

## PRADHAN MANTRI AVAS YOJANA

The NDA government has taken up housing in its priority areas and initiated Pradhan Mantri Avas Yojna-Urban (PMAY-U), first of its kind initiative to expedite supply of affordable housing to a cross section of households. The PMAY-U has been launched on 25 June 2015 in a participatory manner having intergovernmental consensus to work as team India. The scheme adopted a flexible approach and gave adequate discretion to states to decide norms for size and other parameters. The scheme has yielded positive results and has achieved fifty percent plus target in the span of five years. PMAY-U has four verticals which promote in-situ slum development, affordable housing through credit linked subsidy, affordable housing in partnership and beneficiary led individual houses. Latest achievement of PMAY is as follow:

PMAY-U had a target to make available 20 million houses by 2022 (Table 2). It has crossed half way mark with 1.05 Trillion Houses Sanctioned by September 2020. About ten million houses are either constructed or being constructed under the scheme. The PMAY has released Rs.72418 crores along with a multiplier effect on investment in housing which is likely to be Rs.6.4 Trillion commitment from perspective house owners. The

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**Table 2 : Progress of PMAY**

| Target Houses by 2022 | Houses Sanctioned | Housed Grounded | Houses Under Construction / Constructed | Amount released out of sanction of Rs.1.66 trillion | Investment Committed |
|---|---|---|---|---|---|
| 2 million | 1.05 Trillion | 6.6 million | 3.5 million | Rs.72418 million | Rs 6.4 trillion |

Source Dashboard of Ministry of Housing and Urban Affairs, GoI September 2020

scheme has grounded 6.6 million houses (already occupied) and, 3.5 million have been constructed. This confirms a multiplier effect of the mission in the supply of urban housing. It is estimated that PMAY sanctions will generate 36.5 million jobs in addition to around 16 million jobs created by the houses grounded under the mission[2].

## THE NEED FOR POLICY AGENDA

The achievements under the mission are substantial and reduce pressure of filtering (demand by relatively higher income group) on low income housing. Yet, the progress of remaining left over mandate of PMAY-U is particularly important in view of large number of population living in low income areas along with congestion factor and dilapidated structures.

As urban development is state subject in the federal structure of India, the respective states have to continue their efforts for enabling environment and motivation of ULBs (Urban Local Bodies) for pro-poor supply of housing. Accordingly, the team India has to target housing the poor taking lessons from the current outreach and backlog among urban poor. These should include the need to city-wide approach to reconstruct low income housing areas which have been developed without appropriate plan, lack of formal credit to poor, scope of incremental housing and self help housing, secure tenure for housing, circulation, open spaces, rental housing, facilitation of construction workers, coverage of all the urban areas under PMAY-U, and revision of National Housing and Habitat Policy 2007.

Further the recent outbreak of COVID pandemic which started from cities and adversely affected the entire urban population and urban poor in particular needs attention. The insufficiency of space has causes migration of millions of poor to their native place. The economic activities in cities got serious setback including house construction and real estate sector which include ninety percent workers from informal sector and poor segment of society.

## THE POLICY AGENDA

The PMAY should be the driving force to consolidate intergovernmental synergy for accelerated supply of housing particularly to facilitate urban poor. Further, a range of actions as elaborated in the following points need to be adapted in the intergovernmental system of housing delivery.

### Citywide Plan for Urban Renewal

The citywide plan under PMAY need to be prepared by ULBs with special focus on slums, squatters, illegal land subdivision and core city areas. It will automatically promote coverage of urban poor .In this regard; land tenure is a major hurdle to initiate housing projects in existing settlements that require reconstruction and augmentation of services as a support to sustainable housing. Suitable instruments need to be devised by respective states to take up renewal in a planned and phased manner.

### Removing Dilemma of Formal Finance

There is a dilemma in the housing market that poor who account for 96 percent of backlog have access to 3 percent of formal credit and other income groups have 97 percent of bank credit account for only 4 per cent of backlog. In this regard the government of India has already initiated financial inclusion through Jan Dhan Yojana which may be utilised to enlarge coverage of formal finance to urban poor.

**Table 3 : Dilemma in Housing Finance**

| Income Group | Housing Baclog (%) | Access to formal credit (%) |
|---|---|---|
| EWS/LIG | 95 | 3 |
| MIG/HIG | 5 | 97 |
| All | 100 | 100 |

Source :HSMI(figures are rounded of to nearest point)

### Incremental /Self-help housing and Infrastructure

Three areas namely incremental housing, self-help housing and infrastructure development in existing areas need special consideration. These are also linked with secure tenure. At the same time a comprehensive plan for infrastruc-

2 Economic Times,18 August ,2020

ture including open spaces should be prepared to promote sustainable housing for poor. Income and employment generation is an integral part of housing the poor. The workplace relationship, Transit oriented development, sale of FSI and land pooling schemes should be encouraged by housing policies. The urban poor have vast potential of self-help housing which should also be encouraged.

## Rental Housing

Rental housing has remained unattended for decades. Recent initiative of government of India has opened the potential of rental housing for a cross section of households and particularly the poor and migrants to cities[3]. The scheme for rental housing is expected to benefit 300000 migrants[4]. States should engage ULBs to prepare rental housing projects in association with private sector, business establishments and industrial sector. It should include a variety of housing types such as employee housing, police housing, housing for construction workers etc. Initial concessions in the property taxes, impact fee etc. should also be devised to encourage rental housing.

## Construction Workers

Construction workers are another important point of attention for housing initiatives. Their income and safety net should be developed in line with intention of Building and Other Construction Workers Act of 1996. Nearly Rs.30000 crores being collected as welfare cess on real estate development is pending with different states for potential use to support construction workers.

Half the states have used only less than 25 percent of cess whereas big states like Maharashtra have used less than 10 percent of cess in the welfare of construction workers. This money should also be used to provide rental housing as per section 34 of the Act and arranging other facilities. Role of ULBs should be strengthened. Registration process of construction workers should be simplified from the restriction of work at one place with more powers to ULBs through suitable amendment of Act.

## Inclusion of Census towns in the ULB system

At the same time all the urban areas need to be brought within the framework of PMAY-U to adequately cover urban housing initiatives in the census towns These towns are urban by character (census definition of 5000 population, density of 400 persons per sq.km. and employment of 75 percent male workforce in nonfarm sector activities) but not given status of urban local government (statutory town) by respective states. Government of India has been insisting states to include census towns in the ULB system since 2016 without a significant follow up by states[5]. As may be seen from table that 91 percent of 3892 census towns do not have city government since many years. Even 9% class VI towns have completed 10 years now without getting status of ULB in most cases. These towns have a sizable number of poor (such as NOIDA) who need to be duly covered for a safe house.

Therefore, the scope of PMAY urban should be increased to census towns along with their time bound inclusion in the ULB system. In this regard PMAY rural should not include census towns which will encourage the states to expedite the process.

**Table 4 : Census Towns : 2011**

| Class Size | Number of Census Towns | | | |
|---|---|---|---|---|
| Class I | 20 | 1% | 10 | 1% |
| Class IV | 1148 | 29% | 448 | 33% |
| Class V | 1713 | 44% | 540 | 40% |
| Class VI | 364 | 9% | 109 | 8% |
| **Total** | **3892** | **100%** | **1362** | **100%** |

## Revision of National Urban Housing and Habitat Policy

The National Urban Housing and Habitat Policy 2007 (NUHHP) need immediate review to incorporate action points as above along with other areas of attention to expedite supply of housing for sustainable habitat. NUHHP 2007 was the first policy of its kind for urban areas in the country and needed a decadal review in 2017. It should be done at the earliest to revise the NUHHP to cover the latest issues and strategies adopted by India and other countries. The policy should also be adopted by respective states with their own housing policies giving due regard to housing the poor.

Finally, the intergovernmental policy agenda on housing the urban poor covering city wide plan, land tenure, access to formal finance, inclusion of census towns and due revision of NUHHP 2007 is necessary to take full advantage of urbanisation process, demographic dividend and competitive edge. At the same time, efforts should also be made to expedite supply of housing to ease pressure from low income housing and facilitate housing to a cross section of households.

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3 Government of India has announced Affordable Rental Housing scheme for migrant workers and urban poor with an outlay of Rs.600 crores.

4 Hindustan Times, July 08, 2020.

5 The Government of India, Ministry of Housing and Urban Affairs (MHUA) wrote to states in May, 2016 to expedite conversion of census towns as statutory town.

# Sustainable Design for Housing in Warm Humid Climatic Region – A Way Forward



*Dr. S.K. Singh*[1] *Sara Ali*[2] *Utkarsh Singh*[3]


## ABSTRACT

Housing is a basic human need. In India, housing shortage in urban areas is around 10 million units. Most of the housing shortage lies in the economically weaker section (EWS) and lower income group (LIG) segment. Several people are still living in informal settlements and slums. Moreover, poor settlements and crowded housing are not only affecting their physical health but also causing stressful environment. Therefore, sustainable and affordable housing is need of hour with better living conditions and basic services. However, energy demand for housing is increasing day by day along with poorer climatic conditions. Thus, incorporation of passive techniques in building designs could lead to affordable housing without compromising with the quality of life. These techniques will reduce thermal cooling loads of buildings to maintain indoor temperature. These strategies could also be adopted for housing schemes for low-income group (LIG) and economically weaker section (EWS) to provide better and comfortable living standards. Passive strategies enhance the usage of renewable sources of energy, which in turn will make the building cost efficient. This paper focuses on various passive design techniques like orientation, window placement, sizes, shading devices, build form and shape and settlement pattern along with efficient use of sustainable building materials for warm-humid regions. Warm humid region climate is categorized by heavy rainfall and high humidity thus it is essential to provide maximum open spaces to allow cross ventilation. By using these strategies in housing, energy demand can be reduced by 25-35% thus making building energy efficient. Therefore, it is necessary to incorporate passive techniques in designing of housing to maintain the thermal comfort with in the buildings in sustainable and cost efficient manner.


**Keywords:** Affordable Housing; Energy efficiency; Passive design; Sustainability; Techniques; Warm-humid climate.

## INTRODUCTION

Houses and its surroundings are always connected to make the buildings comfortable and suitable for living. Built environment of shelter plays a major role on person's physical, psychological and emotional health. For weaker sections in the society, these conditions are lacking which needs to be satisfied. Housing condition is a socio-economic indicator in the evaluation of urban poverty. Physical aspects that size, designing and material used in housing should be of good quality to provide a better life (Zainal et al. 2012). Building sector is growing rapidly and is the third largest consumer of non-renewable source of energy after industries and farming (Chel and Kaushik 2018). In the nation's economy, it has a key role but has major impact and influence on the environment. Thus, sustainable building design techniques have a high potential to make a valuable contribution (Akadiri et al. 2012). Basic strategies like minimizing the energy demand, improved energy efficiency and appliance of passive

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strategies are required. Therefore, environmental evaluation and energy performance audit of buildings are becoming important parameters for sustainable design or green architecture (Ghaffarianhoseini et al. 2013). Sustainable buildings are also known as green buildings, which are eco-friendly and energy efficient. The sustainability is highly influenced by financial system, materials, availability of technology and affordability. The main aims of these buildings are efficient energy usage, water, other resources, and improving user's productivity (Singh et al. 2010).In sustainable designing; there are four main strategies for buildings: (i) passive solar gain, (ii) active solar gain, (iii) active wind gain, and (iv) facade designing. Passive solar means building orientation according to sun while active solar involves appliance of photovoltaic cells. Elevation design along with considering building facade also acts a source for internal heat gain thus appropriate materials should be used to maintain the thermal comfort (Wang and Adeli 2014; Radwan et al. 2015).

## SUSTAINABLE DEVELOPMENT

Sustainable development focuses on the environmental conditions with social and economic issues. Quality life can achieve by creating a balance between living conditions and surroundings (Serag 2013). It not only promotes healthy living environment but also promotes economic development by providing affordable housing to weaker sections of the society. Integrated with sustainability framework, these housing will give better living opportunities to the slums promoting their physical and mental health .Moreover these houses last longer and could act as a better investment for the stake holders (Golubchikov and Badyina 2012).The quality of housing and the environment can be improved by social development and increases the demand for technical and organizational housing (Bredenoord 2015). Construction of housing consumes 38% of the total energy annually (Yüksek and Karadayi 2017).The main usage of energy in a building comprises of lighting, heating, cooling, ventilation etc. It is also consumed during production of materials, known as embodied energy. Thus, there is a need to conserve energy through appropriate designing, proper orientation, better building form, efficient usage of climatic conditions and site planning along with gainful utilization of renewable resources to achieve thermal comfort (Thapa and Panda 2015). Energy usage in a building can also be reduced by using materials with low embodied energy like fly ash bricks; fiber reinforced bricks; timber and adobe bricks. Further cost can be minimized using solar water heater or photovoltaic cells at the roof to fulfil the basic energy demand (Chel and Kaushik 2018). Various policies such as Green Rating Integrated Habitat Assessment (GRIHA), Leadership in Energy and Environment Design (LEED), Bureau of Energy Efficiency (BEE) and voluntary green building rating systems (Sharma 2018) have been already initiated.

## WARM-HUMID CLIMATIC REGION

India is divided in six different climatic zones namely (i) Hot and dry, (ii) Warm and humid, (iii) Moderate, (iv) Cold and sunny, (v) Cold and cloudy and (vi) Composite. Warm humid region is comparatively high temperature region ($30^0$C -$35^0$C), heavy rainfall and relatively high humidity all over the year. The temperatures remain same all through the day with light winds. The intensity of solar radiation is also high with heavy precipitation and humidity levels (Conservation and Code 2007).Temperature, humidity and wind are the main elements of warm-humid climatic region, which effects thermal comfort of dwellings. As low income group (LIG) and middle income group (MIG) cannot afford the mechanical cooling to maintain the internal temperature thus passive techniques are effective measures to have an energy efficient building with economical annual cost (Roux 2015).

### Affordable Housing

In present scenario, there is a massive shortage of affordable housing in India. With the rise in economy, energy consumption in households is also increasing. By the appliance of air conditioning, operation and maintenance cost add on to the building cost and thus making it away from the budget of people. The building allows natural ventilation to maintain the comfortable internal temperature and reduce the consumption of energy in affordable housing as compared to commercial and institutional buildings (Sen 2014). The division of household according to JNNURM mission directorate (2011) as shown in Table 1 (TERI 2014).

