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Message from Chief Editor

Dear Fellow Consulting Engineers & Readers,

Housing for the masses has seen many avatars. Schemes have been launched by the Governments – Central and State, to meet the requirements of affordable housing but it is like chasing a moving target. Many committees have worked on the solutions and schemes announced and implemented – with different degrees of success. One needs to ponder on whether it is the right path or is it required to tweak it or change it drastically. The answer would perhaps lie in doing both.

Urban Planning for providing “*Affordable Housing*” needs to be rethought. The key words “*Sustainability*” and “*Climate Change*” must be the yardsticks to check all schemes for urban planning. No doubt the same has also to be applied to all other sectors of life as well so that they are properly taken care of in all walks of life. The current scenario needs to be urgently transformed.

For urbanisation to be a boon, construction of dwellings, especially the unauthorized ones, have to be checked. Even the authorized ones should be rethought. One-upmanship need not necessarily be good in the long run. Tall and high-rise buildings may change the skyline but let us pause to consider the public infrastructure that each of them demands - an infrastructure that was neither planned nor designed and would be a challenge to now provide for them.

The green lungs and water bodies in and around the urban areas could then be conserved. If the latter is not addressed then neither can the issues that are plaguing the urban areas all over the world.

The unsustainable mushrooming of dwelling units, both the so called temporary as well as the permanent ones have resulted in umpteen issues. Air quality in urban areas has deteriorated, morning sunlight streaming into the house and fresh breeze airing the dwellings is becoming a dream with high-rise buildings becoming a norm. Health of the people is sacrificed. Water supply, sewerage, storm water, garbage management are other challenges.

Spiralling number of vehicles – 2, 3 & 4 wheelers, tempos, trucks, buses, dumpers, etc. are choking the roads. Free ‘garaging’ of all types of vehicles even the construction ones on public roads is the in thing. Public transportation is struggling to keep pace. Emergency vehicles including ambulances run an obstacle race every time they answer an emergency call.

To address and tide over all that and provide good air space and access to direct sunlight for every dwelling unit, which are both essential, urban areas could be planned in a hub and spoke layout and the development limited to what the natural resources of that area can support. The services infrastructure could also then be provided in a much better manner rather in already congested and over populated areas. It is only then that a better quality of life could be provided to the habitants.

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Happy Reading & Learning

A P Mull



Indian Economy News

Government to provide assistance to construct three crore rural and urban houses under Pradhan Mantri Awas Yojana (PMAY)

 Press Information Bureau  June 11, 2024

Since its inception in 2015-16, the Government of India has implemented the Pradhan Mantri Awas Yojana (PMAY) to provide housing assistance to eligible rural and urban households. The program ensures that all constructed houses have essential amenities, such as household toilets, LPG connections, electricity connections, and functional household tap connections. These amenities are provided through convergence with other Central and State Government schemes. Over the past decade, PMAY has completed the construction of 4.21 crore houses for eligible low-income families.

In a recent Cabinet meeting, it was decided to extend assistance to an additional three crore rural and urban households to address the housing needs arising from the increase in eligible families. This expansion of the PMAY scheme will continue to focus on providing comprehensive support, ensuring that each newly constructed house includes all necessary basic amenities. The initiative underscores the government's commitment to improving living conditions for its citizens through holistic development and inter-scheme convergence.

Disclaimer: This information has been collected through secondary research and IBEF is not responsible for any errors in the same.

Affordable Housing in India – Scenario and Suggestions



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Introduction

घर, ग्रहम (Home, House) – a dream every human family, be it small or big, desires and wants to pursue since owning a house is a matter of pride. “कुछ हो न हो, सर पर छत होनी चाहिए” is the quintessential belief of every Indian household.

Housing has been valued globally, not only as a basic necessity of human living but also as a provider of safety, security, identity, dignity, and assured quality of life. It has been acknowledged as a major contributor to the economy, providing employment and promoting industrialisation.

India, like other countries, is also facing a big shortage of houses. Owning a house particularly for Low-Income and Middle-Income Groups has become more and more difficult. It is therefore necessary to initiate cost effective, innovative, and environment-friendly housing technologies for the construction of houses to enable the common people to own one at an affordable cost.

India, the third largest developing economy in Asia enjoys a unique position. The present government with its focus on business and growth for the nation is keen to undertake reforms that are critical for reviving and sustaining growth. As India gears itself towards sustained growth; the real estate sector's significance

becomes an area of key importance. Rapid urbanisation and the growing demand are key factors that are expected to drive the real estate demand.

This article presents the scenario of affordable housing, identifies key issues, the loopholes in the housing ecosystem and policies, and recommends the use of technology driven techniques. The government is making efforts to ensure that every Indian citizen has access to an affordable house – it is one of the important challenges that it faces currently.

The article also attempts to address the potential issues of residential inclusion of the poor, in Indian cities through the technique of Inclusionary Zoning (IZ) and Inclusionary Housing (IH). IZ and IH are emerging as the dominant paradigm for the promotion of affordable housing to low-income populations in several countries. However, this technique is yet to be adopted in India in an appreciable way.

The article discusses the goals of the Pradhan Mantri Awas Yojana (PMAY) which was introduced by the Government of India in 2015 with its aim being “*Housing for All by 2022*”. The Mission is a bold attempt to address housing requirements of the Economically Weaker Section (EWS) and the Low Income Group (LIG). These two jointly account for 95.7 percent of the housing shortage in India which was estimated at 18.78 million in 2012 (MoHUPA, 2012). The major factors

to be addressed are the lack of suitable, litigation-free, reasonably-serviced urban land, located at a reasonable distance from the workplace or being easily accessible by means of a good public transportation system. The reason for the problem not being addressed earlier is attributable to the exclusionary urban planning process that Indian cities adopted - the concept of the 'Master Plan'. That paradigm was borrowed from the 1947 Town and Country Planning Act of the United Kingdom and adopted the space norms of the middle class in the city.

Affordable Housing For All Mission

The objective of National Mission for Urban Housing or "Housing for All by 2022" was to construct two crore affordable homes over a period of 7 years from 2015 to 2022. The target beneficiaries are poor people belonging to EWS and LIG categories, with special focus on women, Scheduled Castes and Scheduled Tribes.

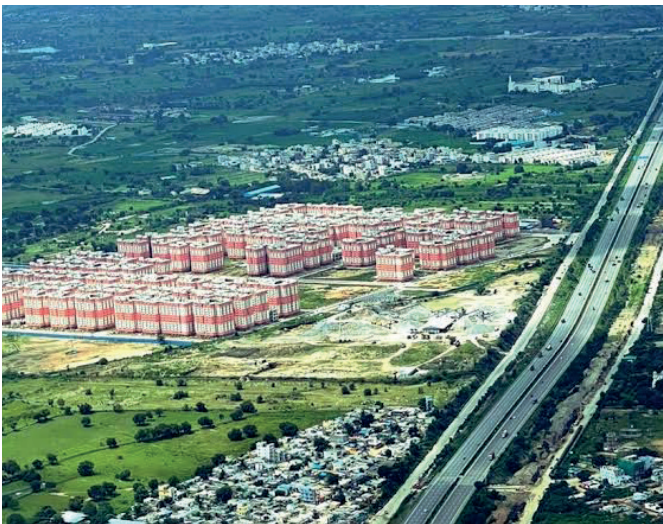


Photo-1: 2 BHK -15396 Units at Kollur, Hyderabad
Government of Telangana

Definition of Affordable Housing

It is firstly important to delineate the contours of this topic by defining the term "affordable housing". There is no clear-cut definition of the term "affordable", as it is a relative concept. Even, "affordability" as a concept is very generic and could have different meanings for

different people of different income levels. Different agencies and countries have defined "affordable housing" as the economic potential of an individual to buy a house.

The Task Force on promoting Affordable Housing of MHUPA has defined affordable housing as "*Affordable housing refers to any housing that meets some form of affordability criterion, which could be income level of the family, size of the dwelling unit or affordability in terms of EMI size or ratio of house price to the annual income*".

Critical Issues in the Affordable Housing Sector

- Land is the most critical cost in housing projects. For affordable housing the land cost should be such that the benefit can be passed on to the end-user. The land cost in urban city centres is high, often constituting more than 50% of the project cost for developers; that makes affordable housing projects unviable.
- Excessive control on the volume of construction in some centrally located areas of large urban centres, pushing development to peripheral areas that lack infrastructure facilities.
- For affordable housing projects, even construction costs can form a large factor in making projects unviable, since the profit margins for the developers increase exponentially as compared to the construction costs when evaluating projects ranging from affordable to mid-segment to premium and luxury segments. A control on these costs is also crucial for any housing project to stay affordable.
- Lack of marketable land parcels in key areas, where large tracts of land are owned by public entities such as railways and are lying un-utilised or under-utilised and which the authorities are unable to utilise for affordable housing developments.
- Many of the people who belong to the Lower Income Groups (LIG) are not qualified or eligible or in no

position to avail the subsidies from the housing schemes and other facilities due to low salaries and more responsibilities with limited income. Besides a large percentage of them are working in an unorganised sector and often lack documents such as Proof of Address due to migration to semi urban and urban areas, pay slips, etc. though they possess Aadhar cards., they are perceived as high-risk category.

- Requirement for focused government policies that enable and incentivise the affordable housing segment such that it is more lucrative for joint developers/ PPP developers to build affordable housing projects.

Why Affordable Housing is Important?

According to a Government of India report in 2012, an estimated 18.78 million more houses were required to cater to the housing demand in the country. A study done by the Indian Council for Research on International Economic Relations (ICRIER) in 2020 found that India's urban housing shortage rose by 54% from 2012 and became 29 million in 2018.

The recently elected Government again announced plans to build 30 million homes under PMAY that included homeless populations, inadequate houses that could not be upgraded, obsolete houses and congested households. As Asia's third-largest developing economy, India finds itself in a unique position. The government, with its emphasis on business and growth for the nation, is eager to implement critical reforms for reviving growth. As India strives for long-term growth, the real estate sector will become increasingly important. Rapid urbanization and rising occupier demand are expected to drive real estate demand in the course of time.

A few of the reasons why affordable homes are important in India are:

- Migration is the primary driver of urbanization. The attraction of cities for employment opportunities; better standard of living, better educational facilities,

infrastructure, need for status, and so on, stimulates the influx of population into urban areas. And, with the advancement of sophisticated technology, as well as improved infrastructure, communication, and medical facilities, people believe they can live comfortably in major cities.

- Slums and sprawls- slums are prevalent because of haphazard planning processes, while sprawls, in turn, contributes to hidden urbanization, especially on the outskirts of major cities, which is not captured by official statistics.
- Affordable homes not only meet a basic human need for shelter but also benefit the well-being of both parents and children. According to studies, children who live in stable housing perform better in school and are less likely to experience disruptions in their education because of unwanted moves. Adequate housing reduces stress, contact with toxins and infectious diseases, thus resulting in better physical and mental health.
- Affordable housing also frees up funds in families' already-strapped budgets for health care and food. Living in decent, affordable housing also means less stress for parents because there is less fear that high housing costs will lead to foreclosure and eviction; that, in turn, leads to fewer physical and mental health problems and lower job absenteeism.
- Teachers, cops, nurses, firefighters, and other key service providers are drawn to the community by affordable, high-quality housing. Transportation options allow residents to search for and find jobs in areas that are convenient for them, providing job security, improving their financial situation, and removing the need for cars. In contrast, access to essential products and services, as well as employment opportunities, is provided by commercial spaces. Shorter commutes allow workers to spend more time with their families while reducing traffic congestion, air pollution, and road expenditures, all of which benefit the community.

Requirement of Affordable Housing in India

According to the definition by the government, affordable housing properties are those properties which have an area of not more than 60 sqm and the price is capped at Rs. 45 lakhs. The right to housing has been held to be a part of the Fundamental Right to Life by the Supreme Court under Article 21 of the Constitution of India.

WHO IS AFFECTED BY HOUSING AFFORDABILITY?



