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3 October 2022 World Habitat Day Mind the gap

World Habitat Day

3rd October, 2022

Mind the gap : Leave no one and place behind

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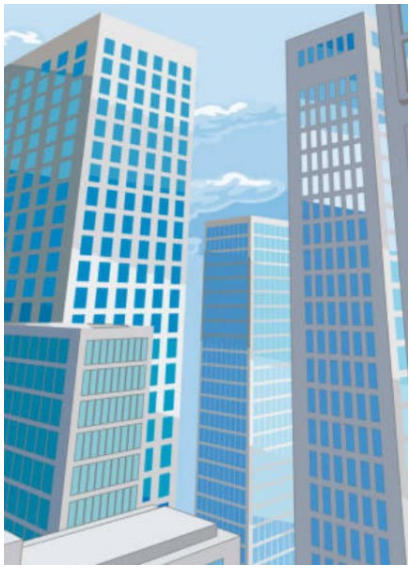
निर्माण सामग्री एवं प्रौद्योगिकी संवर्द्धन परिषद्
आवासन और शहरी कार्य मंत्रालय, भारत सरकार
BUILDING MATERIALS & TECHNOLOGY PROMOTION COUNCIL
Ministry of Housing & Urban Affairs, Government of India

"Creating Enabling Environment for Affordable Housing for All"



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From the Desk of
Executive Director

I am pleased to publish the special Newsletter *Nirman Sarika* of BMTPC on World Habitat Day being celebrated globally under the banner of UN-Habitat. The World Habitat Day is celebrated on the first Monday of October on a proposed theme of UN-Habitat related to urban issues. This year's theme of ***Mind the Gap, Leave No One and Place Behind*** deals with problem of growing inequality and challenges in the cities & human settlements. Ministry of Housing & Urban Affairs (MoHUA), Govt. of India and its urban renewal mission programmes, one of the world's biggest initiatives in terms of scale namely PMAY-U (Housing for all), Swachh Bharat Mission, Smart Cities, AMRUT, Urban Transport, Antyodaya Yojna are all designed, aligned & being operationalized successfully to include bottom of the pyramid citizens of the country. Alleviating Poverty, generating employment, upgrading skills, women empowerment, universal access, augmenting basic services are some of the dictums enshrined in all these missions which shows present Govt. commitment towards inclusive growth in line with this year's theme. The outcomes of these missions stand testimony to India's growth as now we are World's fifth largest economy & marching towards $5 trillion economy. Our Cities are now slowly transforming to be powerful engines of economic growth to foster inclusive (leaving no one behind) & sustainable growth, ensure better quality of living and are *Receptive*, *Innovative* & *Productive*.

BMTPC in its bit to contribute towards nation building is working towards bringing technology transition in the construction sector by introducing Industrialized Building systems which are SAFER (Superior, Affordable, Functional, Environment-amenable, Resource-efficient) and fast track the construction (reducing the construction time by 50%). MoHUA through GHTC-India have shortlisted 54 such construction systems which are now being propagated across the country. We are also executing six light house projects across six cities in six states showcasing six such distinct systems for the benefit of our professionals & citizen & aspire to make them as *future construction systems* to build new young India in this Amrit Kaal: towards the centenary of India's Independence. These light house projects true to their name are beacon of field level implementation of state-of-the-art modern technologies for mass housing and serving as live laboratories for professionals to study, comprehend, study, assess & adapt them to build sustainable resilient India.

BMTPC publishes this special newsletter *Nirman Sarika* on the World Habitat day's theme every year without fail & this is my uninterrupted 15th Newsletter since I joined BMTPC in 2008, a matter of personal attainment & gratification. It could have been possible because of researchers, academicians & industry experts who contribute articles for the publication. I also place on record my deep appreciation to my design team especially Shri Sharad Gupta & Dalip Kumar for excellent compilation & timely publication of this year's newsletter.

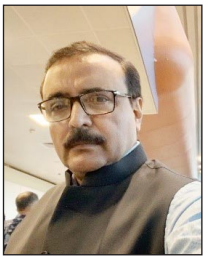
Let us treat buildings as BaaP (Building as a Product)

(Dr. Shailesh Kr. Agrawal)

Themes over the years

Year	Theme
2022	*Mind the Gap. Leave No One and Place Behind*
2021	*Accelerating urban action for a carbon-free world*
2020	*Housing For All: A Better Urban Future*
2019	*Frontier Technologies as an Innovative Tool to Transform Waste to Wealth*
2018	*Municipal Solid Waste Management*
2017	*Housing Policies: Affordable Housing*
2016	*Housing at the Centre*
2015	*Public Spaces for All*
2014	*Voices from Slums*
2013	*Urban Mobility*
2012	*Changing Cities, Building Opportunities*
2011	*Cities and Climate Change*
2010	*Better City, Better Life*
2009	*Planning our urban future*
2008	*Harmonious Cities*
2007	*A safe city is a just city*
2006	*Cities, magnets of hope*
2005	*The Millennium Development Goals and the City*
2004	*Cities - Engines of Rural Development*
2003	*Water and Sanitation for Cities*
2002	*City-to-City Cooperation*
2001	*Cities without Slums*
2000	*Women in Urban Governance*
1999	*Cities for All*
1998	*Safer Cities*
1997	*Future Cities*
1996	*Urbanization, Citizenship and Human Solidarity*
1995	*Our Neighbourhood*
1994	*Home and the Family*
1993	*Women and Shelter Development*
1992	*Shelter and Sustainable Development*
1991	*Shelter and the Living Environment*
1990	*Shelter and Urbanization*
1989	*Shelter, Health and the Family*
1988	*Shelter and Community*
1987	*Shelter for the Homeless*
1986	*Shelter is my Right*

A Model to Leave No One Behind in Housing Improvement Programs - learning from Global and Local Cases



Dr. Subrata Chattopadhyay [1]
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Kasturi Palit [4]

Introduction

People who are left behind in the process of development are often economically, socially, physically, and/or politically marginalised, due to their financial status, ethnicity, race, gender, age, disability, or combination of these factors. When policies for development are framed following a top-down approach, without consulting the beneficiaries, the result is denial of opportunities and discrimination.

Marginalized people in India are often subject to poor and unhygienic living conditions, lack of education, social support and employment opportunities which further prevents them from improving their condition and the cycle of deprivation continues.

In order to address to these problems, the Pradhan Mantri Awas Yojana (Urban) Mission was launched on 25th June 2015 which intended to provide *housing for all* in urban areas by year 2022. Currently, the Scheme is extended till December 31, 2024 as only 60% of the target was achieved during its previous tenure. Hence, major developmental activities in housing sector is foreseen in recent years, which however needs to be planned in alignment with the country's commitment to 'leave no one behind',

Leave No One Behind (LNOB) as part of the 2030 agenda for Sustainable Development Goals (SDG) targets to reduce inequalities and vulnerabilities. Of the seventeen number of SDGs, SDG 11 particularly focuses on making cities and human settlements safe, resilient and inclusive. At this juncture, and India being a signatory to the 2030 Agenda for SDG, it is prudent to deliberate and research about how to make the future policy on housing and urban development in the country inclusive.

Urban Inclusiveness, according to Henry Lefebvre (1996), can be achieved through "participation," "appropriation," and the creation of "value" in the context of urban life of its marginalized subjects.

This can be achieved by ensuring access to adequate, safe and affordable housing and basic services for the urban poor through sensitive housing improvement programmes Given the well-established connections between poor housing, poor health, and poverty, social housing or housing upgrades in disadvantaged communities may offer a population-based method to enhance health and lessen health disparities. Housing upgrades that lessen people' exposure to particular risks may improve their current health and shield future generations from detrimental exposure (Thomson & Petticrew, 2005).

Thus, the paper aims to understand the different success and failure factors of a housing improvement program comparing the same with the principles of LNOB. The primary objective of this paper is to understand how residents of a housing improvement programme (user group) react to the provision by the policy-makers, done with the help of producers. The paper discusses both global and Indian case studies to understand the context of inclusion of the under privileged dwellers.

2. Case studies on slum upgradation projects

This section elaborates on case studies used to understand

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the critical success and failure factors based on access to essential amenities, opportunity to employment, empowerment to investing in housing, freedom for personalisation and incrementality, preservation of culture and context, inclusivity in design and the community's resilience.

2.1 Global context

Three international case studies, namely, Kenya Slum Upgradation Program (Kenya), Orangi Pilot Project (Pakistan) and Kampung Improvement Program (Indonesia) are selected for the above-mentioned analyses at a global level. The three stakeholders involved were common for all the projects viz. users, producers, and policymakers. The primary role of the users is to organize their site with the help of producers, who would be responsible for execution and flow of fund and the policymakers played the role of facilitators.

2.1.1 Kampung Improvement Program, 1969

The first initiative to upgrade an urban slum was the creative Kampung Improvement Programme (KIP), which was started in Jakarta, Indonesia, in 1969. KIP rose to prominence as a leading initiative that helped slums transform from unofficial settlements to becoming an integral part of urban life (Juliman, 2000). Three tiers of infrastructure were provided by this government-assisted, self-help community development programme: paved access roads, bridges, and pathways; water supply, sanitation, and drainage canals; schools, and health facilities. With little disruption to the existing dwellings, these improvements were woven along the existing rights-of-way.

2.1.2 Orangi Pilot Project, 1980

Dr. Akhtar Hameed Khan, a famous social scientist, launched the Orangi pilot project in Pakistan in the year 1980. In order to analyse the issues facing the Orangi settlement and then find workable answers through action research and extension education, he formed the initiative as a research institute. Its approach has always been to support locals in meeting their own developmental needs rather than relying on outside aid.

2.1.3 Kenya Slum Improvement Program, 2004

A joint project of the Kenyan government and UN-HABITAT, the Kenya Slum Upgrading Programme's (KENSUP) principal goal is to enhance the standard of living for those who reside in and work in Kenya's urban slums and informal settlements (UN-Habitat, 2007). On October 4, 2004, KENSUP was introduced during the worldwide celebration of World Habitat Day. KENSUP's goal is to show how, in Kenyan towns and cities, interventions that support a multidisciplinary and integrated approach to slum upgrading can help meet the goals outlined in the Habitat Agenda and the Millennium Development Goals, which are intended to enhance the lives of slum inhabitants.The following

Table 1 Actors in Housing: Global case studies

ACTORS	FUNCTIONS	CASE STUDIES		
		GLOBAL		
		KIP	OPP	KENSUP
USER	Primary stakeholders and user of space	Residents of Kampung	Slum dwellers	Slum dwellers
PRODUCER	Execution of upgradation	Community Based Organization (CBO)	Orangi Communities	UN HABITAT through NGO (Non-Governmental Organisation)
		Project Manager and Project Secretary	Physical health Engineering department	Kibera Slum Upgrading Initiative, Nairobi
		Sub-district chiefs (Camats) and Village Heads (Lurahs)	BCCI (now Infaq)	Cities without Slums, Kisumu
			OPP-RTI (Research and Training Institute), OPP-OCT (Orangi Charitable Trust), OPP-KHASDA (Karachi Health and Social Development Association)	Sustainable Neighbourhood Programme, Mavoko
			SMC (Sakkut Municipal corporation	Mombasa Slum Upgrading Programme
POLICY-MAKER	Distribution and allocation of funds	Central Government of Indonesia	Orangi Pilot Project Society	Government of Kenya

encapsulates briefly the prime issues, target users of the studied cases and the unique approaches undertaken in each project leading to distinctly varying outcomes.

2.2 Indian context

Three case studies were selected from India for a more contextual analyses of the critical success and failure factors of housing projects for the urban poor. They are Belapur low cost housing program of Navi Mumbai, the Sanjaynagar in-situ slum redevelopment program in Ahmednagar, and the Sangharshnagar slum rehabilitation project of Chandivili, Mumbai. The selected cases showcase the typical nature of successes and failures of three distinct approaches to developing housing for the poor, ie. low-cost social housing, in-situ slum redevelopment and slum rehabilitation.

The prime issues and target user groups involved in each of the projects are summarised briefly as follows. The uniquely varying approaches undertaken that led to specific outcomes are to be noted.

2.2.1 Belapur Incremental Housing Project, Navi Mumbai, 1983

The Belapur incremental housing project was a proposal for mass affordable housing at the artist village of Navi Mumbai, designed by Charles Correa. The unique feature of the project rested on the architect's vision to achieve high density residential neighborhoods, without compromising on the existing traditional spatial syntax of the low rise housing communities. (Harvey, 1985) The cardinal principles followed in the unique settlement design were, (i) incrementality of housing units, (ii) user's participation in decision making, (iii) income generative capacity of space, (iv) pluralism in design and finally (v) equity in space allocation among user groups. (Saha, Das, Agarwalla, C., & Chittaranjan, n.d.)This project was originally intended to be a village that housed primarily the artisans, however in the course of time it was observed that the aspirations of the residents changed giving way to structural transformations in individual houses resulting in an overall change in settlement typology. (Modi, 2016)

2.2.2 Sanjaynagar Redevelopment Project, Ahmenagar, 2022

The in-situ redevelopment project of Sanjaynagar slum located in Ahmednagar was a self-help housing program, that involved an active participatory planning and design approach and poses as a model project for the future. As a public private partnership project, the housing development was majorly financed through the 'Housing for All scheme' under Pradhan Mantri Awas Yojana (PMAY-Urban). (Abdel, 2022) The previously existing lack in basic infrastructure, and dismal living conditions leading to rising health issues, pushed the residents to take collective action in order to build an environment according their own heart's desire. The new upgraded community exhibited low-rise housing typology with special focus on improvement of quality of life of residents through provisions made for safe, healthy and private communal spaces. (Carlson, 2022)

2.2.3 Sangharshnagar Slum Rehabilitation Project, Chandivali, Mumbai, 2007

The rehabilitation township of Sangharshnagar, located in Chandivali, Mumbai is an example of a public housing project intended for dislocated slum dwellers, funded under the Slum Rehabilitation Scheme (SRS) and carried out by the Slum Development Authority (SDA) of Mumbai. The project aspired to accommodate more than 18,000 families, in high density planned neighborhoods with provisions for robust social infrastructure including schools, hospitals, playgrounds and other community facilities. (Varma, 2016) However ultimately only half of the plan was realised, and the project turned out as a typical top-down slum rehabilitation scheme, lacking sensitivity towards the way of life of the resident communities.

Table 2 summarises briefly the major actors (users, producers and policymakers) involved in the implementation of the selected projects.

2.3 Analysis

This section involves a comparative study both in the global and Indian context, for identifying the successes and failures of each project on the basis of key identified factors that are critical to the success of housing projects for the urban poor. The critical success factors identified for all the six projects are access to essential amenities, opportunity to employment, empowerment for investing in housing, freedom for personalisation and incrementality, preserving culture & context, community-oriented neighbourhood, inclusivity in design, and resilience.

To align with the aim of the study, the authors have tried to align these eight critical factors with the 5 principles of Leave No

Table 2 Actors in Housing: Indian case studies

ACTORS	FUNCTIONS	CASE STUDIES		
		INDIAN		
		BELAPUR Maharashtra	SANJAY NAGAR Maharashtra	SANGHARSH NAGAR Maharashtra
USER	Primary stakeholders and user of space	Artisans	Slum dwellers	Slum dwellers
PRODUCER	Execution of upgradation	City and Industrial Development Corporation	Community Design Agency, Mumbai	Sumer Corporation
		Maharashtra State government	NGO: Snehadalay	Maharashtra government under Slum Rehabilitation Scheme (SRS)
			Curry Stone Foundation	
			Rang De, Bengaluru	
POLICY MAKER	Distribution and allocation of funds	City and Industrial Development Corporation	Ahmednagar Municipal Corporation (AMC)	Sumer Corporation under Maharashtra State government

Figure 1: 5 Principles of Leave No One Behind (LNOB)

One Behind (LNOB)as outlined in Figure 1.

The principle of 'Discrimination' is associated with lack of access to essential amenities, and opportunity to employment in the context of a housing upgradation programme. The second principle of 'Geography' is aligned with the factors of empowerment for investing in housing, 'Governance' with freedom for personalisation and incrementality, 'Socio-economic status' with preserving culture & context, and community-oriented neighbourhood and 'Shocks and Fragility' with inclusivity in design, and resilience. The six case studies are documented along these 5 principles of LNOB that are aligned with the eight critical factors (Table 3 and Table 4).

Sanjaynagar Redevelopment Project, Ahmenagar
https://communitydesignagency.com/projects/sanjaynagar/

Table 3 Comparative study: Global cases

LNOB principles	Critical success factors	GLOBAL CASE STUDIES		
		KAMPUNG Indonesia	ORANGI PILOT PROJECT Pakistan	KENYA SLUM UPGRADING PROGRAM Kenya
DISCRIMINATION (1)	Access to essential **amenities**	SUCCESSES: (2, 4, 5) • Provision of road and footpaths • Provision of drainage channels, communal lavatories & washrooms (MCK), pit privies • Connection to water taps and well	SUCCESSES: (2, 4, 5) • Provision of sanitation and sewerage • Connection to electricity grid • Connection to piped water supply	SUCCESSES: (2, 4, 5) • Shelter improvement • Provision of physical infrastructure: sewerage system, water supply and sanitation, access roads, storm water drainage, electricity, and street lighting • Provision of social infrastructure: schools, health centres, community centres and recreational facilities
	Opportunity to employment	SUCCESSES: (1, 2, 4, 5) • Clinics and health education programs • School facilities and teacher training programs	SUCCESSES: (1, 2, 4, 5) • Redevelopment scheme generated scope of employment among locals	SUCCESSES: (1, 2, 4, 5) • Employment and income generation: markets, skills enhancement, micro-financing, and credit systems
GEOGRAPHY (2)	**Empowerment** for investing in housing	FAILURES: • No security of tenure lead to unwillingness in investment in housing.	SUCCESSES: (1, 2, 3, 4, 5) • Legalisation of tenure	SUCCESSES: (1, 2, 3, 4, 5) • Legalisation of tenure • Minimization of shelter security risk
GOVERNANCE (3)	**Freedom** for personalisation and incrementality	-	SUCCESSES: (3, 4, 5) • Community participation enabled sense of ownership and belongingness	-
SOCIO-ECONOMIC STATUS (4)	Preserving **Culture & Context**	-	SUCCESSES: (1, 3, 4) • The participatory approach and the extensive research by OPP-RTI ensured the preservation of culture	SUCCESSES: (1, 3, 4) • Participatory approach ensured consideration to the local context
	Community oriented neighbourhood	SUCCESSES: (1, 3, 4) • Efficient coordination at community level • Residents contributed to operations and maintenance only	SUCCESSES: (1, 3, 4) • Community driven self-help group	SUCCESSES: (1, 3, 4) • Community organization and mobilization
SHOCKS & FRAGILITY (5)	**Inclusivity** in design	FAILURES: • No women participation	SUCCESSES: (1, 3, 4) • Affordable working model allowed the inclusion of every resident	SUCCESSES: (1, 3, 4) Creation of gender awareness
	Resilience	SUCCESSES: (1, 3, 4, 5) • Support from the local enabled a shift from a physical approach to community-based development FAILURES: • Continuous improvement of living conditions in Indonesia's kampungs is a challenge	SUCCESSES: (1, 3, 4, 5) • The residents were taught to manage fund and maintain the basic services	SUCCESSES: (1, 3, 4, 5) • The involvement of relevant local authorities ensured the maintenance of the housing condition • Local people guaranteed programme ownership and sustainability

Table 4 Comparative study: Indian Cases

LNOB principles	**Critical success factors**	**INDIAN CASE STUDIES**		
		BELAPUR Mumbai	SANJAYNAGAR Ahmedabad	SANGHARSHNAGAR Mumbai
DISCRIMINATION (1)	Essential **amenities**	SUCCESSES: (1, 4, 5) • Provision of basic infrastructure. • Provision of ample amount of open and green spaces. FAILURES: • Provisions made for external toilet blocks were later abandoned.	SUCCESSES: (1, 2, 4, 5) • Provision of low-rise homes replacing unsafe temporary ones. • Provision of greenery and open space. • Provisions for water, drainage, roads, street lighting, childcare and community centers, courtyards for healthy recreation, and edible rooftop gardens.	SUCCESSES: (1, 2) • Provisions for basic service infrastructure. FAILURES: • Spatial disparity in provision of social infrastructure. • Failure to provide for balconies, open spaces and common courtyards. • Lacked provision for commercial spaces.
	Opportunity to employment	SUCCESSES: (2, 4, 5) • Houses constructed by traditional masons generating employment for local workers. FAILURES: • Underutilisation of cultural center provided for artists.	SUCCESSES: (2, 4, 5) • Designed and built with locally sourced materials with help from local community. • Provision for space for livestock	SUCCESSES: (2, 5) • Location near upper-class residential area opened up new avenues of employment. FAILURES: • Decreased employment opportunity. • Lack in commercial spaces.
GEOGRAPHY (2)	**Empowerment** for investing in housing	SUCCESSES: (2, 3, 4) • Equitable distribution in plot size among different economic groups.	SUCCESSES: (2, 3, 4) • PPP based financing model • Enabled successful participatory planning. • Collaboration with expert groups. • Innovative peer to peer lent home loan • Financial literacy program ensured timely repayments.	SUCCESSES: (2, 3, 4) • Demand for rehabilitation post-eviction, with the help of intervention by NGO. FAILURES: • Poor accessibility from site to major transport system
GOVERNANCE (3)	**Freedom** for personalisation and incrementality	SUCCESSES: (3, 4) • The houses were low cost and flexible to future expansions and adaptations. • Free standing homes added to incrementality. FAILURES: • Lack of commercial spaces led to illegal transformations of housing units. • No provisions for parking. • Original buildings later on demolished and replaced with bigger concrete houses by the aspiring middle classes.	SUCCESSES: (3, 4) • Resident's contributions in design decisions both at neighbourhood level to their individual homes. • Customization at individual unit. • Personalisation of space by individual families, allowed for women entrepreneurship, children's education etc. FAILURES: • The participatory planning process took longer than the direct approach.	FAILURES: • No provisions for commercial spaces led to illegal use of individual residential spaces as shops.
SOCIO-ECONOMIC STATUS (4)	Preserving **Culture & Context**	SUCCESSES: (2, 3, 4) • Planning and design based on observation of traditional Indian settlements • High density with open spaces achieved with low rise typology FAILURES: • With time residents no longer wanted a village with a rural backdrop.	SUCCESSES: (2, 3, 4) • Study of lifestyle of people, use of participatory approach to understand the needs. • Focus on quality of construction, and use of vernacular techniques keeping in mind the local soil and weather conditions.	FAILURES: • Lacked sensitivity towards the way of life of residents. • Lacked provisions for common spaces.
	Community oriented neighborhood	SUCCESSES: (1, 4, 5) • The housing project offered the quality of life of a village with the sophistication of a city. • Clusters permitted emergence of a local community feeling allowing enhanced social interactions.	SUCCESSES: (1, 4, 5) • Creating a balance of safe, healthy private and communal spaces that enhance social bonds. • Wide corridors designed to act as common spaces.	SUCCESSES: (1, 4) • 'Pada' concept involved blocks oriented around central courtyard which would act as communal spaces for preserving neighbourhood character. FAILURES: • Initial plans of 'pada' concept failed in some parts. • Space provisions for communal spaces, and angans were later occupied by lift shafts and ther services.

Table 4 Comparative study: Indian Cases...contd.

SHOCKS & FRAGILITY (5)	**Inclusivity** in design	SUCCESSES: (1, 3, 4) • Several plans co-existed covering the social spectrum of family structures. • Originally built for artisans, later on developed into mixed occupancy. • Dense cluster of dwellings gave a sense of security to the inhabitants. FAILURES: • With time remodelling and addition of new houses, some clusters become mini-gated communities.	SUCCESSES: (1, 3, 4) • Promoted women ownership. • Slum residents used open spaces for gathering and recreation, retaining neighbourhood character in their participatory redesign	FAILURES: • Spatial disparity in provision of social infrastructure.
	Building **resilience**	FAILURES: • No arrangements made for fire safety provisions.	SUCCESSES: (1, 2, 4, 5) • An approach based on prioritising quality of life. • Proposal of solutions to the problems inferred from analysing base survey reports about health of children living in slums and the quality of life. • Guiding the community and equipping them with information and tools needed to operate effectively as a cooperative housing society.	FAILURES: • Transformation into vertical slums due to lack in maintenance.