### 3.2. Passive Strategies and Climate Responsive Design

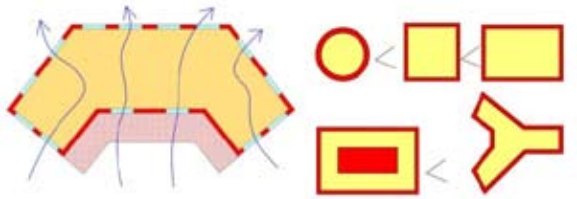
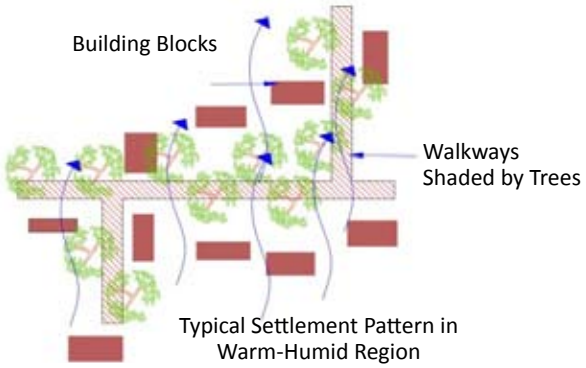
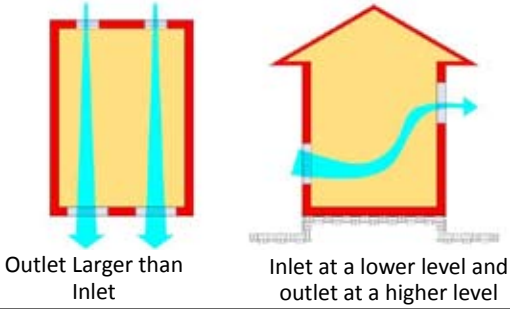
To enhance the indoor temper-

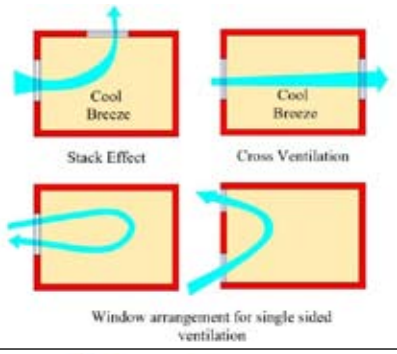
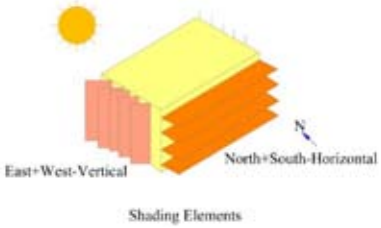
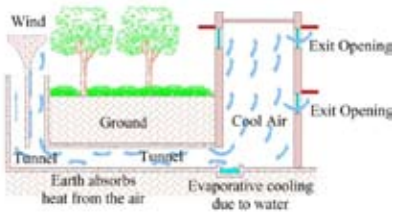
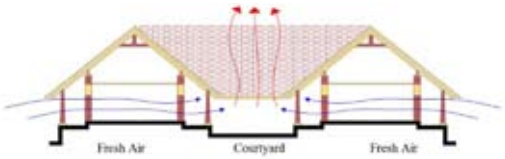
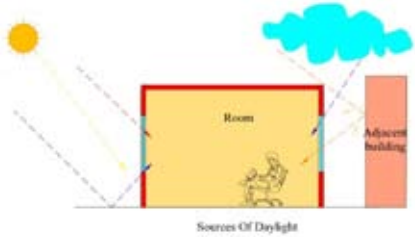
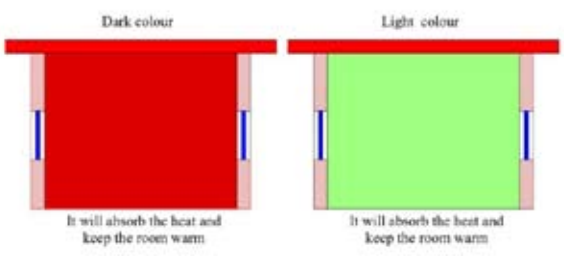
**Table 1: Definition of affordable housing: JNNURM directorate (2011)**

| Category | Size | EMI/Rent |
|---|---|---|
| EWS | minimum 27 sq m built up area & maximum 25 sq m carpet area | not more than 30-40% of gross monthly income of consumer |
| LIG | minimum 46 sq m built up area & maximum 48 sq m carpet area | |
| MIG | 55sqm-111 sq m built up area & maximum 80 sq m carpet area | |

ature insulation is required in wall and roof. The shading of windows by overhangs and side fins and using energy efficient materials in construction are also needed (Kini et al. 2017). Building are placed in scattered manner to allow air movement as it is needed in warm-humid region. Large openings are needed both in plan and elevation and the placement of bedrooms should be on east side as human body is more responsive to climate (Factors Governing the Design Aspects of Sustainable Building in Different Climatic Zones 2017). Passive design strategies and their applications are discussed below as shown in Table 2:

**Table 2: Passive strategies and their applications**

| S. No. | Passive Strategies | Sketch | Brief discussions |
|---|---|---|---|
| 1. | Orientation of buildings (Subramanian 2016) |  | Warm-humid regions are located near equator, thus longer sides facing north -south direction to avoid solar radiations. East and west require shading devices. |
| 2. | Open spaces and building form (Pawar and Hangargekar 2016) |  | Elongated plan with several openings to allow movement of air. Less the surface to volume ratio, less is the heat gain in a building. |
| 3. | Street width and settlement pattern (Environment 2016) |  | In the sub-urban areas the houses are scattered to maximize the prevailing winds. Trees plantation required in order to provide shading to walkways. |
| 4. | Window positioning and sizes (George and Dash 2019) |  | Window size is kept smaller on the windward side while in the leeward side greater windows are encouraged for regular ventilation. |

| S. No. | Passive Strategies | Sketch | Brief discussions |
|---|---|---|---|
| 5. | Stack and Cross Ventilation (Aldawoud 2017) |  | Stack ventilation promotes the airflow by creating temperature difference while cross ventilation is governed by the window size and location. |
| 6. | Shading devices (Kannan and Dhanalakshmi 2017) |  | It aims in reducing the solar heat gain through opaque operable window with louvers acting as individual shading device. |
| 7. | Light Shelves (LoomanEt Al. 2007) |  | These are used to prevent unwanted solar rays entering in the building and divert the natural light on the ceiling to reduce dependence on mechanical lights. |
| 8. | Earth Air Tunnel -Passive Cooling (Gupta and Tiwari 2016) |  | The tunnel is made 2m-3 m below the earth surface since at that depth it is cooler than outside in summers through thermodynamic process. |
| 9. | Courtyard Planning (Dili et al. 2010) |  | It improves the microclimate, and promotes movement of air with in the house along with natural lighting. |
| 10. | Day lighting (Subramanian 2016) |  | Integrating day light with artificial lighting is essential to reduce the energy usage during the day and enhances the visual comfort. |
| 11. | Colour of the interior spaces (Hettiarachchi and Emmanuel 2017) |  | Dark colors absorb heat and keep the rooms warmer as compared to light cool color interiors that absorb less heat. |

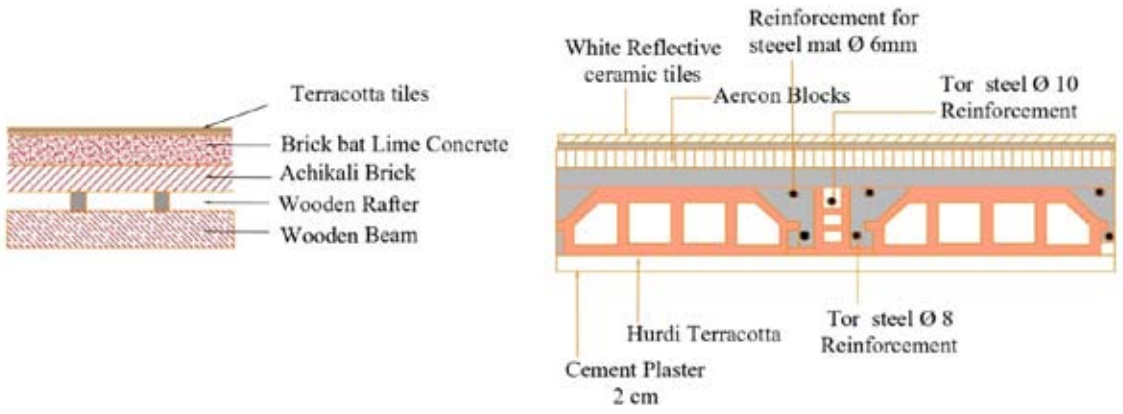



**Fig. 1:** (A) Traditional terracotta Madras roof (B) Sloped hollow block roof

## Construction of Roof

The construction of roof using traditional techniques and materials is shown in Fig. 1 (Pingel et al. 2019).

## SUSTAINABLE BUILDING MATERIALS

Building materials used that are locally available with less transportation cost, minimal $CO_2$ emissions, require less energy and sustainable. The application of sustainable building materials promotes skill development and offers employment opportunities to the community members (Aminu Umar et al. 2012). Some commonly used sustainable building materials for warm humid climate are discussed below:

Hollow concrete blocks are economical, environment friendly and low maintenance building material .It has good thermal insulation, fire resistance and load bearing capacity. In addition, its strength can be specified according to the site requirements (Fig. 2) (Chaureet al. 2018).

Timber has good thermal resistance, high heat storage capacity, and good regulation of humidity as warm-humid region has high moisture content (Fig. 3) (Harte 2018).

**Fig. 2:** Hollow concrete blocks wall (Source-Chaure et al. 2018)

Bamboo Roofing Sheet is a successful roofing material it has almost similar tensile strength as that of steel. In addition, it is eco-friendly, light- weight, tough and long lasting and has minimum fire hazard (Refer Fig. 4) (Chowdhury and Roy 2013).

Ferrocement is made up of cement mortar and wire mesh reinforcement. It is thin in section and has less steel. It has lower embodied energy. It is strong durable and a cost effective material and used in construction of hollow columns, walls, beams and for repair of deteriorated structures(Deshmukh, 2013).

Laterite stone is commonly used material in low-cost construction at Kerala, Karnataka, Goa and Andhra Pradesh. Usually, plastered with lime mortar and it gains strength on exposure to air and sun(Fig. 5) (Maklur and Narkhede 2018).

**Fig. 3:** Timber construction

**Fig. 4:** Low cost bamboo housing

**Fig. 5:** Red Laterite stone construction

Mangalore tiles are cheap, durable and eco-friendly material used in roofs. Applied in kitchen and bathroom to remove the smoke through the air gaps in between the tiles. It is made up of laterite clay and placed over sloping roofs as it experiences heavy rainfall (Fig. 6) (Sarathraj and Somayaji 2014).

**Fig. 6:** Mangalore tiles used in roofs (Source -Sarathraj and Somayaji 2014)

Coconut palms used as a vernacular building material in Tamil Nadu and Kerala due to its presence in large quantities. It is cheap, used in making thatch and mats from woven leaves. It is ecofreindly and suitable material for warm humid region (Fig. 7)(Killmann, and Fink 1996).

**Fig. 7:** Coconut palms roofs (Source-Killmann, and Fink 1996)

Adobe brick is made up of sand, clay along with chopped straw and moistened with water. For strength cow dung are also added. It is then dried in shape of the brick .Adobe bricks are ecofriendly, provides thermal comfort, requires low maintenance and is cheap. It used in construction of foundations, walls, door, windows, beams and roof (Fig. 8) (B. 2014).

**Fig. 8:** Adobe Brick wall construction (Source-B. 2014)

Rat-trap bond is masonry technique with cavity inside the wall. It requires brick as a building material. Along with the thermal load reduction it also saves the electricity usage (Refer Fig. 9) (Ullah et al. 2018).

**Fig. 9:** Rat Trap Bond masonry technique

Stone is the most ancient building material available in the form blocks and can be cut into various sizes. Stone can be used in construction of foundations, walls, columns, lintels, pavement of road due to its durability, appearance, and strength and is economical (Fig. 10) (Balasubramanian 2017).

**Fig. 10 :** Flat stones and large undressed stones (Mitigation and Centre 2013)

Raw Earth as a building material aims to build a link between raw earths as a building material with modern technologies. It has developed new techniques that save energy, environment-friendly and feasible. It focuses mainly on reduction in the usage of steel and cement. Compressed earth blocks are most widely used as a building material in Auroville (Refer Fig. 11) (Auroville's Case study).To prevents water erosion it is stabilized with 3-5% cement. These are durable, ecological, and cheap and require easy workmanship. Most of the construction in Auroville demonstrates this through vaulted floor and roof designs. (Bhatia, B. 2014).

**Fig. 11:** Buildings made from compressed earth blocks (CEB) (Auroville's Case study)

The Auram Press 3000 can create 80 types of blocks with 18 moulds. They are compressed in a press (manual or motorised) and cured for 28 days.

**Fig. 12:** Different construction blocks created by Auram Press 3000 (Source-Google images)

## ISSUES AND CHALLENGES

Urbanization in India has led to various challenges;

- **Changing climatic conditions:** Fossil fuel, change in land use and varied human activities leads to green house gas emissions, which in turn results in natural calamities.
- **Spatial planning:** Most of the urban growth is unplanned. The challenge is to deal with the sprawl areas and provide them with safe physical infrastructure like safe drinking water, electricity, sanitation, roads, transports and social amenities.
- **Social issues:** The skill system is being vanished and rich is becoming richer while the slums are increasing in no. The local bodies should be empowered and participation that is more public should be involved in planning process.
- **Governance:** It involves the process of decision making and implementation, but among various stakeholders there is a lack of coordination which leads to unplanned approach (Bahadure and Bahadure 2014).

## CONCLUSIONS

In urban housing sustainable living environment can be achieved by giving equal emphasis to environment and development issues. Enhanced living standards should be provided with basic human need and sustained eco-system. The climate responsive design helps in maintain the indoor environment quality and also helps to adopt traditional building methods using materials like laterite blocks, hollow concrete blocks, hollow clay blocks along with energy efficient passive design strategies. These strategies are good replacement to artificial cooling methods and

these are cost effective. Thus, it should be made mandatory for all the planners to incorporate these passive strategies and make the building energy efficient. Along with these proper spatial planning, socio-economic consideration is also needed .To attain sustainable development government authorities and stakeholder should develop sustainable housing plans with proper mechanism for future housing.