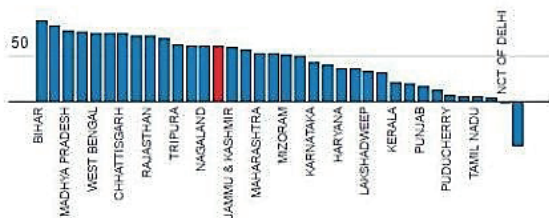
Figure-2: Key Persons Who Need An Affordable House

percentage of households by ownership status of houses in India for 2001 and 2011 census

	Total 2001	Total 2011	Rural 2001	Rural 2011	Urban 2001	Urban 2011
owned	86.7	86.6	94.4	94.7	66.8	69.2
rented	10.5	11.1	3.6	3.4	28.5	27.5
any other	2.8	2.4	2.1	1.9	4.7	3.3

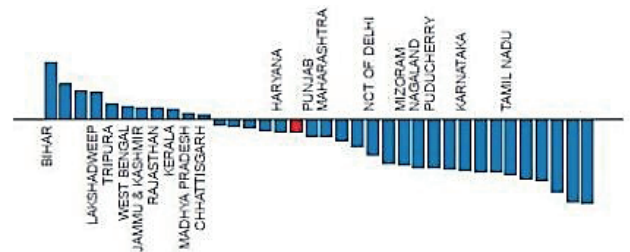
Number of total households was 19.2 crore (13.8 crore rural and 5.4 crore urban) in 2001 and 24.7 crore (16.8 crore rural and 7.9 crore urban) in 2011 census

Figure-3: Most households own their houses in India



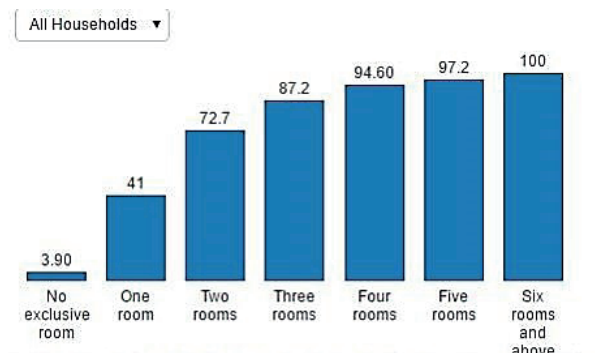
If 60% households own a house and 30% own a TV in a state the corresponding column would show a value of 30

Figure-4: Own a House, but No TV (Rural)



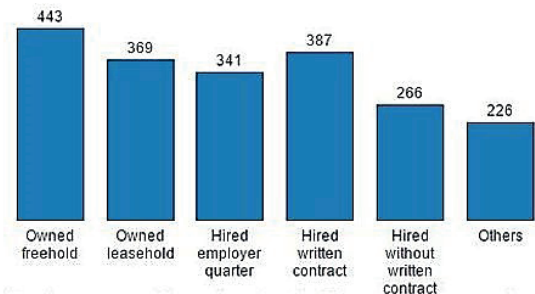
If 60% households own a house and 30% own a TV in a state the corresponding column would show a value of 30

Figure-5: Own a House, but No TV (Urban)



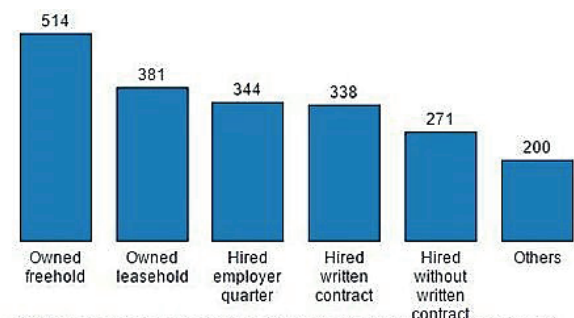
Graph shows cumulative distribution of households by number of rooms. The value for 41 for one room means 41% have one room or less in their houses.

Figure 6: Not Enough Room for Half of India



All values are means of respective categories. TFA means total floor area. It includes living rooms, other rooms, covered veranda and uncovered veranda.

Figure-7: Most Houses are Little Boxes (Rural TFA)



All values are means of respective categories. TFA means total floor area. It includes living rooms, other rooms, covered veranda and uncovered veranda.

Figure-8: Most Houses are Little Boxes (Urban TFA)

	total	rural	urban
share of vacant houses in 2001 (% of all houses)	6.3	5.3	9
share of vacant houses in 2011 (% of all houses)	7.5	6.2	10.1
% change in number of vacant houses between 2001 and 2011	56.3	44.7	70.8

Figure -9. India's Ghost Houses

Policies and Regulations in India

Several policies adopted by the Central Government have assisted in the delivery of affordable housing for the EWS, LIG and lower MIG. The first National Housing Policy was formulated in 1988, followed by the formulations of the National Housing Policy in 1994 and later by a few more. Some of the housing policies which made a strong impact on the people and the society.

Jawaharlal Nehru National Urban Renewal Mission (JNNURM)

JNNURM was launched in December 2005 with an aim to implement a form-driven, planned development of cities in a Mission mode with focus on up-gradation of urban infrastructure, creation of housing stock and provision of basic services to the urban poor, community participation and accountability of Urban Local Bodies (ULBs)

Credit Risk Guarantee Fund (CRGF) (2012-17) (12th Five Year Plan)

With a view to improve access to loans for EWS and LIG persons, a Credit Risk Guarantee Fund (CRGF) with a proposed corpus of Rs. 1,000 crores in the 12th Five Year Plan under RAY to guarantee the lending agencies for loans of upto Rs. 8 lakhs (earlier Rs. 5 lakhs) without any third-party guarantee or collateral security.

Rajiv Awas Yojana (RAY) (2013)

It was launched as a Centrally Sponsored Scheme (CSS), and implemented in Mission mode during 2013-2022 for the slum dwellers and the urban poor. It envisaged a 'Slum-free India by encouraging States

and Union Territories to tackle the problem of slums in a definitive manner, including water supply, sewerage, drainage, solid waste management, approach and internal roads, street lighting, community facilities such as community toilets and baths, informal sector markets and livelihoods centres.

National Urban Housing Mission (NUHM), 2015

The NUHM was launched as a Centrally Sponsored Scheme in 2015. It sought to meet the gap in urban housing units by 2022. It has four broad components or verticals out of which credit linked subsidy would be implemented as a Central Sector Scheme and not a

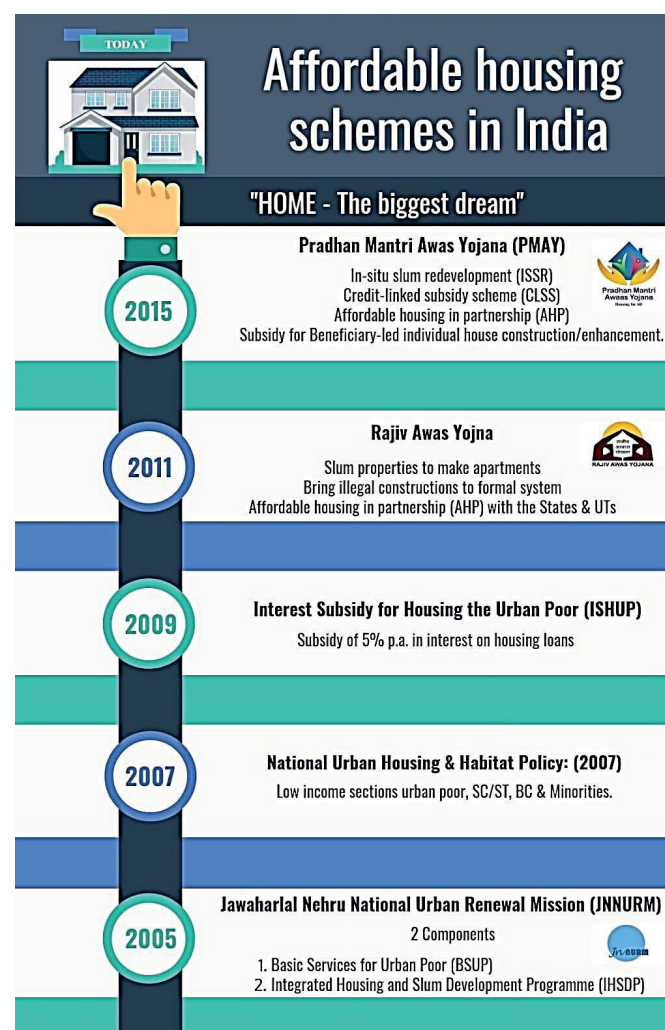


Figure-10: Affordable Housing Schemes in India 2005-2015

Centrally Sponsored Scheme. The Mission was initially to cover 500 Class I cities and be spread across 3 phases (2015-2022). It comprised the following:

- Slum Rehabilitation of Slum Dwellers with participation of private developers using land as a resource - The Centre would provide a grant of Rs.1 lakh per house to the State for deployment in the development of any slum rehabilitation project.
- Promotion of Affordable Housing for Weaker Section through credit linked subsidy - An interest subsidy of 6.5% on housing loans would be provided to EWS/ LIG categories which could be availed upto a tenure of 15 years. It would cover all the 4041 statutory census towns from the beginning.
- Affordable housing in partnership with Public sectors-Central assistance at the rate of Rs.1.5 lakh per house for the EWS category to be provided.
- Subsidy for beneficiary-led individual house construction or enhancement – central assistance at the rate of Rs. 1.5 lakh per house for the EWS category will be provided.

The Salient Features of the NUHM are:

- Provides flexibility to the States to choose the option, which could best meet the demand of housing in their states and empower the States to formulate and approve projects for their faster implementation.
- Promotes the adoption of modern, innovative, and green technologies and building material for faster and quality construction of houses, which would be selected based on discussions with regulatory and administrative bodies.
- Provide technical and financial support in accordance with the guidelines to the states to meet the challenge of urban housing.

Affordable Housing in Partnership (AHIP)

The scheme of Affordable Housing in Partnership (under RAY) aimed to increase affordable housing stock through promotion of various types of Public-Private

Partnerships amongst the private sector, cooperative sector, financial services sector, state parastatals and urban local bodies. Central support was provided at the rate of Rs. 75, 000.

The following graph shows to what extent the government schemes mentioned above have been successful.

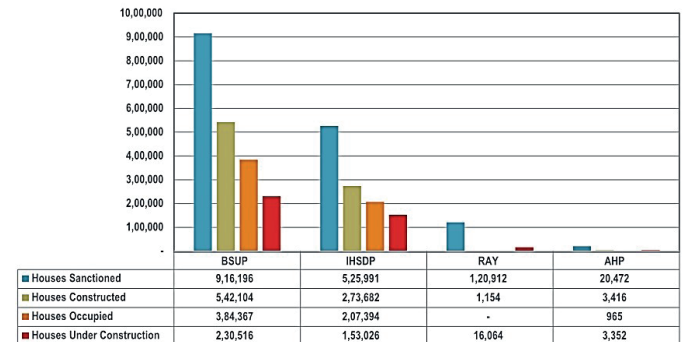


Figure-11: BSUP: Basic Services To The Urban Poor; IHSP: Integrated Housing and Slum Development Programme; RAY: Rajiv Awas Yojana; AHP: Affordable Housing in Partnership

Impact of Affordable Housing on Households.

Affordable Housing (AH) provisions are important at the national level, the city level as well as the individual level. Cities are engines of economic growth, and housing is that which can be afforded by the median wage-earner. It is therefore a prerequisite for the city to attract and retain the labour force required to ensure its economic success. From a national perspective, AH is one of the indicators of balanced growth in the country. When housing becomes unaffordable, there is either a bubble in the housing market, with serious repercussions to the economic policy which can create other imbalances in the economy. AH has multiple linkages to other aspects of the individual's well-being. Mueller and Tighe (2007) consider evidence on the relationship between AH and benefits to the larger community in education and health. They also find, like Lubell et al. (2007), that there is a positive externality to health due to AH provisions.

AH has led to better access to health care, to education, and to perceived control and life-satisfaction (Rohe

and Stegman, 1994). AH also serves to reduce crime (Horner, 2009) and has significant wealth effects on the residents due to employment stability (Rohe and Stewart, 1996; Berry, 2003).

Challenges in the Affordable Housing Sector in India

Despite the government's intervention in the Affordable Housing sector in India, there are multiple challenges associated with them:

- PMAY (U) promised houses for 1.18 crore families by December 2024. However, as of March 2024, it has only achieved around 67% of its target, i.e. around Rs. 80 lakhs. That is because there are several constraints attached to these schemes. The PMAY (U) is applicable only for families having access to capital and land, and not for urban landless poor.
- The high cost of land and construction materials makes affordable homes economically unviable for low-income people. The low-income class cannot afford a house without subsidy.
- According to an analysis done by the Centre for Social and Economic Progress of the 2011 Census data, despite the urban housing shortage of 19 million units, there are 11 million vacant units. However, these vacant units are unaffordable for the lower middle class.
- Scarcity of suitable low-cost land within city limits poses a significant challenge for the development of affordable housing projects in the city limits.
- The affordable housing developers lack the access to institutional finance for affordable housing development.
- The real estate developers operating in the affordable housing sector suffer from the challenges of lengthy approval procedures, multiple clearances, and thin profit margins. All these contribute to delays and hamper the swift execution of projects.

The Road Ahead

Developing AH on a large scale is the greatest challenge in urban India today. It promises a solution to the proliferation of slums, unorganized real estate development, unplanned growth, and transit congestion. It is vital that certain critical issues are addressed urgently to make AH a possibility. On the demand side, identification of the right clientele, micro mortgage financing mechanisms and self-help groups for larger reach with flexible paying mechanisms to cater to variable income flows are called for. On the supply side, incentivising through policy (extra floor space index, free sale areas and so on), schemes for slum redevelopment and rehabilitation, adequate availability of land, streamlining of land records, inclusion of mass housing zones in CDPs and encouragement to private participation and partnership, single window clearance for smaller projects on the lines of large township projects are necessary.



Figure-12: Outcome of a Planned Affordable housing Scenario

Developers need to focus on the marketability of small formats with reduced down payments. Success in the AH segment demands management of project cost and timelines so as to prevent cost-time overruns. Inadequate infrastructure is also a challenge. As

developments increasingly tend for suburban and semi-urban locations, the concomitant development of connectivity and access becomes vital.