3. Discussion & recommendations

This section presents a discussion on means of achieving project success in an inclusive manner. The authors argue that the various success criteria which have been identified from the case studies discussed in this paper are also instrumental in achieving the principles of LNOB.

3.1 Discrimination

The primary success factor which is quite effective in eliminating discrimination is equitable access to basic urban services for all. With Government acting as provider of major facilities like solid waste management system, water treatment plants, hospitals, colleges / universities at the city level, at housing cluster level, the residents can be effectively involved in managing community amenities like sewage, water supply, schools / anganwadis, clinics. Access to social infrastructure, open spaces, parks and playgrounds ensure social inclusion. Pre-planned spaces for future development supports incremental development and need-based spatial appropriation as per priorities of the community in a participatory manner.

3.2 Geography

Isolation and risk of exclusion is a deterrent to empowerment and inclusion. The negative implications of these factors can eventually lead to reduced interest in community-led initiatives for improving the overall living condition of the inhabitants. Thus, accessibility to affordable mass transport systems are very important components of housing improvement programmes.

3.3 Governance

The analysis shows that the willingness to invest in houses tends to increase with better security of tenure. The Government must therefore focus on ensuring protection against forced eviction. There should be scope for personalization and incremental development integrated into the housing improvement programmes for better socio-cultural inclusion.

3.4 Socio-economic status

Ensuring access to hygienic living conditions and essential amenities help people overcome many barriers in achieving desired quality of life.

Creation of amenities and services by the community and for the community also ensures economic inclusion by generating employment opportunities for the local youths. Economic empowerment will further enable them to invest for improving their living conditions by self-upgradation and sustained maintenance of their individual houses.

In addition, community-led neighbourhood design accommodates the social and behavioural aspects of the inhabitants, strengthens social bonding, builds communal harmony, reduces conflicts, increases socio-economic resilience and ensures cultural inclusion.

3.5 Shocks & fragility

In times of crisis posed by climate changes, economic downturns, or health emergencies, the marginalised communities are the

most vulnerable and exposed to their aftermath. However, some examples of excellent resilience amongst slum population have been shown during the latest Covid 19 pandemic. All the success criteria discussed earlier like access to water, sanitation and healthcare services, enhanced employment opportunities, scope for socialization, personalization and incremental community-led development increase the socio-economic resilience of the community.

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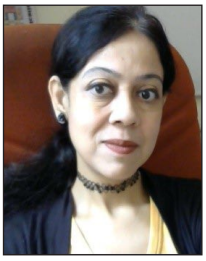
Adequate and Inclusive Housing for All: a human right based approach



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Introduction

Cities are rapidly urbanizing and this in turn aggravates the global challenges like climate changes, extreme weather events, and poverty. As compared to 2018, when 55% of the world's population lived in urban areas, it is estimated that by 2050, this number will rise to 68%. Urbanization could add another 2.5 billion people to urban areas, with close to 90% of the increase taking place in Asia and Africa **(United Nations, 2018)**. India alone is projected to add 416 million urban dwellers to its population. In 2016, the New Urban Agenda (NUA) was adopted by the United Nations Conference on Housing and Sustainable Urban Development (Habitat III), emphasizing the importance of the concept of inclusivity in designing and managing our cities. It also promulgated the concept of Right to the City (R2C) for developing a revised planning framework to fulfill the international objectives and targets under the Sustainable Development Goals (SDG) **(United Nations Habitat III, 2016a).**

Housing is placed at the core of the NUA, indicating diverse housing opportunities can support the accomplishment of Goal 11 of SDG – specifically target 11.1 i.e. ensuring access to adequate, safe, and affordable housing and basic services to all including people residing in informal settlements. As per Habitat-III's Policy Paper on Housing by **United Nations Habitat III (2016b),** around 880 million people presently don't have adequate housing in cities worldwide and estimated that at least 2 billion people will require housing by 2030. Achieving housing targets have a multiplier effect on other goals such as achieving no poverty, healthy societies, inclusive economies, gender equality, cohesive society, and environmental sustainability **(United Nations Habitat III, 2016b).** There is an unequivocal realization that the linkages between the 4 A's of housing and basic services - availability, accessibility, affordability, and adequacy, which are critical for the successful realization of human rights for all, thereby including everyone and not leaving anybody or any place behind.

The housing demand in Indian cities are increasingly growing due increased number of people migrating to cities in search of better opportunities and lifestyle. This also creates a need to adopt mechanisms for making our housing inclusive and adequate for all. As per the data released by the Government of India (GoI), the country observed an urban housing shortage of around 18.78 million houses for the period 2012-2017- 96% of which correspond to low-income households **(Ministry of Housing and Urban Affairs, 2012).** To sustain this rapid urbanization, GoI has launched several flagship programs and schemes focusing on inclusive and sustainability agenda. Pradhan Mantri Awas Yojna – Housing for All (PMAY-HFA) is such a mission to tackle national-level housing challenges under four verticals. The mission is currently extended till 2024 and there were around 122.69 lakhs houses sanctioned till 31st March 2022. This article introduces the concept of Right to City (R2C) and draws international and national commitments to meet unprecedented housing challenges using an integrated and inclusive approach.

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2. Concept of the Right to the City (R2C) and Right to Housing

The R2C model provides an exemplary opportunity for city experts to deal with their urban challenges by extending the human rights-based approach (HRBA) in planning, building, and managing our cities. This approach has the potential to reduce socio-spatial inequalities, enhance equity, promote participatory methods, and enhance the quality of life of its citizens **(OFFICE OF THE UNITED NATIONS HIGH COMMISSIONER FOR HUMAN RIGHTS, 2006; United Nations Habitat III, 2016a).** This concept was originally introduced by Henri Lefebvre in 1968 in the book Le Droit à la Ville, who stated that urban inclusiveness can be achieved through participation, appropriation, and the creation of value in the context of urban life of its marginalized subjects **(Jeanne, 2016; King, 2019)**. Lefebvre's thinking on rights highlights the need for an 'opening'. Lefebvre (1968/1971) argues that this opening, starting within the experience of misery rising out of housing shortages or standardarized mass housing involves the yearning for freedoms and the formation of a series of rights including those beyond housing, relating to the city. In recent years, housing activists often refer to the idea of a right to the city in struggles for access to housing and against displacement as a result of gentrification and privatization **(Samara, Sinha, & Brady, 2013).**

Figure 1 shows the evolution of this concept into a worldwide movement, which ultimately resulted in a World Charter on Human Rights.

United Nations Habitat III (2016a) defines R2C as the right of all inhabitants to inclusive and sustainable cities, as a common good comprising nine components as depicted in **Figure 2**. These include non-discrimination, inclusive citizenship, political participation, equitable access to services, quality public spaces, gender equality, cultural diversity, inclusive economies, and a common ecosystem that respects rural-urban linkages and biodiversity. The underlined concept focuses on enabling participatory and transparent approaches for democratic cities, grounded in three universal principles advocated by the United Nations to make SDG a reality - Human Rights Based Approach, Leave No One Behind, and Gender Equality & Women's Empowerment **(UN Sustainable Development Group, 2022).** These three principles develop a conceptual and operational paradigm shift in the way urbanization is planned and governed, for which diversity is acknowledged in terms of gender, age, geography, disability, income, culture, and other aspects.

However, much earlier in 2000, the UN Human Rights Council appointed its first rapporteur on the

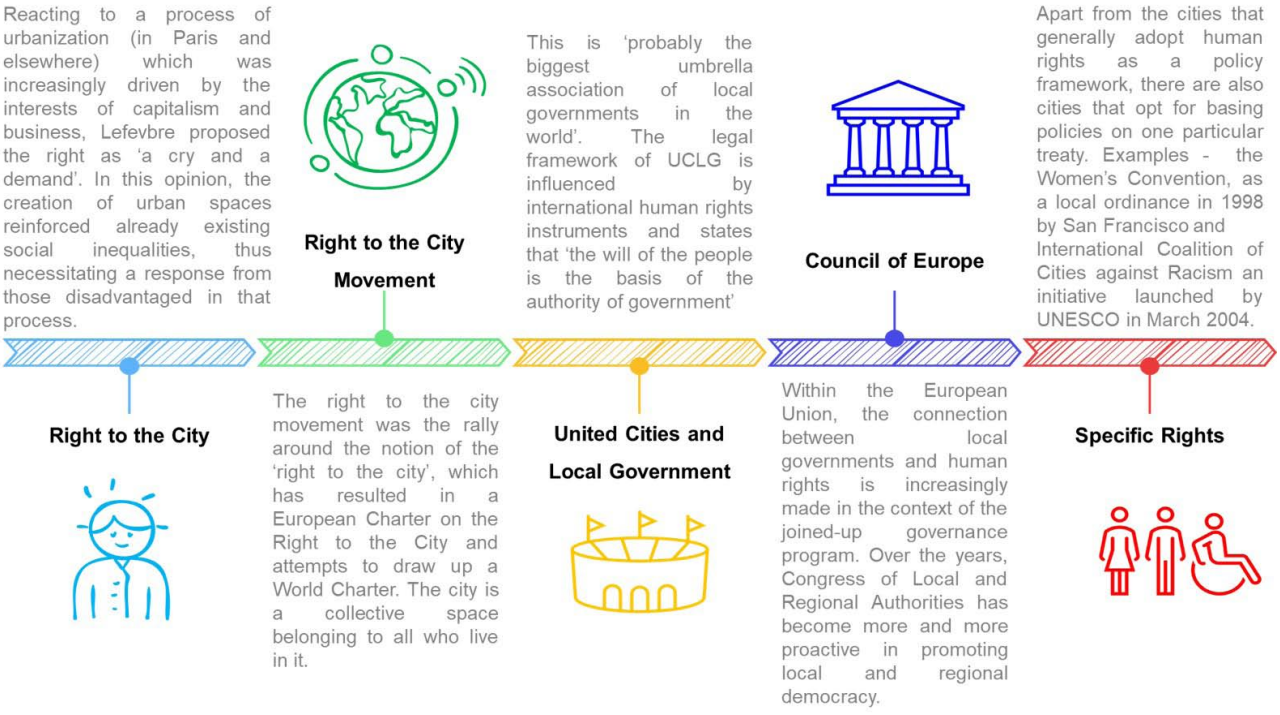

Figure 1: Evolution from the R2C concept to World Charter on Human Rights

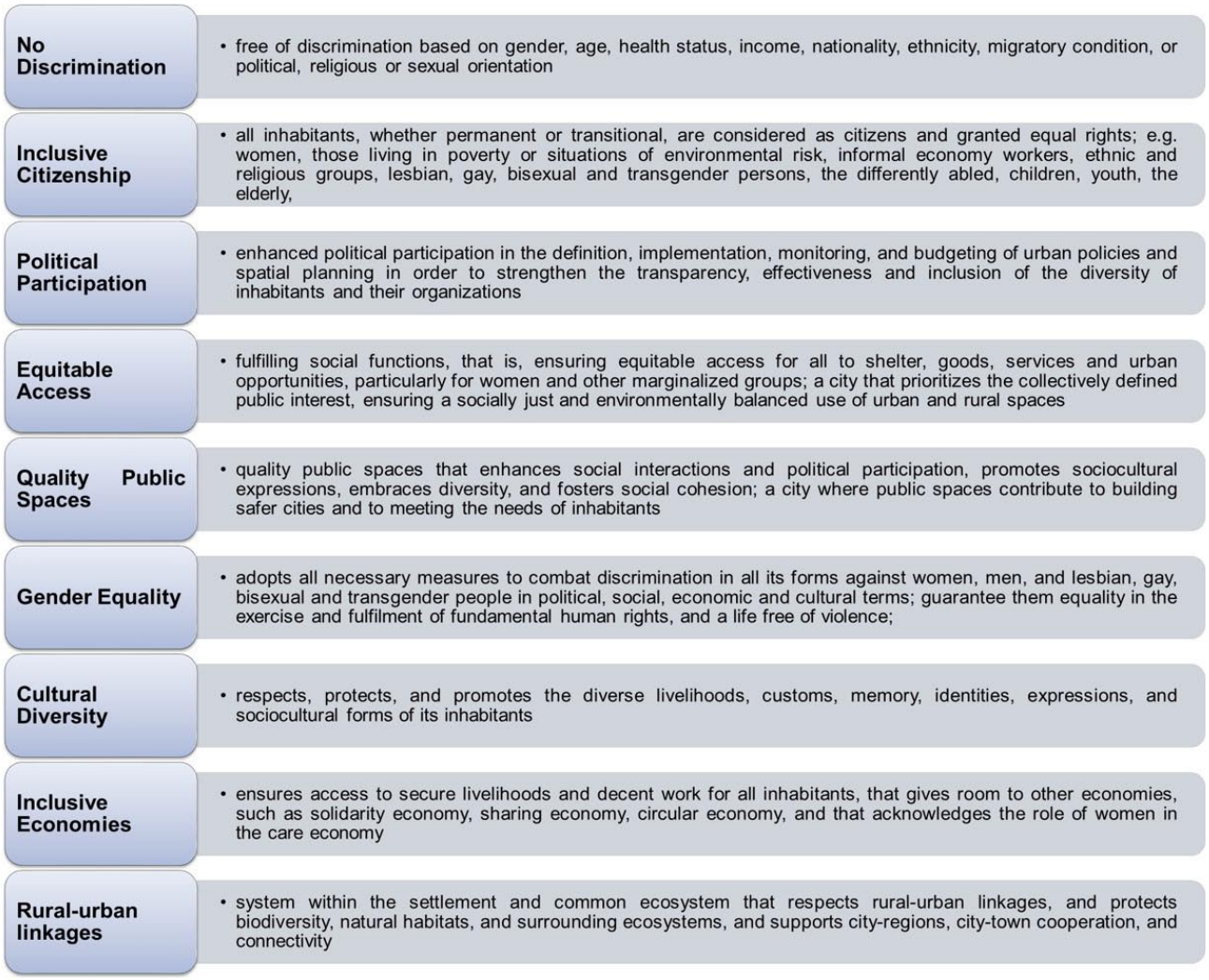

Figure 2: Components of City as a Common Good

right to housing, Miloon Kothari, who in 2008 was succeeded by Raquel Rolnik **(Manuel, 2014).** In her contribution, Rolnik stresses the connections between social movements that have brought the right to the city to the streets and concrete struggles for adequate housing.

3. International Commitments to Housing

Human rights are universal legal guarantees of fundamental freedoms, entitlements, equality, and human dignity for all, giving everyone basic freedom of choice, and expression as well as basic needs required for the full enjoyment of other rights such as education, water, sanitation, food, health, and housing. The right to Adequate Housing for All is identified as one of the most important components of human rights protected under international declarations, conventions, and treaties such as Article 25 of the Universal Declaration of Human Rights, Article 14 of the Convention on the Elimination of All Forms of Discrimination against Women, Article 43 of International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families, Article 9 and 28 of Convention on the Rights of Persons with Disabilities (CRPD), Article 21 of Convention Relating to the Status of Refugees, Article 27 of Convention on the Rights of the Child and Article 11 of International Covenant on Economic, Social and Cultural Rights **(UN-Habitat, 2017).**

SDG 11 also acknowledges access to adequate housing as a basic human right especially considering marginalized, migrants, displaced people, elderly, children, youth, minority groups, disabled, and women as vulnerable or special needs groups. Housing targets can directly impact indicators concerning SDG 1 (no poverty), SDG 5 (gender equality), SDG 6 (clean water and sanitation), and SDG 13 (Climate Action). Housing and Basic Services also have direct and indirect implications on other policy areas of the NUA –

Social Cohesion and Equity, Urban Frameworks, Spatial Development, Urban Economy, and Urban Ecology & Environment. This is also reflected in other international declarations such as the Vancouver Declaration on Human Settlements (1976), Agenda 21 (1992), Istanbul Declaration on Human Settlements (1996), Habitat Agenda (1996), and Millennium Declaration Goals (2000).

The most recent is the Housing at the Centre (H@C) approach which recommends a people-centered, integrated, and holistic housing development framework **(UN-Habitat, 2017)**. This implies that urban policies, programs, projects, and interventions should consider HRBA for the development of our cities and urban settlements. This approach also takes into account the socio-economic dimensions of housing and prioritizes the needs of the vulnerable group of people in society. Transformative actions are also suggested to mainstream the availability of basic services, affordability, habitability, and accessibility for all while addressing equal participation, non-discrimination, security of tenure, transparency, and accountability.

4. Adequate and Inclusive Housing for All

Achieving global housing goals depends on the following five dimensions mentioned under the Habitat III framework **(United Nations Habitat III, 2016b)** i.e

i. an integrated housing framework
ii. inclusive housing
iii. affordable housing
iv. adequate housing
v. informal settlement upgrading

An integrated housing framework recommends coupling housing with other urban programs and strategies at all levels concerning basic services such as water and sanitation, land use planning, urban mobility, ecology, and biodiversity. This would ensure coordination between sectoral policies leading to a more spatially just resource distribution and mobilization, especially for the vulnerable group **(as cited in United Nations Habitat III, 2016b).** Exclusionary zoning, lack of mixed-use regulations, social discrimination against certain groups, income differentials, and significant rise in housing prices are some of the factors which usually deter the provision of adequate housing to all. Inclusive housing supports a participatory approach, fair housing policies, and considerable sensitivity towards the needs of special needs groups. This study defines an inclusive built environment as one which ensures equal opportunities and scope for dignified, independent, and productive participation in various aspects of urban life for all citizens including the vulnerable groups. UN-Habitat's H@C approach provides five guiding principles as shown in **Figure 3** to assist policymakers in dealing with housing issues under NUA.

The right to adequate housing for all can be implemented under

Figure 3: Five Guiding Principles under the H@C approach

various themes such as technical, legislative, and financial to provide everybody with ample opportunities which are affordable, safe, and accessible. Incorporating gender, age, and disability aspects in housing strategies enhance inclusivity for all and benefits everyone and not just the ones with financial needs. The seven dimensions of adequate housing for all are represented in **Figure 4**.

5. India's approach to Inclusive Housing

The Government of India (GoI) is working towards an integrated approach to achieving larger goals of sustainable development under the present urbanization scenario. There are many central-level schemes and flagship programs that intend to achieve the targets in alignment with the global commitments to achieving inclusive city planning. For instance, India is a signatory to many international conventions and declarations focused on the human rights-based approach and vulnerable sections of society such as UDHR, CEDAW, CRC, Madrid International Plan of Action on Ageing, UN-CRPD, Incheon Strategy, Beijing Declaration, NUA and 2030 agenda of SDG. Under the housing sector, in particular, it is the PMAY-HFA mission which was launched by the Hon'ble Prime Minister as a centrally sponsored scheme under the Ministry of Housing and Urban Affairs (MoHUA). The mission focuses on assisting states and UTs in providing houses to eligible households by 2024, covering all notified statutory towns.

It ssupports the construction of houses of up to 30 sq. m. carpet area with basic civic infrastructures such as water, sanitation, roads, and power. The mission is implemented under the four verticals i.e. In situ Slum Redevelopment (ISSR), Affordable Housing through Credit Linked Subsidy (CLS), Affordable Housing in Partnership (AHP), and Subsidy for Beneficiary-Led Individual house Construction or Enhancement **(Ministry of Housing and Urban Affairs, 2021b).** Also, the detailed project reports under AHP and ISSR support providing ramps and other facilities for barrier-free access to persons with disability (PwD) as identified under the provisions of the Rights of Persons with Disabilities (RPwD) Act, 2016. Providing infrastructure for rainwater harvesting and solar energy to meet the needs of common public facilities is also highlighted

Figure 4: Seven Dimensions of Adequate Housing

under the mission guidelines.

The houses constructed under the mission require to comply with the minimum standards of safety and space provided under the National Building Code and Bureau of Indian Standards such as meeting the structural safety standards during earthquakes, flood, cyclone, and landslides. By making sure that the houses are in the name of the female head of the household or joint ownership of the male head and his wife, the mission ensures gender empowerment. Implementation of CLS makes sure that home loans taken by eligible beneficiaries under the Economically Weaker Section (EWS)/Low-Income Group (LIG) and Middle-Income Group (MIG) are affordable. The mission also observes convergence with the following ongoing programs of GoI:-

a. Smart Cities Mission was launched in 2015 under MoHUA focussing on sustainable and inclusive development of 100 smart cities, which act as lighthouses to other aspiring cities. It aims to provide core infrastructure, a sustainable urban environment, and decent quality of life to its citizens by harnessing the potential of smart innovative solutions **(Ministry of Housing and Urban Affairs, 2014).**

b. HRIDAY scheme was also launched in 2015 under MoHUA for the revitalization of identified heritage cities' development of infrastructures such as public roads, drainage, footpaths, sanitation, street lighting, water supply, waste management, and social infrastructure that are accessible and visually appealing.

c. Atal Mission for Rejuvenation and Urban Transformation of 500 Indian cities under MoHUA intends to converge public amenities and infrastructure development to make some part of the city can be used for housing for EWS **(Ministry of Housing and Urban Affairs, 2021a).**

d. Swachh Bharat or Clean India Mission aims to reduce open defecation and improve solid waste management in both urban and rural areas. Under this mission, public toilets, community toilets, and individual household toilets are constructed - – specifically all houses built or expanded under the PMAY-HFA should have a toilet facility.

e. RPwD Act, 2016 provides a legislative framework for the Accessible India Campaign (Sugamya Bharat Abhiyan) **(Government of India, 2016)**, which aims to provide equal opportunities for participation in all aspects of life to persons with disabilities. It focuses on developing an accessible physical environment including infrastructure pertaining to housing, employment, education, healthcare, culture, recreational, communication, public facilities, and transportation system **(Department of Empowerment of Persons with Disabilities, 2021)**.

f. Housing for employees – whether contractual or permanent working in industries should be provided with housing facilities. Similarly, land owned by railways and other central government agencies should undertake in-situ redevelopment of slums to eligible beneficiaries.

g. State and UTs should ensure the convergence of other relevant schemes such as the National Urban Livelihood Mission, National Health Mission, Sarva Siksha Abhiyan, Solar Mission, etc. with housing projects under the PMAY-HFA mission.

6. Conclusions

A city or an urban environment that is not designed in a manner that is safe, accessible, and inclusive prevents a significant percentage of its population from productively participating in various activities denying them opportunities and a decent quality of life. India is already moving forward to accomplish its housing goals in alignment with its international commitments to the 2030 agenda of sustainable development. So far, the process is integrative of other urban and rural missions of the Government of India. PMAY-HFA primarily takes into account the affordability issue via the provision of a credit-linked subsidy scheme and affordable housing to the beneficiaries. Besides, in-situ slum redevelopment focuses on providing security of tenure to the poor and marginalized groups. Accessible housing and public faculties is another area of concern on which the GoI is focusing especially under the Accessible India Campaign. With all these small steps, it is very much possible to have adequate and inclusive housing for all.

However, the real challenge is the seamless implementation of these missions by various ULBs and executing agencies. The local government must consider housing, not just a commodity but also a social good, and understand a human-rights-based approach to urban planning. Appropriate ca-

pacity building and training workshops should be conducted for the government officials to identify the issues which restrict the right to adequate housing for all. They should also be made aware of interlinkages with other areas of concern along with technical standards and guidelines. Planners and architects should make the best use of innovative building construction technologies and research tools to accomplish the mission's targets.

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18th Meeting of the Technical Assessment Committee (TAC) of Performance Appraisal Certification Scheme held on March 11, 2022 in BMTPC.

Innovative Construction Technologies for Mass Housing

Dr. Shailesh Kr. Agrawal[1]

Introduction

Urban India is transforming at an unprecedented rate as regards urban revival is concerned. Besides, Atal mission for rejuvenation and urban transformation (AMRUT), there are other flagship programmes run by Ministry of Housing & Urban Affairs such as Smart Cities Mission, Swachh Bharat (Urban) Mission, Heritage City Development & Augmentation (HRIDAY) Scheme, Urban Transport & Pradhan Mantri Awas Yojana - Urban (PMAY-U). The PMAY-U has been the landmark in the annals of India history where it is dreamt to provide shelter security to one and all by the 75th year of Independence. It is one of the biggest missions ever thought of around the globe providing 12.13 million houses within the span of eight years starting from 2015 to 2022.