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# Demonstration Housing Projects – A step towards implementation of Emerging Technologies under PMAY (U)

BMTPC has been promoting new / alternate building materials & technologies in different regions of the country through identification, evaluation, standardization, certification, capacity building, training and field level application of such technologies. In order to showcase the field application of new / alternate technologies, MoHUA has taken an initiative to construct Demonstration Housing Project (DHP) through BMTPC as a part of Technology Sub-Mission under PMAY(U). The construction of Demonstration Housing Projects in different parts of the country aims to facilitate wide spread dissemination and adoption of new / alternate and sustainable building materials and technologies in preference to the conventional technologies and create enabling environment for the large scale adoption of such materials & technologies in different geo-climatic region of the country, thus making housing more affordable and accessible. Earlier, BMTPC has completed DHPs at Nellore, Andhra Pradesh; Bhubaneswar, Odisha; Lucknow, Uttar Pradesh; Biharshariff, Bihar; and Hyderabad, Telangana using emerging technologies. Presently the construction of DHP are under progress in following States:

## Demonstration Housing Project at Panchkula, Haryana

The Municipal Corporation, Panchkula has provided the land measuring 1400 sq.mts for construction of Demonstration housing projects to be used as working women hostel.

**Salient Features of the Project**

- Plot Area for DHP : 1412.36 Sq.mts.
- Total Covered Area : 2015.95 Sq.mts.
- No. of Units/Rooms : 40 (G+3)
- Carpet Area of a unit : 21.86 Sq.mts.
- Each unit consist of a room with attached toilet and kitchen
- Other provisions includes Guest Room Medical Room, Care Taker Room, Daycare Centre, Common Room/Dining Room and Laundry.

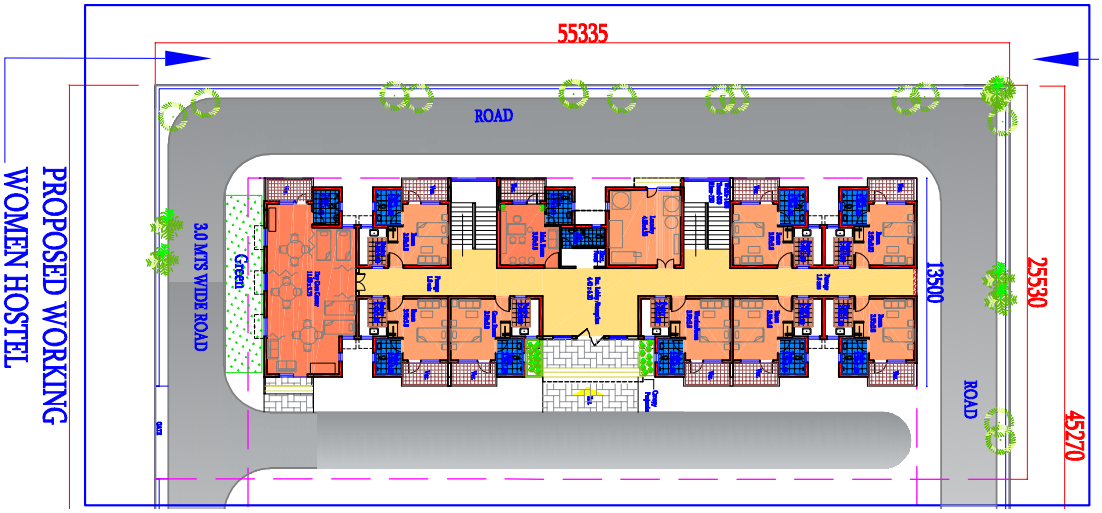
**Technology being used:**

Foundation

- Isolated RCC column footing with Plinth beam

Walling

- Light Gauge Steel Framework




Layout Plan of Demonstration Housing Project at Panchkula, Haryana

Use of Light Gauge Steel Framework System at Panchkula, Haryana

System (LGSFS) with Cement Fiber board on both side of walls and infill of rock wool.

Floor Slabs/Roofing

- Light Gauge Steel roof truss with MS deck sheeting resting on web joist and concrete screed with false ceiling of gypsum board.

***Joinery & Finishing***

Door frame/shutters:

- Pressed steel door frame with flush shutters
- PVC door frame with PVC Shutters in toilets.

Window Fame/ 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 and Staircase

Finishing:

- Weather Proof Acrylic Emulsion paint on external walls
- Oil Bound distemper over POP on internal walls

**Infrastructure Components**

- CC Roads & Paver tiles in pavements,
- Rain water Harvesting,
- Solar Street Lights,
- Landscaped Court.
- Barrier Free Building

## Demonstration Housing Project at Agartala, Tripura

The Social welfare & Education Department has provided the land measuring 2360 sqmts (approx.) for construction of Demonstration housing projects to be used for social purpose. The proposed building would be used as hostel / home for destitute women.

**Salient Features of the Project**

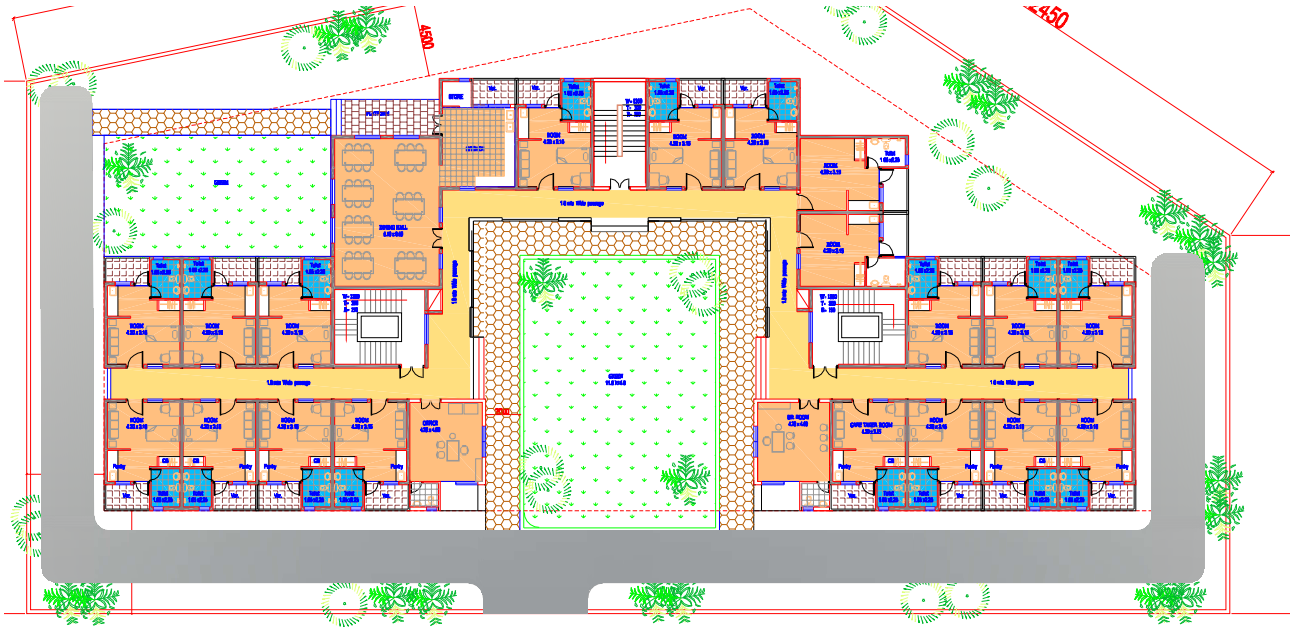
- Plot Area for DHP : 2360 Sq.mts.
- Total Covered Area : 1833.74 Sq.mts.
- No. of Units/Rooms: 40 (G+1)
- Carpet Area of a unit : 21.86 Sq.mts.
- Each unit consist of room with attached toilet and Pantry
- Other provisions includes Guest Room Medical Room, Care Taker Room, , Common Dining Room with Kitchen and Activity Room

**Technology being used:**

Foundation

- Isolated RCC column footing with Plinth beam

Use of Structural Stay-in-Place Steel Formwork (Coffor) System at Agartala, Tripura



Layout Plan of Demonstration Housing Project at Agartala, Tripura

Walling

- Structural Stay in Place Steel Formwork (Coffor)
- Floor Slabs/Roofing Cast in situ RCC Slab

***Joinery & Finishing***

Door frame/shutters:

- Pressed steel door frame with flush shutter
- PVC door frame with PVC Shutters in toilets

Window Fame/ 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 and Staircase

Finishing:

- Weather Proof Acrylic Emulsion paint on external walls
- Oil Bound distemper over POP on internal walls

Infrastructure Components

- CC Roads & Paver tiles in pavements,
- Provision for Rain water Harvesting,
- Solar Street Lights,
- Landscaped Court

## Demonstration Housing Projects at Ahmedabad, Gujarat

The Gujarat Housing Board has provided the land measuring 2400 sq.mts for construction DHP consists 40 DUs.The main feature of the project are:

**Salient Features of the Project**

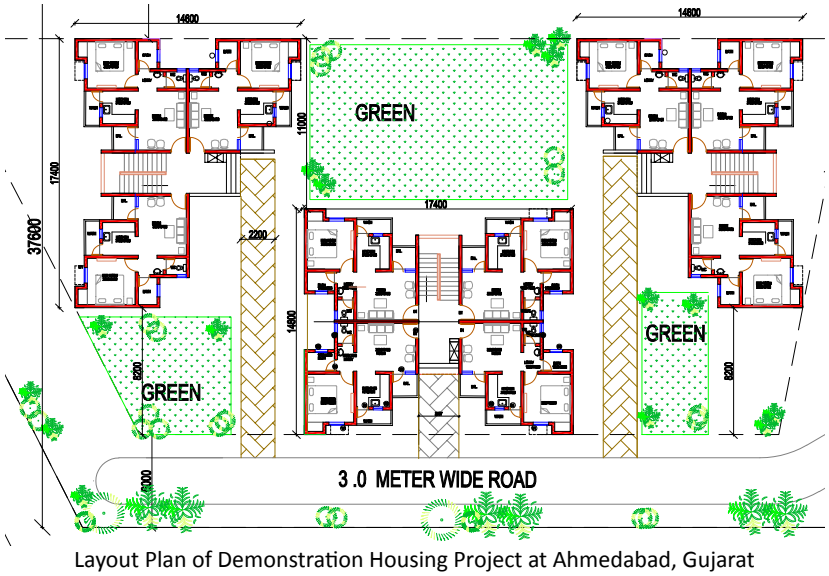
- Plot Area for DHP : 2372 Sqmt.
- Total Covered Area : 2056.80 S qmt.
- No. of Units/Rooms : 40 (G+3)
- Carpet Area of a unit : 35.78 Sqmt.
- Each unit consist of a living room, bed room, lobby kitchen, bath, WC, verandah and separate wash area.

**Technology being Used**

Foundation

- Strip-step footing with plinth bend for earthquake resistant structure

Walling




Layout Plan of Demonstration Housing Project at Ahmedabad, Gujarat

- Load bearing interlocking blocks (Hydra Form Blocks)

Floor Slabs/Roofing

- Precast RC Planks and Joists System with screeding.

***Joinery & Finishing***

Door frame/shutters

- Pressed steel door frame with flush shutter.
- PVC door frame with PVC Shutters in toilets.

Window Fame/ Shutter:

- uPVC frame with glazed panel and wire mesh shutters

Flooring

- Vitrified tile flooring in Rooms & Kitchen
- Anti-skid ceramic in bath & WC
- Kota Stone Flooring in Common area and Staircase

Finishing

- Weather Proof Acrylic Emulsion paint on external walls
- Oil Bound distemper over POP on internal walls

**Infrastructure Components**

- CC Roads & Paver tiles in pavements,
- Boundary wall with gate
- Under water tank
- Rain water Harvesting,
- Solar Street Lights,
- Landscaped Court
- Firefighting work

## Demonstration Housing Projects at Goa

Goa State Urban Development Agency, Goa has proposed to use the DHP for social welfare cause (Old Age Home) and Institute of Public Assistance (Provedoria) provided the land within its own premises at Chimbel, Goa measuring 2000 sq.mts for DHP. The main feature of the project are:

**Salient Features of the Project**

- Plot Area for DHP: 2000 Sq.mts.
- Total Covered Area: 1954.2 Sq. mts.
- DHP is double storied building consists of five single rooms, two double rooms, one 3-sharing, four 4-sharing, one 7-sharing and one 10-sharing rooms
- The other provisions includes Activity room, prayer room, dining hall with kitchen reading room doctors room, Physio therapy room, emergency care room, nurses room, caretaker room guest room, office, convenience room, and separate toilets for ladies & gents, ramp & Lift Room

**Technology being Used**

- Foundation: Isolated RCC column footing with Plinth beam
- Walling: Light Gauge Steel Framework System (LGSFS) with Precast concerte panel on both side of walls and light weight concrete as infill.
- Floor/Roofing Slabs: Light Gauge Steel roof truss with MS deck sheeting resting on web joist & screed concrete with false ceiling of gypsum board.

***Joinery & Finishing***

Door frame/shutters

- Pressed steel door frame with flush shutter
- PVC door frame with PVC Shutters

Window Fame/ Shutter:

- uPVC frame with glazed panel and wire mesh shutters

Flooring

- Vitrified tile flooring in Rooms & Kitchen
- Anti-skid ceramic in bath & WC
- Kota Stone Flooring in Common area and Staircase

Finishing

- Weather Proof Acrylic Emulsion paint on external walls
- Oil Bound distemper over POP on internal walls

**Infrastructure Components**

- CC Roads & Paver tiles in pavements,
- Boundary wall with gate
- Under water tank
- Rain water Harvesting,
- Solar Street Lights,
- Landscaped Court
- Firefighting work
- Barrier Free Building.