There is also a special responsibility on the State to create an enabling environment for AH developers, not necessarily through subsidies but by fast tracking the approval processes, demystifying land laws, and deconstructing the financing and land assembling processes, and innovative mechanisms such as earmarking areas for development, encouraging public private partnerships, and rethinking Floor Space Index (FSI) limits.

In respect of subsidies, the targeted subsidies to low-income segments can be continued; and in addition, enabling low-cost credit to low-income developers and Housing Finance Companies (HFCs) can be enabled. A robust industry calls for better customer education, more transparency and better communication. Industry associations, International Development Agencies, practitioners should collaborate periodically to monitor the market, disseminate information, and provide feedback to both industry and the general public.

AH thus calls for collaborative multi-pronged and concerted effort from all stakeholders.

Different Housing Schemes in the Different States of India?

- a. DDA Housing Scheme: The first in the state-wise housing schemes is the specialised offering from the Delhi Development Authority (DDA). The scheme provides apartments to homebuyers, high to medium to low-income, within the city limits. The DDA Housing Scheme also ensures reservation of apartments at economical rates for the Economically Weaker Section (EWS). That way, the initiative empowers the EWS applicants to shift their families to homes of their own.
- b. Tamil Nadu Housing Board Scheme: The TNHB Scheme caters to the residential demand in the State and ensures easy accessibility to good quality homes. Under the scheme, the Tamil Nadu

government provides affordable apartments to natives of Tamil Nadu.

- c. NTR Urban Housing Scheme: It is for residents of Andhra Pradesh who are scouting for affordable housing. The stellar feature of the scheme is that the beneficiary needs to put in just one-third of their home loan principal amount, while the rest is taken care of by the Central and State governments.
- d. Telangana 2BHK Housing Scheme: It is a commendable initiative by the Telangana government which aims to provide affordable and dignified housing to economically weaker sections of the State. According to the scheme, eligible candidates would get a 2BHK housing facility to fulfill their shelter needs.

Housing Loans Eligible Under Priority Sector Lending

- i. Loans to individuals of an amount up to Rs.25 lakhs in metropolitan centres with population above ten lakh and Rs.15 lakh in other centres for purchase/construction of a dwelling unit per family excluding loans sanctioned to bank's own employees.
- ii. Loans for repairs to the damaged dwelling units of families of an amount up to Rs.2 lakhs in rural and semi-urban areas and up to Rs.5 lakhs in urban and metropolitan areas.
- iii. Bank loans to any governmental agency for



Figure 13: Cabinet approves development of Affordable Rental Housing Complexes (AHRCs) for urban migrants/poor as a sub-scheme under Pradhan Mantri Awas Yojana 2020

construction of dwelling units or for slum clearance and rehabilitation of slum dwellers subject to a ceiling of Rs.10 lakhs per dwelling unit.

- iv. The loans sanctioned by banks for housing projects exclusively for the purpose of construction of houses only to economically weaker sections and low-income groups, the total cost of which do not exceed Rs.10 lakh per dwelling unit. For the purpose of identifying the economically weaker sections and low-income groups, the family income limit of Rs.1, 20,000 per annum, irrespective of the location, is prescribed.
- v. Bank loans to Housing Finance Companies (HFCs), approved by NHB for their refinance, for the purpose of purchase/ construction/ reconstruction of individual dwelling units or for slum clearance and rehabilitation of slum dwellers, subject to an aggregate loan limit of Rs.10 lakh per borrower, provided that the all-inclusive interest rate charged to the ultimate borrower does not exceed the lowest lending rate of the lending bank for housing loans plus two percent, per annum.

The eligibility under priority sector loans to HFCs is restricted to five percent of the individual bank's total priority sector lending, on an ongoing basis. The maturity of bank loans should be co-terminus with average maturity of loans extended by HFCs. Banks should maintain necessary borrower-wise details of the underlying portfolio.

City	2010	2019	2021	2022	2023
Mumbai	93%	67%	52%	53%	51%
Hyderabad	47%	34%	28%	30%	30%
NCR	53%	34%	28%	29%	27%
Bengaluru	48%	32%	26%	27%	26%
Chennai	51%	30%	24%	27%	25%
Pune	39%	29%	24%	25%	24%
Kolkata	45%	32%	25%	25%	24%
Ahmedabad	46%	25%	20%	22%	21%

Table-I: Affordable Matrix Calculated as EMI or Income ratio
Source: MOSPI, Knight Frank

State or local policies to reduce the cost of homeownership include: **below- market interest rates on mortgages from a state or local housing finance agency**; down payment assistance to help families afford the costs of private-market homes or programs to fund the construction of homes that sell for a reduced cost.

Gaps in Demand and Supply

There is a huge gap between supply and demand and people have fewer choices when it comes to affordable housing supply. While the supply side constraints for affordable housing include lack of availability of land and finance at reasonable rates, the demand drivers include the growing middle class and urbanisation. Real estate developers, private players in particular, have primarily targeted the luxury, high-end and upper-mid housing segment owing to the cost of land and higher returns that can be gained from such projects. In addition, several structural issues, such as the high gestation period of housing projects, limited and expensive capital, spiralling land and construction costs, high fees, and taxes as well as unfavourable development bottlenecks restrict the desired growth of the housing stock in India.

Demand Side

To overcome the issues relating to the Demand it is suggested that:

Guidelines be formulated for identifying the right beneficiaries: There is a need to formulate guidelines that would help identify right beneficiaries for affordable housing projects. That would help in ensuring the reach to right beneficiaries and avoid involvement of speculative investors into the projects. Creation of the National Population Register and issuance of unique identity through Unique Identification Authority of India will become crucial steps in identification of the right beneficiaries, if they are linked with income levels.

Innovate on micro mortgage financing mechanisms to ensure a larger reach: Effective financing through micro mortgages by utilising the reach of Self-Help Groups (SHGs) and other innovative financing mechanisms would ensure that housing finance is available to large sections of LIG and EWS populations. Flexible payment

mechanisms should be put into place, as households in low-income groups typically have variable income flows.

Supply Side

As with the Demand side there are also issues on the Supply side and to solve them it is necessary that:

- Land Records be streamlined to improve planning and utilisation of land: Adequate availability of land should be ensured for housing and infrastructure by computerisation of land records, use of Geographical Information Systems, efficient dispute redressal mechanisms and implementation of Master Plans.
- Mass housing zones: These be included in city plans and be developed within a planned schedule for the future requirement of affordable housing.
- Policies be formulated for greater participation from the private sector by way of technological solutions, project financing and delivery: Disruptive innovation in terms of technological solutions, project financing and delivery is required, which would reduce cost of construction significantly despite rising costs of inputs.

Measures to Make Housing Affordable

The government needs to accelerate the efforts to broad-base and significantly augment Public-Private Partnership programmes introduced in the past. The Urban Local Bodies (ULB) and Urban Development Authority (UDA) could be directed to incentivise private developers in the affordable housing segment by allotting them economical land, higher FSI, single window clearance for approvals, tax subsidies and by reducing External Development Charges (EDC) and Interest During Construction (IDC) costs. That would help in encouraging more developer's participation in creating affordable homes.

Reduction in Interest Rates

The Government needs focused measures for the empowerment of EWS/ LIG households such as lower interest rates for home loans in EWS and LIG category, micro-finance, and other innovative financing measures.

That would help end users to get cheaper home loans and reduce the inventory overhang in affordable schemes.

Encouraging Low-Cost Housing Techniques

Introduction of best practices and new low-cost construction and pre-fabricated techniques in affordable housing projects. Although pre-fabricated techniques can be expensive, but they save labour cost and also construction time as compared to conventional methods.

What should be the Way Forward?

1. Addressing Demand side constraints: Provision of subsidies, funds for affordable infrastructure development and provision of basic services/ amenities around those housing projects, would help in rejuvenating the affordable housing sector in India.
2. Matured rental market for affordable housing: Development of a matured rental market that specifically enhances the robustness of affordable rental housing would enable holistic development of the affordable housing sector.
3. Promotion of Rental Vouchers: The National Urban Rental Housing Policy's rental voucher scheme must be implemented more broadly to help urban poor and migrants afford private rentals in suitable locations.
4. Administrative efficiency: The regulatory authorities must proactively speed up the process of regulatory clearances for the affordable housing projects, to spur growth in that sector.
5. Increase focus on Urban Housing Needs: Resources must be redirected from rural to urban housing projects. That would support the workforce in urban and semi-urban settings, and would in turn enhance labour mobility and economic productivity.
6. Increase Options: Offering more options to low and middle-income households would increase prosperity, reduce poverty, and enhance the quality of life for urban dwellers across India

What Needs To Be Done?

Development of large-scale affordable housing is one of the greatest necessities of urban India today. Indian cities

lack them, and that has resulted in the proliferation of slums and unorganised real estate across the landscape. All that is detrimental to the planned growth of cities. Large-scale urban developments are becoming increasingly difficult due to lack of land parcels, congested transit routes, lack of finance, rising input costs and regulatory hurdles. However, it is vital that these issues are addressed urgently so that a comprehensive framework can be established for ensuring the development of affordable housing.

As a long-term preventive approach, planning and land-management processes need to carefully balance projected housing demand and population growth with land and housing supply or production capacity. Before considering what governments should do to carry out that approach, it would be useful to estimate how much land is needed to meet the projected demand for housing arising from urbanisation and household formation trends up to 2050. The answer to that would also depend on whether most of the existing backlog can be accommodated on existing urbanised land and the population density of these new developments.

Affordable housing is one which is deemed affordable to those with a household income at or below the median as rated by the national government or a local government. Policy reforms for the affordable housing sector should be participatory. They must also take into account other

stakeholders and the reality of the real estate market, access to improved water (in sufficient amounts at an affordable price), access to improved sanitation (in the form of a private or public toilet shared by a reasonable number of people), and sufficient living area (not more than three people sharing the same room) as rated by the national government or a local government.

Other initiatives for affordable housing have included land trusts and land banks, which separate the cost of building from the cost of acquiring land. A non-profit land trust, a municipality, or some other body holds the title to the land, but the building is developed separately so that the cost of the housing is limited to erecting the structure and operating it. Granting tax credits for development, waiving development levies and taxes, and providing rent-geared-to-income assistance either through a housing initiative or directly to individuals have been tried as ways to encourage for-profit developers to construct housing or to continue to provide it for those with low incomes.



Figure- 14: Image showing the result of distribution of houses through various ways by the Government of India

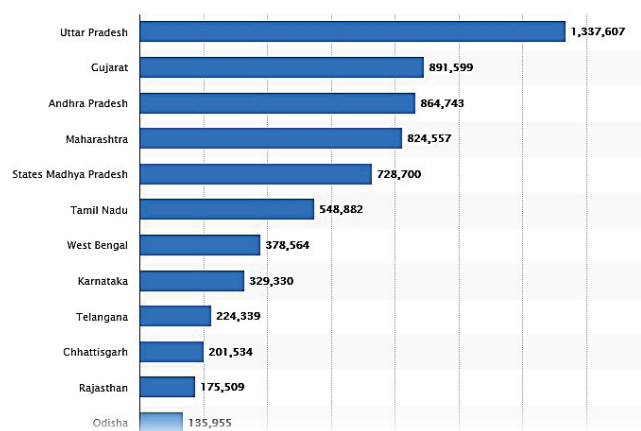


Figure15: Number of Affordable Housing Units Completed in India as of November 2023, by States

Role of Technology in Reducing Cost of Construction

The four main types of modern construction technology are Information Technology for Project Management, Building Modelling & Design Software, Automation & Robotics, and Advanced Building Materials.

Each type plays a crucial role in enhancing efficiency

and productivity. Using prefabricated materials, utilizing the latest technologies and equipment, and employing energy-efficient design techniques are some that can be used to reduce construction costs.

Furthermore, smart material choices and efficient project management can also lead to cost savings.



Figure 16: Technology in Construction

With the help of automation and robots, one can create a safer and more efficient construction environment that would benefit both clients and the construction team. Using high-tech tools and technology ensures greater precision. That means more accurate measurements for foundations, corners, or perimeters but also more detailed mapping of existing structures. All of that greatly contributes to creating and delivering high-quality buildings.

The increase in productivity reduces the average cost per unit, leading to lower production costs. Secondly, technology can also automate certain processes, reducing the need for labour. That can lead to significant cost savings, as labour is often one of the most expensive inputs in the production process. Some of the technologies that can be used are:

- a. 3D Printing. Another technology that is commonly used in construction at a faster pace.
- b. Virtual Reality, and
- c. Building Information Modelling (BIM)
- d. Using different kinds of shuttering technologies - Aluminium form work, Shear wall, etc.
- e. Usage of locally available sustainable materials.

These enable architects, engineers, and builders to design and construct buildings with lowered environmental impact, improved energy efficiency, and enhanced occupant health. However, it needs to be kept in mind that the new construction technology is not a silver bullet and cannot inherently fix all problems on the jobsite.