With the global buzz about sustainability, reduction of carbon emissions, climate change mitigation strategies, the use of greener good practices in the construction sector has gained importance and has become relevant today. BMTPC under Ministry of Housing & Urban Affairs, Govt. of India has been promoting sustainable technologies for field level applications since 1990, however, during last few years, BMTPC is in the process of mainstreaming alternate housing technologies other than conventional ones which are suitable for affordable mass housing specially in urban areas. These alternate construction systems offer a basket of appropriate structural systems which are not only superior than the existing RCC/load bearing construction practices but also deliver quality, safe & sustainable houses at a much faster rate with much improved functional performance.

Innovative Construction Technologies

BMTPC has been engaged in identification & evaluation of such suitable technologies, which can be adapted in Indian context. BMTPC operates Performance Appraisal Certification Scheme (Gazette Notification No. I-16011/5/99 H-II in the Gazette of India No. 49 dated December 4, 1999) under which 42 new technologies have been identified, assessed for their suitability in different geo-climatic regions of the country & certified for usage by public & private agencies. The certified technologies are from the specific firms/agencies/technology providers with their specific trade names, however, they can be generalized and classified broadly here. These technologies along with other potential technologies under broad classification are as follows:

Technology Brief

A. Precast Concrete Construction System – 3D Precast Volumetric

Volumetric (3D) Concrete Printing Technology (VCPT)

3D Concrete Printing Technology (3DCP) constructs concrete structures by selectively placing a special quick-setting concrete mix using a numerically controlled robotic printer layer by layer as per a 3D CAD model. The operation can be performed with minimal human intervention/support and eliminating the need for formwork to construct walls. It is either executed on the site (like cast-in-situ)

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or offsite in a centralised set-up (like precast).

B. Precast Concrete Construction System – Precast Components Assembled at Site

SRPL Building System (Waffle-Crete)

Large structural ribbed panels of reinforced precast concrete, bolted together and the joints between the panels are caulked to form the walls, floor and pitched or flat roofs of buildings.

Precast Large Concrete Panel System

Structural system comprising of various precast elements such as walls, beams, slabs, columns, staircase, landing and customized elements. There are two types of precast concrete elements, namely precast reinforced concrete elements and precast pre-stressed concrete elements, prefabricated in a precast yard or site.

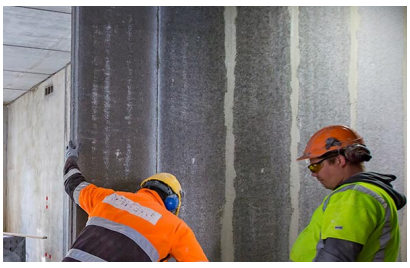
Industrialized 3-S system using RCC precast with or without shear walls, columns, beams, Cellular Light Weight Concrete Slabs/Semi-Precast Solid Slab

Industrialized total open prefab construction technology based on factory mass manufactured structural prefab components.

Walltec Hollowcwcore Concrete Panel

Factory produced extruded non-load bearing concrete hollowcore wall panels using light weight concrete made of river sand, crushed stone aggregate, light weight aggregate and Ordinary Portland cement.

Robomatic Holloollowcore Concrete Wall Panels



Fully automated machines factory produced extruded non-load bearing concrete hollowcore wall panels using light weight concrete made of river sand, crushed stone aggregate, light weight aggregate and Ordinary Portland cement.

K-Wall Panels

K-Wall panels are factory produced non-load bearing hollow core wall panels using light weight concrete made of ordinary Portland cement, fly ash, perlite, foam, fevicol DDL, fiber-glass mesh, river sand and water.

Urbanaac Precast Construction

Urbanaac precast construction technology is essentially a offsite precast concrete construction system under controlled environment using a reusable mould or "form". The components produced are then transported to the construction site and later lifted & assembled to produce structure.

Integrated Hybrid Solution - One

This is an Intermediate Building System (IBS) having three main components namely, interlocking walling system, precast floor & roof system and ferrocement building elements i.e. stairs, shelves, etc. All three components are integrated to construct a building.

Kon_Crete Reinforced Autoclave Aerated Concrete Panels

KON_CRETE Reinforced AAC wall & floor/roof panels are innovative Autoclaved Aerated Concrete (AAC) products, having properties such as light weightness, high thermal resistance, acoustics & energy efficiency.

C. Light Gauge Steel Structural Systems & Pre-Engineered Steel Structural System

Light Gauge Steel Framed Structure (LGSF)

Factory made galvanized light gauge steel components assembled as panels at site with infill walls of fibre cement board / cement particle board filled with insulation materials e.g. rockwool.

Light Gauge Steel Framed Structure with Infill Concrete Panels (LGSF-ICP)

Factory made Light Gauge Steel Framed Structure with infill wall of factory made precast panels filled with light weight concrete at site.

Factory Made Fast Track Building System

Factory Made Fast Track Modular Building construction system is hot rolled steel frame structure with different walling components, manufactured and fabricated in a controlled factory environment.

Speed Floor System

Suspended concrete flooring system using hybrid concrete/steel tee-beam in one direction and an integrated continuous one-way slab in other direction.

Continuous Sandwich (PUF) Panels With Steel Structure

Prefabricated, modular, factory made panels consisting of an insulating layer of rigid polyurethane foam (PUF) between two layers of pre-coated metal sheets.

PUF Sandwich Panel with Pre Engineered Building Structure

PUF Sandwich Panels with Pre Engineered Building structure is a combination of Structural Steel

Framing System designed as per relevant Indian Standards, with PUF Sandwich Panels in wall and roofing system. PUF panels consist of a rigid PUF core sandwiched between color coated Galvanized Steel/Galvalume steel sheet facing on both sides, complete with joint sealants and fixing ancillaries, which is easy to install and affordable.

D. Prefabricated Sandwich Panel System

Advanced Building System – EMMEDUE

Factory made panels consisting of self-extinguishing EPS core sandwiched between two welded wire fabric mesh made of high strength galvanized wire and finished at site using shotcrete of mix of cement and coarse aggregate on both sides.

Rapid Panels

Prefabricated assembly of high-strength steel wire forming a panel with core of expanded polystyrene (EPS). The basic unit of the Rapid Panel is the zig-zag truss.

Reinforced EPS Core Panel System

Factory produced sandwich panel system for the construction of low rise buildings up to G+3 and as filler walls in high rise RCC and steel frame buildings.

QuickBuild 3D Panels

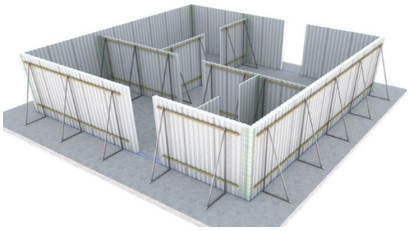
Consists of a welded wire space frame integrated with expanded polystyrene insulation core. The panels are placed in position and a wythe of concrete of required thickness is applied to both sides.

Concrewall Panel System

Comprises of a layer of welded wire mesh on either side of EPS core welded together by steel orthogonal trusses which penetrates through EPS core and sprayed on both sides with shotcrete to form a sandwich type construction.

BauPanel System

Panels of Expanded polystyrene (EPS) and steel wire mesh which are applied with shotcrete to form



a sandwich panel type construction at site.

Rising EPS (Beads) Cement Panels

Lightweight composite wall, floor and roof sandwich panels made of thin fiber cement/calcium silicate board as outer and inner faces with a core of EPS granule balls, adhesive, cement, sand, fly ash and other bonding materials in mortar form.

Flyash EPS (Beads) Cement Sandwich Panels

Lightweight solid core sandwich panels made of 5mm non-asbestos fiber cement boards on both sides of panels as facing sheet and the core material of expanded polystyrene beads, admixture, cement, sand, fly ash and other bonding materials in mortar form.

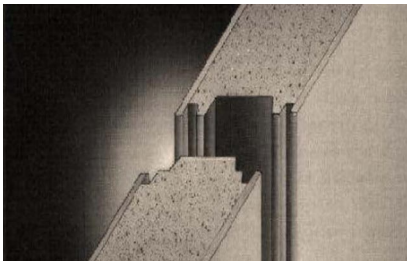
PIR Dry Wall Pre-Fab Panel System

A system where two fibre cement boards of 10 mm thickness are filled with insulation material namely Poly Isocyanurate (PIR) in-situ and erected to produce straight to finish walls. Used for non-load bearing applications.

Nano Living System Technology

Nano Living System Technology comprises of an inner and outer skin of magnesium oxide (MgO) board, with an injected core of closed cell, polyurethane foam, free of Chlorofluorocarbon (CFC) blowing agent. Cold formed metal studs are incorporated within the foam and between the magnesium oxide board skins at nominal 600mm centres.

Prefabricated Fibre Reinforced Sandwich Panels



Sandwich panels, made of two fibre reinforced cement facing sheets, on either sides of a lightweight concrete core. These panels have a unique tongue and groove jointing system that facilitates rapid construction & are fully cured at the factory itself and used as filler walls.

V-Infill Wall (Light Weight EPS Wall)

V-Infill Wall is factory made 8/10mm fibre cement boards (V-board) on either side of GI studs and erected to produce straight to finish walls which are filled with light weight concrete made of EPS, cement, sand and additive.

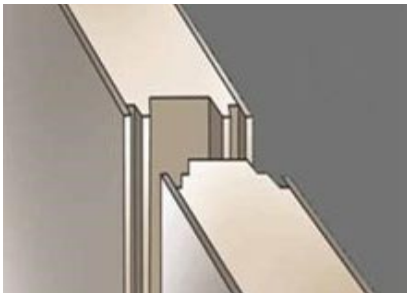
Factory Assembled Insulated Sandwich Panels using Mineral Wool

These factory assembled insulated sandwich panels consist of an insulating layer 'sandwiched' between two layers of metal sheets and manufactured using mineral wool bonded between pre-coated steel sheets to produce profiled finish panels.

Factory Assembled Insulated Sandwich Panels using PUF

These factory assembled insulated sandwich panels consist of an insulating layer 'sandwiched' between two layers of metal sheets and manufactured using rigid Polyurethane Foam (PUF) bonded between pre-coated steel sheets to produce profiled finish panels.

Everest Rapicon Panel / Solid Wall Panel



Rapicon panels are sandwich panels, made of two non asbestos fibre reinforced cement facing sheets of Everest wall boards as per IS 14862, on either sides of a light-weight foam concrete core. The core is made from a mix of Portland cement, fly ash, cellulose, lime, gypsum, synthetic fibre, fillers & water. These panels have a unique tongue and groove jointing system that facilitates rapid construction and maximizes space utilization.

E. Monolithic Concrete Construction

Monolithic Concrete Construction System

All walls, floors/slabs, stairs together with door & window openings are cast in-situ monolithically using specifically custom designed modular formwork made up of aluminium/ plastics/ steel/ composites, for the entire modular unit.

Modular Tunnel Form

Mechanized system for cellular structures based on two half shells which are placed together to form a room or cell. Several cells make an apartment. With tunnel forms, walls and slab are cast together.

F. Stay-in-Place Formwork System

Glass Fibre Reinforced Gypsum (GFRG) Panel System

Integrated composite building system using factory made prefab load bearing cage panels using GFRG and monolithic cast in-situ RC infilled for walling and floor/ roof slabs.

Sismo Building Technology

Insulating shuttering kit for whole building unit based on doubled walled EPS panel and a three-dimensional lattice made of galvanized steel wire. The lattice is filled with materials of different nature to serve as formwork.

Structural Stay-in-Place Formwork System (Coffor)

Structural stay-in-place form-work system to build load bearing monolithic concrete wall structures based on shear wall concept.

Insulating Concrete Forms (ICF)

Sacrificial formwork systems which are left in the structure after concreting and act as insulation. It comprises of a panel of two walls of Expandable Polystyrene (EPS) separated by a nominal distance of 150mm by hard plastic ties.

Monolithic Insulated Concrete System (MICS)

Formwork system with a rigid thermal insulation that stays in place as a permanent interior and exterior substrate for walls, floors and roofs, comprises of two layers of EPS connected by plastic ties.

Lost-in-Place Formwork System – Plaswall Panel System

Lost in place formwork, where two fiber cement boards (FCB) of

6mm thickness each are bonded through HIMI (High Impact Molded Inserts) spacers. These panels are erected in situ to produce straight-to-finish panels.

Lost-in-Place Formwork system – Plasmolite Wall Panels

Lost in place formwork system, where two fibre cement boards of 6 mm thickness are bonded together through High Impact Molded Inserts spacers and erected in situ to produce straight to finish panels which are filled with light weight foam concrete.

Stay-In-Place PVC Wall Forms

This is a prefinished wall form-work comprising of rigid Poly-Vinyl Chloride (PVC) based polymer components that serve as a permanent stay-in-place durable finished form-work for concrete walls. The hollow Novel wall components are erected and filled with concrete, in situ, to provide a monolithic concrete wall.

Permanent Wall Form (PVC)

"Permanent Wall form" is an innovative permanent structural walling system consisting of rigid Poly-Vinyl Chloride (PVC) formwork that serve as a stay in place finished form-work for concrete walls. Wall components are erected and filled with concrete, in situ, to provide a monolithic concrete wall.

Global Housing Technology Challenge - India

To give it further impetus Ministry of Housing and Urban Affairs (MoHUA) has conceptualized the Global Housing Technology Challenge – India (GHTC-India) as a platform with which a holistic eco-system can be facilitated so that appropriate technologies from around the world and relevant stakeholders can be catalysed towards effecting a technology transition in the housing and construction sectors of India. The challenges has three components (i) Conduct of a biennial Construction Technology India, Expo-cum-Conference, to provide a platform for all stakeholders to exchange knowledge and business (ii) Identifying Proven Demonstrable Technologies from across the world, and mainstreaming them through field level applications in Light House Projects (LHPs) across India, (iii) Promoting Potential Future Technologies through the establishment of Affordable Sustainable Housing Accelerators-India (ASHA-

India) for incubation and accelerator support.

GHTC-India was launched by Hon'ble Minister of State (Independent Charge), MoHUA on 14.01.2019 at Press Conference Hall, National Media Centre, Press Information Bureau, New Delhi. Subsequently, Construction Technology India – 2019 (CTI-2019) : Expo-cum-Conference was held at Vigyan Bhawan, New Delhi during 02-03 March, 2019 to bring together multiple stakeholders involved in innovative and alternative housing technologies, for exchange of knowledge and business opportunities and master classes. The Expo was inaugurated by Hon'ble Prime Minister of India in the presence of Hon'ble MoS (I/C), MoHUA.

The applications were invited online globally through a dedicated web site. 54 alternate technologies were shortlisted based on the technical parameters and are being promoted as future technologies for the construction sector. These 54 technologies have been further categorized into 6 broad categories:

A. Precast Concrete Construction System - 3D Precast volumetric (4 Technologies)
B. Precast Concrete Construction System – Precast components assembled at site (8 Technologies)
C. Light Gauge Steel Structural System & Pre-engineered Steel Structural System (16 Technologies)
D. Prefabricated Sandwich Panel System (9 Technologies)
E. Monolithic Concrete Construction (9 Technologies)
F. Stay-in-Place Formwork System (8 Technologies)

The technical details of about these technologies can be accessed at https://ghtc-india.gov.in.

Construction of Six Light House Projects under GHTC-India

The above shortlisted global technology providers are invited to plan & construct Light House Projects(LHPs) within the framework of PMAY(U) on pre-selected sites across six identified PMAY(U) regions. These light house projects shall serve as *open live laboratories* for different aspects of transfer of technologies to field applications. Through online Request for proposal(RFP) & bidding process, the construction agencies along with technology have been finalized and are as follows:

S. No.	Location	DUs, Storeys	Technology
1.	Indore, MP	1024, S+8	Precast Sandwich Panel system (Precast RCC Columns & Beams, Hollow Core Slabs, EPS Cement Sandwich Panel walls)
2.	Rajkot, Gujarat	1144, S+13	Monolithic Concrete Construction (Tunnel Form)
3.	Chennai, Tamil Nadu	1152, G+5	Precast Concrete Construction –Precast components assembled at site
4.	Ranchi, Jharkhand	1008, G+8	Precast concrete construction – 3D Volumetric Construction
5.	Agartala, Tripura	1000, G+6	Light Gauge Steel Structural System & Pre-Engineered Steel Structural System
6.	Lucknow, UP	1040, S+13	Stay-in-Place Formwork System (Steel Structural System, composite decking floor & Stay-in-Place Formwork for walls)

Epilogue

BMTPC through Ministry of Housing & Urban Affair has been advocating use of fast track construction technologies for housing and it is more apt now since India is committed to climate change mitigation, reduction of carbon foot print, resource-efficient & environment-responsive clean technologies. Introduction of the identified construction systems will bring not only paradigm shift in construction sector but also bring cost-effective systems, better environment, enhanced building marketability, reduced liability, improved health & productivity, low life cycle cost. Already, a sizeable number of companies have set up plants for manufacturing customized building components in India. It is required to give them little push/incentive and create an enabling eco-system which facilitates use of these systems through our procurement methodologies. The day is not far when India will start manufacturing buildings.

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Sustainability in Built Environment

Deepak Bansal [1]
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There are many definitions of sustainability which are complex to understand, but the simple one is that, where the natural resources (like land, air, water, sunlight, minerals/metals, fossil fuels, soil, flora & fauna, diversity, etc.), used by the current generation, must also be available to the next generations. Everything that we get for our survival, comes from the Earth or the Sun, be it food, water, air, clothes, houses or others ancillary requirements, however over use of these natural resources, are leading to its fast depletion. We are also releasing lots of wastes (toxic gases, liquid & solid wastes), which are polluting natural resources. This unsustainable development is causing huge pollution & global warming, which is causing changes in weather, extinction of some flora & fauna, melting of glaciers, rising of water in oceans, increasing toxicity in air, water & land, resulting in a threat to our survival on this green planet. It is estimated that, with this current rate of exploitation of our earth, we may require more than one earth, to survive on this planet. Hence, current form of development is not sustainable.

Industry, Transport & Buildings (along with physical infrastructure), are considered as three main sources of pollution, as they consume significant amount of primary energy (energy produced from fossil fuel) and natural resources, thus these are responsible for releases of substantial amount of greenhouses gases (GHGs) & other toxic gases (CH_4, CFC, COx, SOx, NOx, etc.). These GHGs are anthropogenic gases, which entraps heat in the atmosphere, resulting in rise of atmospheric temperature. Currently there are no standards in India, regarding permissible amount of primary energy consumption and related pollution, on sectoral basis. Energy production in our country is primarily through burning of coal, which is mostly lignite, which has less calorific value & high ash content, hence energy production process produces more fly-ash, which is another environmental nuisance (however, now energy production through solar power is increasing in India). Hence, our primary energy is more polluted, than the primary energy produced in countries, which are using anthracite coal, coal gas, hydro, wind, solar, etc., or countries like France etc., where most of the energy is produced from nuclear fuel. Hence, sustainability primarily comes through managing energy production and amount of energy use in various sectors. There are other dimensions of sustainability also like social/environmental impact and LCA (Life Cycle Analysis). It is common knowledge that initial cost & initial energy is important, but operational cost & operational energy is more important in any sector (especially in building sector due to longer service life), in terms of affordability & sustainability. It is further found that in Indian affordable houses, recurring cost & recurring embodied energy is at par with initial construction cost & initial embodied energy in its LCA. The beak-even of construction cost & energy is very important in sustainability. In highly consumer driven market, products are being marketed by this concept (LCA) only and now they are also rated

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as per their Life cycle energy consumption for sustainability. The ministry of Power through BEE (Bureau of Energy Efficiency) has started marking energy rating of electrical appliances & buildings and issued codes like ECBC 2017, but its effects need to be studied sector wise and at national level on GWP (Global warming potential).

Water, air and land pollution is also significant part of sustainability management, as water is precious and there is tendency of flushing surface water, sullage & sewages in the same drainage/ sewerage system, resulting in wastage of lots of water & increasing loads on STPs/ETPs. This wastage of wholesome water must be minimized by increased usage of recycled water coupled with usage of low flow faucets and checking pilferages in service lines. These low flow water faucets & fixtures are not very expensive and life time saving of water & money is much higher than initial investment. It is possible to reduce & utilise 80% or more water from drainage, sullage & sewerages system and reuse it without any harm or appreciable increase in cost & energy. The same is true with energy efficient BEE rated electrical/electronic appliances, through which substantial amount of energy & cost can be saved.

It is estimated that cities like Delhi, that generate about 10,000 MT (year 2018) of solid waste per day and most part (about 60%) of this is inorganic (large part of this is construction & demolition waste), which is simply dumped on the overcrowded land filling sites. Overfilled land filling sites are becoming disastrous, as they are collapsing on nearby habitats due to toppling by wind, water/ rain, and other manmade disasters. This solid waste can be used in constructive way rather than just dumping, by segregation of organic & inorganic waste. BIS (Bureau of Indian standards) has allowed usages of manufactured sand & aggregates in construction; hence large part of construction & demolition wastes can be used in civil construction.

Air pollution is one of the biggest killers in the world and especially in city of Delhi. Lots of people are asthmatic and have ailments related to lungs, skin, & eyes, etc, which are due to exposure to air pollution. Exhaust from vehicles, generators, construction industry, power plants, industry based on thermal plants and sweeping is biggest factors of air pollution. Now agriculture waste (stubble) burning in states like Delhi, Haryana, Punjab and U.P., is aggravating the problem of air pollution in Delhi. Air quality index, in Delhi generally remains in bad to worst category and not fit for human habitation, but people are forced to live due to no other choice.

Recently city of Delhi, has been declared as the most polluted city in the worlds, and people were forced to stay in homes for few days because of pollution. Delhi has a land area of about 1483 SqKm with a population of about 20 million as per estimation of year 2011. The gross density of population is 13,500 people per SqKm of land, which is very high. The demand for space for housing & related infrastructure (roads, parking, hospitals, schools, shopping centres, recreation, Railways/ Bus/Metro/Aero-Port, sewer, solid waste management, water /electricity/fresh air etc,.) is also very high and must be available to all. However, it is not. Many people in Delhi are putting up in slums or are not getting fair share of their resources. This is not sustainable as people are not getting fresh air, water, sunlight, electricity, and do not have access to drainage & sewerages. Transportation & related infrastructure has collapsed and people are fighting with each other for these basic services.

The built environment is nobody's business, as there is multiple land-owning agencies and development authorities, but enforcement is missing. More than half of Delhi is non engineered construction in Lal Doras/ slums/ urban villages/ Private squatter and even the planned/engineered development done by government agencies is being modified/extended illegally and are becoming unauthorized, rendering it vulnerable to collapse. The conditions of DDA flats are worst as illegal addition of floors on top, extension of balconies, converting cantilevered balconies into rooms, removal of load bearing walls/columns/beams and opening in walls for windows/ doors, etc., are making these buildings vulnerable not only to user but to whole community.

The buildings can be made energy efficient by low rise high density-based physical passive planning and by usage of low embodied energy based local construction materials. Carbon in built environment can be sequestered by planting trees, as on an average an Indian tree sequester about 14-21 kg of carbon per annum. Trees not only sequester carbon, but improve microclimate, reduce UHI (urban heat island) effect and

improve rain water harvesting. Construction materials consumption, maintenance cost and energy are also less in low rise construction. Energy efficient equipment in these buildings further reduces energy & cost and even this reduced energy can be supplied through renewable sources.

Building bye laws are just on papers as they are being flouted openly. Every year there are floods, cyclones, landslides, lightening (these incidences are surprisingly increasing day by day due to climate change), fires along with occasional earthquakes, but sustainable development is nowhere. It is seen that people are converting unauthorized spaces as schools, factories & shops and inviting unsuspecting people for business in these death trap. It is estimated that, if one take care of design & construction of buildings including maintenance as per local building bye-laws, construction cost does not increase much, but in case of failure of buildings due to non-adherence of these safety norms, the cost of rehabilitation is enormous along with loss of precious life. Most of Indian codes of design/construction, bye laws are very exhaustive and sustainable, but its implementation on ground is not enforced properly. This has been seen recently in a demolition case of a high rise RCC framed structure in Noida due to violation of building bye laws. Sustainability is not a fashion statement, but a way to happy & healthy life in beautiful surrounding with high happiness index. Now, since our population is very high and natural resources are depleting, hence we need to do sustained efforts to survive on this planet, or we may perish.

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RACHNA - Resilient, Affordable, Comfortable Housing with National Action

75 RACHNA training programmes spreading over 30 cities have been successfully conducted across India, covering over 5000 stakeholders. RACHNA - Resilient, Affordable, Comfortable Housing with National Action - is a collaborative effort of MoHUA, BMTPC and GIZ. Different group of stakeholders, ranging from urban practitioners, Central/State Government officials, Urban Local Body (ULB) officers, architects, engineers, builders, professors, students and construction workers, were included in the online/offline trainings programmes and workshops imparted on importance of thermal comfort, building materials, methods of construction for affordable housing and technology.