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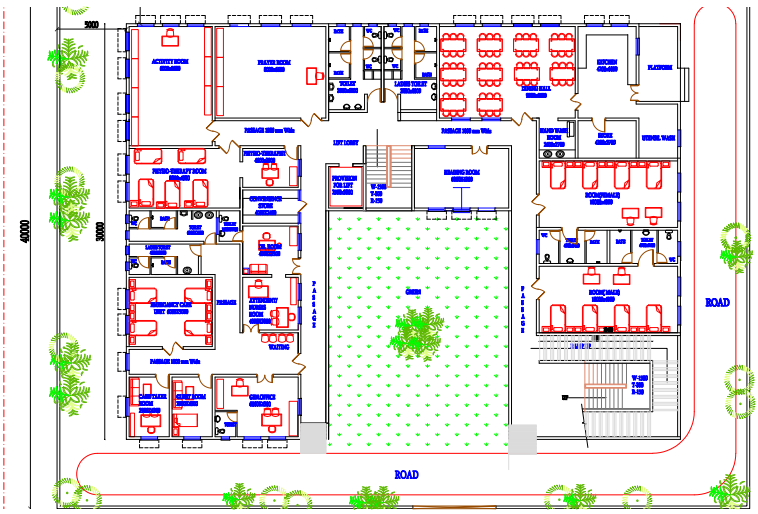


Layout Plan of Demonstration Housing Project at Chimbel, Goa

# Environment friendly Cellular Blocks for Masonry Construction

*Dr.Ajay Chourasia*[1] *Shubham Singhal*[2]


## Abstract

Burnt solid clay (BSC) units are prevalent in masonry construction, owing to traits of durability, thermal insulation and economy. However, manufacturing of BSC units leads to adverse environmental impact due to firing and depletion of natural resources. Moreover, masonry buildings with BSC units have shown poor seismic performance during the past earthquakes. To these considerations, alternate materials are required for masonry, which can impart seismic resistance, efficiency and sustainability in the construction. This paper proposes innovative fly-ash and cement based cellular (FCC) blocks, having eco-friendly manufacturing process. The FCC blocks measured 590 x 270 x 140 mm, with four vertical holes (60 mm in dia) and trough shaped projected notch, which fixes into the notch of upper FCC block, thus bestowing an interlocking mechanism. Material characterization of FCC block was carried out to evaluate water absorption, dry density, compressive strength, elastic modulus and Poisson's ratio. To examine seismic performance of masonry using FCC blocks, a full scale confined masonry (CM) building was constructed with FCC blocks for lateral load test. The building plan dimensions were 2.90 x 2.90 m, with a height of 3.20 m. Two out of four holes in each FCC block were casted with M20 grade concrete and provided with 8 mm dia vertical reinforcement. The seismic behaviour of CM building was evaluated in terms of damage pattern and seismic parameters. The tested building demonstrated superior seismic performance with higher strength, initial stiffness and deformation characteristics. Thus, the proposed FCC blocks may be adopted in the construction of masonry buildings in the regions to moderate to high seismicity.


**Keywords:** FCC blocks, material characterization, confined masonry, lateral load test, seismic performance.

## 1. Introduction

Masonry is one of the most commonly adopted construction material, owing to its advantages like durability, fire resistance, thermal insulation, easy to construct methodology and economy. Masonry construction is widely adopted for low-to-medium rise buildings. However, masonry using burnt solid clay (BSC) units has its own limitations i.e., poor strength, low interfacial strength between mortar-unit, workmanship, time consuming construction etc.

Masonry buildings have shown poor seismic performance in past earthquake like Bhuj earthquake (Jagadish et al. 2001), Great Sumatra earthquake (Boen 2006), Kashmir earthquake (Rossetto and Peiris 2009) and Chile earthquake (Alcaino et al. 2012). Lack of integral action between masonry units and poor shear strength are major causes for their undesirable behaviour during the ground motion. Owing to certain drawbacks of masonry construction, there is a need to explore alternate building materials as a substitute to BSC units, which can impart sustainability, efficiency, strength and seismic resistance in masonry construction.

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Literature mentions several innovative materials for masonry construction. Salinas et al. (2008) proposed tubular bricks for masonry construction, which showed higher shear strength as compared to standard bricks. Pradeepa et al. (2016) evaluated the behaviour of reinforced thermocol panels, which provided large bending stiffness. Other building materials for masonry construction are weakly reinforced masonry panels (Calvi and Bolognini, 2001), semi-interlocking masonry (Totoev 2015), AAC sandwich blocks (Farid et al. 2017), light weight concrete panels with polypropylene fibers (Aqeel et al. 2017) etc. Literature reveals studies on individual behaviour of such systems, while full-scale experimental investigations on global seismic behaviour of masonry buildings using such systems are scarce.

This paper focuses on the Fly-ash and Cement based Cellular (FCC) blocks for masonry construction. The FCC block consists of fly-ash, cement, foaming agent and water in appropriate proportion. The FCC blocks have eco-friendly manufacturing process unlike BSC units, with the production of latter involving firing, consumption of coal and top soil, which consequently results in negative impact on the environment. Thus, construction using FCC blocks bestows sustainability in the construction. The FCC block was tested for its material properties and implemented in a full-scale confined masonry (CM) building, which was tested under displacement controlled reversed cyclic lateral loading to evaluate its seismic parameters.

## 2. Fly-ash and Cement based Cellular (FCC) Blocks

### 2.1 Material composition and geometry

Fly-ash and cement based cellular (FCC) block consists of cement (140 kg), fly ash (580 kg), foaming agent and (80 litre) and water (80 litre) per cubic meter. FCC block has dimensions 590 mm (L) x 270 mm (H) x 140 mm (T), with a 20 mm x 72 mm trough shaped projected notch, which fixes into the notch of upper FCC block, thus bestowing an interlocking mechanism and enhancing integral action of the masonry. Fig. 1(a) to (d) gives the geometry of FCC block, while the actual FCC block is portrayed in Fig. 1(e). FCC block consists of four number of vertical holes (60 mm in dia), provided equidistantly at a spacing of 157 mm c/c. These blocks can be implemented in load bearing masonry walls in masonry buildings, as well as masonry infill for Reinforced Concrete (RC) frame buildings.

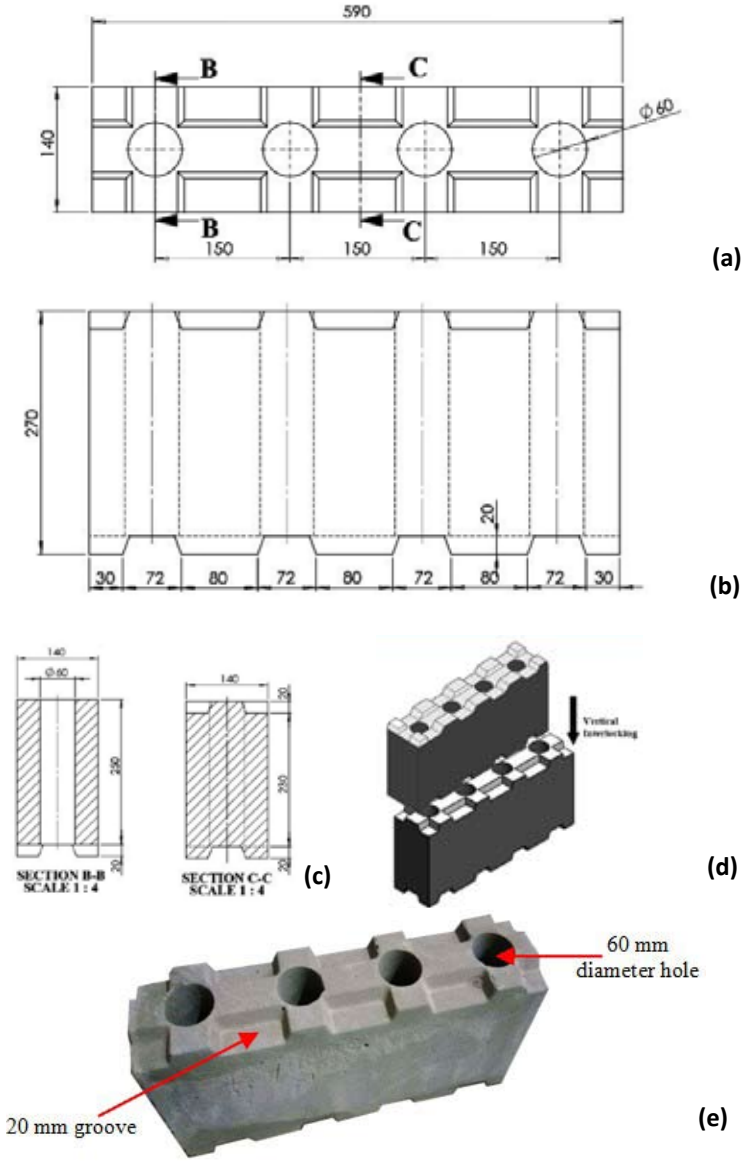


Fig. 1: (a) Plan; (b) front elevation; (c) side elevation; and (d) isometric view; and (e) actual view of FCC block

### 2.2 Salient features of FCC blocks

The proposed FCC blocks have the potential to provide speed in construction, safety, sustainability, economy and more carpet area, leading to end user satisfaction; and satisfying the pre-requisites of tenets:

- safety: satisfactory performance in axial and lateral loads;
- functionality: providing thermal comfort and acoustic insulation;
- sustainability: use of waste products viz. fly-ash and eco-friendly manufacturing process;
- aesthetics: compliant to social environment, reduced cross-section giving more carpet area;
- efficiency: faster pace of construction (5-6 days / floor), no use of heady equipments; light weight, easy installation; and
- economy: cost-effective than RC buildings.

### 2.3 Material characterization

In order to evaluate the material and engineering properties of FCC blocks, extensive experimental investigation was carried out. The dry density was obtained to be 7.93 kN/m$^3$, while water absorption capacity was found to be 41% in accordance with IS 3495-2002 (Parts 1 and 2). High water absorption is attributed to the usage of foaming agent which leads to pores on the surface. Uni-axial compressive strength of material cubes and FCC block was determined in compliance with IS 516: 2004 and ASTM C-1314-b respectively. The specimens were subjected to displacement controlled load with 100 ton Universal Testing Machine (UTM), at a rate of displacement 2 mm/min. Fig. 2(a) shows the compressive strength test set-up. Fig. 2(b) and (c) show the failure mode of cube and FCC block respectively. The compressive strength of material was determined as 3.17 MPa, while compressive strength of masonry was obtained as 1.2 MPa. Engineering properties computed were elastic modulus (1200 MPa) and poisson's ratio (0.12).

Fig. 2. (a) Compressive strength test set-up; (b) failure pattern of material cube; and (c) failure pattern of FCC block under uni-axial compression

## 3. Construction of CM building using FCC blocks

A full scale CM building was constructed with FCC blocks in the laboratory for lateral load test. The building plan dimensions were 2.91 m x 2.91 m, and a height of 3.20 m. The thickness of masonry walls was 140 mm, supporting a RC slab of 100 mm thickness. The tie-columns (140 mm x 140 mm) were provided at the wall intersection and bond beams (140 mm x 150 mm) at lintel level. M20 concrete and Fe500 rebars were used in RC elements, which consisted of 4-10 mm diameter longitudinal reinforcement and 8 mm dia stirrups at 200 mm c/c. Two out of four holes in each FCC block were casted with M20 concrete and provided with 8 mm dia vertical reinforcement projecting from the plinth level up to the roof slab. The casted holes act as core columns and will impart strength and stiffness. Fig. 3 shows the construction sequence of CM building using FCC blocks.


Fig. 3. Construction sequence of CM building using FCC blocks

## 4. Quasi-static lateral load test on CM building using FCC blocks

Full-scale CM building constructed using FCC blocks was tested under displacement controlled quasi static reversed cyclic lateral load at the top level through a 50 ton servo hydraulic actuator with a stroke length of ±75 mm. The lateral load was distributed through rollers ball bearings fixed with grillage mechanism and distributed over eight points at the roof level. This simulated a fixed boundary condition as a rigid diaphragm. Fig. 4 portrays the full-scale FCC block building subjected to lateral load at the roof level. Linear variable displacement transducers (LVDTs) were placed at critical locations to capture building deformations. The LVDTs were connected to data acquisition system to record displacement. The cyclic displacement was applied at equal intervals in accordance with ASTM 2126. The frequency was defined as 0.004 Hz to simulate time history displacement. The experiment was terminated at the attainment of failure state just before the collapse to prevent damage to the set-up and instruments.

Fig. 4. Experimental set-up for CM building constructed using FCC blocks

## 5. Results

The seismic behaviour of CM building using FCC blocks was evaluated in terms of damage pattern, lateral load carrying capacity, stiffness degradation and deformation characteristics. These seismic parameters are briefly discussed below.

### 5.1. Damage pattern

The cracks initiated at the lower course of masonry and near the bond mean during the 10 mm cycle. These cracks developed only in the plaster and not in the FCC blocks. At 15 mm cycle, horizontal cracks at the interface of upper and lower FCC blocks appeared, but interestingly restricted by the vertical interlocking between the blocks. During 25 mm cycle, the in-plane wall with opening developed diagonal shear cracks originating from the window corner, which extended diagonally towards the bottom in the further cycles. Spandrel masonry experienced significant cracks at 40 mm cycle. The cracks widened during the later cycles. FCC blocks started crushing at 45-50 mm displacement cycle. Although, core columns were found to be effective in controlling the crushing of blocks. The crushing intensified at higher loading. It can conveniently be said that the vertical interlocking and core columns in FCC blocks were advantageous in restricting the damage in masonry walls and provided integrity in the masonry. Fig. 5 shows the final damage pattern of the tested building.

### 5.2. Seismic performance parameters

The maximum lateral load capacity of the tested CM building constructed using FCC blocks was obtained as 133.6 kN at about 30 mm lateral deformation, which degraded to 113.5 kN at 42 mm displacement cycle (0.85 times the maximum load). The test building did not show much damage at this state, and test was continued till 65 mm. Fig. 6 shows the lateral load-displacement hysteretic curve of the tested building using FCC blocks. Initial stiffness was found to be 21 kN/mm, while stiffness at yield state was obtained as 8.22 kN/mm. Stiffness at peak load and ultimate state was evaluated as 4.35 kN/mm and 2.70 kN/mm. The CM building showed competent deformation characteristics, with a drift of 1.41% at ultimate state. Ductility was obtained as the ratio of ultimate displacement to the yield displacement, which was found to be 4.13. Response reduction factor was evaluated as 3.00, which is in accordance with IS 1893: 2016.