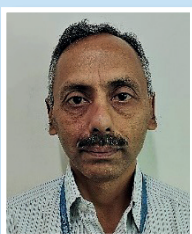
Conclusions

Due to increased urbanization in India, it is mandatory to address the huge demand supply gap in the affordable housing segment, especially for the LIG and EWS segment of the population. The main reason behind the skewed and haphazard development is the lack of affordable housing. Some incentives from the government and private sectors in terms of sustainability and technical approach could help to achieve the “housing for all” under the Sustainable Development Goals (SDG 11). It is necessary to address the major loopholes of these segments and provide an efficient regulatory framework for the execution of affordable housing projects. That would vary from area to area depending on the local political outlook, planning, legal, policy and contexts of the land area to be made available.

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Affordable Housing in India – Balancing Affordability and Sustainability



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Introduction

Every person, irrespective of his/ her means, cherishes the dream to own a property that he/ she can call his/ her own. Though there is no single parameter to define affordability for houses, the most general concept applied in this context is in terms of providing housing to the low-income group persons. The definition of affordability for housing also varies across different regions and countries and is usually determined by local governments. The Department of Housing and

Urban Development in the United States defines housing as affordable when its cost is limited to 30 percent of the gross income of the occupant ^[1], whereas the Government of India defines affordable housing in urban areas as those having less than 60 sqm carpet area. Various categories are listed by the Ministry of Housing and Urban Poverty Alleviation (MHUPA) in their publication as shown in *Table-1*. In financial terms, the cost of such housing should be 20 percent of the occupant's income ^[2].

Table-1: Definition of Affordable Housing, MHUPA, India

DEFINITION OF AFFORDABLE HOUSING – MHUPA 2012			
Income category	Size	Income Criteria	Affordability
EWS (Economically Weaker Section)	21-27 sqm carpet area EWS maximum area could be between 25.2 and 30.8 sqm if subsidies are tied to them	The maximum Household Income for the EWS and LIG category are recommended to be INR 8,000 to INR 16,000 per month and since many households in this category do not have regular monthly income an annual income of INR 100,000 for EWS and INR 200,000 for LIG households could also be used	The Task Force recommends that the desirable goal of a house price to income multiple that should be pursued for Affordable Housing projects should be 5
LIG (Low Income Group)	28-40 sqm of carpet area Maximum area for LIG could be between 36.9 and 45.1 sqm if subsidies are tied to them		
MIG (Middle	41-60 sqm of carpet area		
Source: Task Force on promoting Affordable Housing, MHUPA 2012			

The Great Urban Rural Divide

A deep chasm exists with respect to providing sufficient and requisite housing between the urban and rural contexts in India. Studies show that while 95% of the rural population own houses, in urban settings this figure of house ownership falls to 69%. Cities have a large amount of migrant population at various income levels who live in rented housing and those at low or very low-income levels live in slums or even encroached lands. Even in cities, the percentage of house ownership varies across different states as shown in *Figure-1* [3].

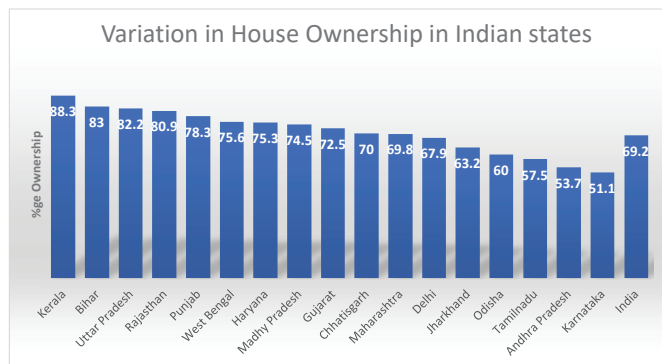


Figure-1: House Ownership variation across Indian States [3]

Another pattern noted with house ownership in cities is that the percentage reduces to 60 percent in larger cities with population above 40 lakhs compared to 67-68 percent in smaller cities as shown in *Figure-2*. In larger cities the component of migratory population is higher

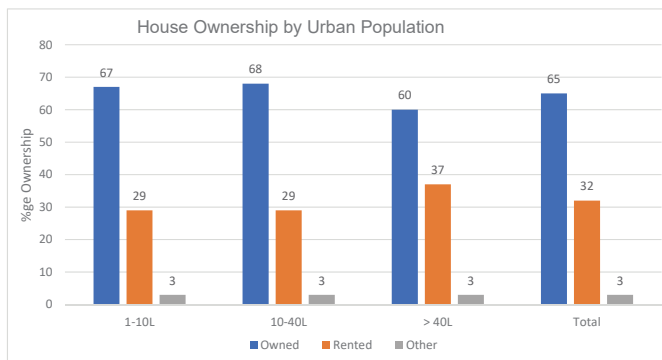


Figure-2: House Ownership variation according to Urban Population

The above study and analysis show that the requirement of mass and affordable housing is most critical in the larger cities compared to smaller cities and rural centres.

Another differentiating pattern between urban and rural housing noted in surveys ending in 2021 is on the structure of the house itself. Almost all urban houses (96.7 percent) are pucca houses while 79.5 percent of rural houses are pucca according to NSS standards having sturdy materials for walls and roofs (not floors). When pucca floor is also brought into the picture for pucca house according to National Family and Health Survey (NFHS) criteria, the pucca houses percentage was 60.3, semi-pucca house 34 percent and 4.6 percent kutch house [4]. Despite the almost complete presence of pucca/ semi-pucca urban housing, 16.3 percent of urban population lives in slums and squatter settlements with poorly built, temporary shelters with inadequate drinking water, unhealthy sanitary facilities, and poor hygiene [4].

Other Aspects of Affordability

Traditionally, affordability has been measured solely in terms of price of making an initial, one-time investment or purchase on an asset. However, this definition is only a partial representation since there are many other factors that play a very important role in the usefulness of the asset over its lifetime. A single time investment for purchasing a house can be financially supported through various schemes from financial institutes that take into consideration the economic condition of the purchaser. Thus, only price points may not constitute a complete definition of affordability. Some other equally important aspects can comprise [3]:

Location Convenience to Utilities – Transport, Medical, Market, Workplace

Cost of commuting to the workplace, marketing for daily needs, availing medical facilities, education, leisure hours, and other necessities are recurring expenses that a family must bear. If these costs get added disproportionately to the cost of house ownership, then the overall cost of living goes up and the affordability of the housing unit declines. Though locating the house away from the city centre eases the land cost significantly, the running costs go up impacting the overall expenditure. Thus, affordable housing away from major areas of activity will also need an affordable public transport system to support.

Minimum Facility Requirements

Most definitions of affordable housing are tied to a predetermined floor area since that is the primary factor that determines the cost of a house. However, to make the property useful to the owner basic amenities and facilities must be integrated into the floor plan. Those would comprise adequate provisions for power, water supply, sanitation, natural light, and ventilation as necessary items. Additionally, it is desirable to also plan for facilities like community spaces, parks and gardens, children play tots which will enhance the liveability aspect for the occupants. In addition to these the other requirements are markets, medical clinics, hospitals, and different modes of affordable transportation networks.

Maintenance and Upkeep

Cost of assets like houses should consider the entire lifecycle from construction through use and end of design life and not only the initial purchase cost. The systems provided for the use of the property by occupants, the running expenditures on power, periodical and routine maintenance also need to be factored into affordability over the life cycle of the house. Design optimization interventions should consider not only capital construction cost optimization but also the optimization for building use phase involving energy cost, water cost, waste disposal cost, and repairs and refurbishment costs.

Loss of Nearness to Nature

Development of low cost and affordable housing generally considers high intensity of development to optimize on the high cost of land. That tends to leave little space for natural elements to be featured in the housing area. The loss of contact with nature not only adversely affects the occupants but also introduces the provision of artificial means of environmental control for healthy living adversely impacting the affordability of the living environment.

Urban versus Rural

The type and demography of urban and rural population impact the degree of affordability of houses in the respective settings. Due to the differences between rural and urban living, the definition of affordability

changes in the two contexts. In urban areas, completely readymade units with all facilities and amenities need to be provided at one go while in rural areas, houses are built slowly adding facilities in phases which allows the owner more flexibility in developing the asset, thus making it easier to bear the costs.

Methods Towards Improving Affordability

Affordability of houses can be improved/ increased by adopting planning and design intervention measures and better construction practices. Some important aspects include:

Optimization of Planning & Design

Planning and design optimization through efficient use of land, space planning, structural elements, alternate materials, can all significantly lower the construction cost of houses.

Energy Efficiency Improvement

Use of energy efficient appliances and fixtures, low power consuming equipment can help reduce the running cost of the building during its occupancy stage.

Natural Environment

Keeping provision for naturally running systems in the housing development plan like biogas generation, vermi composting, solar power generation, water bodies that provide local cooling effect can reduce dependence on external resources and lower running cost of living.

New Techniques

Using new/ latest techniques for construction like prefabrication, precast construction, modular construction can result in material optimization, lower construction cost through repeated use, ensure better quality that reduces future maintenance requirements and improve the appearance and desirability of a house making it more affordable.

Local Materials

Local materials can help in cost reduction from lowered transportation costs, ease of procurement and ease in replacement and repair.

Vernacular/ Traditional Design

Vernacular architecture using local design methods, construction strategies, locally available materials, can provide many benefits like efficient thermal comfort in internal environment, natural lighting and ventilation and easily amendable and repairable construction that can significantly improve affordability of the house in terms of capital and operational costs.

A New Concept Towards An Affordable House

All established definitions for affordable housing are connected to a cost implication in one way or another. However, the increasingly apparent effects of human activity on climate change and the growing concern in this field opens a new approach towards affordability. An asset may be affordable to an intending buyer on price point, but can Nature afford the carbon emissions and consequential environmental impact of the construction and the occupation phase of the house? It has become increasingly evident that many man-made systems, even when used for basic human needs, are not in the right tune with natural systems and the ability of the natural systems to recuperate from the ecological shock. Natural systems are fragile and finely balanced on an intricate symbiotic relationship of many subsystems. These systems are disturbed due to human interfering activities at different stages and intensities. The extent of damage is sometimes evident in a short time span e.g., flooding due to improper land development and upending natural drainage systems. In most cases, natural systems react slowly to change, and the effects are seen in gradual changes which operate at more fundamental levels, like change in land usage from rural/ forest land to urban/ agricultural land can lead to gradual desertification. This aspect is rarely studied in any detail while developing projects including housing development. Adverse impacts on biodiversity of a region through unplanned development with further emphasis on cost optimization severely impact small local biosystems. Such incremental interventions to local biosystems coalesce into major environmental changes with irreversible effects.

The Total Energy consumption in the built environment stands at a whopping figure of 34% of global energy use. Out of the predicted 42.7% increase in CO₂ emission in 2035 over 2007 levels, construction sector contribution is estimated at 40%. Materials in construction will contribute 10% to 20% of this increase in CO₂ emissions. This stark picture calls for a relook into the design and construction methodology for all structures. Mass housing projects which are normally considered under affordable housing schemes use inferior materials, designs and inefficient construction methods as means to lower cost and thus end up increasing the carbon footprint. These built properties therefore end up impacting nature than the more carefully designed and constructed projects.

The author proposes that evaluating carbon emission from housing projects may be implemented on affordable housing projects during the approval process. Carbon footprint assessment for buildings is best carried out using the Life Cycle Approach (LCA) based on EN 15978. That covers embodied carbon emission at all stages involved in the complete lifecycle of a building starting from production of building materials, using those materials in construction, energy required during operation, materials used for building maintenance, repair and repurposing, waste products on demolition of building and benefits from reuse/ recycling of demolition products. Various documented frameworks are available for carrying out Whole Life Cycle Analysis (WLCA) studies from international standards like ISO, EN, RICS, WBSCD, and ASTM.

To pursue the goal of improving sustainability in building design and construction through reduction in embodied carbon content, some of the strategies that may be adopted include ^[5]:

- a. use of alternate and new materials with lower embodied carbon footprint, e.g., replacement of cement with fly ash/ ground granulated blast furnace slag, and other cementitious materials
- b. reduce material consumption through optimization, value engineering and use of latest tools and technologies, and maximize structural efficiency
- c. reducing material variation in the project, use

less finishing materials which usually have high embodied carbon content

- d. using locally sourced elements to reduce transport and logistics related costs in the extraction to manufacture stage
- e. use materials that have lower carbon footprint in extraction, production, and preparation for use in construction
- f. use construction materials with higher recycled content, e.g., concrete using recycled or manufactured aggregates or using reinforcing bars or structural steel sections that have been manufactured from recycled scrap steel (charged in electric furnace), after testing to verify that the products meet physical and chemical properties in relevant standards
- g. maximize use of prefabrication and modular designed units assembled at site

The materials for which design intervention strategies can be planned for carbon footprint reduction are shown in *Figure-3*. It shows that reduction of material related embodied carbon need not involve providing costly solutions. Most of the reductions will come at zero or low cost. The figure also shows that alterations in the concrete, reinforcement and insulation materials can achieve huge carbon footprint reduction at practically no cost.