Under RACHNA, series of trainings and workshops were conducted with the aim to create awareness among stakeholders on thermal comfort, its necessity in the affordable housing sector and ways to achieve it. The trainings delivered in-depth knowledge on thermal comfort, material influences and its relationship with building physics. Moreover, it would also familiarise participants with design strategies, construction techniques, low-cost solutions, policy documents, building codes, international practices and other aspects relevant to thermal comfort in affordable housing. The outcome focussed on making the stakeholders in the affordable housing sector understand the need for thermal comfort and urge them to include no cost or low-cost strategies in upcoming projects. The participants were equipped with advanced knowledge and skillset to ensure provision of thermal comfort and emerging technologies in India's affordable housing sector.

Construction sector is constantly experimenting with modern building materials and technologies.

DR. SHAILESH KR. AGRAWAL
Executive Director, Building Materials & Technology Promotion Council (BMTPC)

Recent Interview for 8th Anniversary Edition of Construction Times Magazine

Q1. How do you view the evolution of Indian construction market over the years?

Construction sector has been reticent about innovations in the construction sector or rather slow in embracing modern technologies. For last several decades, ever since Portland cement came in to existence, the world over cast-in-situ RCC framed construction is in vogue besides brick and mortar masonry construction. This brick and stick business as usual approach is not sustainable as it puts pressure on existing natural resources, adds to pollution, enhances greenhouse gas emission, and is not economical over the life span of a building. Further, in light of climate change, extreme events, recurrent disasters across the globe, the construction industry is constantly evolving building materials & technologies which are sustainable. There have been successful case studies across Europe, USA, Russia where after world war, in order to quickly reconstruct, industrialised building systems such as prefabricated construction was adopted. Ever since there have been constant research and development so as to evolve and adapt the modern construction methods into mainstream. India is also not lagging behind and our public & private players are going for emerging construction technologies, which help in fast tracking the construction and at the same time bring resource efficiency, environment friendliness and sustainability. Systems such as monolithic concrete construction (aluminium formwork), precast concrete construction and pre-engineered buildings are being adopted and preferred in the Indian construction market. Building and infrastructure are being given top priority in the country so as to become world's fastest growing economy and build new young India and therefore, construction sector is constantly experimenting with modern building materials and technologies. The government sector is also contributing proactively towards evaluation, assessment and mainstreaming of modern construction systems through its Housing for All and other infrastructure related mission mode programmes.

Q2. What are the perceptible changes visible in India in terms of adoption of modern construction materials and technologies in projects?

The Government of India

launched Pradhan Mantri Awas Yojana (Urban) in 2015 with the objective of providing Housing for All. This mission has a Technology Sub-Mission with the objective to facilitate modern, innovative and green technologies and building materials in place of conventional construction for faster and quality construction of houses. The Sub-Mission also aims to mainstream and upscale the deployment of such modern technologies through coordination with public and private agencies and creating enabling environment. Under this Technology Sub-Mission in 2019, Global Housing Technology Challenge-India (GHTC-India) was organised where global players dealing with modern construction systems were invited in a two days Construction Technology India (CTI 2019) Expo cum Conference to showcase proven demonstrable construction systems which can not only minimise the construction time but also resource efficient, climate responsive, sustainable and disaster resistant. The event was held on 2-3 March, 2019 and inaugurated by Hon'ble Prime Minister of India. Through this Challenge, 54 innovative construction systems are shortlisted and being promoted across the country. These 54 construction systems are divided into six broad categories namely, (1) Precast Concrete Construction System – 3D Precast Volumetric, (2) Precast Concrete Construction System –Precast Components Assembled At Site, (3) Light Gauge Steel Structural System & Pre-Engineered Steel Structural System, (4) Prefabricated Sandwich Panel System, (5) Monolithic Concrete Construction, and (6) Stay In Place Formwork System.

Further, to give impetus, Government of India is constructing six Light House Projects comprising of 1000+ houses with basic and social infrastructure using six distinct technologies shortlisted under GHTC-India at six cities in six States e.g. Lucknow, UP; Rajkot, Gujarat; Indore, MP; Chennai, Tamil Nadu; Ranchi, Jharkhand; and Agartala, Tripura. These Light House Projects are treated as Live Laboratories with large scale citizen participation so as to sensitise the professionals and citizens about these modern construction technologies and at the same time build capacities in construction sector for adaptation and replication. The foundation stone laying for all the six Light House Projects was done by Hon'ble Prime Minister on 1.1.2021 and the project at Chennai is already handed over to the beneficiaries on 26th May, 2022 and the other projects are at the advanced stage of construction.

To give further fillip to these emerging construction systems, Government of India through CPWD has mandated use of these technologies and detailed Schedule of Rates (SORs) have also been developed. BMTPC also through its Performance Appraisal Certification Scheme (PACS) has certified most of these technologies. Under Pradhan Mantri Awas Yojana (Urban) around 1.6 million houses are being constructed using alternate and emerging technologies. Also various States including public & private agencies are adopting these technologies and therefore, it can be safely presumed that construction sector is slowly albeit surely going towards modern technologies replacing conventional RCC cast-in-situ frame and load bearing masonry construction. The website https://ghtc-india.gov.in can be accessed to get further insights about the various initiatives.

Under PMAY (U), more than 60% individual houses are constructed by beneficiaries themselves which are primarily single or double storey houses through local masons/ artisans. The requirement of building materials and construction technologies is different for these individual houses than those required for multi storeyed mass construction. It was, therefore, imperative to identify innovative appropriate construction technologies, materials and processes available in India for their use in construction of these houses. Accordingly, MoHUA organised Indian Housing Technology Mela (IHTM) during 5th -7th October 2021 in Lucknow, UP which was inaugurated by Hon'ble Prime Minister. The objective of the Mela was to provide a platform for indigenous and innovative building materials, components, tools & equipment, construction processes and technologies that are sustainable and suitable for construction of low and medium rise (upto G+3 storey) houses for demonstration, cross learning, enabling better adoption, market linkages and achieving desired scale.

Various stakeholders of construction industry like Construction technology providers, architects, builders & developers, Structural Engineers, Corporates, Designers, Facility Managers, Government, Institutions, Contractors, Dealers, Distributors, Nodal agencies, Product manufacturers & suppliers, Machinery and Equipment dealers, Service Consultants associated with housing construction got the opportunity to exchange their knowledge and business. IHTM also provided an interface for traditional technologies, new innovators & start-ups in the sector, technologists, to interact with end consumers and exchange their knowledge along with generating business opportunities under one roof. Through IHTM, 84 innovative technologies/systems/products/materials/machinery have been shortlisted and being promoted at present (https://ghtc-india.gov.in/IHTM).

Q3. How do you relate the demand-supply scenario of building materials in the country? What are the challenges faced by the building materials segment?

With US $3 trillion GDP, India is one of the largest and fastest growing economies in the world. It is witnessing massive public investment, robust private consumption, and structural reforms leading to rapid growth of >7%. Further, India is poised to become $5 trillion economy & aspiring to become a $10 trillion economy in near future. Also, construction in India is emerging as the third largest sector globally; it may reach US $1000 billion in value. Besides, India is fast urbanising with 377 million people (31%) living in urban areas as per 2011 Census. This population will continue to grow and will reach 590 million (40%) by 2030 and 815 million (50%) by 2050. This rapid urbanisation also opens growing opportunities and it is estimated that India has to build 600-800 million m2 urban space every year till 2030 i.e. a new Chicago every year, to meet urban aspirations. Therefore, cities, which will contribute over 80% to GDP by 2050, need to be Receptive, Innovative and Productive to foster sustainable growth and ensure better quality of living.

With these statistics, it is clear that there is huge demand in years to come and therefore, we need to take a paradigm shift from business as usual approach and adopt the comprehensive strategy of 3-S mantra i.e. Skill, Scale and Speed.

In order to meet the growing demand, there has been several initiatives by Government of India such as AatmaNirbhar Bharat, Make in India, Startup India, which aim to look at the supply side. There have been spurt of young entrepreneurs and engineers who are venturing into modern construction technologies. There are also foreign investment and number of technology providers setting up their manufacturing facilities for providing modern technological solutions to cater to this growing

urban demand. Despite of all these efforts, there is lot more desired to have hassle free demand and supply chain. There are several challenges which need to be looked into for mainstreaming sustainable technologies which can be enlisted as follows:

1. Cost economics
2. Lack of professional engineers and architects
3. Paucity of construction agencies and contractors
4. Skills at artisans level
5. Confidence building and sensitisation of construction fraternity and masses.

Q4. What is your take on introducing more sustainable materials and solutions in construction? How far does BMTPC promote sustainability and green solutions?

In the wake of Sustainable Development Goals, Paris Agreement, COP 29, India is committed to move towards carbon neutral development. As it is known that construction sector consumes 40% of precious energy, 25% of water, 40% of natural resources and at the same time contribute 50% towards air pollution, 42% of GHG emission, 50% of water pollution and 48% of solid wastes. Also GHG emissions will double by 2050 if we continue with business as usual scenario in construction sector. It is high time that we bring clean and green building materials and technologies including modern methods of construction and processes which can lead India towards sustainable development. Sustainability is now one of the deciding factor while undertaking development work and therefore it is important for the construction fraternity to look for materials, processes & technologies which are resource efficient, climate resilient, energy efficient and eco-friendly.

BMTPC since its inception has been promoting green and sustainable solutions for building construction. BMTPC is authorised to operate a scheme called Performance Appraisal Certification Scheme (PACS) through which innovative sustainable building materials and technologies are being evaluated and assessed for their suitability in the construction sector. So far 76 such innovations have been certified which can be downloaded from BMTPC website (https://www.bmtpc.org). Out of this 76, 42 innovative construction systems have been given PACs. This PAC is also kind of pre-standard which helps later to develop Indian Standards on these innovations. Also to showcase building materials and construction technologies under Pradhan Mantri Awas Yojana (Urban), BMTPC is executing Demonstration Housing Projects across India to showcase emerging systems and materials and at the same time sensitise and train professionals during execution. There are other promotional activities being undertaken on constant basis such as expositions, webinars,

conferences, road shows for dissemination, wider advocacy and outreach.

Under GHTC-India, the Ministry of Housing & Urban Affairs, Government of India has taken Affordable Sustainable Housing Accelerators- India (ASHA-India) initiative which aims "To nurture upcoming Indian individuals or technology ventures in the field of construction technology in housing sector in their start-up phase by providing all the support necessary to help entrepreneurs establish themselves before they scale up their ventures and to support entrepreneurs translating innovations into products and services that are commercially viable."

Five ASHA-India Centres have been established namely at Indian Institute of Technology, Bombay; Indian Institute of Technology, Kharagpur; Indian Institute of Technology, Madras; Indian Institute of Technology, Roorkee; and CSIR-CBRI/CSIR-NEIST, Jorhat where incubation and acceleration support is being provided to potential future sustainable technologies namely (a) Pre-Prototype (that are not yet market ready) which includes innovative technologies that are at ideation and prototyping stage, and essentially require further technical hand-holding through longer-term incubation to reach a viable product in the domain of construction systems and components and (b) Post Prototype (that are market ready) which includes technologies that have a working and viable product but require strategic guidance and acceleration to mainstream their product in the market, in the domain of construction systems and components, solutions that improve efficient usage of natural resources in housing and construction, self-help innovations, and digital technology solutions. At present, 11 shortlisted Pre-Prototype technologies and 37 Post-Prototype technologies are being nurtured.

In addition, there has been National Building Code 2016 which has chapter on Sustainability and recently, there have been concerted efforts by Government of India by bringing out Green Rating Systems and Eco Niwas Samhita (Part 1 & Part 2) which are energy codes on new buildings for ushering energy efficiency in the building sector.

Q5. With the Government coming out with mega plans on infrastructure and real estate developments, what opportunities do you visualize for building materials and technology players?

Sky is the limit for the construction sector to adopt building materials and modern construction technologies and processes as India is poised to become world's one of the largest economy. Also as India celebrates Azadi Ka Amrit Mahakaal, the next 25 years are going to be golden opportune time for technocrats and professionals to introduce fast track sustainable building materials and technologies which can help build cost effective, resilient and sustainable structures and lead India towards its 100th year of Independence. The kind of scales India have, India can surely become a global leader in the area of building materials and construction systems and show the world the path towards sustainable development.

A few potential areas which have tremendous opportunities are (i) Industrialised Building Systems, (ii) gainful utilisation of agricultural and industrial wastes into building materials and products, (iii) green building materials such as low carbon cement, manufactured sand, artificial aggregates, (iv) geo-polymer concrete, (v) prefabricated/precast pod elements, buildings and structures, (vi) digital solutions in the construction sector

such as BIM, Internet of Things etc., (vii) alternate building materials & technologies using local materials & skills, and (viii) disaster resilient technologies.

Q6. What are the key initiatives from the association to improve the efficiency and productivity levels of the industry, considering the possible demand escalation in future?

BMTPC being technical organisation of Ministry of Housing & Urban Affairs is in constant pursuit to bring paradigm shift in the construction sector by introducing emerging construction systems and technologies which can ensure faster delivery of sustainable, resilient and economical housing.

In order to mainstream these innovations in the sector there have been several key initiatives being taken by BMTPC in association with Government of India which are :

1. Identification, assessment and evaluation of innovative building materials and construction systems
2. Mainstreaming innovations through demonstration constructions
3. E-Certificate Courses : (i) NAVARITIH : e-Certificate Course on Innovative Construction Technologies, (ii) e-course on Vulnerability Atlas of India; (iii) e-course on Earthquake Resistant House Construction.
4. Networking with academic institutions and research laboratories and Chambers/Associations for further study, promotion, replication and adaptation.
5. Creating enabling eco-system for emerging construction systems with CPWD and BIS through development of Schedule of Rates, Specifications and Indian Standards.
6. Expositions, workshops, webinars, capacity building programmes, handholding of states, public & private construction agencies
7. Publication of technical literature, manuals, guidelines, compendiums

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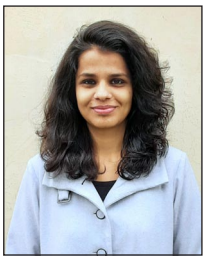
Mind the Gap - Leave No One and No Place Behind

Ground Learnings for Rural Housing and Habitat



Rashi Sirohi [1] *Urvashi Yadav* [2]

Guide : Zeenat Niazi, Development Alternatives

Introduction

"Leave no one behind*" is* a key principle of the United Nations Sustainable Development Goals (UN SDG) that resonates with the Indian Constitution's Directive principles of State Policy and quite recently has been popularised under the slogan of *Sabka Saath Sabka Vikas*. The key theme amongst these is the call for an inclusive development which transcends people and place.

In the Indian context, there exists multiple dualities in the approach to development and the ground realities. On one hand is the regional imbalance and rural-urban divide while on the other hand are the ecological limitations brought about by climate change and global warming. Although sustainable urban development is being prioritised in development works, the momentum for sustainable and environment friendly rural development has unfortunately lagged behind on multiple indicators.

The future of India, as emphasised by Mahatma Gandhi*, lies in its villages* . Under the contemporary rural development landscape, however, village housing still remains a cog in the wheel. Historically, housing and habitat conditions in India have been the result of social and economic processes. However, with changing environmental conditions, multiple influences are seen to be affecting the housing sector. Some of these interlinking factors are climate change, geographical isolation, social deprivation, economic exclusion, discrimination and poverty. These are inadvertently reflected through inadequate housing, shelter and infrastructure. To address the myriad challenges , various efforts have been undertaken by successive governments. Some of the most notable ones are the Pradhan Mantri Awas Yojana (erstwhile Indira Awas Yojana) and the revised PURA (Provision of Urban Amenities to Rural Areas) which together aim to bridge the gaps in arriving at inclusive rural development through housing and infrastructure.

Economic and Housing deprivation has been measured through different indicators like those in the Multidimensional poverty index (NITI Ayog) and the seven parameters in the Socio-Economic and Caste Census (SECC)[1] 2011. The key observation that emerges from both is that housing and economic deprivation is more rampant in rural India.

As per the SECC 2011 deprivation data on rural housing, only 3.8% (69.43 lakh) households in rural India are female headed while 0.4% (7.2 lakh) households have differently abled members; 21% (3.87 crore) are SC/ST households while the landless (manual labour) constitute 30% households (5.5 crore) . This points to the fact that the landless are the most deprived out of all groups. In addition to the socially and economically deprived, housing deprivation has also been estimated through the lack of *pucca* roofs and walls and is dependent

1 SECC 's Deprivation data has been categorised under following 7 parameters for Households with one or less room, kuccha walls and kuccha roof ; No adult member in household between age 18 and 59 ; Female headed household with no adult male member between 16 and 59 ; Households with differently able member with no other able bodied adult member ; SC/ST Households ; Households with no literate adult above age 25 years ; Landless households deriving a major part of their income from manual labour.

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upon the number of rooms.

Status of Rural Housing

Despite rural to urban migration, a major part of India (68 %) still lives in rural areas, as reported by the Census of 2011. These 83.3 crore Indians who live in rural areas constitute around 16 crore households in villages, covering an area of around 31 lakh sq.km, with 279 people living per sq.km. However, the living conditions of these 16 crore rural families is far from adequate.

According to the SECC 2011, there are a total of 17.97 crore rural households in India, out of which 13% (2.38 crore) have one or less than one room, *kuccha* walls and *kuccha* roofs. In fact, in its 'automatically included list' ,the SECC categorised 15.9 lakh households as those without shelter or inhabitants that are destitute, manual scavengers, primitive tribal groups or legally released bonded labour.

Such dire straits of rural housing and habitat can be attributed to factors like

- Inadequate access to information, services and technology
- Socio-cultural norms and caste-based discrimination
- Hesitance among entrepreneurs to invest in rural areas

Despite the progress made under different government programmes, housing shortage is still pervasive and excludes many deprived and discriminated groups . This would continue even in the near future along with other anticipated challenges, if not addressed on time with the right sustainability principles which are :

- Gender equality (SDG-5)
- Affordable and clean technology (SDG-7)
- Industry innovation and infrastructure (SDG-9)
- Sustainable cities and communities (SDG-11)
- Responsible consumption and production (SDG-12)

Housing Shortage

To address the housing shortage in rural India, Government of India (GOI) under its 'Housing For All' mission initiated PMAY (*Gramin*) to construct 2.95 crore *pucca* houses by 2021-22. However, this has recently been extended by the Union Cabinet till March 2024. This was done since 1.3 crore houses were still pending as of November 2021. Despite delays in achieving deliverables, the mission has been successful in including the otherwise excluded beneficiaries like disabled people, women and transgenders. To ensure that no one is left behind, PMAY (G) accords highest priority to landless beneficiaries in allotment of houses. To address the related issue of rural housing finance, the Government of India has also initiated the Rural Housing Interest Subsidy Scheme (RHISS) with an aim to provide easy access to institutional loans to needy households for construction/modification of their dwelling units. However, the situation on ground is far from ideal. This can largely be attributed to implementation gaps which need to be addressed through innovative solutions.

Housing poverty, which is viewed as the shortage of housing stock, is synonymous with inadequate housing. It is estimated that 43 million rural households still do not have adequate houses to live in (Kumar, 2017). Hence, in addition to the shortage in terms of quantity, the quality of housing stock remains a crucial issue to be resolved. The answer to this lies in implementing context-appropriate lessons from the ground. Since each village comes with its own unique challenges, a participatory and bottom up approach holds the key towards introducing and sustaining any new developmental intervention.

Habitat and Housing - Characteristics of rural housing

While housing is concerned with the objective of providing shelter as a physical structure, habitat includes the harmonised connection of multiple networks to create a conducive environment for inhabitants. Habitat in that sense includes the physical, social and economic networks (Hausmann, 2013) and respective infrastructure which together enhance the overall living conditions of inhabitants.

Housing in rural India can be characterized by a dispersed settlement pattern. Such a spatial organisation is a reflection of the socio-cultural and economic leanings of its inhabitants. In addition to this, rural housing is largely unorganised, unconnected, and marked by low affordability and low credit worthiness for rural households.

In terms of the shelter requirements, the basic utilities include provision for toilet, bath, drinking water, kitchen space for livestock, a space for storing grain and implements , and working shed etc. , over and above the habitable room[2]. While these spatial requirements acknowledge the economic networks linking a house with the local village economy, the

2 As per BIS (Bureau of Indian Standards) guidelines

implementation and facilitation of funds for ensuring these guidelines require innovative thinking. This is crucial in the context of changing demographics, rural-urban linkages, rural to urban/rural migrations, reverse migration (as witnessed in the Covid-19 induced lockdown), glocalization, climate change and changing nature of technology which makes labour intensive construction practices unviable.

However, while talking about habitat for the poor, different perspectives and narratives exist, each of which add new dimensions to the understanding of physical, social and economic networks. Therefore, rural habitat in the Indian context is not just a shelter which provides physical and social security in a clean and hygienic environment, but is also indicative of the social and economic position of the inhabitants, which may or may not provide stability or reduce socio-economic and climatic vulnerabilities. While it caters to the basic needs of a house, it also doubles up as a workplace, a means of livelihood and a market for products and services for the rural housing market drivers which strengthen the rural economic network. These are corroborated by ground studies by the Development Alternatives group which identified two key priority areas for rural families. In physical infrastructure, priority of families is shelter, roads, clean drinking water, hygienic toilets, electricity/power) while for social infrastructure, it is schools and places to work ; all being disaster resistant

Rural Construction Industry

Various actors are involved in the construction industry, with varying degrees of influence on market dynamics. Although the majority of the houses are built through self-construction, institutional support through PMAY (G) and other State level schemes are increasingly being relied upon, both for new buildings and for retrofitting/existing buildings.The low involvement of institutional and formal methods/actors of construction lead to bypassing of many environmental regulations and sustainability features. Due to this, the rural construction industry has become characterised as polluting, energy intensive, resource guzzling, and inefficient , while also being unable to provide value to the low-income customers and the poorest of poor.

There is, however, immense potential in the rural housing construction sector to catalyse economic growth and rural development since it provides employment generation and profitable economic activity even at small scales. This is dependent on the demand and supply drivers . Key drivers of demand in rural housing are :

1. **Household Income** – if stable and consistent, household income can propel the shift from *kuccha* to *pucca* houses. ठ strengthen it, income streams can be stabilised or enhanced through better employment generation (over and above to MGNREGA) or entrepreneurship, livelihoods, improved lending channels and more reliable financial institutions.
2. **Household size –** It has a direct relationship with demand since with increasing family size , number of married couples , the spatial requirement increases and thereafter the demand for more dwelling units arises.
3. **Occupation related requirements –** drives the market towards catering to these requirements
4. **Village infrastructure –** The state of village infrastructure, both physical and economic determine the access, affordability and inclusivity.

This demand can however, only be catered to if supply side factors like land , finance/capital , subsidies , materials , skilled labour are available and the cost of each is affordable /reasonable.

Challenges

Emerging challenges in the rural housing and construction sector as emphasised by UN Habitat and corroborated by ground studies include the 'triple C crisis' – Covid-19, climate change and conflict. In rural India, the key constraints include reduced accessibility to land, finance, technology, low affordability and inclusion which are spread across following determinants:

1. Socio - Economic Factors

Key economic challenges include low affordability of rural housing for the different income groups/poor and a depressed local economy. Further, social issues are often interlinked with and influence economic conditions of families. Rural India is the hotbed of socio-economic divides which is manifested in various forms. Some of the most visible ones are:

Poverty

In rural India, housing poverty is identified through shortages in the supply of housing/dwelling units and the lack of redevelopment of collapsible or dilapidated units.

Unemployment

Unemployment remains the most prominent issue for rural youth and the aging population who are left back after outward migration of the working population. It takes different forms such as disguised unemployment, open employment and seasonal unemployment.

2. Rural Housing Delivery

The current housing delivery model for rural India is fraught with setbacks. Key amongst these are poor housing access, poor quality of housing and unsustainable trends in the housing construction market.

Poor access to housing is on account of poor asset base, low credit worthiness of villagers and limited livelihood options available to them either due to lack of information of such and the over dependence on subsidies. This lack of economic reach eventually leads to low demand for housing amongst the poor.