## 6. Conclusions

The paper illustrates innovative FCC blocks for masonry construction, imparting efficiency and sustainability in the construction. Experimental investigation included material characterization of FCC blocks, followed by displacement

Fig. 5. Damage pattern of tested CM building using FCC blocks

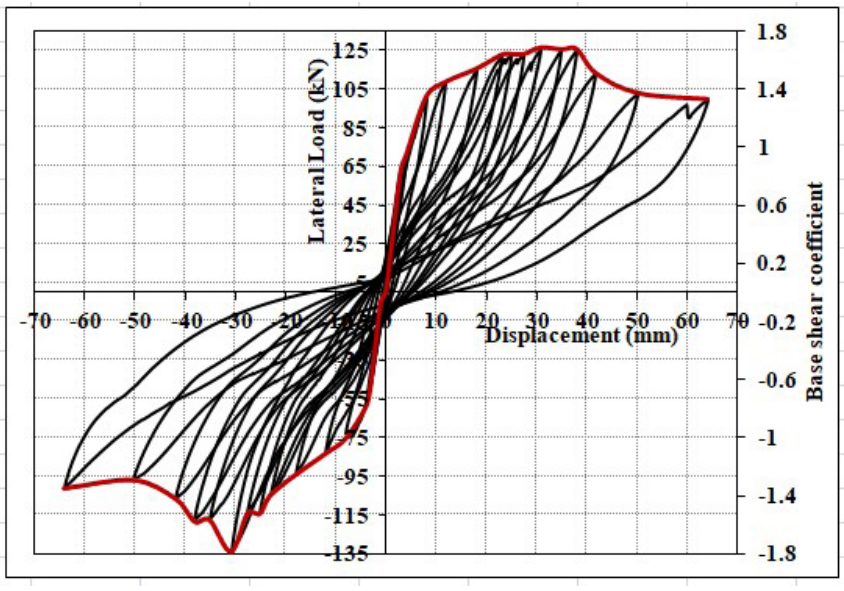


Fig. 6. Lateral load-displacement hysteretic curve of tested CM building using FCC blocks

controlled reversed cyclic quasi-static lateral load test on CM building constructed using FCC blocks. The key conclusions drawn can be summarized as:

1. FCC blocks have several advantages over the conventional masonry units in terms of being light weight, rapid construction, providing benefit of extra floor space due to reduced thickness and easy to construct methodology. FCC blocks impart sustainability by utilizing waste material (fly ash) and eco-friendly manufacturing process.
2. The proposed FCC blocks impart interlocking mechanism, which gives shear resistance and prevents block to block separation at the interface as observed during the lateral load test of CM building.
3. The tested CM building demonstrated crushing of FCC blocks at toe-region. The confining elements were found to be efficacious in limiting the damage by arresting the cracks in masonry. Core columns in FCC block masonry prevented extensive crushing and contributed in lateral load resistance of the building.
4. CM building using FCC blocks demonstrated superior seismic performance with higher strength, initial stiffness and deformation characteristics. Lateral load carrying capacity was found to be 133.6 kN, while stiffness at peak load was 4.33 kN/mm. Drift, ductility and response reduction factor were obtained to be 1.41%, 4.13 and 3.0 respectively.
5. The proposed FCC blocks will

be useful in affordable housing, imparting economy, safety, sustainability, speed and efficiency in masonry construction.

Based on extensive experimental investigation, it can conveniently be summarized that FCC blocks have potential to be deployed in low-to-medium rise masonry buildings in the regions of moderate to high seismicity. It is expected that the experimental results would be beneficial for practising engineers involved in design and construction of masonry buildings.

## Acknowledgement

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# Utilization of Coal Bottom Ash (CBA) as Fine Aggregate for Developing Eco-friendly Mortar

*Abhishek Srivastava*[1] *Dr. S. K. Singh*[2]


## Abstract

Coal bottom ash (CBA) is a by-product of thermal power plants produced during electricity generation. It is a melted ash accumulated at the bottom of the boiler. There are million tons of coal bottom ash (CBA) waste in piles and ponds adjoining the power stations threatening the health and safety of our life. In many countries, CBA is identified as hazardous material. In addition, the prohibition on mining in some areas and the growing need for natural environment conservation further exacerbate the problem of river sand availability. Therefore, utilization of coal bottom ash as partial or complete replacement to natural sand in mortar is one of the feasible solutions to reduce the environmental issues. This will not only reduce the demand of sand but help in reducing landfill areas. The present study gives an insight about the fresh and hardened properties of mortar reported in literatures. Most of the studies revealed that CBA has a potential to be used as fine aggregate in cement mortar. Furthermore, it can be used to develop light weight structures and thermal insulating envelops.


**Keywords:** Coal bottom ash: Fresh properties; Hardened properties, Mortar; Sustainable material.

## Introduction

The natural sand is one of the key components of construction industry used for manufacturing the concrete, mortar and plasters. Due to infrastructure development, the demand of good quality sand is increasing day by day, which leads to its rapid extraction. Rapid extraction of natural sand from riverbeds causes several environmental issues [1]. Loss of bio-diversities, land, coastal erosion, and river shores sliding, lowering of riverbeds, etc are some of the detrimental impacts [2-4]. Therefore, researchers have shifted their attention towards finding the sustainable alternative sources of sand.

Recently, utilization of industrial wastes in fabrication of cement, concrete and mortar is gaining importance due to its various environmental benefits. CBA, which is a by-product of thermal power plant is accumulating on the land sites and causing negative effect on nearby environment and living beings [6-7]. The typical view of process involved in coal fired thermal power plant is shown in Fig.1. Utilization of CBA as "alternative sand" is a promising solution of meeting

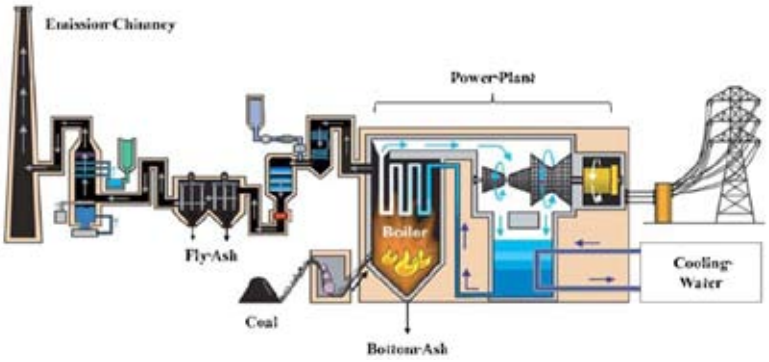


Fig. 1: Typical view of thermal power plant [5]

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the growing demand of sand and reducing the negative impact occurring due to over exploitation of natural sand. The incorporation of CBA in mortar provides additional advantages in terms of economic considerations.

The present work reviews the important studies, which focuses on fresh and hardened properties of the CBA mortar made with inclusion of CBA at different replacement percentage of fine aggregates. This paper has aimed to provide a substantial base of knowledge for those who are interested to work in this area.

## 2. Characterization of CBA

### 2.1 Physical properties

Coal bottom ash is a byproduct from thermal power plants. During burning of coals for boiling water in boilers, unburned materials (80% of total coal weight) produced in the form of flue gas and heavy ash particles, termed as coal combustion ash [8]. These flue gases are trapped by Electro Static Precipitator, collected and termed as Fly ash (FA), whereas the heavy ash particles, settles down in the bottom of combustion chamber in hoppers, called as Coal Bottom Ash (CBA) or simply bottom ash [9]. Fig. 2 shows the natural sand and coal bottom ash.

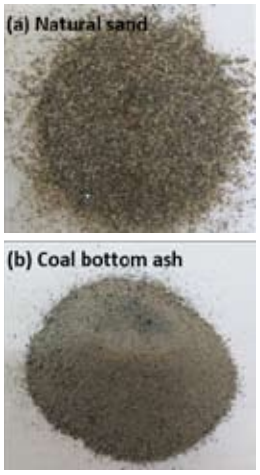


Fig. 2: View of (a) natural sand (b) coal bottom ash

**Table-1: Physical properties of coal bottom ash (CBA)**

| Author | Water absorption (%) | Specific gravity | Saturated surface dry density | Apparent density | Fineness modulus |
|---|---|---|---|---|---|
| Baitie et al. 2016 | 20.15 | 2.22 | -- | 770 | 2.71 |
| Gafoori & Buchloc 1996 | 7.0 | 2.33 | -- | -- | 2.80 |
| Ghose et al. 2018 | | 2.24 | -- | -- | 1.146 |
| Hashemi et al. 2018 | 2.77 | 1.80 | -- | -- | -- |

CBA is a grayish black in colour, granule spherical, irregular shape and porous structure. This has rough surface [10]. The physical properties of CBA are summarized in Table 1. The physical properties of CBA mainly depend on the properties of rock detritus present in the fissures of the coal seams.

CBA is much coarser material than natural fine aggregates. The specific gravity of bottom ash varies from 1.80 to 2.33. These low values are due to the existence of voids in them and depend on coal combustion method. Fig. 3 shows the particle size distribution of CBA. Particle size distribution of CBA is similar to natural sand [14]. SEM micrographs of CBA show that CBA particles are highly porous and possess rough surface texture as shown in Fig. 4.

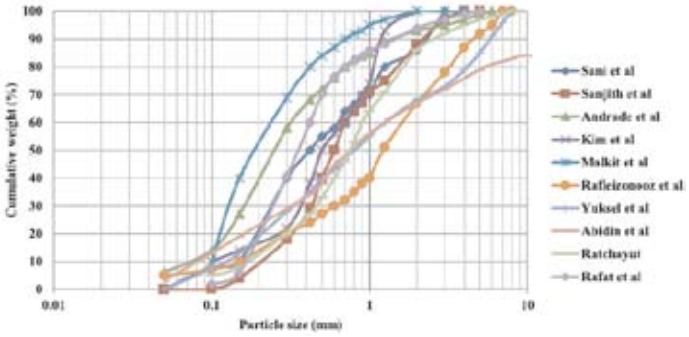


Fig. 3: Particle size distribution of CBA [13]

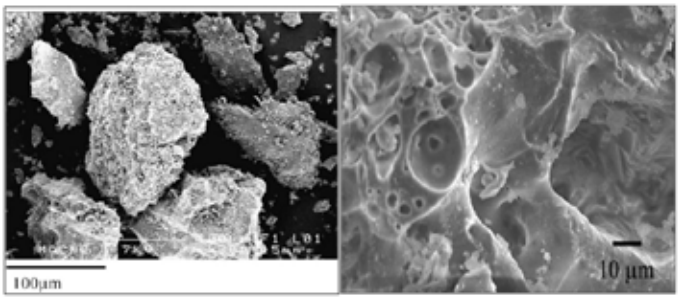


Fig. 4: SEM image of (a) CBA Particles (b) CBA particle surface [11,15].

### 2.2 Chemical properties

The chemical composition of the CBA was analyzed by X-ray energy dispersive spectrometry (EDS). Table 2 summarizes the chemical composition of coal bottom ashes. The chemical contents of CBA vary depending on the coal origin and incineration method. X-ray fluorescence (XRF) analysis reveals the main chemical compounds including oxides of silica ($SiO_2$), alumina ($Al_2O_3$) and iron ($Fe_2O_3$). Other compounds present in smaller percentages. Data from many researchers shows that CBA can be classified as pozzolanic material (Class C or F) in accordance to ASTM C618 [16] as the total composition for pozzolanic compounds exceeds more than 70%. However, in few studies [17], summation of major oxides ranges from 53.6% -58.5%, suggesting that CBA belong to class C of ASTM C 618 [16]. This is probably due to exposer to heat for longer duration, leading to burning of most of the carbon/ material. CBA has lower loss of ignition value ranging from 0.79% to 4.6% [18].

## 3. Properties of mortar incorporating CBA

### 3.1. Consistency

The flowability of CBA mortar (Fig. 5) is lower than the conventional natural sand mortar, which is attributed due to porous nature of CBA particles. Due to porous structure, available water in the mix is absorbed by the porous CBA particles, hence, reduces the workability. Torkittikul et al. (2017) reported that mortar containing 100% CBA as fine aggregate shows reduction of 34.3% in flowability with respect to reference mortar mix. Hardjito et al. (2011) reported that in geo-polymer mortar containing CBA, the demand for extra water making workable mortar reduces up to 50% replacement.

Fig. 5: Flow table test of CBA mortar

### 3.2. Fresh density

The fresh density of mortar reduces with increasing replacement percentage of CBA. This reduction usually varies ranges between 13%-25% [11, 21]. This behavior of CBA mortar is attributed due to lower specific gravity of CBA particles and higher water content compare to conventional natural sand mortar [11,15, 17].

### 3.3. Compressive strength

Inclusion of CBA into mortar up to 40% replacement percentage of natural sand does not have significant effect on mortars compressive strength, however, further increment in replacement percentage leads to lower compressive strength as shown in Fig. 6 [19,22]. Torkittikul et al. (2017) found that mortar mix containing 50% of CBA as fine aggregate possess required grade strength, however, beyond that strength reduces gradually. This fall in strength with increasing content of CBA is due to reduction in density and effective cross section caused by higher porosity of the CBA, which in turn results in formation of local tension zone around the pores under compression loading. Formation of local tension zone around the pores promotes local failure, thus to reduction in strength values were observed [22]. However, in some studies [23], increment in strength was noted at 20% replacement due to filler effect.

### 3.4. Flexural strength

The flexural behavior of CBA mortar was investigated by Ramadoss and Sundararajan (2014) by replacing the natural sand with CBA at 0%, 20%, 30%,40% and 50% substitution percentage. The experimental results show that to flexural

**Table. 2: Chemical composition of CBA**

| Author/ Source | $SiO_2$ | $Al_2O_3$ | FeO | $K_2O$ | $TiO_2$ | MgO | $Na_2O$ | CaO | $Fe_2O_3$ | $SO_3$ | MnO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Baitie et al. 2016 | 62.3 | 21.2 | 3.6 | 2.58 | 2.15 | 0.95 | 0.7 | 0.5 | -- | -- | 0.01 |
| Ghafoori & Bucholc. 1996 | 41.7 | 17.1 | -- | 0.4 | -- | 4.91 | 1.38 | 22.50 | 6.63 | 0.4 | -- |
| Ghose et al.2018 | 60.7 | 25.9 | -- | 1.28 | 6.81 | 0.63 | 0.38 | 0.89 | 1.97 | - | -- |
| Jang et al.2015 | 22.6 | 12 | -- | 0.5 | 1.0 | -- | 2.7 | 50.5 | 0.6 | 2.3 | 0.4 |

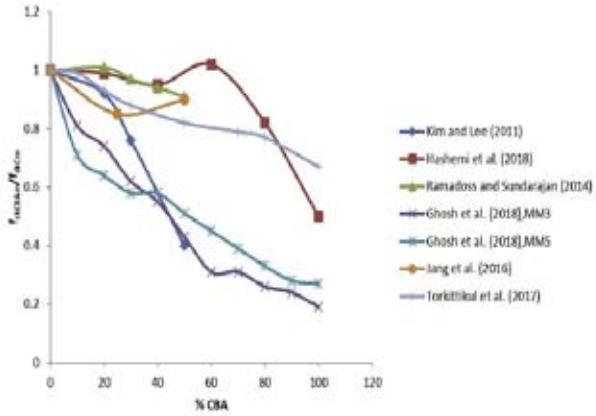


Fig. 6: Variation in compressive strength of CBA mortar [24]

strength of mortar increases by 2.2% for 20% replacement level. However, with further rise in CBA content, flexural strength reduces from 6.07%-17.1% for 30%-50% replacement of natural sand with CBA as fine aggregate.