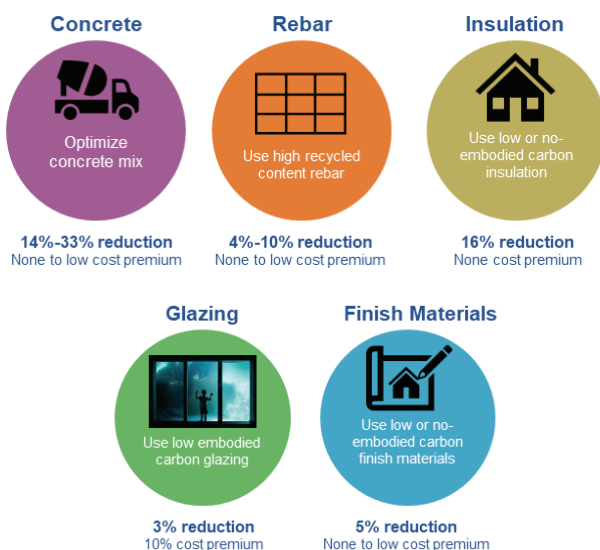


Figure-3: Reducing Carbon From Building Materials ^[6]

Strategies can be adopted for controlling carbon emissions in the use stage of the building through resource efficient fixtures that are not only of low carbon content in the manufacturing phase but are also frugal in energy usage, using more durable materials for building elements in severe exposure, and easy to modify or disassemble elements. Bringing the end-of-life stage into the carbon emission picture by considering the activities of demolition of the building, transporting the demolished materials to designated areas, and end of life processing for reuse, recovery, or landfill operations will provide for better management of embodied carbon in the building's whole life.

Global benchmarks are available that define carbon emission targets for new construction. This data can be used to identify engineering designs and incorporate best practices that can provide the best sustainability outcome for the building. There are various published targets for embodied carbon targets in buildings of various categories. The institutes include names like Royal Institute of British Architects (RIBA), London Energy Transformation Initiative (LETI), Greater London Authority (GLA), Carbon Leadership Forum (CLF), World Green Building Council (WGBC), and World Business Council for Sustainable Development (WBCSD). The most feasible figures for embodied carbon that can be achieved in construction are in the range of 1000 to 1300 kg CO₂eq/ m² of building area. This comprises components of 600 – 800 kg CO₂eq/ m² in the construction stage (upfront embodied carbon) and 300 – 500 kg CO₂eq/ m² in the use and end-of-life stages. Operation stage energy use targets used in design of running utility systems are in the range of 75 – 220 kW-hr/m²/year. Setting targets to achieve these numbers in the design of structure and utility systems will go a long way in achieving sustainable design.

Using principles of resilience in building design leads to better assessment of building performance. Resilience analysis improves upon the traditional design concept allowing the structure or system to better respond to undetermined hazard intensities and evaluate the capacity of the structure to recover functionality after the event. This concept is used for both structural and non-

structural elements using analysis tools and procedures set by bodies like National Institute of Standards and Technology (NIST), National Fire Research Laboratory (NFRL), Federal Emergency Management Agency (FEMA), and American Society of Civil Engineers (ASCE). Resilient design aims to provide mitigation measures to avoid, resist, reduce, and recover from disasters like earthquakes, extreme weather events, floods, tsunamis, landslides, or other emergencies like fire, pandemic, major vehicle accidents or explosions. Structural engineers play a vital role in developing a built environment with resilient and adaptive structures. Resilient design principles will also contribute to improved sustainability through better material utilization and effective repair schemes for recovery of functionality.

Conclusions

The noble objective of providing housing for all is becoming a big challenge with the exponential growth in urban population. With development of industry, infrastructure, and economic improvement, increase in urbanization is imminent. Reports indicate that the number of housing units required to meet the deficit that was 19 million in 2015 is expected to be 38 million in 2030 and 64 million in 2036 of which 95% will be in the EWS and LIG categories of affordable housing [7, 8]. However, this high pressure of development is marginalizing and polarizing the development process itself creating gross imbalances in human life and nature. House ownership is a cherished goal for all human beings but so also are the other factors that contribute to a wholesome life. A much broader outlook is required when the schemes for development and upliftment of economically weaker sections are planned with a wholesome view of people, price, and planet. The management of environmental impact for this huge scale of construction will require adoption of low carbon materials, new construction

techniques and traditional designs that are in tune with natural systems. Monitoring project viability using Environmental, Social and Governance (ESG) norms in addition to financial and economic viabilities is called for in this proposed approach. This effort will be supported by engineering design and construction using the latest tools and construction techniques which *inter alia* include digitalisation and using a WLCA approach for a holistic solution that propagates sustainable solutions. The sustainability score will be better served by also adopting resilience in building design through performance assessment approach and design for recovery of functionality.

Acknowledgements

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Indian Real Estate Industry and Affordable Housing

Affordable housing cannot be defined based on one unit size or cost since the requirements are different for the different sections of the society. Amongst the various definitions, the one by NCL100 ⁽¹⁾ '*housing on which the occupant is paying not more than 30 percent gross household income*' seems more acceptable and applicable to all segments of society.

Going by that definition, there is a huge demand-supply gap in the affordable housing segment across the lower to middle income groups in India. The rate of supply is also very low, thus widening the gap every year, despite the various government schemes to provide affordable housing. An average delay of a year in most of the housing projects and the increasing shortage of construction workers, both skilled as well as unskilled, is worsening the situation. Thus, changes and intervention on various fronts are necessary. These would *inter alia* include:

1. Government Policies for Affordable Housing
2. Construction Skill Development Initiatives
3. Research In Cost Effective and Sustainable Construction Materials
4. Innovative Construction Technologies
5. Sustainable Construction to Reduce Recurring Cost

These are discussed in the following paras.

Government Policies for Affordable Housing

- a. Pradhan Mantri Awas Yojana-Urban – PMAY provides housing loan interest subsidy for purchase of construction of homes varying from 3% to 6.5% based on economic sections. This is applicable to all States and UTs
- b. Pradhan Mantri Gramin Awas Yojana – This scheme provides financial assistance and share of the cost of construction for rural houses.
- c. Rajiv Awas Yojana – This scheme aims to bring all illegal construction within the formal system to achieve slum free India.

There are many other State specific schemes like DDA housing scheme for Delhi, Tamil Nadu Housing Board Scheme, MHADA lottery scheme in Maharashtra, etc.

Construction Skill Development Initiatives

Construction Skill Development Council of India ⁽²⁾ focuses on skill development in the construction sector and works on all aspects of skill development right from development of standards, creating learning resources and technology to conducting courses.

This initiative has potential to overcome construction worker shortage and to improve efficiency of construction

workers by means of formal training. Wholehearted participation from private sector developers is essential for the industry to benefit from this initiative.

Reuse of Construction and Demolition Material

Material cost contributes to almost 60% of the total structural cost. The construction cost of affordable housing is directly dependent on the reduction in cost of materials. Effective reuse of construction debris is one of the areas which can have a major impact on the cost of input material, in addition to a great impact on climate sustainability. Some companies are promulgating and doing this but it has a long way to go to be accepted as a norm.

Global agencies like the United States Environmental Protection Agency (EPA)⁽³⁾ does a lot of research in this area. Since the characteristics of construction debris vary a lot based on construction material used locally, specific research using construction debris in India, area wise needs to be promoted.

Reuse of demolished concrete to manufacture aggregates and concrete blocks for use in partition walls, boundary walls, etc. could be one of the many potential sustainable uses.

Currently in India steel reinforcement is almost completely recycled to produce rebars known as secondary steel. Though this is a sustainable initiative, the product lacks consistency in engineering properties. Standardisation of the manufacturing process and greater quality control during production of the secondary steel is needed to minimise variation in the material properties.

Innovative Construction Technologies

Construction technology can play a major role in making affordable housing cost effective. Technology can optimise material consumptions, reduce or nullify wastage and reduce labour requirements, all of which can contribute to cost reduction. This also reduces the

carbon footprint of the project thereby contributing to sustainability.

The Building Materials And Technology Promotion Council (BMTPC)⁽⁴⁾ of the Government of India has been working towards operationalising a comprehensive and integrated approach for promotion of cost-effective, environment-friendly, and energy-efficient innovative building materials and construction technologies for housing in urban and rural areas including disaster resistant practices.

Conventional construction technology, the ‘beam column frame with brick infill wall’ system, has many limitations. This technology is labour intensive, structurally inefficient, uses unsustainable material like clay bricks and is prone to many quality issues. Its shortcomings are labour and material wastage.

Considering the above, it is essential to adopt newer technologies which would make the structural system more effective, climate friendly and require lesser manual labour at the construction site.

Safety and quality also need immense improvements and that could happen only if construction is modularised and moved to an off-site location or even if at site for very large projects, in a controlled area.

Some examples are:

- a. Monolithic Construction
- b. Reinforced Concrete Block Shear Wall - Slab System
- c. Precast Technology
- d. 3D Precast Technology
- e. GFRG Panels Shear Wall Slab System
- f. 3D Printing for Construction

a. Monolithic Construction

This utilises a lightweight aluminium formwork system, wherein all the elements of one floor including walls, slabs, staircase, etc. are cast in one go, resulting in saving of construction time. The formwork can be used for more than 100 repetitions, thus achieving economy.



This technology overcomes major limitations of conventional technology as below:

- i. The structural system is a shear wall – slab system, hence a major portion of the structure comprises load bearing element instead of just adding to the dead load thus making the structural system very efficient.
- ii. Plaster is eliminated with smooth off-shutter finish, making it less labour intensive.
- iii. Since the entire floor is cast in one go, a typical slab cycle is 7 days, making it much faster compared to the conventional mode of working, wherein a typical slab cycle is 15 days or more.

b. Reinforced Concrete Block Shear Wall - Slab System



RCB – under construction, New Haven, Ahmedabad – Tata Housing

The Reinforced Concrete Block Shear Wall - Slab System is an improvement over the conventional load bearing wall construction, which was prevalent but now largely replaced by RCC framed construction. The conventional load bearing construction went out of vogue because of two issues – a) Strength of bricks used was limited by the quality of the local clay available. That necessitated thicker walls as the height of a building increased, and

b) structures constructed using the technology were poor in earthquake resistance. Recent advancements have made it possible to manufacture high strength concrete blocks, which can replace conventional clay bricks. That has resulted in keeping the wall thickness to 200mm even for a seven-storey building. Introduction of reinforcement and ductile detailing of the structure made it one of the best systems for earthquake resistant structures. In fact, RCB is used as earthquake resistant seismic rehabilitation structures in almost all earthquake prone areas in India.

The major advantage of this technology is significant cost and time saving compared to conventional construction. Use of this technology for the structures more than 10 storeys high needs to be done with caution.

c. Precast Technology



Precast construction - under erection at Peenya, Bangaluru – Tata Housing

One solution to reduce the labour dependency at a site is to change the place of construction from sites to a controlled factory like environment where precast concrete elements could be prepared for construction.

Then the process can be mechanised using cranes and allied equipment. The structure of course would have to be designed for 'handling stresses' in addition to the usual loads/ forces. The initial cost of structure does become slightly higher compared to conventional construction, but for mass housing it will be cheaper. It is no doubt a faster method and thus saves time. The precast industry for buildings has evolved considerably globally.

Systems for Precast Buildings

- i. **Hollow Core Slab:** These are prestressed, pretensioned hollow core slabs, suitable for large spans. These are mainly useful for commercial buildings, parking shades, etc. where large uninterrupted spans are important.
- ii. **Double Wall + Filigree Slab:** This system combines the advantage of precast and cast-in-situ monolithic construction. A monolithic cast-in-situ concrete layer is provided both for the wall and the slab, thus eliminating the chances of leakages through joints.
- iii. **Long Wall-Slab System:** These are precast shear wall and slab systems. In this case there are multiple joints, which need to be detailed properly to avoid leakage. PU sealant from outside is a must in addition to non-shrink grout and joint detailing.
- iv. **Pre-Finished, Precast, Volumetric Construction (PPVC):** In this system, three dimensional precast modules are cast, fully finished along with services and architectural finishes, lifted, placed in position, and joined side by side and one above the other to construct a high-rise building.
- v. **Tilted Wall System:** Large walls are cast on ground and tilted up. This is useful for low rise structures.

Plants for Precast Construction

Various types of equipment and their combinations are used for manufacturing the precast construction units. The two major types of precast plants are:

- i. **Battery Moulds and Tilting Table combinations with or without hollow core slab unit:** In this case the battery moulds are used to cast typical walls and a tilting table is used to cast 'non-typical walls' and

other elements. Slabs can be cast either using hollow core machines or using separate slab moulds.

- ii. **Carousel Plant:** The plant is very similar to a car factory, wherein all elements of a building including walls and slabs are cast on workstations known as pallets. The pallets move on pedestals from one workstation to another after a particular activity is over. The plant can be fully automated with minimal manual intervention. The elements cast in the factory are then moved to the site, erected, and joined to complete the building.