The poor quality of housing stock can be attributed to the lack of alternative choices either due to low skills, information, or environmentally sustainable eco-technology delivery mechanism or low support for delivery agents of such technologies.

Unsustainable construction trends are another hindrance in rural housing delivery owing to inefficient resource conversion, inadequate technology promotion, inadequate eco-technology delivery mechanism and low demand for the same in rural areas.

3. Financing factors

Financial constraints perpetuate due to irregular incomes and inadequate information on credit history, conflict and issues in land title regularization and digitization, high interest of loans by microfinancing institutions tied along with low servicing of housing finance companies. Another challenge is the perception that since housing loans are long term and large, they are viewed as non-productive by finance institutions.

4. Ecological Factors

Limited natural resources and use of high embodied energy materials are key challenges in the rural construction industry. To address this, the Ministry of Rural Development (MoRD) recommends that PAHAL (Prakriti Hunar Lokvidya)'s compendium of design suggestions for construction of houses using climate resilient technologies be properly implemented and adopted by the beneficiaries of PMAY (G) or by individuals making their own houses under any other scheme.

5. Land Ownership Constraints

Land is the key factor of production for any housing intervention. However, issues in the landownership and land holding system in rural Indian society are deeply embedded under socio-cultural inequalities. Due to this, a large proportion of households in rural India is landless. Where they can attempt to buy land, it inadvertently translates into a higher cost of housing for the rural poor. Although village lands are fully utilised for housing, the market for house sites is poorly developed and the non-agricultural land titles are difficult to establish.

6. Market Trends

Demand and supply factors are influenced by trends in urbanisation , globalisation and the degree of efficiency of decentralised service delivery of rural housing. The challenge of growing demand and inadequate supply in this backdrop is an emerging cause of concern.

In terms of the materials and technology market, although modern alternative technologies and building materials have not penetrated the rural housing market, vernacular building technologies and materials offer low-cost, low-carbon solutions for building. To balance the increasing housing demands with sustainability practices, feasibility of prefabricated and alternative materials and products for construction must be explored.

7. Information and Skills

The construction, manufacturing, Medium Small and Micro Enterprises (MSME) and service delivery sector is estimated to create millions of job opportunities. This offers a great opportunity to upskill the rural workforce in the latest green technologies, automation, renewable innovations through innovative financing and capacity building, thereby promoting entrepreneurship to create sustainable local solutions leading to job creation and eventually income creation in order to prepare a future ready sustainable rural housing market.

Status of Capacity Building in the Construction Sector (Rural):

- Low exposure to new technologies is widening the skill gap for the rural workforce and reiterating social divides further. Depletion of skills and loss of traditional knowledge has also been observed over the years
- Skills in terms of formally trained masons, carpenters,

electricians, or plumbers are not available in rural areas. This leads to inefficient use of resources and may also lead to the construction of unsafe houses.

- Building contractors appropriate for construction in rural areas are yet to appear in large numbers and at a more influential scale. As of now, informal contractors are designing and executing low quality houses while exploiting the inhabitants and natural resources inefficiently.

Ground Learnings

Pilot studies and housing interventions were undertaken by Development Alternatives Group at Mador village , Madhya Pradesh to promote an integrated and cross sectoral housing strategy .This involved linking entrepreneurship, technology and skills training, capacity building and community participation with housing construction. The exercise offers immense potential for replicability and scalability. Chief among them are :

1.Housing Finance Model

No rural housing development intervention, even for the poorest of poor, shall be completely grant-based or completely self-financed or loan-based . Financial contribution , even if with little amount, from intended customers/families, along with **some grant component**, ensures participation due to a sense of ownership which manifests into a personal responsibility to create the intended habitat. However, while doing so, it must be ensured that the poorest of poor have ready access to alternative/additional income sources of livelihood.

Finance models that can be pursued in this light are

- Grant cum Credit
- Build Together, Pay Together (BTPT)[3]

2. Alternative Livelihoods For Additional Income Generation - Sustainable Habitats Need Sustainable Livelihoods

Some of the livelihood options which may be combined with housing in a complementary relationship are :

- Women Savings groups led decision-making and construction management
- Local poultry based livelihood model for earning income to pay housing loans (as has been demonstrated in the Mador project)
- Local artisan group , as demonstrated by the TARA Karigar Mandal

3. Demand Side Potential - Supply Side Imperatives

Rural housing has tremendous business potential. Field observations done by Development Alternatives suggest that rural families are, in fact, demanding customers and are willing to pay for services that they value. The key to enabling sustainable choices amongst them lies in access to information as value perception of rural families can be influenced.

However, to unlock this demand side potential and enhance sustainable habitat activity in rural areas, certain supply side imperatives need to be addressed. This requires an increased menu of technology options, improved skills for management and implementation, access to customized financial products and knowledge and information to make relevant choices.

4. Sustainability Imperatives

While implementing the housing finance models and alternative livelihoods, key imperatives of sustainability that must be given equal consideration include cleaner production, more production and supply, improved access through better delivery and affordable options, increased affordability though demand creation and financial options .

5. Capacity Building

Any new initiative must include a capacity building component as an essential part of the project to ensure participation of village communities to manage the development of their own habitats.

Any project that seeks to demonstrate cost-effective and energy efficient technologies in its implementation will have to build up capacities of local artisans, set up local production systems and also create adequate awareness about these materials and technologies. The budgets for these components must be part of the projects.

6. Awareness Creation

During introduction of new technologies, awareness must be created among villagers and rural customer through simple messages, posters, pamphlets, models, Radio, Demonstration, participa-

3 Development Alternatives in collaboration with FEM Sustainable Social Solutions Has created a revolutionary 'housing ecosystem'. Eco-housing + tackles the dual challenge of providing adequate shelter to our rural population while reducing the resource and carbon footprint of construction activities. This housing model provides financial and technical services to the rural families through the 'Build Together Pay Together' (BTPT) process. The client is linked to the bank or any other financial institution through the 'Build Together Pay Together' process enhancing efficiency and finance procurement for them and ensuring timely repayments to the bank

tory design exercises

7. Toilets

While introducing toilets in households or villages, it is crucial to create awareness about health and hygiene related to the use and maintenance of toilets among the users. Equally critical is ensuring availability of water for toilets. All these aspects need to be built into any project design , sufficient funds must be allocated for them, otherwise the construction of toilets and their proper utilization shall always be a question.

8. Sustainable Water Availability

Water issues are inevitably tied with habitat. The participatory design exercise in Mador village demonstrated the success of a sustainable and reliable pay for using water service in villages which was achieved through a series of steps demonstrated in the Figure-1.

9. Technical Services Delivery - Introduction Of New, Sustainable Materials And Construction Technologies

Any project that seeks to demonstrate cost-effective, energy efficient technologies and ensure its adoption by village communities in its implementation will have to ensure quality, cost, durability and performance criteria are properly met prior to introduction. It must also ensure

- That technologies are made locally available and accessible
- Awareness creation of the materials and technologies is sufficiently done
- Setting up local production systems and delivery of building elements and technologies
- Capacity building of local artisans is conducted

The Mador project demonstrated that by using local skills, materials and, masonry, it was possible to achieve-

- **30%** reduction in carbon footprint.
- **20%** reduction in material footprint,
- **70%** money in the local economy
- **30% - 60%** credit at affordable EMIs - increase in demand

- That budget for these components are part of project
- Community based teams are formed , along with mason supervisors
- Technical Tools For Design And Estimation are available along with

10. Land Titles resolution

Resolution to challenges around land titles can be addressed by

- Getting documentation from the local *patwari or Collector*, affidavits and certificates from the Panchayat and local magistrate
- Use land title papers as notional securities
- Delivery models that can be replicated include micro-enterprises, TARA *karigar mandal*
- BMSB (Building materials and services bank)

11. Stakeholder Partnerships

It was found that the most successful sustainable model would be through an integrated housing strategy which *integrates varied components such as technology, finance, local skills and local management.* This involves fostering cross disciplinary partnerships among the stakeholders and within each stakeholder group (private sector, civil society, financial institutions and research agencies). Some suggested roles for different stakeholders are given in Table-1:

Conclusion

In conclusion, the rural housing sector would benefit from improved access and information to finance, livelihood options , sustainable building technologies. To facilitate this, policy intervention is needed for facilitating land access and management, financial accessibility, infrastructure development

- **Building Materials And Services Bank (BMSB)**: It is a common infrastructure hub and a convergence point for artisans, masons, MCR supply chain stakeholders, materials etc. which would later become a training hub for local mason, contractor and a sourcing hub for materials
- **TARA *karigar mandal* (TKM)** : *TKM* is an initiative of Development Alternatives to undertake eco- construction work at scale through local masons. Registered as a Mutually Aided Cooperative Society (MACS) with the Madhya Pradesh State Government, TKM is an essential component of this eco-housing+ model acting as a 'service provider'. Training local masons for the construction of the houses and toilets and supervising the overall construction work, TARA Karigar Mandal is at the forefront of green job creation and also acts as an important tool for climate change mitigation

Table-1: Some suggested roles for different stakeholders

Stakeholder	Role
Public Sector (State Government and Local Government)	Provide promotional and fiscal support to production and skill suppliers
	Integrate the "new" technologies in schedule of rates, train the engineers at various levels
	Set up a supportive monitoring system right up to the Gram Panchayat level.
	Ensure safety and security for partners to function
Private Sector	Invest in and help setting in large numbers of building production units
	CSR for Village habitat development
Research and Development Agencies	Develop standards, and standardized elements for production and delivery at scale
	Set up demonstrations across the state
	Set up testing and quality assurance tools, systems etc.
	Training modules, Transfer of Technology
Civil Society	Organize PMAY-G beneficiaries in Housing-Self Help Groups, facilitate savings towards housing loans
	Due diligence for access to loans
	Promote ecological and cost-effective technologies – education, information, training
	Social audits of quality and quantity
	Could even play the role of construction management
	Nodal facilitators – at block, or cluster of Gram Panchayat level
Financial Institutions	Ensure bridge loans are available and tuned to needs of PMAY beneficiaries
	Insure loans, have risk mitigants in place

for housing, capacity development , livelihoods-habitat-finance program linkage, monitoring and access to information.

From the technological point of view, various opportunities are available for achieving sustainability, using industrial wastes (to make fly ash, stone dust, red mud), harnessing the potential for small enterprises in manufacturing and delivery and in the new urbanisation which provides opportunity for new technologies like prefabrication in rural transformation.

To facilitate adoption of sustainable choices, habitat may be promoted based on sustainability assessment, cost effective eco-friendly technologies through techno-entrepreneurial packaging, connecting network suppliers with implementers, habitat products with service suppliers all at local level.

To improve the quality of habitat products , enterprise support such as TARA *karigar* needs to be replicated. To arrive at this, a three-tiered model is proposed, comprising of

- **Local delivery system to reach to the customer** involving small entrepreneurs, local contractor groups
- **State and national level facilitation to enhance efficiencies at local level**
- **Intermediaries** such as TARA Nirman Kendra, ACF, Line Departments, Panchayat as the engines of techno- financial-market for guidance support.

This has been further categorised in Table-2 which delineates the strengths of each stakeholder.

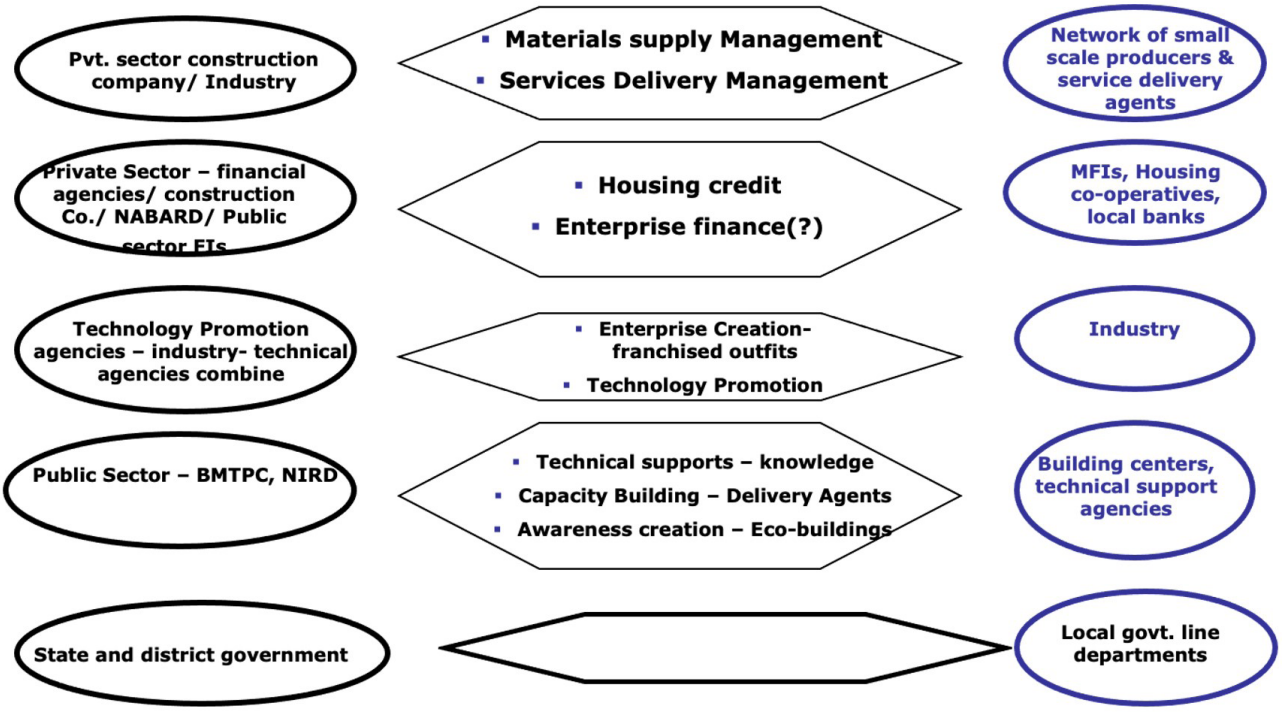
Way Forward

Sustainability in rural habitat processes requires fostering an attitude and approach of incremental growth and continuity in improvement with an aim to achieve perceptible positive change in quality of life. This can take the form of ensuring cultural continuity through gradual lifestyle change and building upon local strengths.

In terms of institutional restructuring, a paradigm shift from **housing to sustainable habitat development** is needed. To ensure this shift, measures are needed which can facilitate access to habitat for all segments of rural population based on their unique socio-economic and geographical conditions while responding to the growing needs of a rapidly transforming rural environment.

Table-2

Stakeholder	Strength	Benefits/stakes
Private sector(industry)	-Initial investment -Focus on timely delivery and efficiencies in management -Technical rigor and expertise pooling	Brand recognition, customer loyalty, tax or other fiscal benefits, profits from supply
Private sector – Local / small enterprise	Cost efficiencies through local production and delivery	Business, livelihoods, skills
Public Sector – State Government	Policy facilitation – fiscal incentives, tax benefits	Provision of housing to its constituency, votes
Public Sector – District and Local	Land and infrastructure facilitation/ provision	
Intermediate - Social Sector	Customer aggregation – cooperative, SHGs Promotion of ecological construction	Wealth creation in the local area, reduced environmental impacts, quality habitation



Housing delivery services at a large scale

In addition, what is also needed is a conscious response by all stakeholders involved in sustainable rural habitat to reach to the customer in the remote village and small town and leave no one and no place behind, reduce environment costs, introduce cost effective techniques, build local capacities, seek new resources, green the construction sector, decentralize the supply and reduce costs of delivery to aggregate and increase value to customer. **Leave no one behind** by making materials and skills available and accessible to emerging markets. On a larger scale, locally fabricated quality materials, skill upgradation, better management of water and sanitation, affordable solutions and efficient planning, management, monitoring and evaluation must be incorporated.

Further, catalyzing demand in the larger rural construction market through finance and promotion while augmenting supply by filling the gaps in availability, accessibility and delivery of materials, skills, technology, and finance is also needed.

We must strive to provide options, opportunity and access to physical resources, knowledge, skills and livelihood opportunities. Both process control and decision control are also equally important to ensure sustainability in the habitat processes. Process control can

Case study: Learning on-ground experiences from the Punjab model	
The Punjab model consisted of an eco-village consisting of 129 houses for low-income – landless families in a well laid out development located in Gaggar Village 40 km from Bathinda town at a cost of Rs. 470/sq ft. (as of 2009). The model deployed a Public-Private initiative with strengths of various partners pooled in which has the potential for replication in both rural and urban areas with minor modifications.	
The House	**Each house is built on a plot of 1200 sq.ft. It has 2 rooms, a kitchen and a verandah, a bath and a toilet** ● Covered Area: living and cooking area of 370 sq.ft. plus a bath and toilet of 15 sq.ft. ● Space for a cow shed and a cycle/ scooter shed and possibility of vertical expansion with another floor that may be added along with a staircase
Construction Technologies	**Walls:** fly-ash bricks laid in rat trap bond in walls **Roofing:** RCC planks and joists in roofing **Sanitation:** toilets along with the two pit leach pit system **1. Building materials and their supply** ● Fly-ash bricks supplied by a local entrepreneur –laid in cost saving Rat-trap bond technique ● Prefabricated RCC planks and Joists supplied by a local entrepreneur ● MCR roofing tiles supplied by a local entrepreneur **2. Construction services** ● Groups of local masons under local petty contractors ● Training of masons by technical consultants – TARA Nirman Kendra ● Construction managed by Ambuja Cement Foundation (ACF)
Infrastructure	**Water harvesting from roofs and site drainage into ground water-recharge** ● Water supply – Piped to Houses - metered ● Streets – concrete pavers ● Grid electricity – metered
Delivery Model	**Land – by the Panchayat** ● Housing design and construction management – Ambuja Cement Foundation through technical consultants - TARA Nirman Kendra ● Land development and Infrastructure- roads, drainage, water supply, landscape, water harvesting – by various line departments of Govt. of Punjab ● Sanitation by Sulabh International
Key Components	**Social and market development aspects** ● Customer aggregation – Panchayat ● Technology promotion – ACF and TNK **Supply and construction management- through ACF** ● Design and planning – TARA Nirman Kendra ● Technical know-how – TARA Nirman Kendra ● Training – through TARA Nirman Kendra ● Quality management – TARA Nirman Kendra and ACF **Financing** ● costs shared between GoP and ACF

be ensured through acquisition of habitat within self and local control and by building upon local skills and strengths. Decision control on the other hand is influenced through perception of possible impacts and benefits through awareness and information sharing.

Looking to the future, key areas that need to be focussed on are innovation and facilitation. Innovation in technology would entail using prefabricated materials, waste as resources and eco-materials alongside innovative, decentralised and small scale networks for housing delivery.

Facilitation is needed for the different subcomponents of housing. These include facilitating new skills, small enterprise development, housing - self help groups , promotion of market development , housing cooperatives and facilitating incentives for eco-construction.

To ensure that no one is left behind, firstly, priority must be given to inclusive rural development in any development narrative . Secondly, a dedicated rural housing and habitat policy must be put in place which expands upon the PURA (Provision of Urban amenities in Rural Areas) strategy to bridge the housing poverty and inadequacies in the rural housing sector. Thirdly, the interlinked components of poverty, purchasing power and exclusion must be addressed in a war footing through innovative public-private partnership (PPP) models for livelihoods, land-natural resource management linkages and market creation.

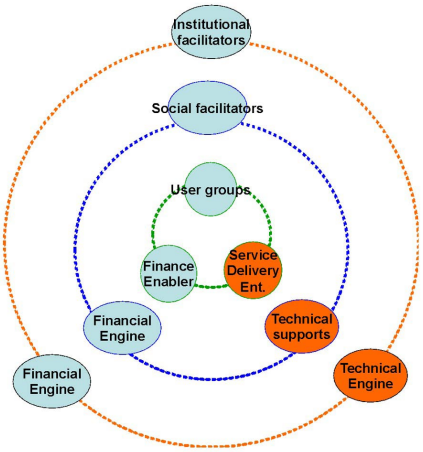


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Photo Gallery-

Mador project, Madhya Pradesh

Source: Development Alternatives Group

Photo Gallery-

Mador project, Madhya Pradesh

Source: Development Alternatives Group

1. https://www.devalt.org/images/L2_ProjectPdfs/FEM_Capitalisation_Document.pdf?Oid=253
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3D Volumetric Precast Concrete Construction System : Light House Project, Ranchi

Dr. Shailesh Kr. Agrawal[1] *C. N. Jha* [2]

Preamble

Under Pradhan Mantri Awas Yojana (PMAY)-Urban, a Technology Sub Mission has been set up by Ministry of Housing & Urban Affairs (MoHUA), Govt. of India, to facilitate the adoption of modern, innovative and green technologies and building material for faster and quality construction of houses in various States/UTs. Under Technology Sub mission, MoHUA conceptualized & initiated 'Global Housing Technology Challenge – India (GHTC-India)' as a platform to develop an eco-system for transplanting best global proven construction technologies to India and also nurture innovative home grown indigenous materials, technologies and construction processes. It is aimed to bring technology transition in the construction sector in a holistic manner and enable a paradigm shift to have sustainable development.

As part of GHTC-India, an Expo-cum-Conference named Construction Technology India - 2019 (CTI-2019) was organized on 02 -03 March, 2019 at Vigyan Bhawan, New Delhi. One of the main components of GHTC-India was identification and mainstreaming of Proven alternate technologies from across the globe that is disaster resilient, sustainable, cost effective, adaptable to different geo-climatic conditions of the Country & can deliver quality houses at faster rate. Under GHTC-India, a basket of 54 proven innovative technologies were shortlisted in six broad categories by MoHUA, namely, (a) Prefabricated Sandwich Panel System, (b) Monolithic Concrete Construction, (c) Precast Concrete Construction System–Precast components assembled at site, (d) Precast concrete construction System–3D Precast Volumetric, (e) Light Gauge Steel Structural System & Pre-Engineered Steel Structural System, and (f) Stay-in-Place Formwork System.

In order to showcase these emerging systems, six Light house projects (LHPs) of about 1000+ EWS houses each with allied physical & social infrastructure facilities are being constructed in six identified regions of the Country using six distinct technologies under six broad categories, as per the details given in Table-1.

Besides the use of innovative technologies, the Light House Projects also include various sustainability features as use of renewable energy as part of total requirement,

Table-1: Light House Projects

S. No	Location	DUs, Storeys	Construction System
1	Indore, Madhya Pradesh	1024, S+8	EPS Cement Sandwich Panel with Pre- engineered Steel Structural System
2	Rajkot , Gujarat	1144, S+13	Monolithic Concrete Construction using Tunnel Formwork
3	Chennai, Tamil Nadu	1152, G+5	Pre-cast Concrete Structural system comprising of pre-cast column, beam, precast concrete / light weight slab, AAC blocks/infill concrete walls
4	Ranchi, Jharkhand	1008, G+8	3D Modular casting using steel mould and high performance concrete of building modules in factory
5	Agartala, Tripura	1000, G+6	LGSF along with Concrete Panels & In-situ concrete with pre-engineered steel structural Frame
6	Lucknow, UP	1040, S+13	Stay-in-Place PVC Formwork with Pre-engineered Steel Structural System

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use of STP & recycling of waste water, Rain water harvesting, solid waste management etc. A provision for Green Rating of minimum 3 Star by GRIHA-TERI, has also been kept as the requirement for all six Light House Projects.

The foundation stones of all six LHPs were laid jointly by Hon'ble Prime Minister through Video Conferencing and the concerned Hon'ble Governors and Hon'ble Chief Ministers/State Ministers at the site of the 6 LHPs on January 1, 2021.

3D Volumetric Precast Concrete Construction System

An already established System for building construction in Europe, Singapore, Japan & Australia, this 3D Volumetric concrete construction is the modern method of building by which solid precast concrete structural modules like room, toilet, kitchen, bathroom, stairs etc. & any combination of these are cast monolithically in Plant or Casting yard in a controlled condition. These Modules termed as Magic PodS are transported, erected & installed using cranes and push-pull jacks and are integrated together in the form of complete building unit. Subject to the hoisting capacity, building of any height can be constructed using the technology.

Manufacturing Process of the Building Modules/ Magicpods

- 3D Steel moulds are created as suiting to various sizes of building Units
- High strength steel as per the structural design is placed inside 3D moulds
- Electrical and plumbing lines are set up. Block outs for doors and windows are also set up at the same time.
- The pods are cast into their final shape using high-performance concrete.
- Stringent quality checks is taken for each pod before they are packed for shipping, which ensures that the construction project adheres to strict quality standards.
- The pods are then loaded and shipped. Care is taken to ensure that the shipping is done as per the sequence of erection at the site.