### 3.5. Dry density

The dry density of mortar incorporating CBA follows the same trend as fresh density. With increases in CBA content, the dry density of the mortar reduces. Due to low specific gravity of CBA particles and high porosity of CBA mortar matrix caused by more water content the overall weight of the mortar reduces for a particular volume and thus dry density reduces [11, 15,22].Nevertheless, lower dry density of CBA mortar can be advantageously be used in making light weight structural elements [11].

### 3.6. Scanning Electron microscopy (SEM)

SEM micrograph analysis of CBA mortar shows that with inclusion of CBA in mortar, the number of pores in the mortar matrix increases as shown in Fig. 7. Torkittikul et al. 2017 reported that the permeable pore space of CBA mortar increases from 21.9% to 37.05% by 100% substituting the natural sand with CBA as fine aggregate. However, with increase in curing age, number of voids in the mix gets reduced [22].

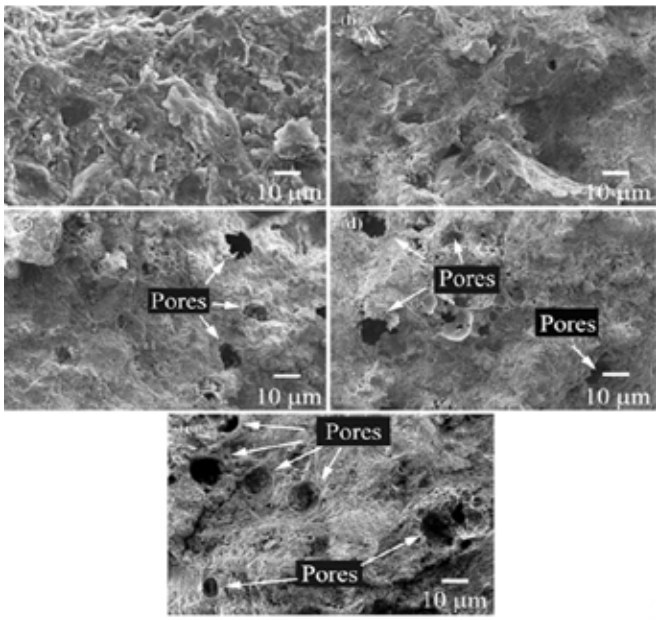


Fig.7: SEM analysis of mortar at 0%,20%,50%,80% and 100% CBA replacement levels[15]

### 3.7. Thermal conductivity

Thermal conductivity of CBA mortar reduces with increase in CBA content. Different researchers has reported that 100% substituted CBA mortar shows 68%-75% lower thermal conductivity as compared to conventional natural sand mortar [15,18]. This fall in thermal conductivity is attributed due to rise in number of pores with CBA inclusion, these pore present insulation for the heat conduction through the mortar matrix [11,15]. Lower thermal conductivity of CBA mortar makes it suitable thermal insulating building envelops.

### 3.8. X-ray diffraction analysis

X-ray diffraction analysis is conducted to examine the compound composition of mortar. Hashemi et al. (2018) investigated the chemical compound of CBA mortar containing increasing percentage of CBA from 20%-100% in steps of 20%. They found the peaks of quartz, mullite and calcite as can be seen in Fig 8. Peaks of Bogus compound like CSH (calcium silicate hydrate), CH (calcium hydroxide) were also observed. Formation of calcite is reasoned due to reaction between

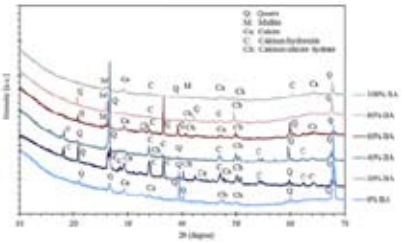

Fig. 8 XRD analysis of CBA mortar [22]

hydration phases and atmospheric $CO_2$.

## Discussion and conclusions

The coal bottom ash, which is by-product from thermal power plant, is readily suitable for use as a sand replacement in cement mortar. The microstructure of the CBA particles are porous and surface texture is rough. Due to porous particles, the water content and porosity of CBA mortar mix increases with increase in replacement percentage. High water absorption leads to high water demand and increases the water-cement ratio for maintaining the particular flow. Fresh and hardened density of the CBA based mortar is lower than the control mortar having natural sand due to lower specific gravity of the CBA particle and higher number of voids. Lower dry density of CBA mortar is advantageous in making light weight structures. Variation in compressive and flexural strength is positive at lower percentage of replacement 20 percent, beyond that it starts decreasing. Researchers has pointed out that, this decrement at higher replacement percentage is due higher porosity and formation of local tension zone around the pores. SEM analysis results show that permeable pore space of mix increases but decrease with age of curing. Higher porosity and lower density of the CBA mortar mix resist the flow of heat, thus leading to lower thermal conductivity. Lower thermal conductivity makes it suitable for making thermal insulating envelops.

The present review of fresh and hardened properties of CBA mortar has shown that it has a potential to be used as building material. However, further research work is needed to fully explain the performance of CBA mortar as the variation in the results could be due to variation in fineness and chemical composition of CBA from different power plants.

## Acknowledgment

The financial support provided by M/s NETRA, NTPC for the study is acknowledged.

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# Accelerator Workshop for Affordable Sustainable Housing Accelerators – India (ASHA-India)

BMTPC jointly with WRI India organized Accelerator Workshop for Affordable Sustainable Housing Accelerators – India (ASHA-India) under GHTC-India, on 28-29 January 2020 at New Delhi. The workshop offered one-on-one interactions with key stakeholders such as government procurement agencies, certification and standardization agencies, builders and developers, angel investors, venture capitalists, and research & development institutions mainly IITs.


# A commentary on the Affordable Rental Housing Complexes under PMAY(U)

*Prakriti Mehta*[1]

**Abstract**

The COVID 19 pandemic has brought to light the plight of the Urban Poor and the migrants in the city. Amongst other initiatives, the Ministry of Housing and Urban Development launched the Affordable Rental Housing Complexes (ARHC) under the Pradhan Mantri Awas Yojna-Urban (PMAY–U) in July 2020. It is an attempt at creating vibrant, sustainable and inclusive affordable rental housing avenues for urban poor or migrants by 'aggregation of their demand at a given site'. The paper critically analyses the rental housing scenarios in India. It highlights the importance of the shift from owned house to rental housing schemes due to reasons such as availability of existing vacant houses in urban areas, resolving issues of affordability coupled with a declining trend in owning a property for investment, and a growing need for shared accommodation. The Affordable Rental Housing Complexes (ARHC) under PMAY (U) can be seen as an opportunity with a positive impact on the urban poor or migrants in terms of a dignified living closer to their workplace. At a larger scale, the ARHC reduces the burden on the city infrastructure, provides business opportunities to the private developers and triggers a multiplier effect on the economy. This paper also identifies the potential issues related to conflicts between parties involved, land use compatibility with the master plan, and recommends for it to be an integral part of the future urban city design process.

**Keywords:** Rental Housing, Urban Development, Migrant, City

India's urban population would rise to 39 % by 2036 from 31 % in 2011, according to the final report of the technical group constituted by the National Commission on Population (NCP) under the Ministry of Health and Family Welfare on population projections between 2011 and 2036 in July 2020. The reason for the sharp rise is an increase in migration from rural to urban areas.


Figure 1 Aspirations of Migrants
(Source: Author)

The domestic help, carpenter, painter, cobbler, gardener, potter, construction labour, security guard, factory workers etc., are all on whom the city is dependent for running a daily life. They make the city dynamic. The city gives them an opportunity to enhance their skills, earn more than what they would have in their village in the rural areas. The city is dependent on them, and they are dependent on the city. The urban poor or the migrant who may be, skilled or unskilled, under or uneducated from a rural area moves from one place to another in search of work opportunities and better living conditions.

Migration has impacts on economic activity, social conditions, demographic structure, political activity, ecology, physical environment, and in the urbanisation

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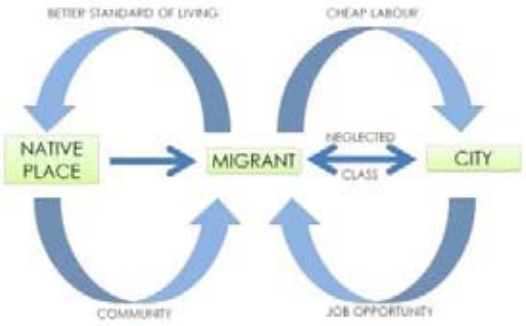


Figure 2 Migration process (Mehta, 2017)

Figure 3 Migrant workers gather outside Bandra West Railway Station as they leave for their native places after Prime Minister Narendra Modi had announced the extension of nationwide lockdown till May 2020 (Source: Press Trust of India)

process (Mehta, The first Entrant to a Smart CIty, 2017). Rural to Urban migration changes the hierarchical order of the urban centres. The city does not grow uniformly because of unequal growth of industries, construction work and other activities which generate employment opportunities and attract migrants. Large scale arrival in urban centres leads to an increased need of transport and communication and health care, educational facilities, institutions, recreational centres, water supply , sanitation and power supply(Trunk infrastructure). The process of migration needs due attention to resolve problems of habitable living within the city. The Indian city fails to address this issue; in turn leads to poor standards of living, health hazards, no light, no ventilation, etc. These pockets in city are not sustainable for living – environmentally, socially and economically.

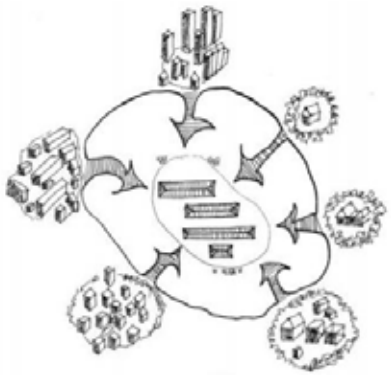

Figure 4 Unequal growth in the city (Source: Author)

The Urban poor or migrants stay in rented accommodations at the periphery of planned urban city areas, spread over the acquired land, once belonging to the native residents whose traditional occupation was agriculture. None of the master plans have a development policy for making these enclaves compatible with the surrounding urban areas. The urban poor or migrant looks for cheap rental accommodation, near their work place. The native residents are unwilling to sell their land, and builds sharing tenements which help them generate a regular rental income. As there are no development control norms, the construction is devoid of professional inputs. The physical outcome is inappropriate utilization of land resource, a haphazard urban form and unhealthy living conditions. In this process, the socio cultural needs of the migrant are completely missed out.

The city is under a continuous process of evolution and the migrants make the city dynamic in its functioning. Their financial condition and personal preference of living with their community are the basic reasons they do not wish to own a shelter. This pushes them

Figure 5 transformation of Land (Mehta, 2017)

Figure 6 Migrant during COVID Pandemic Source: Left: Reuters, Right : Rajesh Balouria from Pixabay


Figure 7 Rental Housing Scenarios (Source: Author)

to accommodate themselves into inhabitable or inhumane conditions like was witnessed during the COVID 19 pandemic. Thus, it is necessary to ensure economic, social and environmental security to all the city dwellers, especially with respect to shelter.

## Owned Vs Rental Housing Scenarios

Historically, the Indian housing policies have been directed towards home ownership. Rental housing has been passed over subject for the last 72 years since independence with no policy framework to accommodate 21.72 million urban rental households.

As per the Census 2011 data (India C. o.), 11.09 million houses remain vacant in urban areas despite the massive housing shortage. In 2014, around 1.08 lakh houses under Jawaharlal Nehru National Urban Renewal Mission (JnNURM) or Rajiv Awas Yojna (RAY) are still vacant in 159 cities as per the ARHC Operational Guidelines (Ministry of Housing & Urban Affairs, 2020). The scheme of PMAY (U) is rapidly moving towards achieving the vision for providing a pucca house to every household by 2022 under "Housing For All 2022" .As per the progress data in August 2020,out of 1.05 crore houses approved, 66.2 lakhs have been grounded for construction, of which 35.1 lakh houses have been completed and delivered (Affairs M. o., 2019). A portion of these are assumed to be lying vacant due to various reasons such as poor maintenance of vacant stock, dilapidated state of buildings , lack of incentives, and affordability . The private developer barely sees it as a profitable opportunity and does not guarantee a steady income, even to the landlords.

Affordability is a concern in ownership of housing for the Economically Weaker Section (EWS) and Urban Poor. The housing prices are relatively high, pushed up by high construction and transaction costs. Access to finance is available to them but the beneficiary is unable to avail it. The key concern is to provide shelter to the poorest, who is barely earning enough to survive and save, to send back to his family in their village. The income of the daily wage earners would just be enough for sustenance. An investment for ownership of a house may not be a priority or possibility for them.

As per Knight Frank India's research report, India Real Estate (Khaitan, 2019) – January to June 2019, the residential prices have stagnated across cities with Mumbai, Pune, Chennai and Kolkata witnessing a price decline of 3%, 4%, 3% and 2%, respectively. Ahmedabad, Bengaluru and the National Capital Region (NCR) noted only 1%, 2% and 3% price growth while Hyderabad has 9% price growth. The capital value growth hardly presents ownership of a residential property as an investment asset. On the other hand, the affordable housing under the Housing for all 2022 is not a tradable asset for two reasons. A prospective buyer can himself get it from the government, secondly, it is a subsidised product and there exists a lock- in period.

As per Census 2011 data (India C. o.), 79 % of the total rental households in India are in Urban Areas.