Carousel Plant at New Haven, Peenya, Bangaluru, Tata Housing

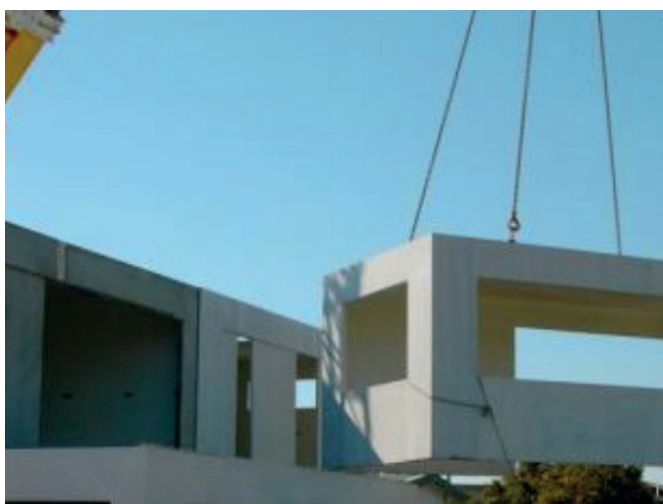
Advantages of Precast Technology

It can help in economising the cost of affordable housing by:

- i. Reducing labour requirement by 60% as compared to cast-in-situ construction
- ii. Reduction in construction time by 50%
- iii. Ensuring on-time completion of projects
- iv. Reducing construction waste to an almost negligible level.

d. 3D Precast Technology

The 3D Precast technology is an advancement over plain 2D precasting technology, wherein three-dimensional modules are cast in the moulds, off-site. A series of the 3D modules are then transported and erected at the construction site to complete the building. The advantage in this case over plain precast is the reduction in number of joints, thus making it less vulnerable to leakages.



e. GFRG Panels Shear Wall Slab System

In this system the panels are made up of 'Glass Fibre Reinforced Gypsum' which are fabricated in the factory. These panels are then transported and erected at site like precast concrete construction. Climatically this is a very sustainable technology of all described above as the panels are made up of phosphogypsum, which is a byproduct of the fertilizer industry and recycled glass fibre.

f. 3D Printing for Construction

3D printing is disrupting the entire manufacturing industry including the housing industry, however, much more development is necessary. There is still a long

way to go before it becomes practical and affordable for housing construction. A major hurdle currently is the availability of printable construction material which has good compressive as well as tensile strength in addition to other essential properties like modulus of elasticity, durability, etc. and in due course of time it will be the preferred method.

Sustainable Construction to Reduce Recurring Cost

The call for sustainable construction by focusing on reducing, reusing, and recycling construction material has been growing especially since Climate Change problems forced attention on sustainable planning and deployment of resources especially those that are becoming scarcer. Some of the means of providing for sustainable construction and sustainable living would be by-

- a. Maximising use of natural lighting during the day,
- b. Providing Renewable Energy sources such as solar, wind, mini-hydro, tidal, geo-thermal, etc. for supply to a limited area or even locally to a colony,
- c. Use efficient light and electrical fittings and fixtures,
- d. Planning and designing for natural ventilation, cooling and heating,
- e. Using energy efficient air conditioning systems like geothermal air conditioning
- f. Use energy efficient appliances and household equipment
- g. Use of water efficient fixtures
- h. System for Collection, Storage and use of rain water
- i. Reuse of treated sewage for flushing, landscape and for new construction.
- j. Providing Zero discharge from housing colonies
- k. Providing Composting system in housing colonies
- l. Generating biogas in housing colonies and use for cooking

All these will go a long way in reducing the recurring cost of a household.

A systematic way of achieving this could be to go for green building certifications such as Griha, IGBC Green Homes, etc.

Conclusions

Shortage of affordable housing can be met only by addressing all aspects of the subject including policy interventions, skill development, use of technology, sustainable construction materials and practices. These

can be effectively achieved by cooperation between the government, the people and the private stakeholders.

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Business Standard

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Budget 2024: Real estate sector bats for revival of affordable housing

Industry executives say the definition of 'affordable homes' should be changed in terms of price



Representative Picture

Raghav Aggarwal **New Delhi**

The real estate sector wants “high-impact” measures, like special schemes and tax breaks for developers, to revive the fortunes of the affordable housing segment in the country, multiple executives told Business Standard. This segment has been struggling since the Covid-19 outbreak, in contrast to larger and costlier homes which have been selling like hot cakes.

The demand comes at a time when the government is taking suggestions from industry players before tabling the General Budget in the Parliament next month.

According to the data from real estate consultancy Anarock, the sales share of affordable housing in India reduced significantly from over 38 per cent in 2019 to 20 per cent this year. Due to low demand, the share of affordable homes in the overall supply also fell to 18 per cent this year, from nearly 40 per cent in 2019.

Some other demands include granting industry status to the sector and raising tax exemption limits on home loan repayments.

Eyeing a boost

- > Special schemes, subsidies for affordable homes in metros
- > Additional incentives to developers engaged in affordable housing
- > Space, pricing cutoffs for the segment should be increased from 90 square metres and Rs 45 lakh
- > Affordable housing segment struggling since Covid-19 outbreak
- > Sales share of affordable housing reduced from 38% in 2019 to 20% this year, shows an Anarock report



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Introduction

The basic needs of civilization are air, water, food, clothing and shelter. However, affordability of these basic needs in today's world is a big question. Amongst numerous factors affecting affordability, the gap in supply and demand is a growing concern. The population explosion, rising costs and dwindling resources are the major challenges in the journey towards countering affordability. It is estimated that 3 billion people will need access to affordable housing by 2030^[1], which translate in to making available 96,000 housing units every day. With the rapid growth of urbanization, affordable and accessible housing is already a never

die challenge for the global community. In the Indian scenario, the urban population has grown from 109 million in 1971 to 377 million in 2011 and is expected to be 600 million by 2030 ^[2].

Affordability is relative in the wide spectrum of countries, demographics, economies and social fabrics across the globe. Primarily, the growing demand coupled with rising cost of acquisition of a house are the major challenges. Affordability does not merely imply the ability to buy and maintain a new house, the proximity to workplace and the availability of a necessary social infrastructure also factors to be considered. According to UN-HABITAT, 2011 report,

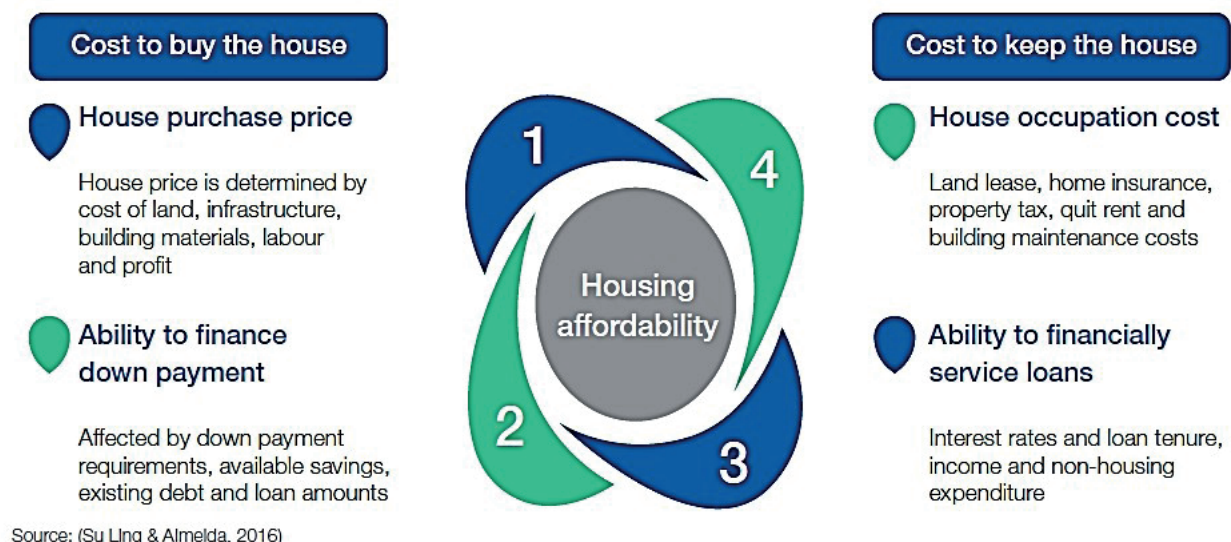


Figure-1^[3]: Basic Components of Financial Affordability of Housing

affordable housing should have adequate quality and locational accessibility and should be cost permissive so that meeting other expenses like basic cost of living and enjoying the basic human rights do not become a burden^[3]. Figure-1 shows the financial affordability.

There are primarily three methods by which affordability is measured: - a) The Median Multiple Method, b) The Housing Cost Burden Method, and c) The Residual Income Method. The Median Multiple Method considers houses to be affordable when the house price is less than three times or below the median annual household income. The Housing Cost Burden Method requires that the housing related expenditures like loan repayment, rents, taxes, repairs and maintenances, etc. do not exceed 30% of the annual income. The Residual Income Method refers to the disposable income that a household can have after incurring the costs of all basic needs. In this context, the approach by the Australian Housing and Urban Research Institute (AHURI) happens to be more specific. It identifies households with income level under the bottom 40% of the country's income distribution and incurring more than 30% of income towards housing costs. That category of population is targeted to be provided with

affordable housing. The Pradhan Mantri Awas Yojana – Urban (PMAY-U), the flagship scheme launched by the Government of India (GOI) with the theme of “*Housing for All*” targets the economically weaker section (EWS), Lower Income Group (LIG) and Middle Income Group (MIG) to be eligible for the affordable housing. The metrics showing the advantages and disadvantages of the various methods are presented in Figure-2.

Once the beneficiaries for affordable housing are decided by any of the aforesaid methods, the next step is management of financial, technological, societal, sustainability and regulatory challenges.

Sustainability Challenges

There are several challenges to meet the mammoth demand of the housing market. While the availability of land commensurate with ease of living and accessibility, cost of land, and funding are the major issues, the environmental impacts and sustainability cannot be ignored so as to factor in climate change and global warming. It is obvious that construction of a large numbers of houses need holistic and meticulous planning and collective engagement of government, public and

Macro-level method	Approach	Definition of housing affordability	Advantages	Disadvantages
 Micro	Median Multiple (MM)	Median house price that is three times or less than the annual income of the median household (e.g. house price-to-income ratio of 3.0 and below).	Easy to calculate. Allows comparison of housing affordability across countries and within a country over time.	Ignores the role of credit.
	Housing Cost Burden (HCB)	Housing expenditure (e.g. mortgage repayment) that is less than 30% of household income.	Considers the effect of leverage and non-housing expenditures of household. Allows comparison of housing affordability across countries and within a country over time.	Rigid threshold of 30%. Accuracy of cross-country comparison could be affected by differences in cost of living and repayment structure of mortgages across countries.
	Residual Income (RI)	Residual income (after deducting non-housing costs) that is sufficient to service monthly mortgage obligations.	Considers the effect of leverage and the household's spending patterns. More reflective of a household's ability to purchase a house.	Limited cross-country comparability. Requires detailed data on household income and attributes, cost of living and housing costs.

Figure 2^[3] – Advantages and Disadvantages of Various Measures of Affordability

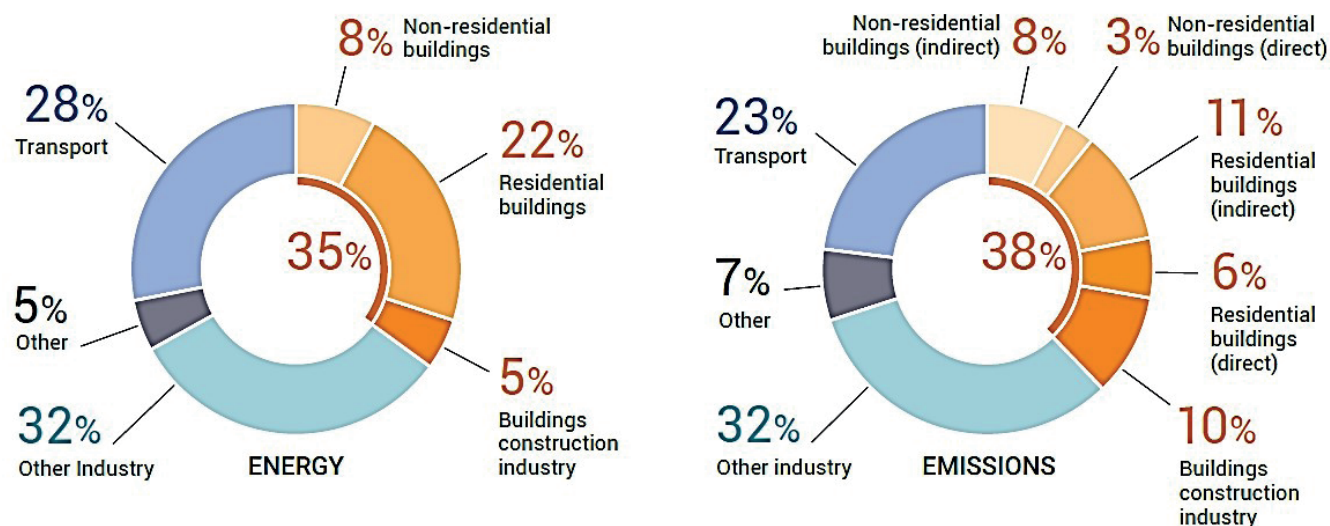
private institutions. It is a matter of mass housing and construction materials in millions of metric tons are required to be used. Building construction materials are

highly carbon intensive as shown in Table-1 and hence the construction industry also contributes significantly to the carbon emissions Figure-3,

Table-1^[4]: Accepted Carbon Footprint of Building Materials

Material	Embodied carbon kgCO ₂ e/ kg	Material	Embodied carbon kgCO ₂ e/ kg
Concrete	0.159	Plywood	1.07
Bricks	0.24	Glass	1.44
Marble	0.116	Terrazzo tile	0.12
Stainless steel	6.15	Ceramic tiles	0.72
Timber	0.72	Wallpaper	1.93
Sawn hardwood	0.86	Iron	1.91
Glass wool	1.35	Lead	1.57
Clay tile	0.45	Copper	2.60
Aluminium	8.24	PVC pipe	24.40
MDF	0.72	Steel rebar/ section	1.20

Global share of buildings and construction final energy and emissions, 2019



Notes: Buildings construction industry is the portion (estimated) of overall industry devoted to manufacturing building construction materials such as steel, cement and glass. Indirect emissions are emissions from power generation for electricity and commercial heat.