Construction & Installation Process

Sequential construction in the project here begins with keeping the designed foundation of the building ready, while manufacturing of precast concrete structural modules are taking place at the factory. Factory finished building units/modules are then installed at the site with the help of tower cranes. Gable end walls are positioned to terminate the sides of building. Pre stressed slabs are then installed as flooring elements. Rebar mesh is finally placed for structural screed thereby connecting all the elements together. Consecutive floors are built in similar manner to complete the structure.

Advantages

- About 90% of the building work including finishing is completed in plant/casting yard leading to significant reduction in construction & occupancy time
- The controlled factory environment brings resource optimization, improved quality, precision & finish
- The required concrete can be designed using industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resources. In this project Ground granulated blast furnace slag based cement is being used in the concrete.
- With smooth surface it eliminates use of plaster
- The monolithic casting of walls & floor of a building module reduces the chances of leakage
- The system has minimal material wastage (saving in material cost), helps in keeping neat & clean construction site and dust free environment
- Use of Optimum quantity of water through recycling
- Use of shuttering & scaffolding materials is minimal
- All-weather construction & better site organization

Light House Project at Ranchi

The project at Ranchi using 3D Volumetric Construction is first ever demonstration of the technology at such large scale. It comprises of 1008 (G+8) dwelling units in 7 blocks/towers and 144 nos. of units in each tower. The project started on October 2021 and is schedule to be completed by March 2023.

Casting Yard (Production of Components)

In the casting yard, 20 numbers of customised different components e.g. pods, H & I wall elements, gable wall elements, prestressed slabs, staircases, lift wall, etc. are being produced (Fig.1).

Fig.1: Production of components at Casting Yard

Fig.2: Erection of Precast Components

Erection of Precast Components

The building components cast in the casting yard which is at the site itself are being erected and assembled with the help of two tower cranes (Fig.2).

The quality testing laboratory has been set up at the site for strict quality control and compliance. In addition, IIT Madras has been appointed as Third Party Quality Assurance (TPQA) Agency. Concurrently, the work on physical infrastructure is also going on.

Light House Projects as Live Laboratories

Hon'ble Prime Minister during the event of Foundation laying stone of LHPs, emphasized that in a way, these projects will be incubation centres and our planners, architects, engineers and students will be able to learn and experiment with new technology. Now, these LHPs are serving as **Live Laboratories** for different aspects of transfer of technology to the field with the objective of promoting wide scale learning on the use of innovative technologies on ground and mainstream the globally identified proven innovative technologies in Indian context. The whole process of Live Laboratory is based on the principles of Learning, Exploration, Adaptation and Replication through site visits, multi stakeholder's consultation, virtual tours, finding ideas for solutions, learning by doing, experimentation and innovation for further adaptation of these disruptive technologies as per their local needs and contexts. For this purpose, site visits/ study tours, periodic interactions, webcasting etc. are being organized. All details including a dedicated module related to Live Laboratories is available on GHTC-India website i.e. https://ghtc-india.gov.in wherein all stakeholders can register themselves as Technograhis to visit six LHPs to learn the use of latest innovative technologies.

Closure

Light House Projects are pilot projects being undertaken to spread technical know-how, adapt and replicate emerging construction systems in the construction sector. A number of IEC activities are also being taken up at all the LHP sites so as to comprehend the field level application of these technologies. State Governments and other public & private agencies are also being handheld and sensitized about these Light House Projects. Further, CPWD, BIS and BMTPC are working towards certification, standardization and Schedule of Rates of these technologies so as to ensure large scale field level application particularly by government agencies.

It is for the first time that Government pro-actively has taken a lead role in bringing technology transition in the construction sector and constructing Light House Projects under PMAY(U). This gives unique opportunity for the construction fraternity to learn and make these technologies as future technologies.

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Functionality Tests on Emerging Construction Technologies: Thermal and Water Tightness Investigations

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

Abstract

Apart from structural performance of building system i.e. axial and lateral loads; acoustic, thermal comfort, water tightness etc., are the important functionality tests to be performed for evaluation of efficient functional performance of buildings. The present study evaluates the thermal and water tightness performance on a two story building constructed using different technologies i.e., precast reinforced concrete (RC) building with AAC (Autoclave Aerated Concrete) block infills; steel building with insulated fibre cement sandwich panels infill; bamboo building (bamboo strips walling) and precast building component masonry building using Round Boulder Mortar (RBM) units. The water tightness test was performed firstly by ponding the water on floors/roof, 75mm deep for 7 days and secondly under a simulated rain fall / cloud-burst condition of 210 mm per hour for continuously 5 hours on each face the building, including roof top. Similarly, thermal measurements were recorded and analysed for 24-hours over seven days between April to June month (summer season) and November to January month (winter season). Based on the extensive functionality tests performed in this research program on different building technologies vis-à-vis comfort requirements, the systems regarded as functionally efficient building.

Keywords: Functionality tests, water tightness, test, thermal comfort, precast building, bamboo building, RBM building, steel building.

1. Introduction

The acoustic, thermal comfort, water tightness etc., are the important parameter for efficient functional performance of buildings which are given least importance, in general. The real time thermal performance of emerging construction technologies needs to be evaluated to find its suitability and also to determine building's energy needs, for heating and cooling. Therefore, there is a need to monitor the temperature profile of the buildings with respect to the different environmental scenarios.

These construction techniques facilitate time-saving, less manpower, material requirement, and ease of construction at the actual site (Ali et al. 2013; Ma et al. 2020; Shukla et al. 2020; Wu et al. 2020). In drywall construction techniques, porous concrete based cement fibreboard is speedy and efficient construction. Drywall provides safety and adequate strength as compared to conventional masonry brick walls.

The present study evaluates the thermal and water tightness performance on two story building constructed using different technologies i.e., precast reinforced concrete (RC) building with AAC (Autoclave Aerated Concrete) block infills; steel building with as insulated fibre cement sandwich panels infill; bamboo building and masonry building using Round Boulder Mortar (RBM) units.

2. Building systems tested

In order to evaluate the functional performance of emerging construction technologies, as proposed in this paper, two-storey buildings with different construc-

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Fig. 1. 3S Precast RC Component Building

Fig. 2. Steel building with light weight infill panels

tion technologies, having similar architectural plans, orientation etc., having total covered area of 110 sqm were constructed in Construction Technology Demonstration Park of CSIR-CBRI, Roorkee. The brief structural description of emerging building technologies are illustrated here under:

2.1. Precast building system

The precast building (Fig. 1) consists of precast structural components and Autoclave Aerated Concrete (AAC) blocks walling units. The in-situ concrete connections were implemented so as to provide the adequate anchorage between the joints between precast structural components. The precast building system utilizes Precast Dense Concrete Hollow Column shell of modular design size in combination with precast dense concrete Rectangular/ 'T' shape or 'L' shape RC beams and precast RC slabs for floors and roofs.

2.2. Steel building

The building is a pre-engineered building consisting of light weight panels. The wall is constructed using dry cement fibre boards, having a thickness of 75 mm, with length and breadth as 3000 mm and 600 mm respectively. The density of cement fibre boards is 892 kg/m3 and a thermal conductivity of 0.14 W/mK. The jointing of multiple boards was done with fly ash and sodium silicate in 1: 15 proportion weight to make paste form. The ICFs (Insulated Concrete Forms) consist of two panels of foam, where both the layers of insulation are held together with cross ties or "webs" which creates a block. Cross-ties or webs are made up of High Density Polypropylene (HDPE) hard plastic stud wall-tie. Fig. 2 shows the actual building constructed.

2.3. Bamboo house

A demo house made up completely of bamboo has been constructed at demo park of CSIR-CBRI. The building is a two storey structure, with a total area of 1100 sq ft. Built-up sections of beams and columns have been constructed using Bamboosa balcoa bamboo of average outer diameter of 80 mm. The bamboo was treated with Borax solution to achieve a reasonable life span of bamboo elements. Walls of the structure have been made using splitted bamboo and bamboo boards. Foundation of the structure has been provided of double bulb under reamed pile foundation. The structure after completion has been given a pucca look by application of cement plastering over steel wire mesh on the outer walls. Fig. 3 shows the bamboo structural systems building.

2.4. Round Boulder Units (RBM) Confined Masonry Building

The two storied building using precast building components

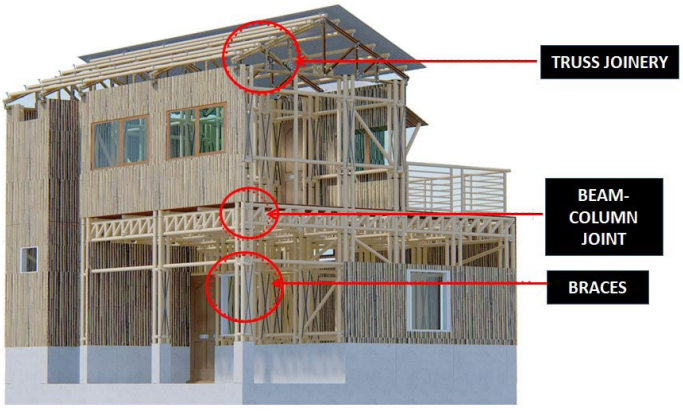

Fig. 3. Bamboo Construction Technology

Fig. 4. Round Boulder Units Confined Masonry Building

viz. slab, beam, and load bearing walls using Round Boulder Mortar units, stone concrete blocks, has been constructed , with the aim to assess the real time functionality of the RBM technology. The primary features of this building is units are manufactured using locally available boulders, mostly in hilly regions, confined masonry technology for seismic resistance and precast RC elements and MS hollow box section of beam to achieve speed, safety and economy in construction.

3. Functionality Tests

3.1. Thermal Comfort Measurement

The constructed AAC building was tested for temperature variation for outside and inside walls structures, ambient and inside room temperature, relative humidity and water tightness/leakage performance on ground plus storey building.

The wall temperatures, inside temperatures and relative humidity were recorded at 1-hour interval for 24-hours and over the period of seven days in the month of April to June. The average of the data plot has been shown in the manuscript.

3.2. Water Tightness Test

The water tightness test was performed firstly by ponding the water on floors/roof, 75mm deep for 15 days and secondly under a simulated rain fall condition of 210 mm per hour for continuously 5 hours on each face and roof top. Sprinklers were installed. The deflector of the sprinklers creates a uniform spray pattern over the roof and walls. The water from supply tank was supplied to the sprinklers through a 180 litres per minute pump having 50 m head. The sprinklers on the roof and on the front wall can be activated one at a time or simultaneously. Pressure gauges were installed at different locations in addition to the water flow meter to measure the water flow rate. The water was recycled to prevent its wastage. Fig. 5 shows the view of water tightness test setup and actual water testing facility in building. The whole building was subjected to a flow rate of 210 mm/hour for a continuous period of 5 hours which is representative of a cloud burst phenomenon. The water tightness was examined by superimposing thermal imaging before the rainfall and after 1, 7 and 15 days of rainfall respectively, on different elements and joints of the precast building.

4. Results and Discussion

4.1. Precast Building

The outer and inner wall surface temperature were recorded and plotted as sinusoidal curve. Fig. 6 shows the surface wall temperatures of the directional faces of AAC building namely east, west, north and south recorded for summer season (April to June). It is evident that outside wall tem-

Fig. 5. Actual water testing setup facility in AAC building

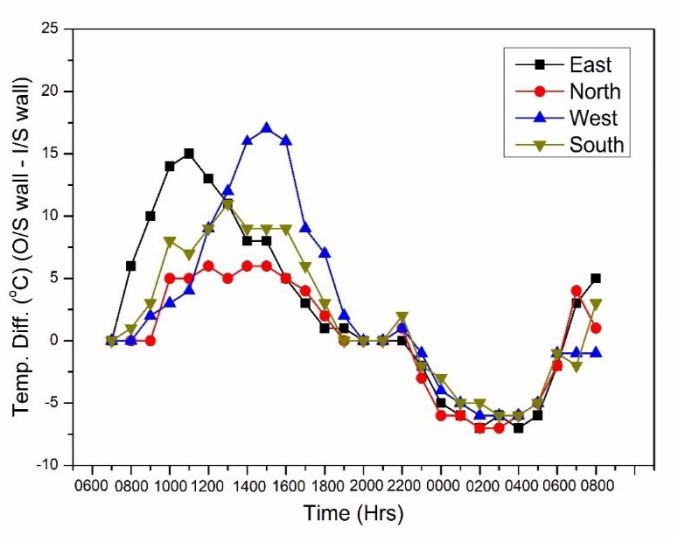

Fig. 6. Temperature difference of outside and inside wall variation of all directional faces for precast building

perature reaches to a maximum of 45°C for east and west facing walls at 1100 and 1500 hrs respectively. Whereas, for north and south facing side, the maximum outside wall temperature has reached to 40°C. The inside wall temperature of all the directional faces does not exceed 32 ºC. Fig. 6 shows a sinusoidal nature of the difference in temperature of outside and inside wall temperatures with maximum temperature at daytime and minimum temperature at night time. The inside wall temperatures show an approximate straight plot ranging from 28-32 ºC. The thermal imaging after 7 and 15 days of ponding is shown in Fig. 7 and 8 which show very less/ no water ingress inside the walls.

4.2. Steel building

The constructed dry wall of cement fibre boards building was tested for temperature difference for outside and inside walls, ambient and inside room temperature, on ground plus storey building of 600 sq. ft. Table 1 shows the physical properties of dry wall and related thermal conductivity values.

Fig. 9. shows the directional temperature variations of steel building. It is evident that the outside wall temperatures rise maximum up to 45°C, but inside temperature reaches a maximum of 30-32°C. The maximum temperature difference between outside and inside temperature walls is around 15°C. The porous concrete sandwiched between fiber cement boards has large number of pores with air trapped. These pores are responsible for exhibiting good

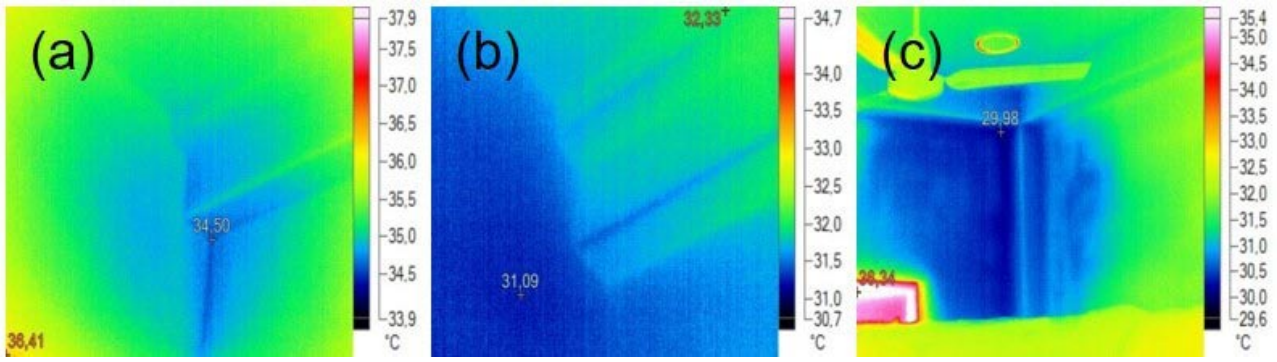

Fig. 7. Thermal imaging (a) Before Ponding at GF-1 (b) after 7 days Ponding at GF-1 (c) after 15 days ponding at GF-1.

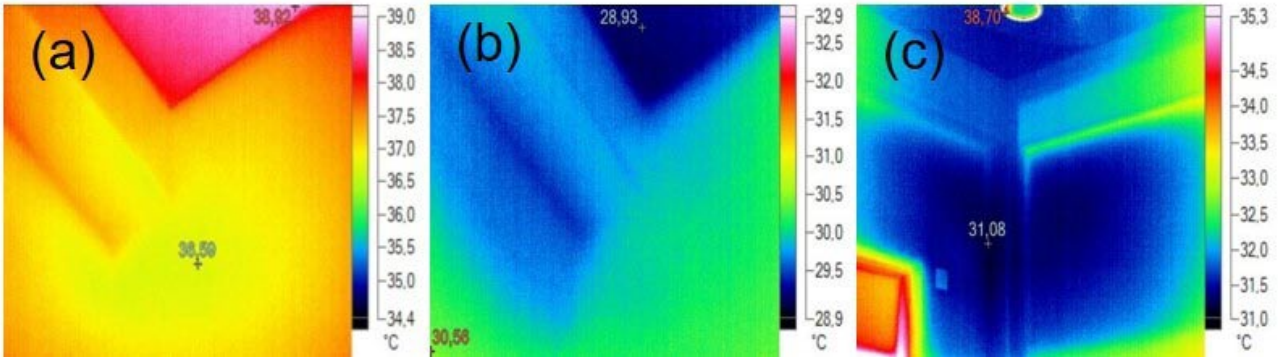

Fig. 8. (a) Before Ponding at FF-7 (b) after 7 days ponding at FF-7 (c) after 15 days Ponding at FF-7.

Table 1. Physical properties of cement fiber board walls and related thermal conductivity values

Physical parameters	Values
Temperature and humidity at the time of testing	41 °C 17 % R.H of April to June
Wall construction	Rapicon cement fiber boards, 75 mm thickness
Length and width	3000 mm and 600 mm
Density	892 kg/m^3
Total wall thickness	75 mm (including plaster)
Thermal conductivity	0.14 W/ m. K
Test location	Roorkee, Hot and Arid zone.

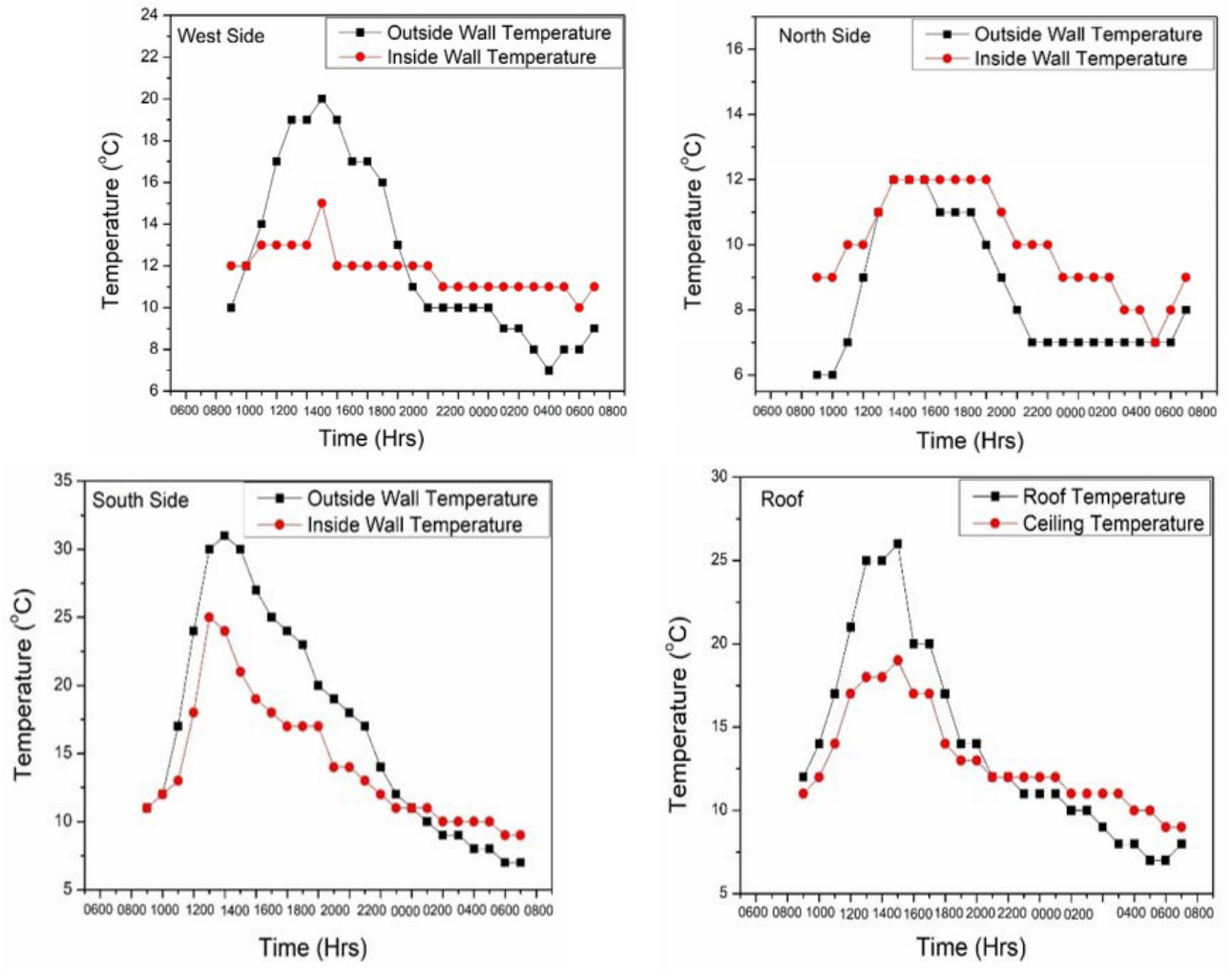

Fig. 9. Wall temperature variation for steel building facing towards east, west north, south side and roof/ceiling temperature variation for winter season

thermal insulation.

4.3. Bamboo building

Thermal admittance (Y) is a measure a material's ability to absorb heat from, and release it to, in space over time. This can be used as an indicator of the thermal storage capacity (thermal mass) of a material, absorbing heat from and releasing it to a space through cyclical temperature variations, thus evening out temperature variations and so reducing the demand on building services systems. Thermal admittance is expressed in W/(m^{2}K), where the higher the admittance value, the higher the thermal storage capacity.

4.4. RBM building

Fig. 10 shows all the directional all directional temperature and roof/ceiling temperature of bamboo building at CSIR-CBRI Roorkee, Demonstration building site.