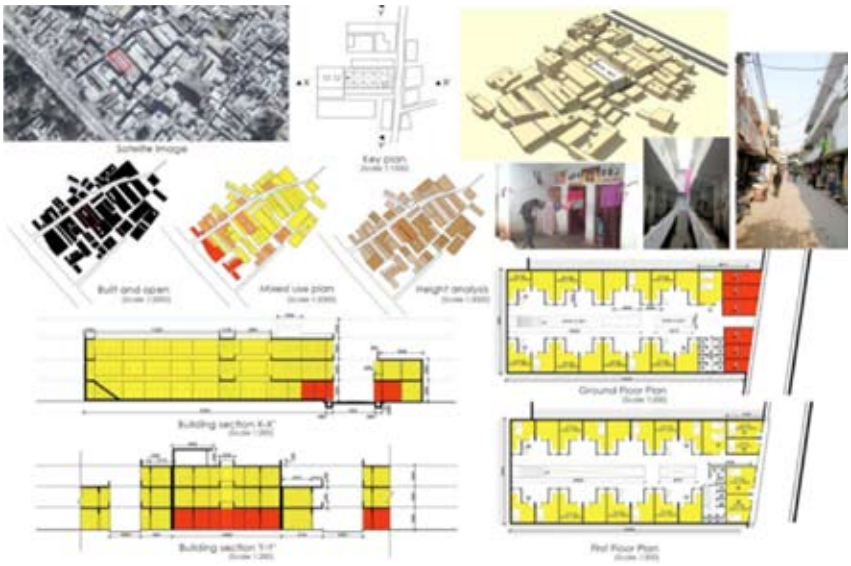

Figure 8 Condition of Shared Rental Accomodation in Bhangel Village in Noida (Source: Author)

A household size of 3-4 comprise of up to 50 % of the rented households in India, which indicates the lower dependency on ownership of a house in urban areas by nuclear families. A household size of 1- 2, ranges between 6 % to 12 % of the total rented households in India. This is expected to rise with the growth of first phase migration[1] of the poor in cities that prefers a shared accommodation.

## Formalising the Urban rental Housing

As per the National Sample Survey Office (NSSO) in 2012, 71% of the households living in urban rented accommodations do not have any written contract (Khaitan, 2019). While a part of this could be due to the informality of the premises itself, the Rent Control Act enacted by the various state governments has become a deterrent to the formalisation of rental agreements across the country.

## Shift to a Rental Housing Approach – Affordable Rental Housing Complexes (ARHC)

The reverse migration of the urban poor or migrant during the COVID 19 Pandemic put forward the need for providing ease of living through access to dignified rental affordable housing close to the migrant or urban poor's workplace. Under the vision of "Atma Nirbhar Bharat " and as a Sub-Scheme to the "Pradhan Mantri Awas Yojana (Urban) " , mission for "Housing for All 2022", The " Affordable Rental Housing Complexes (ARHC) was announced in 2020 in public and private sectors under two models of approach with sufficient fiscal incentives have been provided in the scheme. Utilizing existing Government funded vacant houses in cities by converting them into ARHCs under Public Private Partnership (PPP) mode or by Public agencies as a Centrally Sponsored Scheme, and secondly by Construction, Operation and Maintenance of Affordable Rental Housing Complexes by Public/ Private Entities on their own available vacant land as a Central Sector Scheme. (Ministry of Housing & Urban Affairs, 2020)

The Affordable Rental Housing Complexes (ARHC) scheme apart from impacting the urban poor in a positive manner hosts a few opportunities and advantages to the government and private developers. As all stakeholders are incentivised under the scheme, the urban areas and the country is likely to thrive.

## Advantages for Government

Urban Areas and cities are the epicentres of economic growth which contribute significantly to the Indian economy. According to the Economic Survey 2019-2020, over 60 % of India's current GDP comes from the cities and towns. The construction sector accounts for 8.2 % of GDP which includes housing and employs about 12 % of the workforce (OECD Economic Surveys 2019 , 2019). Therefore, the investment made under PMAY (U) not only provides affordable houses to the poor to achieve the goal of 'Housing for All' under ownership or rental schemes but also triggers a multiplier effect on the overall economy.

The government commits to provide the basic needs of survival of food, clothing and shelter. The scheme aids the National aspiration that is fulfilled as committed to be accomplished by the government in the given tenure to provide shelter to every citizen of the country.

Model – I encourages converting existing Government funded


Figure 9 Stakeholders in the ARHC Scheme (Source: Author)

1 First Phase: The migrant first enters the city based on his connections in the city that may be his relatives or friends or acquaintance at the native village. They rely on them for housing or an accommodation and finding a job immediately when they enter the city.

Second Phase: As a chain reaction, friends and family members of a migrant join the migrant, once he is settled at his new destination.

vacant houses in cities into ARHCs through Concession Agreement for 25 years (Ministry of Housing & Urban Affairs, 2020). This model permits for the vacant housing available with the government to be utilised. It ensures national money will be put to good use.

## Opportunities for Private Developers

The Model II- under the ARHC encourages Construction, Operation and Maintenance of ARHCs by Private/ Public Entities on their own available vacant land (Ministry of Housing & Urban Affairs, 2020). This has created an investment options with a business opportunity for private developers. It is a lucrative option for entrepreneurs to venture into the Rental Housing business.

## Positive Impact on the Urban Poor

The ARHC promotes labour and social mobility to the urban poor or migrant. It assures healthy living conditions which include infrastructural hygiene, access to better food, ventilated accommodations, thermal comfort and mental peace, in a planned area.

It gives the opportunity for the tenant to choose their accommodation closest to their workplace. It reduces commute time and their dependence on different transport modes. This increases their work efficiency and gives them more time to build a socially sustainable environment around them. It caters to the social needs and aspirations of the urban poor by providing recreational and community open spaces, crèche, gender needs, etc.

## City Benefits

As all aspects of living, working and recreating are in close proximity, the number of trips of for live – work- play gets reduced considerably for the urban poor. It reduces the pressure on the city infrastructure, specially required for movement through different modes of transport.

The scheme gives an opportunity to **predict, plan and design for an appropriate** estimation of requirements and optimised utilisation of city's trunk infrastructure like water supply, sewerage, drainage electricity, street lights, telecom, etc.

The employer of the urban poor would reap the most tangible (economic) benefit of the ARHC scheme. The urban poor are likely to be lesser fatigued by long travel hours and redundant routine works. They have an ease of living which gets reflected in the form of a healthy and an energetic human resource thereby increasing the efficiency in performance and resulting in a higher output.

## Recommendations

1. The Draft Model Tenancy Act 2019 (Affairs M. o., 2019) aims to bridge the trust deficit between tenants and landlords by clearly delineating the obligations of tenants and landlords. In order to ensure speedy redressal of disputes, it also proposes to establish Rent Court and Rent Tribunal that will hear appeals for matters connected to rental housing. This Act can be used to fuel the rental housing supply pipeline and thus attracting more investors. It is essential to create a regulatory body to deal with issues related to ARHC separately. It should include dispute redressal, exemption from security and advance rent, delayed rent payments, maintenance of property etc. under the Act. There should be a provision for alternative dispute resolution through mechanisms such as conciliation and mediation at the local or community level under the provisions of this Act.
2. A high density development in the urban areas is expected as an outcome of the ARHC scheme. Hence it is necessary that adequate infrastructure and its contingencies are predicted, planned and should be an integral part of the city designing and master planning.
3. Over the years, when the urban poor or the migrant financially stabilises in the urban areas, he or she would aspire to own a house in the city. As an extension to the ARHC Scheme, a provision could be made for the tenant to have the first right to own the house he or she is residing in, if ever sold by the developer, after the completion of the first phase of the scheme i.e. 25 years. This recommendation would not only bring in a feeling of belongingness but also instil a sense of identity in the urban poor or the migrant as a city dweller.
4. The ARHC allows permitting change in Land use for the purpose of developing rental housings. It is necessary to ensure that the interface of the new rental residential areas is being developed with compatible land uses only. The development under ARHC interfacing

with a non - compatible land use could be hazardous in the longer run.

5. The ARHC Scheme could allow funding for construction and maintenance from the CSR (Corporate Social Responsibility) Initiatives which defines the companies' obligation to take up projects towards social welfare activities.

## Conclusion

Rental Housing has been a neglected space in India for a very long time. Housing is a non-discretionary product. People will need homes in good times and bad. Coupled with the millennial population coming of age, housing non - affordability and the changing perception about home ownership, the pool of renters is only going to expand. Rental housing reforms like the Affordable Rental Housing Complexes (ARHC) sub scheme to the "Pradhan Mantri Awas Yojana (Urban)", mission for "Housing for All 2022", in India will help develop a large residential stock. The Scheme with its proposed two models ensures benefits, opportunities and advantages to all stakeholders i.e the government, the city, the business entrepreneurs and the urban poor or the migrant, all at one go. The government vacant housing stock will be put to use and new housings will add to the economic development of the country. A planned development across all urban areas of the country would mitigate issues of environmental and social sustainability with reduced pressures on infrastructure, better standards of living, equitable and designed social spaces, energy efficiency, comfort etc. Thus, The ARHC and its associated infrastructure, densities and contingencies should be an integral part of the city design and planning process. Many investors in the past were unable to recover from investments in the owned housing sector. The ARHC opens avenues for entrepreneurs to reap the benefits from the fiscal incentives of getting into the rental housing business. The ARHC scheme should perform with the existing laws like the Draft Model Tenancy Act and plug in to social welfare obligations of the Corporate Social responsibility Initiatives under the Companies Act to attract more investors into this realm. Lastly, but very importantly, the Affordable Rental Housing Complexes (ARHC) scheme will offer environmental and health safety, economic viability and social security to the Urban Poor or migrant who enters the urban areas, seeking opportunities of better life.

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# Rejuvenation of a 60 years old primary school building in Agra, UP, India – A Case Study

*Yashika Bansal*[1]

There is a 60 years old government primary (up to class V standard) co-education school at Baluganj area of Agra, UP, India, which has about 50 students enrolled in it, from nearby slum settlements. This school is situated in a very prime location (stone throw distance from the Taj Mahal) and has impressive colonial architecture with plenty of open areas and several grown up native deciduous trees. This is a brick masonry based load bearing, single storied structure with RBC (Reinforced bricks concrete) roof having a plinth height of 1 meter. There are 5 classrooms, one principal room along with one store room & toilets. The sizes of the class rooms are 6x6 meter and height is 5 meter. There are no beams/columns to protect it, in case of any earthquake.

This structure is not maintained, hence is in a dilapidated condition (its walls are cracked and had fallen off at few locations, roof is about to fall, bottom part of roof had already fallen off, reinforcement is heavily corroded, huge seepage, doors/windows are broken, etc.,). There are widespread distress and spalling. Hence there is a constant fear of any mishap in this structure, where classes are held regularly. The poor condition and lack of availability of proper functional toilets & drinking water has resulted in a very low enrolment in the school particularly girls. This is a constant problem for girls to access to the toilets in the school and this has proved a real barrier to their education.

## Proposal for Retrofitting/ Rejuvenation:

India Dreams Foundation (IDF), a leading NGO in the field of education, health, sanitation & community development in slums of Agra, come to know about dilapidated condition of this school, hence adopted this school to be developed as model school in Agra.

IDF contacted many Engineers/ Architects/Contractors locally, and a professional opinion emerged is to demolish this old & dilapidated structure and to construct a new one. The floor area of this building is about 3000 sqft and with current rate of construction of school building in year 2019, in Agra, is about INR 1500-2000 per sqft,

Fig.1: Few Photographs of Existing School Building

1 Ms. Yashika Bansal is a volunteer with India Dreams Foundation (IDF) and a student of B. Des. with FDDI, Noida, E-mail: yashikabansaldelhi@gmail.com

hence the cost of new construction would be about INR 45 lacs to 60 lacs (65,000 - 85,000 USD). This is a huge budget, which neither district administration can afford nor the NGO (IDF). Besides this, there will be lots of legal formalities to be done for reconstruction, like approvals of drawing, owners signature, land documents, many NOCs, etc., which would be difficult to arrange for this 60 year old public building.

Hence IDF contacted few structural engineers, experts in retrofitting works and got an opinion that since foundation of this building is intact, walls in superstructure can be strengthened with Grouting, Guniting & Ferro-Plating and roof can be recast as per provision of National Building Code of India 2016 over new RCC columns & beams, which will not only provide requisite strength to the building but also make this building earthquake resistant as Agra lies in seismic Zone III as per NBC 2016 , within a cost of INR 15 lacs (21,000 USD). i.e approx 30 % of cost of new construction. The work can be done on the basis of principals of sustainability and embodied energy/carbon footprints of the building will be least in retrofitting. The usable building materials (bricks, un-corroded steel, joinery & malba) can be used in retrofitting work. The open space around this building, which improves micro climate is landscaped (plantation and open jointed local stone flooring) for collective learning/activities. Ramps with railings and small low height stage is provided. Toilet facility is available but needs upgradation and wiil be made barrier free. This will motivate staff and students to teach /learn in a very safe, barrier free and environment friendly surrounding.

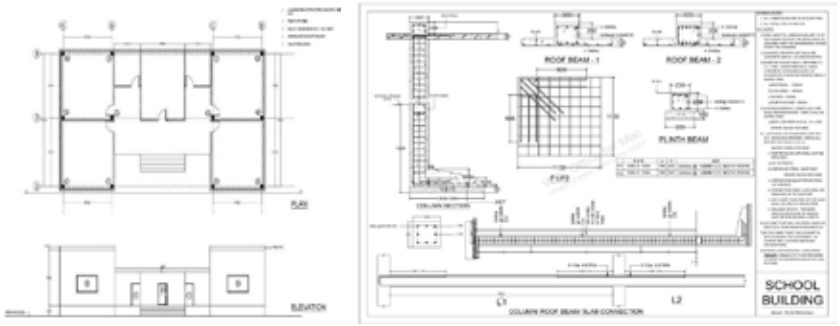

Fig.2: Few Technical Drawings for Retrofitting Works

Through their work, IDF aims to increase enrolment at the school from 50 to about 150 students, with focus on encouraging girl students to take advantage of high quality education, which will be available in a play-way method. As part of their School's reform programme. IDF has a three-fold strategy for achieving this. They aim to put the school at the forefront of educational innovation, through a combination of building eco-friendly environment, innovative curriculum design and community advocacy.

## Process:

As per technical drawings, old roof and out of plain walls were removed and reusable materials were retrieved along with old joinery & electrical equipment. The height of wall was reduced to 3.6 meter and Grouting, Guniting and Ferro-Plating were done. Sixteen new RCC columns from foundations to roof, along with plinth, lintel and roof beams were provided at the inside corners of 5 rooms and new RCC roof was casted. The walls were connected with RCC beams and roof was extended over walls and beyond. Same way verandah & store was also retrofitted with brick pilasters. The retrofitted building will have a further service life of 50 years. The architecture style of the building is preserved and low energy construction was done to make this building a green building. A stage is provided in the open area, where daily school chores can be performed. More toilets were provided and external development in this complex was done to make this school habitable, barrier free and vibrant. The water logging problem in this school is also dealt with by providing a physical water barrier in front of main gate and paving in open areas done with open jointed red stone tiles so that water can percolate in the ground and recharge the water table. The school will include a library, basketball court and environmentally friendly garden, in which children can play and learn in natural environment.