Sources: (IEA 2020d; IEA 2020b). All rights reserved. Adapted from "IEA World Energy Statistics and Balances" and "Energy Technology Perspectives".

Figure 3 ^[5]: Global Share of Buildings and Construction Final Energy and Emissions, 2019

The global share of energy consumption by residential buildings was found to be about one fifth of the total energy consumption but the corresponding carbon emission was as high as 17% of the total emissions globally; refer Figure-3. Though the data pertains to the overall residential buildings irrespective of affordable houses, it gives a fair idea about the negative impact on sustainability with regard to construction of affordable houses enmasse over the years. In addition to house construction there is the initial requirement of large areas of suitable land at cheaper prices that would cater to the needs of eligible beneficiaries so far as affordability and accessibility are concerned. In the process of making the land available, land use patterns may get affected apart from encroachment of waterbodies and resulting in further worsening of biodiversity and environmental sustainability. This dichotomy cannot be set aside and

needs to be properly addressed.

Sustainable Measures

Keeping in mind the adverse influence of the mass housing required to be constructed in the short and long terms, countries are gearing up to create an ecosystem encompassing new technologies that would be sustainable, cost effective and reduce the construction time. Blended cement by part replacement of ordinary portland cement (OPC) with industrial wastes like fly ash (FA) and ground granulated blast furnace slag (GGBS), recycled concrete aggregate (RCA), manufactured sand (M Sand), fly ash brick, etc. are well experimented and documented in National and International Codes and Standards. Some of the innovations in regard to alternative materials are given in Table-2.

Table 2: Technology Innovations in Building Materials

Material	Description
Cement Coated Expanded Polystyrene (EPS)	In Kenya construction of houses by cement coated EPS panels are done and found to save 25% cost and reduction of construction time by 50%. ^[3]
Glass Fibre-Reinforced Gypsum (GFRG) Panels	GFRG panels are eco-friendly components made from industrial wastes of fertilizer plants. These can be used to reduce RCC significantly in building construction. This is a matured technology and BIS allows its use in buildings up to 35.0 m height in low seismic areas ^{[6] [7]} .
Cross Laminated Timber (CLT) Panels	CLT panels are multilayered and a timber board of one layer is laid across the lower layer and so on giving a stiff and rigid product. Life Cycle Assessment study reveals that buildings made by CLT panels consume 9.9% less energy and have 13.2% less carbon contribution compared to RCC buildings ^[3] .
Interlocking Soil Stabilized Blocks (ISSB)	The blocks are made of soil stabilized with lime or cement. These are better strength wise and having better heat insulation in comparison to fire clay bricks. Requirement of mortar is very less reducing embodied energy and cost ^[8] .
Repurposed Plastic Blocks	The blocks are made in standard sizes from recyclable/ unrecyclable plastic wastes and hold together without glues or mortar. Blocks are reported to have carbon emission 83% less compared to concrete blocks ^[9] .
Green Cement	There are multiple types of green cements with technology readiness levels (TRL) at various stages. Green cement made of 95% fly ash and renewable liquid additives is being used which has better strength and durability compared to conventional cement ^[10] .
Glass Fibre Reinforced Polymer (GFRP) Rebar	GFRP rebars are one fourth lighter and four times stronger than steel [11]. The bars are not susceptible to corrosion and hence the life of concrete structures is more. Embodied carbon is less than steel.

In addition to the innovative and sustainable alternative materials, there have been considerable technological advancements in the construction methodology. Recycling of Construction Materials would be a rather effective method. Use of natural renewable building materials must also be encouraged. So also planning of a central city/ town and satellite townships coupled with shifting industries, enterprises to those areas and reduce the demand in a central area. Mass construction of dwelling units in localized areas is desirable rather than a standalone system. The former allows sharing of common infrastructures like roads, water supply, sanitation and enables sustainable solar power supply through microgrids reducing cost of living considerably. However, the urge to build taller needs to be given a relook in the context of sustainability given that the life of structures is limited and replacing them every few decades is not a solution. The essence of modern technologies, for example prefabrication, modular construction, precast construction, 3D printing are saving time and material by considerable reduction of material waste and contribute to lesser consumption of resources and less infusion of carbon to the environment.

Construction of multi millions of affordable houses have consumed and will be consuming million and million metric tons of building construction materials. Conventional building construction materials are carbon intensive and the quantum of carbonization by virtue of meeting the demand of affordable housing is horrible. Taking cognizance of this, the United Nations Environment Programme (UNEP) has recommended the pathway as Avoid, Shift and Improve [14], i.e. avoid extraction and production of new materials, shift to low carbon earth and bio-based materials and improve to decarbonize the carbon intensive conventional materials. Treading on the UNEP's pathway demands research and innovation. Research is resulting in a lot of innovations of which some are in use and others are at various Technology Readiness Levels (TRLs). However, the scale of adoption of the innovative materials and construction technologies for affordable housing appears to be lagging. Notable reasons

might be higher procurement costs due to availability of the new materials at discrete locations, higher manufacturing costs in some cases, limited resources for the new construction techniques, absence of Codes and Standards.

With the conventional materials and systems, the completion of a 12 story building having 96 flats in 96 days using precast technology in the mass housing under PMAY-U by City and Industrial Development Corporation (CIDCO) ^[12] is exemplary sustainable construction demonstrating lesser land use, quicker construction, lesser wastage.

Energy efficient buildings and Artificial Intelligence (AI) driven Building Management Systems (BMS) are few of the state-of-the-art technologies imparting sustainable operations and maintenance.

Conclusion

Population explosion, growing urbanization, and influx of people to urban areas are responsible for the rising demand of housing all over the world. The cost of a dwelling unit is also increasing keeping pace with the rising demand and affordability for acquiring the same either by ownership or rental. Affordability of a shelter suitable to carry on one's daily activities with reasonable ease is becoming harder every day from the economic perspective. The challenge has been acknowledged all over the world and theories have been propagated to determine the eligible section of the society to whom governmental support is necessary. In India, PMAY-U is a vibrant mission with the objective of housing for all and catering to the needs of affordable housing for EWS, LIG and MIGs. Similar schemes for the economically weaker segment under the label of social housing or public housing have been undertaken by the UK, Belgium, Canada, Denmark, Malaysia, Korea, New Zealand and many other countries^[13]. While the basic need of a shelter must be fulfilled, the need to protect the environment from global warming and adoption of sustainable measures cannot taken to be of lesser significance; infact they are more vital for civilization to sustain. In addition, a broad financial

framework for adequate funding and incentivizing the adopters of new technologies, and an elaborate mechanism to evaluate the reduction in carbon footprint would be helpful to accelerate the adoption of new and innovative technologies. In the Indian scenario, the Technology Sub Mission (TSM) set up by the Ministry of Housing and Urban Affairs (MoHUA), Government of India with the mission of promoting the sustainable technological solutions for faster and cost effective construction of houses is a commendable step in the right direction. Transparent framework of sustainable solutions in affordable housing, financial incentives, publication of decarbonization/ other sustainable achievements and collaboration of all the stakeholders would pave the way to drive sustainable and affordable housing.

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Emerging Construction Technologies for Mass Housing: Evaluation of Thermal and Water Tightness Properties



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Abstract

Apart from structural performance of building systems i.e., axial and lateral loads; factors such as acoustic, thermal comfort, water tightness, etc., are the important functionality tests to be performed for evaluation of the efficient functional performance of buildings. The present study evaluates the thermal and water tightness performance on a two-story building constructed using different building construction technologies for mass housing viz., Precast Reinforced Concrete (PRC) building with AAC (Autoclaved 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 first by ponding the water on floors and the roof, 75 mm deep for 7 days and secondly under a simulated rainfall/ cloud-burst condition of 210 mm per hour, continuously for 5 hours on each face of the building, including the 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 the research program on different building technologies vis-à-vis comfort requirements, the construction technologies are regarded as functionally efficient buildings.

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

Introduction

The acoustic, thermal comfort, water tightness, etc., are important parameters for efficient functional performance of buildings but they are generally given the least importance. The real time thermal performance of emerging construction technologies needs to be evaluated to find their suitability and also to determine the 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.

The construction techniques for testing were selected since they save time, require less manpower and materials, and their ease of construction at the actual

site (Ali et al. 2013; Ma et al. 2020; Shukla et al. 2020; Wu et al. 2020). In the drywall construction techniques, the porous concrete based cement fibreboard system is a speedy and efficient construction technique. The drywall provides safety and adequate strength as compared to the conventional masonry brick walls.

The present study evaluates the thermal and water tightness performance on two story buildings constructed using the four different building construction technologies i.e., Precast Reinforced Concrete (PRC) building with AAC (Autoclaved Aerated Concrete) block infills; Steel Building with insulated fibre cement sandwich panels infill; Bamboo Building, and Precast Building Component Masonry building using Round Boulder Mortar (RBM) units.

Building Systems

In order to evaluate the functional performance of emerging construction technologies, as proposed in this paper, two-storey buildings with different construction technologies, having similar architectural plans, orientation, etc., and having a total covered area of 110 sqm were constructed in the Construction Technology Demonstration Park of CSIR-CBRI, Roorkee. The brief structural description of the emerging building technologies is given hereunder.

Precast RC Building System

The Precast RC building (Figure-1) consists of precast structural components and Autoclaved Aerated Concrete (AAC) blocks walling units. The concrete



Figure- 1: 3S Precast RC Component Building

connections were in-situ so as to provide adequate anchorage between the joints of the 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.

Steel Building

It is a pre-engineered building consisting of light weight panels, as infill. 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 the cement fibre boards is 892 kg/m³ and their thermal conductivity is 0.14 W/mK. Jointing of the multiple boards was done with fly ash and sodium silicate in 1:15 proportion by weight in paste form. The ICFs (Insulated Concrete Foam) 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. Figure-2 shows a view of a building.



Figure- 2: Steel building with light-weight infill panels

Bamboo House

A demo house made up completely of bamboo has been constructed at the Construction Technology 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

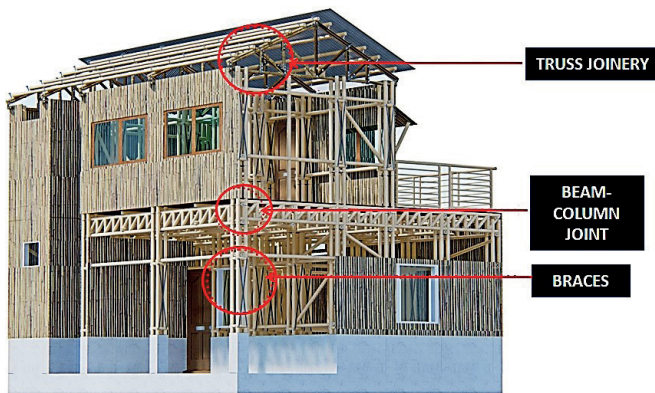


Figure-3: Bamboo Construction Technology

balcooa bamboo of average outer diameter of 80 mm. The bamboo was treated with Borax solution to achieve a reasonable life span of the bamboo elements. Walls of the structure have been made using split bamboo and bamboo boards. The foundation of the structure is single under reamed pile. The structure after completion has been given a pucca look by application of cement plastering over GI chicken wire mesh of 1 mm dia, on the outer walls. Figure-3 shows the bamboo structural systems building.

Round Boulder Units (RBM) Confined Masonry Building

The two storied building using precast building components viz. slab, beam, and load bearing walls using Round Boulder Mortar units, stone concrete blocks, has been constructed, with the aim to assess



Figure-4: Round Boulder Units Confined Masonry Building

the real time functionality of the RBM technology. The primary features of this building are that the units are constructed using locally available boulders, mostly in hilly regions; incorporating confined masonry technology for seismic resistance, precast RC elements, and MS hollow box section for beams to achieve speed, safety and economy in construction.

Functionality Tests

Thermal Comfort Measurement

The constructed Precast RC Component structure with Autoclaved Aerated Concrete Blocks as an infill wall was tested for temperature variation for outside and inside walls, ambient and inside room temperature, relative humidity and water tightness/ leakage performance.

The wall temperatures, inside temperatures and relative humidity were recorded at 1-hour intervals for 24-hours over a period of seven days in the months of April to June. The average of the data plot have been recorded and analysed for evaluation of thermal efficiency.