5. Conclusions

The prime objective of the func-

Table 2. Thermal parameters of various buildings at demonstration park CSIR-CBRI

Building Typology	Heat transfer Coefficient (U) (W/ m^2.K)	Thermal Resistance (K/W)	Thermal Performance Index (TPI)	Time Lag (h)	Decrement Factor	Thermal Admittance (W/m^2.K)	Damping Ratio (%)	Thermal Diffusivity (m^2/s)
AAC Building	2.56	71.6 x 10^{-3}	25	6	0.18	6.19	32	4.83 x 10^{-7}
RBM Building	3.29	13 x 10^{-3}	50	4	0.33	14	28	5.06 x 10^{-7}
Bamboo Building	2.88	19 x 10^{-3}	37.5	2	0.34	9.5	31	3.22 x 10^{-7}
Rapicon Building	1.53	20 x 10^{-3}	25	3	0.1	7.3	29.5	2.67 x 10^{-7}

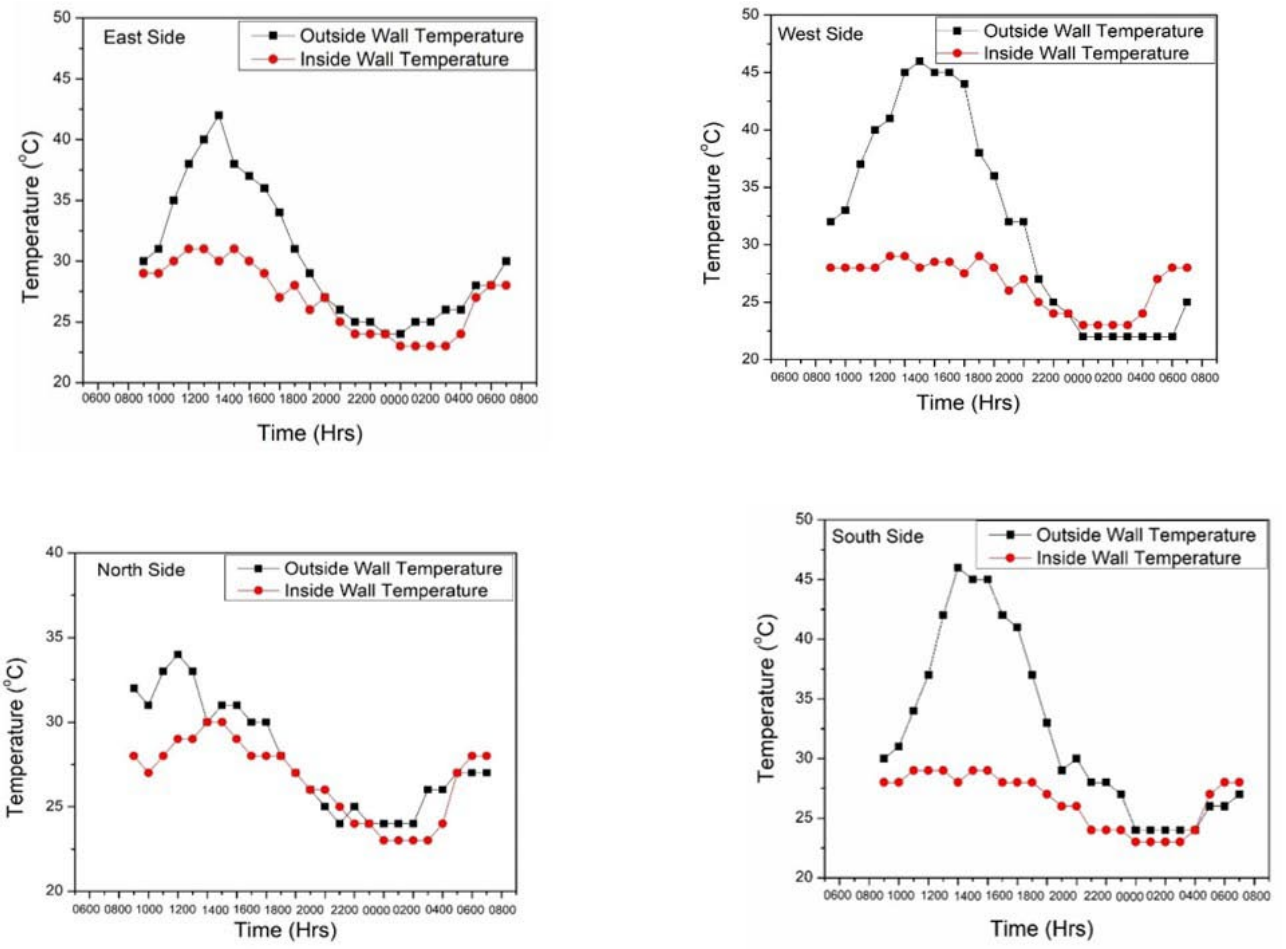

Fig. 10. Wall temperature variation for steel building facing towards east, west north, south side and roof/ceiling temperature variation for winter season

tionality test was to evaluate the thermal, noise and humidity and indoor air quality performance of various buildings at Construction Technology Demonstration park of CSIR CBRI at Roorkee in different seasons. Different buildings such as precast, steel, bamboo and RBM buildings were analysed for various thermal and noise parameters and studied in detail. Key conclusions drawn from the above task are summarized below.

1. The water tightness study of precast building shows no significant leakage inside the building by conducting ponding tests and simulated cloud burst scenario.
2. Thermal performance of the precast and mortar layered walls exhibits good thermal insulation in the summer time with average outside and inside temperature being 45°C and 30°C respectively, i.e. 15°C temperature reduction inside

the building.

3. Overall, the AAC, Rapicon, Bamboo and RBM block walls provide a good thermal comfort and may definitely contribute to energy saving in the buildings.
4. Maximum thermal mass and thermal admittance was provided by RBM buildings because of its dense and heavy structural elements such as bricks and concrete blocks and mortar as compared to other light weight elements viz. cement fiber board, AAC blocks and Bamboo/plywood materials.

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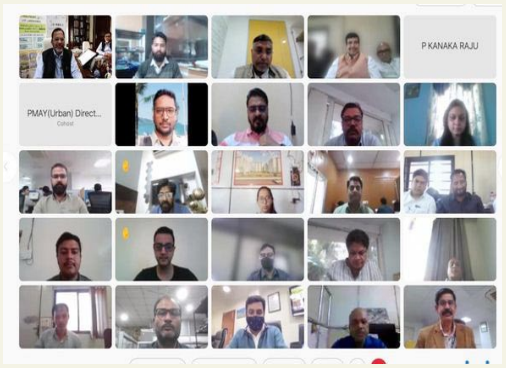
Webinar on e-Learning & webcasting of Light House Projects (LHPs)

The Ministry of Housing & Urban Affairs (MoHUA) in collaboration with BMTPC and GIZ is hosting series of 'e-Learning sessions and webcasting of LHP construction process' webinar to widespread the knowledge about the technologies, construction processes, sustainability, and mass-cum- fast construction to Technograhis. So far more than 35000 Technolograhis have registered for various LHPs.

The main purpose of e-Learning sessions and webinars is to create awareness of the different technologies used in the construction of LHPs through technical session and webcasting of work at site. The virtual on-site tour to LHP site is also being organised to educate the Technograhis on various stages of construction, new techniques, and key features.

The webinar series was launched with the first programme organised in the month of March, 2022 at Rajkot, Gujarat. So far 12 webinars have been organised at all six LHPs. The technical session, explaining in detail about the innovative construction technologies, details and specifications of LHPs, use of technologies was shared by BMTPC. The Technograhis were shown the live construction of LHPs with virtual tour.



बीएमटीपीसी और राजभाषा हिंदी के साथ सफर

(आत्म निर्भर भारत की दिशा में हिंदी का योगदान)

डा. शैलेश कुमार अग्रवाल[1]

1990 में स्थापित निर्माण सामग्री एवं प्रौद्योगिकी संवर्धन परिषद (बीएमटीपीसी), आवासन और शहरी कार्य मंत्रालय, भारत सरकार की एक स्वायत्तशासी अनुदान सहायता संगठन है। बीएमटीपीसी को बड़े पैमाने पर आवास निर्माण हेतु धरातल पर उपयोग के लिए लागत–प्रभावी, पर्यावरण हितैषी, ऊर्जा–दक्ष और उभरती भवन निर्माण सामग्री और आवास प्रौद्योगिकियों के संवर्धन और अंतरण के लिए कार्यआदेश सौंपा गया है। स्थापना के कुछ वर्षो बाद परिषद को भूकंप, चक्रवात और बाढ़ जैसी आपदा से सुरक्षा प्रदान कर सकने वाली निर्माण पद्धतियों के विकास एवं प्रसार की भी अहम् जिम्मेदारी सौपी गयी। समय के साथ–साथ और देश की बढ़ती आवास जरूरतों को आवश्यकता अनुरूप त्वरित गति से पूरा करने के लिए परिषद बहुदिशीय द्रष्टिकोण अपनाते हुए तेजी से आगे बढ़ रही है।

मंत्रालय द्वारा समय–समय पर सौपें गए कार्यआदेशों के अंतर्गत परिषद ने अनेको वृहत कार्यों को पूर्ण किया है, जिनमे प्रमुखतः भारत की जोखिमता मानचित्रावली का प्रकाशन, निष्पादनता मूल्यांकन प्रमाणन योजना (पीएसीएस) का संचालन, नई निर्माण सामग्रीयों, प्रणालियों, प्रौद्योगिकियों और आपदा न्यूनीकरण और प्रबंधन, क्षमता निर्माण, कौशल विकास इत्यादि के बारे में जागरुकता उत्पन्न करने के लिए निरन्तर रूप से प्रदर्शनियों, प्रशिक्षण कार्यक्रमों और संगोष्ठियों का आयोजन, कार्यान्वयन अभिकरण के रूप में लाइट हाऊस परियोजनाओं का संचालन, नवोन्मेषी उभरती प्रौद्योगिकियों से संबंधित सार–संग्रह जिसको माननीय प्रधानमंत्री जी द्वारा 01 जनवरी 2021 को शिलान्यास समारोह के दौरान लोकार्पित किया गया, साथ ही साथ माननीय प्रधान मंत्री द्वारा 01 जनवरी 2021 को छः लाइट हाऊस परियोजनाओं का शिलान्यास किया गया, इसी अवसर पर एक पुस्तक नवरीतिः नवोन्मेष निर्माण प्रौद्योगिकियों पर प्रमाणपत्र पाठ्यक्रम का माननीय प्रधान मंत्री द्वारा विमोचन भी किया गया, योजना और वास्तुकला विद्यालय (एसपीए), नई दिल्ली और बीएमटीपीसी के सहयोग से उभरती आवास प्रौद्योगिकियों के संबंध में एक प्रमाण पत्र पाठ्यक्रम की शुरुआत, किफायती किराया आवास परिसर (एआरएचसी) योजना के अंतर्गत तकनीकी सेवाएं, जीएचटीसी–इंडिया के अंतर्गत, किफायती टिकाऊ आवास, (आशा) – भारत के माध्यम से पहचान की गई क्षमतावान भावी प्रौद्योगिकियों को प्रश्रय देना और उन्हें प्रेरित करने के लिए भी योजना, प्रधानमंत्री आवास योजना–सब के लिए आवास (शहरी) मिशन के अंतर्गत प्रौद्योगिकी उप–मिशन के सचिवालय के रुप में परिषद् का कार्य, अनेकों दिशा–निर्देशों, मैनुअलों और अन्य संवर्धनात्मक साहित्य का प्रकाशन आदि।

इसके अलावा, बीएमटीपीसी पिछले अनेक वर्षों से सबके लिए आवास इत्यादि अनेक योजनाओ

1 कार्यकारी निदेशक, निर्माण सामग्री एवं प्रौद्योगिकी संवर्धन परिषद (बीएमटीपीसी), आवासन और शहरी कार्य मंत्रालय, भारत सरकार, नई दिल्ली

के माध्यम से नई प्रौद्योगिकियों के बारे में सभी राज्यो/संघ राज्य क्षेत्रों तक में जागरुकता उत्पन्न करने और विश्वास कायम के लिए करने भारत के विभिन्न भागों में प्रदर्शन–आवासों का निर्माण भी करता रहा है। और इसी क्रम में हिंदी भाषा में अनेक दिशा निर्देशिकाएं प्रकाशित करता रहा है। इसका एक बड़ा लाभ यह रहा कि कामगार समूह के बीच सुसंगठित ढंग से हिंदी का पुनः संचरण हुआ और तकनीकी ज्ञान को सरल भाषा में दक्ष परन्तु गैर–अभियांत्रिकी समाज में भी प्रसारित किया जा सका।

परिषद ने एक अति महत्वपूर्ण प्रमाणन योजना "निष्पादनता मूल्यांकन प्रमाणन योजना (पीएसीएस)" के माध्यम से अनेको उभरती निर्माण प्रणालियों और सामग्रियों को प्रमाणित किया है। इसके अन्तरगत उभरती प्रौद्योगिकियों के अलावा, नए उत्पाद और सामग्रियों को भी प्रमाणित किया जा रहा है। यह योजना उन सभी निर्माण प्रणालियों, प्रौद्योगिकियों और सामग्रियों के लिए वरदान साबित हो रही है जो अभी अपने विपणन के प्रथम विकास कालखंड में है और उभरती हुई है जिसके कारण उपभोग्ताओं में उनके प्रति विश्वास कम रहता है। निष्पादकता मूल्यांकन प्रमाणपत्र (पीएसी) तैयार करने से पहले विनिर्माताओं द्वारा प्रस्तुत डाटा, उनकी वैबसाइटों पर उपलब्ध सूचना, कार्य स्थलों पर विनिर्माणकारी संयंत्रों के निरीक्षण और उत्पादों/प्रणालियों के नमूनों के परीक्षण के आधार पर उपर्युक्त आवेदनों पर कार्रवाई की जाती है और भारत सरकार की इस महत्वपूर्ण योजना के प्रमाणपत्र से ऐसी उपयोगी उत्पाद और सामग्रियों इत्यादि के प्रति विश्वास सृजन के माध्यम से राष्ट्र को बड़ा लाभ हो रहा है। भारत के माननीय प्रधानमंत्री जी ने भी पिछले दिनों बीएमटीपीसी द्वारा ऐसी उपयोगी उत्पाद और सामग्रियों इत्यादि से निर्माण किये जा रहे प्रदर्शन भवनों के माध्यम से इनकी प्रशंसा की है।

माननीय मंत्रिमंडल के अनुमोदन से, बीएमटीपीसी में राष्ट्रीय शहरी आवास निधि (एनयूएचएफ) का सृजन किया गया जो कि ऋणदायी अभिकरणों अथवा वित्तीय संस्थानों से ऋण प्राप्त कर इकट्ठा कर एनयूएचएफ के लिए ईबीआर के माध्यम से प्राप्त की जा रही धनराशि बीएमटीपीसी को ऋण के रुप में प्रदान की गयी और परिषद् ने इस राशि को राज्यध्केन्द्र शासित प्रदेशों को केन्द्रीय सहायता के रुप में और अपने मंत्रालय के आदेशों के अनुसार मिशन के सीएलएसएस वर्टिकल के अंतर्गत केन्द्रीय नोडल अभिकरणों (सीएनए) को सब्सीडी के रुप में संवितरित किया।

1990 में स्थापना के शुरुआत से ही परिषद् ने अपने कार्यादेश अंतर्गत हमेशा इस बात पर ध्यान दिया कि नवीन निर्माण सामग्री और आवास प्रौद्योगिकियों के संवर्धन और अंतरण के लिए यह भी जरूरी है कि निर्माण उद्योग का जो तबका धरातल पर कम कर रहा है उसका क्षमता निर्माण और कौशल विकास किया जाए। चाहें जबलपुर, मध्य प्रदेश का भूकंप हो, या फिर उत्तराखंड में चमोली का भूकंप हो या फिर कोई चक्रवात की आपदा, परिषद् ने द्रुत–क्षति–आंकलन कराकर चित्रों के माध्यम से अत्यंत सुगम हिंदी भाषा में भवन मरम्मत और पुनर्निर्माण के लिए मार्गदर्शिकाओं का प्रकाशन किया, इसके साथ ही भूकंप के बारे में प्रकाशित टिप्स का हिंदी अनुवाद कर सर्व सुलभ कराकर अभियंताओ और आम जनता के लिए इसको सुलभ कराया। ऐसी अनेको पुस्तिकाओं और पाकेट बुक्स का परिषद् द्वारा सृजन और प्रकाशन कराया जाता रहा है।

इसलिए, परिषद् का समस्त कामकाज तकनीकी प्रकृति का होने के बावजूद भी, जब भी आवश्यकता हुई, परिषद् ने हिंदी भाषा में ऐसे साहित्य का या तो मौलिक रूप से सृजन किया या फिर अंग्रेजी में उपलब्ध तकनीकी साहित्य का हिंदी भाषा में अनुवाद कराया ताकि कामगारों, कनिस्थ अभियंताओ और आम नागरिकों को उनको अपनी सुलभ हिंदी भाषा में साहित्य मिल सके और वो उसका अधिकाधिक लाभ उठा सके।

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Using Technology to make Human Settlement Inclusive, Safe, Sustainable

Amit Pal [2]

Climate change is an inevitable global issue today, affecting not only countries and organizations but also individuals in many ways. The threats of Global Warming and Climate Change have become the defining issues of our era for all humanity. The scientific facts before us are overwhelming and cannot be ignored. What most of us do not realize is that we in our own small ways can indeed make a difference and do our bit to not only avert this crisis but also build a future for the generations to come.

Need of the hour is: We need to adopt methods, technologies to develop human settlements which are inclusive, safe and has potential for scaling up while protecting the local and global environment by promoting the sustainable construction practices. Sustainable construction provides built developments that are efficient and affordable, socially acceptable, and less damaging to the environment. Hence our focus objective should be on:

- Technology for Faster development of Human settlement.
- An Inclusive Human Settlement.
- Safe and Sustainable Human Settlement

Technology for Faster development:

Alternative building technologies provide a wide range of benefits that could help improve the speed of construction, reduce labour dependency, reduce cost and make the development sustainable.

Multiple construction technologies are available now to cater the need for housing demand. Pursuing the vision of Hon'ble Prime Minister to transform housing construction sector, Ministry of Housing and Urban Affairs identified 54 technologies, Six Light House Projects using six distinct technologies. These technologies were finalized to showcase use of these technologies for further mainstreaming in the country. The Hon'ble Prime Minister laid the foundation stone of Six Light House Projects on 1st January 2021.

One of the six selected technologies is "**PVC Stay in Place Formwork**" Technology. It is a permanent structural walling system consisting of rigid poly-vinyl chloride (PVC) based polymer

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components that serve as a permanent durable finished form-work for concrete walls. A sequential construction procedure is adopted to use this technology. PVC wall panels are erected as per design and configuration of the building structure, units and other integral part of the residential unit. All vertical components are done using the PVC formwork and concreting is done after proper alignment and support systems. Floor can be constructed using Aluminium formwork of plywood based decking system or any other decking system. The pre-fabricated walling panels having provisions of holes for services conduits, are fixed along with the reinforcement & cavities inside the wall panels. A typical unit plan is shown below which can be constructed using this technology.

Unit Plan

Description	Unit	Length	Width	Area
Living Room	Sqmt	3.91	3.07	11.98
Kitchen	Sqmt	2.17	1.80	3.91
Bed Room	Sqmt	3.62	3.06	11.04
Passage	Sqmt	1.68	1.20	2.02
Balcony	Sqmt	1.39	1.27	1.77
Toilet Passage	Sqmt	1.09	0.55	0.60
Bathroom	Sqmt	1.59	1.28	2.03
Toilet	Sqmt	1.10	1.09	1.20
Total Carpet Area	Sqmt			34.54

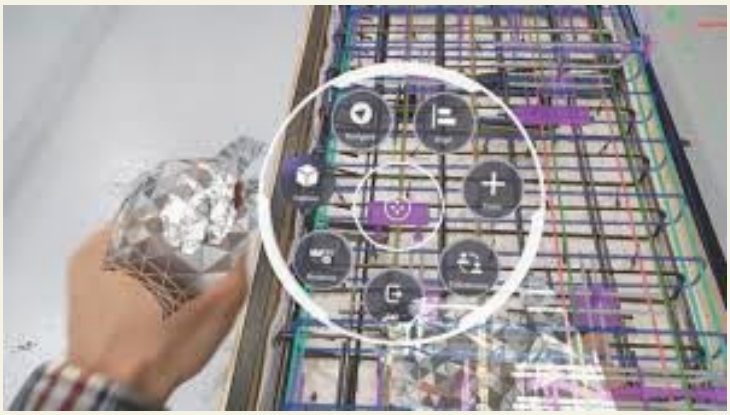
Source : https://ghtc-india.gov.in

Advantages of PVC Stay in Place Formwork:

- No brickwork/ blockwork
- No/minimal external plastering
- No gypsum (internal plastering)
- No de-shuttering
- Guided rebar placement
- Waterproofing requirements reduced
- Service conducting along with formworks prior to casting
- Reduced need for labour in general and skilled labour.

Components of PVC “Stay in Place Formwork”
Source: https://permaform.com.au

Building under Construction using PVC “Stay in Place Formwork”
Picture: 1: (Courtesy: Mahindra Lifespace Developers Ltd.)



These cutting-edge technologies will help us drastically changing how the industry operates and how future projects will be completed. Some applications, techniques used in construction of above stated building are:

- Data Collection Apps
- Drones based Survey
- Building Information Modeling (BIM) Software
- Virtual Reality and Wearables
- Holographic using HoloLens
- Artificial Intelligence

Source : https://www.neowin.net/news/trimble

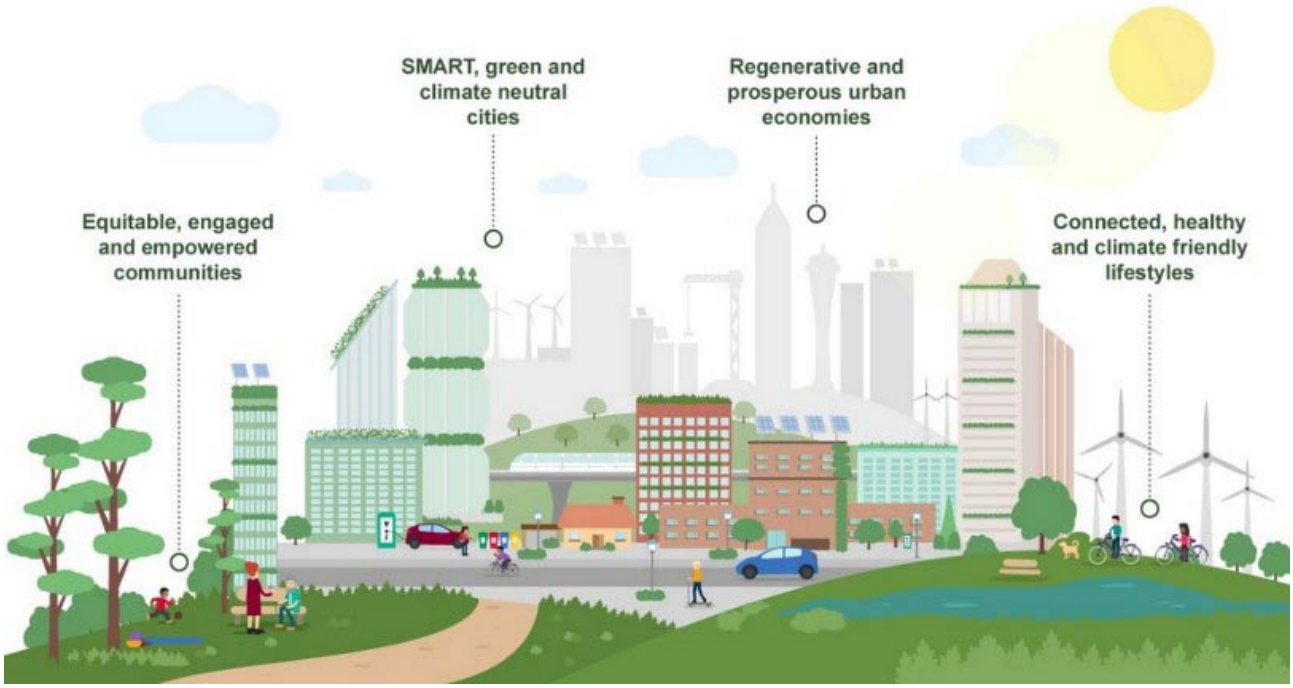
Apart from PVC "Stay in Place formwork" construction technique, other new age **IOT based**, collective framework and network of connected devices are integrated and used while constructing the above building (in Picture :1). There are real, practical applications and benefits to modernizing the construction processes. If we need to develop multiple human settlements / buildings using this type of technology, it's advantageous to integrate IOT based new approaches into our strategy and workflows.

An Inclusive Human Settlement:

Though technology will take care of speedy and integrated human settlements, we also need to consider socio – environmental conditions, security, sustainability in the challenging circumstances of growing and changing nature and influence of urban disasters, related to climate variability and change and geological or geomorphological conditions. Currently more than half the world's population lives in cities. By 2030, it is projected that 6 in 10 people will be urban dwellers. There will be numerous planning challenges in establishing more efficient economies of scale on various levels, with proper provision of goods, services and transportation.

At the same time, we also need to think about digitization of infrastructure services for inclusive Human settlement. Digitizing infrastructure services includes using digital technologies to expand supply, improve demand management, and improve the quality of the services provided.

Source: https://blogs.iadb.org/ideas-matter/en/digitizing-infrastructure-services-brings



Sustainable Human settlement means capable of remaining in existence, and doing so without depleting resources. These settlements are to be capable of remaining in existence using resources - whether natural, financial, or human - as efficiently as possible.

Safe and Sustainable Human Settlement:

For safe and sustainable Human settlement we need to adopt practices which can substantially reduce or eliminate negative environmental impact and improve unsustainable design, construction and operational efficiencies. Planning and design measures to be adopted to reduce operating cost, enhance building lifespan, increase worker productivity and reduces potential liability resulting from various environmental impacts. A safe and sustainable development should incorporate smart design, technology, construction and maintenance elements to significantly lessen the negative impact on the Human settlements.

Conclusion:

The housing sector in India is growing at a rapid pace and contributing immensely to the growth of the economy. While technology plays a major role for such growth and catering the need of Human settlement with inclusive, safe and sustainable manner but for an inclusive growth we need to adopt concepts and techniques which can help address national issues like handling of consumer waste, water efficiency, reduction in fossil fuel use in commuting, energy efficiency and conserving natural resources. Most importantly, these concepts can enhance occupant health, happiness and wellbeing.