A commercial level RO plant is also proposed in this school to provide safe drinking water to the students. New comfortable & multi coloured furniture will be provided in this school. Kitchen and mid-day meal serving area will also be upgraded to be more hygienic.

## Stakeholders in this Project:

School Management, District Education department, Agra Nagar Nigam (Municipal Corporation), District Administration, Forest Department, IDF, Asian Paint-PPG, HN Concrete (Retrofitting Contractor)

Fig.3: Few Under Execution and Final Photographs

and teachers/students.

## Donor:

IDF got a donor Asian Paints & PPG, which is a fortune 500 MNC and is keen in imparting painting skill to children, so that they can earn their livelihood and to promote street art in the city of Taj Mahal under its CSR initiative. They decided to help IDF, in upgradation of this school at minimum cost and to promote concept of sustainability by retrofitting this school with a cost of INR 15 lacs for a covered area of about 3000 sqft, i.e. INR 500/sqft, whereas the cost of new construction would be about INR 45-60 lacs.

## Proposed O & M of this school:

The project has ambitious aim of transforming this school into a model for excellence for other government schools in the region. IDF founder Mr Punit Asthana hopes that when the rejuvenated school opens, it will offer education at par with private institutions, enabling under privileged students to access quality education in English medium and in reducing inequalities in the area, targeting UN Sustainable Development goals no 4 (quality education) and 5 (gender equality). In addition to this, a significant part of work lies in advocating importance of education to local community to encourage families to enrol their children, particularly girls, in school. Many of the parents in the target families are illiterate, alcohol & drug addicts, daily wager and illiterate. It is also proposed to operate a livelihood training/ hobby development center in art & craft, carpentry, music, cooking, counseling & computer training center after school hours in this school. The financial/administrative model for the same will be worked out with donors and district administration.


## Acknowledgement:

Author is thankful to IDF (India Dreams Foundation), Asian Paint -PPG, Distrct Administration, Agra Nagar Nigam, Education Department, Forest Department, School teachers, Contractor, Vendors, Media & Press associated with this work and Engineers for providing honorary professional services in development of this project. Sincere thanks are due to Er. Muthhuswamy of HIH and Mr. Vikas Sharma of Asian Paints-PPG for guiding in every step of this work. Specially thanks are due to Mr Punit Asthana, Ms. Jyoti Singh, Ms. Divya Agarwal, and Mr. Aftab for their tireless efforts in completion of this project.


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# Light House Projects under GHTC-India, PMAY(U)

In order to address housing shortage in a time-bound manner, the conventional system of housing construction is not adequate to achieve the target by 2022. Hence, there is 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 has 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. It has been envisioned to source technologies from all over the world and identify such technologies which would be suitable for adoption in India, given its unique geo-climatic conditions and user preferences based on diverse cultures.

MoHUA launched "Global Housing Technology Challenge-India (GHTCIndia)" and shortlisted basket of technologies suiting different geo-climatic conditions that could be considered for demonstration through actual ground implementation of six lighthouse projects (LHPs) located in six different States/UTs of PMAY(U) regions across the country.

An LHP means a model housing project built with alternate technology suitable to the geo -climatic and hazard conditions of the region. This will demonstrate and deliver ready to live-in houses with speed, economy and with better quality of construction in a sustainable manner.

### LHPs Locations, Technologies to be used and No. of houses

| Location | Technology | No. of Houses |
|---|---|---|
| Indore | Prefabricated Sandwich Panel System | 1,024 |
| Rajkot | Monolithic Concrete Construction System | 1,144 |
| Chennai | Precast Concrete Construction System-Precast Components Assembled at Site | 1,152 |
| Ranchi | Precast Concrete Construction System-3D Pre-Cast Volumetric | 1,008 |
| Agartala | Light Gauge Steel Structural System & Pre-Engineered Steel Structural System | 1,000 |
| Lucknow | Stay in-place Formwork System | 1,040 |

3D view of LHP at Lucknow, Uttar Pradesh

3D view of LHP at Rajkot, Gujarat

3D view of LHP at Indore, Madhya Pradesh

3D view of LHP at Agartala, Tripura

3D view of LHP at Chennai, Tamil Nadu

# Performance Appraisal Certification Scheme (PACS)

## Introduction

Performance Appraisal Certification Scheme (PACS), being operated by BMTPC (vide Gazette Notification No. I16011-/5/99 H-II in the Gazette of India No. 49 dated December 4, 1999), is a third party voluntary scheme for providing Performance Appraisal Certificate (PAC) to manufacturers or installers of a product which includes building materials, products, components, elements and systems etc. after due process of assessment.

Since the Scheme is operated for the products/systems where no relevant Indian Standards are available, it is required to first work out the desired specifications for Performance Appraisal. For the items where no Indian codes are available, international practices are also being referred. In few cases the specifications recommended by the manufacturers have to be modified based on global practices to improve the quality and performance.

Various states, their Housing Boards and other departments are also promoting and using emerging technologies and materials for construction of mass housing in their states. As such PACS has become an important tool for introduction of emerging technologies in mass housing.

## PACs Approved and Issued Till Date

Within the framework of Power and Functions of Technical Assessment Committee (TAC), Applications for appraisal of new building materials and construction technologies were received by BMTPC. Performance Criteria, based on National & International practices were framed in consultation with other members.

So far 16 meetings of TAC have been held and 69 PACs have been issued till now.

## Progress Report of Performance Appraisal Certification Scheme (PACS)

The details of activities carried out recently under Performance Appraisal Certification Scheme (PACS) are highlighted below:

### Approval of PACs

PAC for the following 07 systems/products have been approved in the TAC's 16th meeting held on 17th December, 2019.

1. Integrated Hybrid Solution - ONE
2. Strand Woven Bamboo Wood Flooring, Wall Panels & Door / Window Frames
3. Permanent Wall form
4. Bamboo Wood Flooring
5. MS Closed Door & Window Frame Sections
6. Elastomeric Paintable Plaster
7. Bamboo Wood Flooring & Wall Cladding

Brief about these technologies are given hereunder:

***1. Integrated Hybrid Solution - ONE***

IHS-ONE is an Intermediate Building System (IBS) having three main components: walls, floor/roof and stairs. All 3 components are integrated to construct a building and hence named as "Integrated Hybrid Solution – ONE". It has the integration of the following:

*Walls:* Hydraform Prefabricated Mortarless Interlocking Technology. The interlocking blocks are manufactured with a block making machine offsite or onsite in an open shed. The blocks can be of cement-flyash-sand or cement-soil.

*Floors/Roof:* Mechanized Precast R.C. Plank & Joist system : The RC planks as well as joists are partially precast either offsite or on site. After placement as floor/roof elements, the haunches are filled with in-situ concrete. The assembly with haunch infill provides monolithic behaviour and diaphragm action to transfer horizontal loads to supporting members.

*Ferrocement Elements:* Mecha-

Integrated Hybrid Solution - ONE

nized precast/prefab Ferrocement staircase, kitchen shelves, kitchen platforms, sunshades, lintel bands, water tanks, fines. The Integrated Hybrid Solution – ONE can be used in a load bearing structure, in mid rise structures and as infill wall with R.C. column-beam-framed or light gauge steel (CRF section) column, beam or in a hybrid of R.C. Column and steel beam framed high rise structure. The system has been designed for all loads including earthquake.

### *2. Strand Woven Bamboo Wood Floor Tiles & Wall Panels*

Bamboo Wood is an environment friendly product handcrafted from bamboo, the fastest growing plant on earth. It is manufactured by processing of bamboo poles i.e. boiling and carbonizing to remove food agents present in it to make it termite resistant. Further, the bamboo strands are dried in kilns and thereafter glued by phenolic adhesive. Finally this shall be compressed under very high and uniformly distributed pressure. Bamboo Wood is most versatile substitute of hardwood. It is a conversion of bamboo to wood Bamboo is one of the natural materials available for bamboo wood products and is an alternative to hard wood. Bamboo has a higher fiber rating than any other hard wood which gives it exceptional hard wearing qualities. Flooring and wall paneling are coated with UV coat while decking shall be coated with oil.

### *3. Permanent Wall Form*

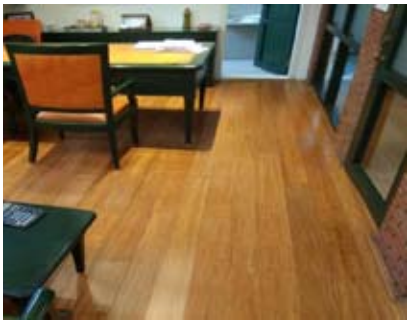
Permaform is an innovative permanent structural walling system consisting of rigid poly-vinyl chloride (PVC) based polymer components that serve as a permanent durable finished form-work for concrete walls. The extruded components slide and interlock together to create continuous formwork with the two faces of the wall connected together by continuous web members forming hollow rectangular components. The web members are punched with holes to allow easy flow of the poured concrete between the components. Wall components are erected and filled with concrete, in situ, to provide a monolithic concrete wall with enhanced curing capacity due to water entrapment, as the polymer encasement does not allow the concrete to dry prematurely with only the top surface of the wall being exposed to potential drying. The polymer encasement provides crack control vertically and horizontally for the concrete, and provides vertical tension reinforcement thus increasing the structural strength of the wall. The resulting system is unique and provides substantial advantages in terms of structural strength, durability enhancement, weather resistance, seismic resistance, design flexibility, and ease of construction. Steel dowels are necessary to anchor the wall to the concrete foundation.

### *4. Bamboo Wood Flooring*

Bamboo wood flooring is made from Strand woven bamboo. It is a conversion of bamboo to wood. Bamboo wood flooring is an eco-friendly product made from bamboo, the fastest growing plant on earth. Bamboo travel through boiling process or burn it under high pressure stream to remove starch and sugar content to make it termite resistant. Further, phenolic resin is used as binder and 9 layers of UV coating is applied on it. Bamboo is one of the natural materials available for flooring and is an alternative to hard wood flooring. Bamboo has a higher fibre rating than any other hard wood which gives it exceptional hard wearing qualities. Flooring and wall paneling are coated with UV coat while decking shall be coated with oil.

Bamboo Wall Panels

Permanent Wall Form



Bamboo Wood Flooring

### *5. Apollo Chaukhat Door & Window Frame Sections*

The door & window frame sections consist of Direct Formed (cold) MS Tubular door frame sections and window frame sections available in Single & Double door/window frame and four side door frame. The Products are of thickness ranging from 1.6mm to 3.0mm.

### *6. Elastomeric Paintable Plaster*

Elastomeric Paintable Plaster is a paste made with minerals, plasticizers and exterior grade polymers to be used as a putty /plaster / water proofing film. It could be used as a binding material to paste tiles, stones and bricks.

Elastomeric Paintable Plaster

### *7. Bamboo Wood Flooring & Wall Cladding*

Bamboowood flooring is made from Strand woven bamboo. It is a conversion of bamboo to wood. Bamboowood flooring is an eco-friendly product made from bamboo, the fastest growing plant on earth. Bamboo travel through boiling process or burn it under high pressure stream to remove starch and sugar content to make it termite resistant. Further, voc compliant phenolic resin is used as binder and 9 layers of UV coating is applied on it. Bamboo is one of the natural materials available for flooring and is an alternative to hard wood flooring. Bamboo

has a higher fibre rating than any other hard wood which gives it exceptional hard wearing qualities. Flooring and wall paneling are coated with UV coat while decking shall be coated with oil.

## PACs for Renewal

i) PACs for the following systems/ products have been renewed:
   1. Sound Proof Drainage Piping System
   2. Rising EPS (Beads) Cement Panels
   3. Underground Water Storage Tank ((Sump)
   4. PVC Profile Door.
   5. PIR Dry Wall Prefab Panel System
   6. Continuous Sandwich (PUF) Panel with Steel Structure.
   7. Prefabricated Fibre Reinforced Sandwich Panels
   8. Bamboowood Products

ii) Application for Renewal of PACs for the following systems/products has been received:
   1. Stay in place PVC Wall Forms
   2. Structural Stay in Place Formwork System
   3. QuikBuild Panels
   4. Precast Construction Technology

## Receipt of Applications for PACs

Applications for the following new products/systems have been received from the manufacturers for processing further for issue of PACs:

1. Insulated Sandwich Panel (Glamet)
2. Insulated Sandwich Panel (Monowall)
3. Insulated Sandwich Panel (Super Wall)
4. Insulated Sandwich Panel (Hipertec Roof)
5. Insulated Sandwich Panel (Hipertec Wall))
6. Integrated Hybrid Solution –TWO
7. Dalmia Magic Premium Skim Coat
8. Modular Building / PEB/LGS Building
9. Insulated (Roof Tile)
10. uPVC Doors & Windows
11. Koncrete Reinforced Autoclaved Aerated Concrete Panel

The above applications are being processed on the basis of data furnished by the firms, information available on their web sites, inspection of manufacturing plants at site of works and testing of samples of the products/systems etc. before preparation of Performance Appraisal Certificates (PACs).

## Inspection of Works

Due to COVID-19 Pandemic, the folloiwng inspection of works has been conducted through video conferencing:

1. Stay in place PVC Wall Forms
2. Structural Stay in Place Formwork System
3. QuikBuild Panels
4. Insulated Sandwich Panel of Glamet, Monowall, Super Wall, Hipertec Roof, Hipertec Wall
5. Dalmia Magic Premium Skim Coat
6. Koncrete Reinforced Autoclaved Aerated Concrete Panel

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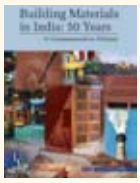

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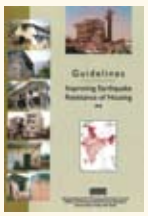

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"BMTPC to be world class knowledge and demonstration hub for providing solutions to all with special focus on common man in the area of sustainable building materials, appropriate construction technologies & systems including disaster resistant construction."

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"To work towards a comprehensive and integrated approach for promotion and transfer of potential, cost-effective, environment-friendly, disaster resistant building materials and technologies including locally available materials from lab to land for sustainable development of housing."

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