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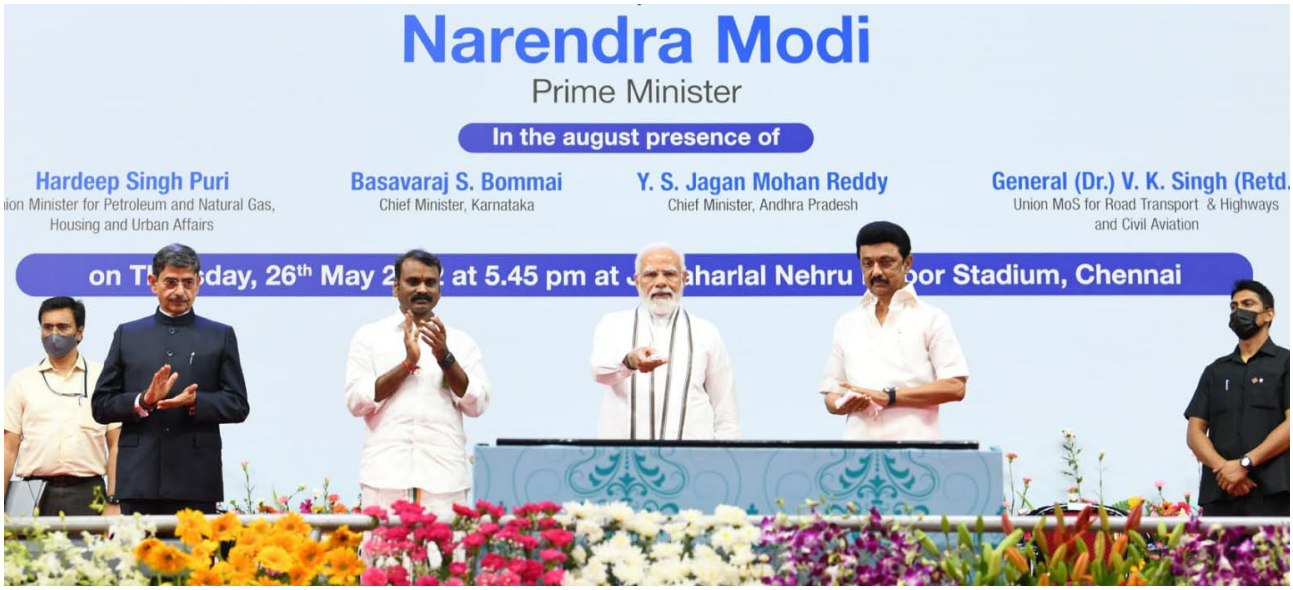
Light House Projects under GHTC-India - showcasing innovative construction technologies



Hon'ble Prime Minister Shri Narendra Modi inaugurated Light House Project (LHP) in Chennai, Tamil Nadu on Thursday, the 26th May, 2022, constructed under Global Housing Technology Challenge-India (GHTC-India) of Pradhan Mantri Awas Yojana (Urban). The event was held at JLN Indoor Stadium in Chennai, wherein Hon'ble Prime Minister dedicated the LHP Chennai & handed over keys to beneficiaries along with other projects to the nation and laid the foundation stone of 11 projects worth over 31,500 Crore. Hon'ble Governor of Tamil Nadu Shri RN Ravi and Hon'ble Chief Minister of Tamil Nadu Shri MK Stalin were present on the occasion. Secretary, Ministry of Housing and Urban Affairs (MoHUA), other officials of the Ministry and BMTPC also attended the event.

While inaugurating the LHP, Hon'ble Prime Minister said, "I congratulate all those getting a house under the historic Light House Project at Chennai under the Pradhan Mantri Awas Yojana. It was a very satisfying project for us. We had started a global challenge to get the best practices involved in making homes that are affordable, durable and environmentally friendly. In record time, the first such LHP has been realised and I am glad it is in Chennai."

LHP at Chennai, Tamil Nadu

No. of Dwelling Units: 1152 Nos. (G+5)
No. of Block / Tower: 12 Blocks
Units in each Block / Tower: 96 Nos.
Technology Name: Precast Concrete Construction System-Precast Components

LHP at Indore, Madhya Pradesh

No. of Dwelling Units: 1024 Nos. (S+8)
No. of Block / Tower: 8 Blocks
Units in each Block / Tower: 128 Nos.
Technology Name: Prefabricated Sandwich Panel System with Pre-engineered Steel Structural System

LHP at Agartala, Tripura

No. of Dwelling Units: 1000 Nos. (G+6)
No. of Block / Tower : 7 Blocks
Units in each Block / Tower : A(112), B(154), C(118), D(168), E(168), F(168) & G(112)
Technology Name: Light Gauge Steel Structural System & Pre-Engineered Steel Structural System

LHP at Rajkot, Gujarat

No. of Dwelling Units: 1144 Nos. (S+13)
No. of Block / Tower: 11 Blocks
Units in each Block/ Tower: 104 Nos.
Technology Name: Monolithic Concrete Construction using Tunnel Formwork

LHP at Lucknow, Uttar Pradesh

No. of Dwelling Units: 1040 Nos. (S+13)
No. of Block/ Tower: 4 Blocks
Units in each Block/ Tower: A(494), B(130), C(208) & D(208)
Technology Name: PVC Stay in Place Formwork System with Pre-engineered Steel Structural System

LHP at Ranchi, Jharkhand

No. of Dwelling Units: 1008 Nos. (G+8)
No. of Block / Tower: 7 Blocks
Units in each Block / Tower: 144 Nos.
Technology Name: Precast Concrete Construction – 3D Volumetric Construction

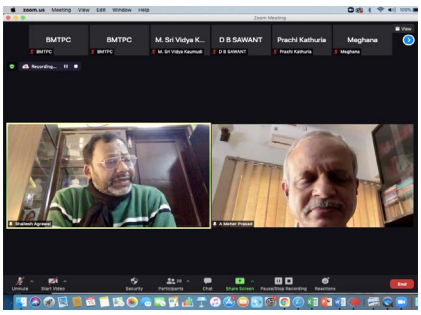
नवरीतिः NAVARITIH – Certificate Course on Innovative Construction Technologies

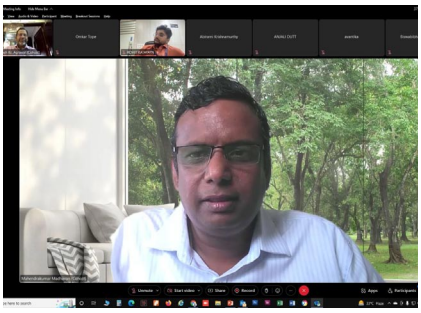
The Ministry of Housing & Urban Affairs in collaboration with SPA, New Delhi and BMTPC, has started NAVARITIH : Certificate Course on Innovative Construction Technologies to train engineers and architects including students. It is of paramount importance that building professionals learn about the new and emerging building materials and technologies for housing and building construction.

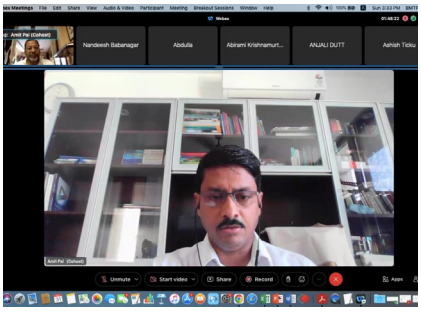
The objectives of the Certificate Course are to (a) Familiarize the professionals with the latest materials and technologies being used worldwide for housing, (b) Provide an awareness of the state of art of materials and technologies in terms of properties, specifications, performance, design and construction 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.

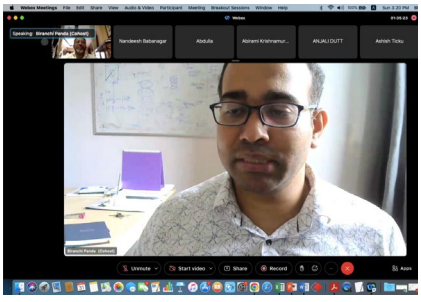
The NAVARITIH Course was launched by Hon'ble Prime Minister through video conferencing on January 1, 2021 during the foundation stone laying ceremony of six Light House Projects (LHPs) being constructed under Global Housing Technology Challenge - India – Pradhan Mantri Awas Yojana (Urban). Subsequently, first batch of NAVARITIH was inaugurated by Secretary (HUA) on 11.02.2021.

The Course has received very good response so far and in 11 batches conducted so far, 922 participants, mainly civil engineers and architects and faculty & students from various engineering and architectural colleges, participated in the Course.









Batch No.	Organising Dates	No. of Participants
First Batch	February 12 to 18, 2021	124
Second Batch	March 19 to 26, 2021	114
Third Batch	April 30 to May 7, 2021	133
Fourth Batch	June 4 to 11, 2021	162
Fifth Batch	July 16 to 23, 2021	152
Sixth Batch	August 27 to September 3, 2021	55
Seventh Batch	November 12 to 19, 2021	43
Eighth Batch	January 14 to 21, 2022	49
Ninth Batch	March 25 to April 1, 2022	26
Tenth Batch	May 27 to June 23, 2022	34
Eleventh Batch	July 29 - August 5, 2022	30

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

नवरीतिः (NAVARITIH)

Certificate e-Course on Innovative Construction Technologies

NAVARITIH : New, Affordable, Validated, Research Innovation Technologies for Indian Housing

An initiative of Ministry of Housing & Urban Affairs, Govt. of India in collaboration with SPA, New Delhi & BMTPC

The objectives of the Course are to (1) **Familiarise** the professionals with the latest materials and technologies being used worldwide for housing, (2) **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 (3) **Provide exposure** to executed projects where such materials and technologies have been implemented.

LAUNCHED BY

Hon'ble Prime Minister during laying of Foundation Stones of Light House Projects at six locations on January 1, 2021

COURSE FEE

Rs.2,500 per person
(One-time, Non-refundable)

REGISTRATION

Registrations open at https://ict.bmtpc.org

Interested applicants may also write to ska@bmtpc.org / drpsnrao@hotmail.com / ghtc-mhua@gov.in for applying to Course.

Target Group

Any person who has successfully completed and in possession of a minimum qualification of B.E. / B.Tech (Civil) or B.Arch. (or equivalent) or Diploma in Civil with 5 years' experience and final year students of Civil Engineering and Architecture shall be eligible to take up the Course. Scanned copy of Degree/Diploma certificate (or equivalent)/College ID Card, to be submitted with application.

Classes & Venue

The duration of the Course will be 8 days.

Classes will be held in the evening from 5.30 pm to 8.30 pm on weekdays and on Saturday and Sunday from 2.00 pm to 5.00 pm.

The classes for the Course will be conducted on virtual platform (video conferencing).

On successful completion of the course, a Certificate will be awarded to the participant.

The Course on Innovative Construction Technologies has been launched as one of the activities under "Construction Technology Year (2019-20)" which was announced by the Hon'ble Prime Minister during Construction Technology India 2019: Expo-cum-Conference under Global Housing Technology Challenge – India on 2nd March, 2019 at New Delhi.

The Course is being offered jointly by the School of Planning & Architecture, New Delhi and Building Materials & Technology Promotion Council (BMTPC), Ministry of Housing & Urban Affairs.

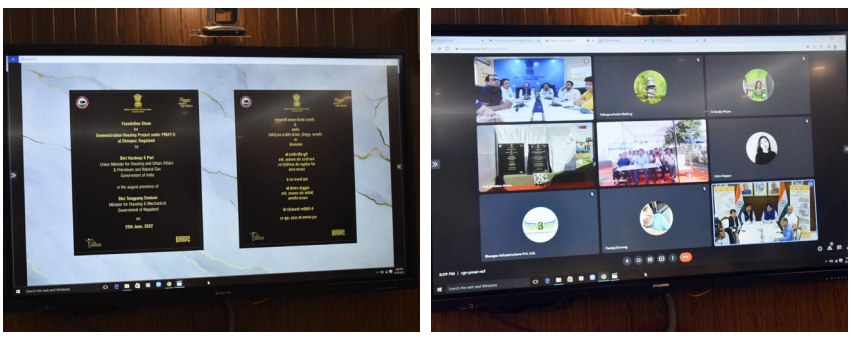
Demonstration Housing Projects – propagation of sustainable emerging construction systems under PMAY (U)

BMTPC has been propagating use of new / alternate building materials & technologies in housing through identification, evaluation, standardization, certification, capacity building, training and field level application by demonstration construction. Under Technology Sub-Mission of PMAY(U), MoHUA has taken an initiative to construct Demonstration Housing Project (DHP) through BMTPC. 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.

It further helps build confidence and create enabling environment for the large scale adoption of such materials & technologies suiting to different geo-climatic regions 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; Hyderabad, Telangana; Panchkula, Haryana and Agartala, Tripura using emerging technologies.

Shri Biplab Kr. Deb, the then Hon'ble Chief Minister of Tripura

Inauguration of Demonstration Housing Project (DHP) at Agartala, Tripura



Shri Hardeep S. Puri, Hon'ble Minister for Housing & Urban Affairs laying the foundation stone of DHP at Dimapur, Nagaland on June 25, 2022

inaugurated the Mahatma Gandhi Memorial Old Age Home in the august presence of Hon'ble Minister of Social Welfare and Social Education Department, Smt. Santana Chakma on April 25, 2022. The Old age home has been constructed under PMAY-U as Demonstration Housing Project (DHP) using new emerging technology "Structural Stay in Place Formwork System (Coffor)".

Shri Hardeep S. Puri, Hon'ble Minister for Housing & Urban Affairs and Petroleum & Natural Gas laid the foundation stone of the Demonstration Housing Project at Dimapur, Nagaland in the august presence of Shri Tongpang Ozukum, Hon'ble Minister, Housing & Mechanical, Government of Nagaland on June 25, 2022 through Video Conferencing. The Demonstration Housing Project (DHP) will be used as Working Women Hostel and is being constructed using EPS Cement Sandwich Panels with steel structure. Foundation Stone for Demonstration Housing Project at Guwahati, Assam was laid by Shri Ashok Singhal, Hon'ble Minister Department of Housing & Urban Affairs (DoHUA), Government of Assam on August 7, 2022. The status of ongoing DHPs is given in the Table-1.

Shri Ashok Singhal, Hon'ble Minister Department of Housing & Urban Affairs (DoHUA) laying the foundation stone for DHP at Guwahati, Assam on August 7, 2022

Table 1: Status of Ongoing Demonstration Housing Projects

Sl. No	Location of DHP	Technology Used	Status
1	Ahmedabad, Gujarat Usage: 40 DUs (G+2) for PMAY(U) beneficiaries	Precast Concrete Construction System-Integrated Hybrid Solution-One	• Finishing work is in final stage.
2	Bhopal, MP Usage: Sports Hostel (G+3)	Stay In Place Formwork System - Load bearing Monolithic Walls using Insulating Concrete Forms (ICF) Block with RCC Slabs as roofing	• Finishing work is in final stage.
3	Guwahati, Assam Usage: 40 DUs (G+3) for Contractual Safai Karamcharis of GMC and Community Centre (G)	Light Gauge Steel Structural System & Pre-engineered Steel Structural System -Light Gauge Steel Frame Structure with V-infill concrete wall	• Construction of Boundary wall completed and foundation work of both buildings are in progress.
4	Tiruppur, Tamil Nadu Usage: Working Women Hostel / Widow Home (G+3)	Precast Concrete Construction System - Precast components assembled at site	• Approval of architectural drawings from Local authorities is yet to be received.
5	Ayodhya, Uttar Pradesh Usage: Destitute widow Ashram & orphanage (G+2) Community Centre (G)	Light Gauge Steel Structural System & Pre-engineered Steel Structural System - LGFS with cement fiber board and mineral wool as in-fill	• Construction of Boundary wall is under progress. • Foundation work of community center is in progress.
6	Dimapur, Nagaland Usage: Working Women Hostel (G+2) Community Centre (G)	Prefabricated Sandwich Panel System-EPS Cement Sandwich Panels with steel structure	• Foundation work for both the buildings are in progress.
7	Bhalwal, Jammu Usage: Sports Hostel	Prefabricated Sandwich Panel System-EPS core panel using Quikbuild Panels as walling and EPS Panels for slabs/ roof.	• Construction of Boundary wall is under progress • Foundation work for both blocks are in progress.

Performance Appraisal Certification Scheme (PACS)

Performance Appraisal Certification Scheme (PACS), being operated by BMTPC (vide Gazette Notification No. I-16011/5/99 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 giving independent opinion about fitness of its intended use in building construction sector.

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/UTs, its Housing & Urban Development Departments, 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 is proving to be 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 TAC members.

So far 18 meetings of TAC have been held and 77 PACs have been issued.

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

Approval of New PACs

PAC for the following four systems/products have been approved in the TAC's 18th meeting held on March 11, 2022.

1. Volumetric (3D) Concrete Printing Technology (VCPT)
2. PUF Sandwich Panel with Pre Engineered Building Structure
3. Everest Rapicon Panel/ Solid Wall Panel
4. WPC Door Shutter & WPC Frame

The brief about these technologies are given hereunder;

1. Volumetric (3D) Concrete Printing Technology (VCPT)

3D Printing, also known as additive manufacturing, is an automated process that produces complex shaped geometries from a 3D Model (Computer-aided design

Volumetric (3D) Concrete Printing Technology (VCPT)

(CAD) model) on a layer-by-layer basis.

3D Concrete printing technology (3DCP) constructs concrete structures by selectively placing a special quick-setting concrete mix using a numerically controlled robotic printer layer by layer as per a 3D CAD model. The operation can be performed with minimal human intervention/support and eliminating the need for formwork to construct walls. It is either executed on the site (Like cast In-situ) or Offsite in a centralised set-up (Like precast). In offsite 3DCP, the units or components are printed in the factory and then transported to the assembly site. In onsite 3DCP, the units are constructed at the site directly.

Special features of the system include;

- Eliminates the use of formwork
- Automated construction ensures excellent build quality and safety
- Rapid construction with significant improvement in productivity
- Cost optimisation possibilities that are constrained in conventional formwork & execution methods
- Innovative design possibilities to elevate aesthetics and convenience to end users
- Optimum usage of skilled workmen
- Highly digitised 3DCP workflow offers good predictability of the execution results
- 3D printers are lightweight systems that can be easily shifted, erected, and commissioned at job sites

PUF Sandwich Panel with Pre Engineered Building Structure

2. PUF Sandwich Panel with Pre Engineered Building Structure

PUF Sandwich Panels with Pre Engineered Building structure is a combination of Structural Steel Framing System designed as per relevant Indian Standards, with PUF Sandwich Panels in wall and roofing system. PUF panels consist of a rigid PUF core sandwiched between color coated Galvanized Steel/Galvalume steel sheet facing on both sides, complete with joint sealants and fixing ancillaries, which is easy to install and affordable.

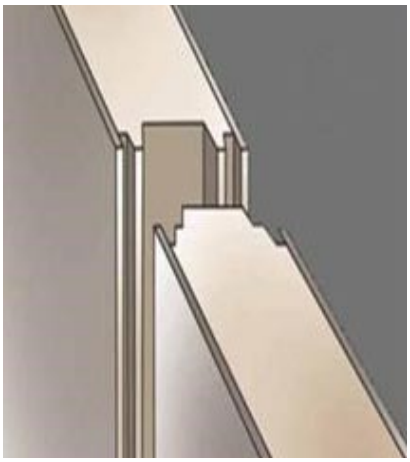
The sandwich panel offers high thermal efficiency, comes with variety of finishes and can be installed easily & quickly for being light in weight. The Steel structural system of Pre-engineered building offers flexible design option with diverse layout possibilities/ architecture. It helps achieve very fast installation & durable structure.

The typical applications of PUF Sandwich Panel with Pre Engineered Building Structures include exterior / interior wall and roof of Industrial buildings, Commercial buildings, Multistory Buildings, prefab buildings, Site offices, Cold storages, Warehouses, etc.

3. Everest Rapicon Panel/ Solid Wall Panel

Rapicon panels are sandwich panels, made of two non-asbestos fibre reinforced cement facing sheets of Everest wall boards as per IS 14862, on either sides of a lightweight foam concrete core. The core is made from a mix of Portland cement, fly ash, cellulose, lime, gypsum, synthetic fibre, fillers & water. These panels have a unique tongue and groove jointing system that facilitates rapid construction and maximizes space utilization. The panels are light in weight & have high thermal efficiency.

The applications of the Panels include Partitions in Residential, commercial, educational and industrial buildings, Prefab Struc-



Everest Rapicon Panel/ Solid Wall Panel

tures (Accommodations units, Schools, Army barracks ware house/godowns, Site offices, security rooms, etc.), cladding, fire separation walls etc.

4. WPC Door Shutter & WPC Frame

Wood Polymer Composite (WPC) Door shutter and Frame are made of WPC sheet which is extruded from WPC compound. The various additives like, stabilizers, lubricants, fillers, blowing agent etc. as added to virgin PVC Resin (K value 57-60 Suspension Grade) and Natural Fibre (Wood Flour) are fed to a high speed mixer and heated to required temperature to blend the various additives and convert into WPC compound.

Special features of the product include;

- Water & moisture resistant,
- High screw & nail holding capacity,
- Good Insulation property,
- Flame Retardant & self-extinguishing in nature,
- Easy to Install, operate & available in various colour options,
- Low maintenance,
- Termite & borer proof,
- The products are fully recyclable,
- No warpage as WPC door is solid, water proof and also of high density

PACs for Renewal

PACs for the following systems/ products have been renewed;

1. M/s Mutha Industries Ltd., Mumbai (Bamboo wood products)
2. M/s Beardsell Ltd., Chennai (Quik Build Panels)
3. M/s Coffor Construction Technology Pvt. Ltd. Vadodara (Structural Stay-in-Place Formwork System)
4. M/s ESES Bio Wealth Pvt. Ltd, Morigaon (Assam) (Strand Woven Bamboo Wood Flooring, Wall Panels & Door/Window Frames)
5. M/s Urbanaac Infrastructures Pvt.Ltd., Ahmedabad (Precast Construction Technology)
6. M/s Metecno (India) Pvt. Ltd., Chennai (For Factory assembled insulated sandwich panels using PUF & Mineral Wool)

WPC Door Shutter & WPC Frame

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. uPVC Doors & Windows
2. Ash based "Geopolymer coarse aggregates (GPCA)" as a replacement to natural stone aggregates in concrete and allied works
3. Artificial Geopolymer flyash fine aggregates (AGFFA) as a replacement to natural sand in concrete and allied works
4. Nano concrete aggregates (NACA)
5. Moducast Precast Concrete Buildings
6. Magicrete Precast 3D Volumetric Building Components
7. J K Structure Building System
8. Agrocrete Blocks
9. Corrosion inhibiter product
10. KINZOK Aluminum Alloy Panels

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 reports of samples of the products/ systems etc. before preparation of Performance Appraisal Certificates (PACs).

Inspection of Works

During COVID-19 Pandemic Phase, the inspections of works were conducted through video conferencing.

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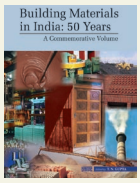
Priced Publications of BMTPC



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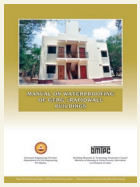

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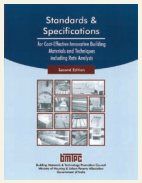

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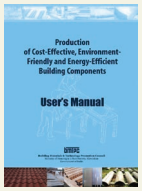

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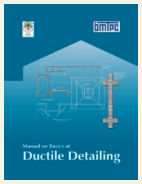

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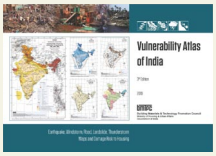

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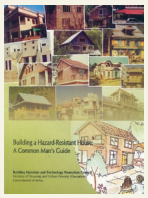

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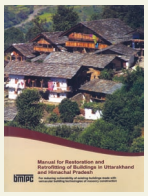

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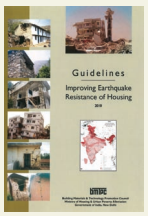

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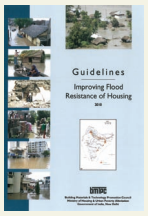

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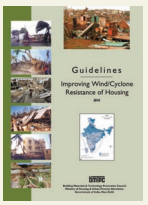

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Building Materials & Technology Promotion Council (BMTPC) under the Ministry of Housing & Urban Affairs strives to bridge the gap between laboratory research and field level application in the area of building materials and construction technologies including disaster resistant construction practices.

Vision

"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."

Mission

"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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