Water Tightness Test

The water tightness test was performed firstly by ponding the water on floors and roof, 75mm deep, for 15 days and secondly under a simulated rainfall condition of 210 mm per hour, continuously for 5 hours on each face and the rooftop. To simulate a high rainfall scenario, sprinklers were installed all around the building both vertically and horizontally at the roof in a grid of 1.25m center-to-center. The deflector of the sprinklers creates a uniform spray pattern over the roof and walls. The water from the supply tank was pumped to the sprinklers at a rate of 180 litres per minute having 50 m head. The sprinklers on the roof and on the front wall are synchronized and 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 wastage. Figure-5 shows the view of the water tightness test setup and the actual water testing facility in the 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, joints of the precast components and fixtures around the opening of a building.



Figure- 5: Full-Scale Test for Water Tightness on RC Precast Component Building

Results and Discussion

Precast RC Component Building

The outer and inner wall surface temperature were recorded and plotted as a sinusoidal curve against the hour of the day for walls in different directions. Figure-6 shows the surface wall temperatures of the directional faces of AAC building namely east, west, north and south, recorded for the summer season (April to June). It is evident that outside wall temperature reaches to a maximum of 45 °C for east and west facing walls at 1100 and 1500 hrs respectively. Whereas, for the north and south facing side, the maximum outside wall temperature reached is 40 °C. The inside wall temperature of all the directional faces does not exceed 32 °C. Figure-6 shows a sinusoidal nature curve for 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 °C. The thermal imaging after 7 and 15 days of ponding is shown in Figures-7 and 8 which show very less/ no water ingress inside the walls.

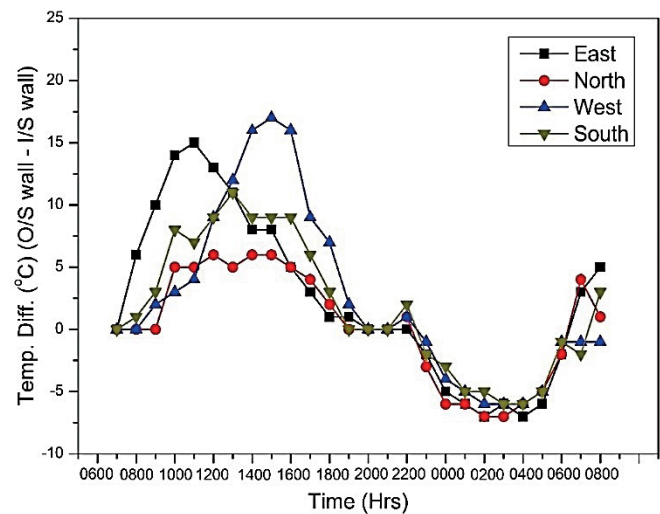


Figure-6: Temperature difference of outside and inside wall variation of all directional faces for precast RC building

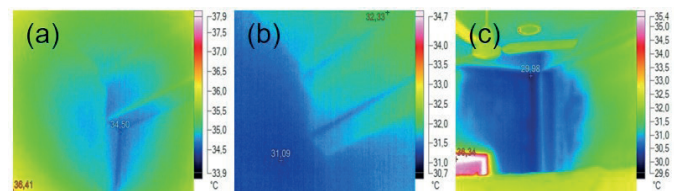


Figure-7: Thermal imaging (a) Before Ponding at GF-1, (b) After 7 days Ponding at GF-1, (c) After 15 days Ponding at GF-1.

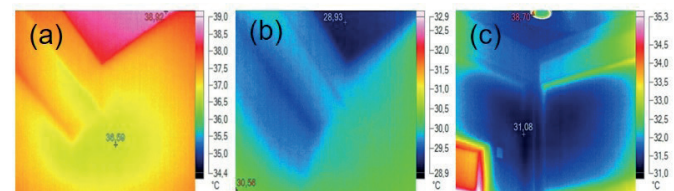


Figure-8: Thermal imaging (a) Before Ponding at FF-7, (b) After 7 days Ponding at FF-7, (c) After 15 days Ponding at FF-7.

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 1100 sq. ft. Table-1 shows the physical properties of the dry wall and related thermal conductivity values.

Table-1: Physical properties of cement fibre board walls and related thermal conductivity

Physical parameters	Values
Temperature and humidity at the time of testing	41 °C, 17 % RH during April to June
Wall construction	Rapicon cement fibre boards (8mm thick boards having 75 mm thick wall – cavity between boards filled with EPS mortar)
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.

Figure-9 shows the directional temperature variations in the steel building. It is evident that the outside wall temperatures rise maximum up to 45°C, however inside temperature could reach to 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 fibre cement boards has a large number of pores with air trapped. These pores are responsible for exhibiting good thermal insulation.

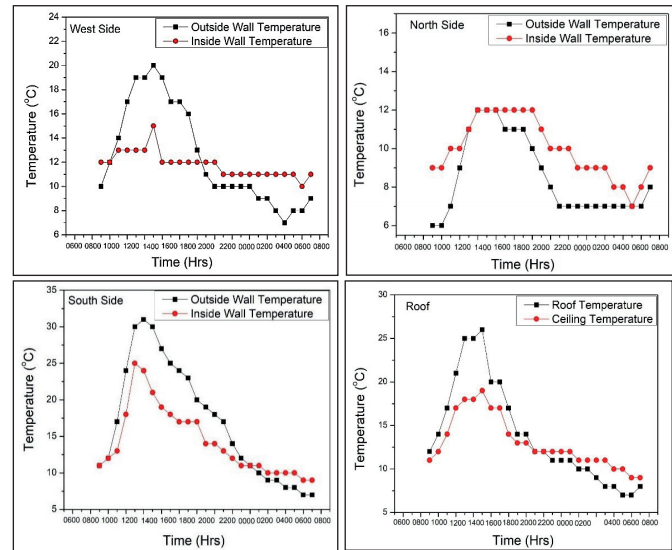


Figure-9: Wall temperature variation for steel framed building facing towards east, west north, south side and roof/ceiling temperature variation for winter season

Bamboo Building

Thermal Admittance (Y) is a measure of 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/(m²K), where the higher the admittance value, the higher the thermal storage capacity.

Table-2: Thermal parameters of various construction materials / systems

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

RBM Building

Figure-10 shows the variation in temperature in walls in different directions during summer season in the load bearing RBM units building system.

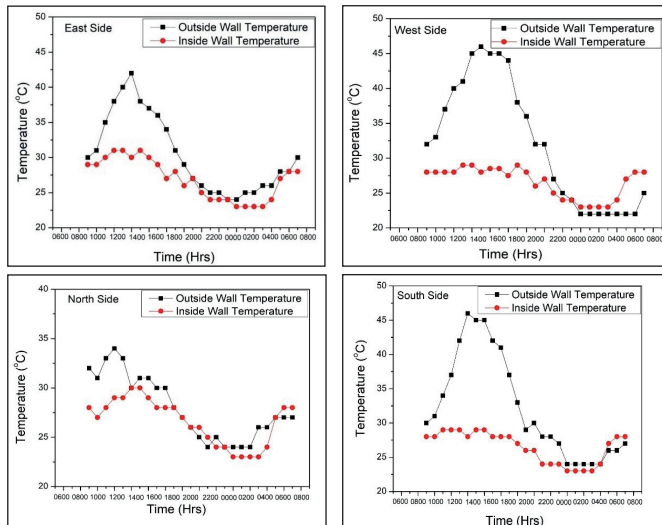


Figure-10: Wall temperature variation for RBM building facing towards east, west, north, and south sides and roof/ceiling temperature variation for summer season

Conclusions

The prime objective of the functionality test was to evaluate the thermal, noise and humidity and indoor air quality performance of various buildings constructed using different materials/ construction technologies at the Construction Technology Demonstration park of CSIR-CBRI at Roorkee in different seasons. Mostly the construction technologies being adopted for mass housing projects viz. Precast RC component system with AAC block infill; Steel frame building with EPS sandwich panel; Bamboo framed with bamboo mat infill; and RBM units load bearing buildings were analysed for various thermal and noise parameters and studied in detail. Key conclusions drawn from the above investigation are summarised below.

1. The water tightness study of the precast building shows no significant leakage inside the building by conducting ponding tests and simulated cloud burst scenarios.
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 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 lightweight elements viz. cement fibre board, AAC blocks and Bamboo/plywood materials.

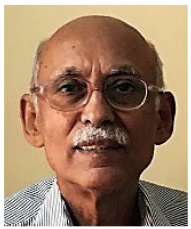
Acknowledgement

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Is Affordable Housing Possible & Practical?



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What is Affordable?

There are no comparative parameters and yard sticks to define 'affordability'. As far as housing is concerned, while someone can afford to have a 'palace' but the other may not be able to afford even a 'Kacha' hut.

The Affordable housing concept is generally derived from the landed cost of a built-up house. It is to have a house to live comfortably though not luxuriously, but which has the minimum area and requirements for comfortable living. The comfort zone varies from person to person. As the income increases – savings increase and any improvements in the house including finishing and furnishing is a continuous process.

Finishing, furnishing, and accessories are choices, but the basic envelope – the structure – foundations, walls, roof, and other structural components in an affordable house can stretch to 60% of the cost of the house, excluding the cost of the land.

A house can be made affordable and practical using simple alternative building construction technologies, which drive the systems to reduce the cost, make it affordable, yet sustainable.

What is Sustainability in Terms of Affordability

Sustainability in life is based on three attributes – the '3M'

being Minimum Possession, Minimum Consumption, and Minimum Waste.

The approach of developed Nation's to sustainability generally concentrates on energy efficiency using innovations based on "High Technologies". Affordable housing construction as per the principles of sustainability are derived from traditional wisdom and practices:

- (i) consuming as little as possible,
- (ii) applying low-cost technology innovations, and
- (iii) performance-oriented technologies.

In conventional construction, any approach to sustainability even for affordable housing leads to an increase in cost impacting it in a way that either the house is left incomplete or the house owner's debt increases. With innovative and cost-effective alternate technologies, the cost of construction can be reduced by 20 to 40%, despite adding on features of sustainability. The author has practiced from grass root level to implement such technologies, which have reduced the overall cost by 25 to 30%. It needs to be clarified that the innovative alternate technologies used and promoted, though they result in reducing the cost of construction and make it more affordable at 'low cost' but it is not at the 'cost of sacrificing quality'. Instead, they perform better than conventional technologies to fulfill the functional requirements ethically.

The cost-effective alternate technologies are semi-mechanised and indigenous technologies which reduce the labour component, but do not eliminate labour altogether and therefore are termed as “Intermediate technologies”, whose features include:

- (i) No heavy equipment or sophisticated T & P required. Besides cost, it saves energy, fuel.
- (ii) Less consumption of cement, steel, sand and aggregates. Less consumption means, reduction in cost and energy.
- (iii) Being semi-mechanised, production of the components is done at site or nearby the site, like in a cottage workshop, which saves energy, fuel, and transportation cost.
- (iv) Reduced centering, form work (shuttering), which saves cost and the forest produce.
- (v) Use of fly ash (a waste product) in mortar for masonry to save cement and energy.
- (vi) Use of fly ash in bricks, masonry bond techniques, perforation in bricks to provide better insulation.
- (vii) All prefabricated floor/ roof systems, eliminate cement plaster on ceilings.
- (viii) Elimination of external plaster means cost saving & less maintenance.
- (ix) Precasting has better quality control on concrete and workmanship, requiring less maintenance with longer life.
- (x) Lesser consumption of concrete, partial precast small components require lesser thickness and reduce the weight of the structure – an advantage for safety in earthquake.
- (xi) Reduction in cement, steel, shuttering means reduction in embodied energy.
- (xii) Due to lesser consumption of materials, saving in water consumption.
- (xiii) All precast components conserve water since they are cured by spraying or in water tanks and hence there is no free flow of water.

- (xiv) Use of ferrocement elements in staircase, sunshades, shelves, etc. which being thin elements consume lesser material and water.
- (xv) Soft permeable pathways pavements with interlocking pavers, reduce heat island effect but enable recharging of the ground water.

The successful promotion and adoption of new technologies (unlike the IT. innovations), requires time to be accepted and adopted to prove their durability and advantages compared to existing ones. Although several examples of affordable housing with alternate materials and technologies have been tried in a few cities however, they are yet to be recognised “as norms”. The reasoning behind it is that construction is has many parameters such as

- (i) Technologies,
- (ii) Labour,
- (iii) Contracting norms,
- (iv) Financing,
- (v) Performance Measures,
- (vi) Standards,
- (vii) Conventional,
- (viii) Aesthetics,
- (ix) Tastes,
- (x) Safety Norms and related perceptions, and
- (xi) Longevity, etc.

The Low-Income common man’s affordable housing (individually built as DIY or through contractors) is very conservative. Any change from conventional, even if it is for betterment is resisted by users, even by some professionals. An entrepreneur, despite having social inclination, gets discouraged, where the question of acceptability by users plays a predominant role. However, there is a bright side. There are 4 ‘Mantras’ for successfully introducing Technologies for Housing and “making it Affordable”.

Mantra 1: All involved are players in the game of

‘Technology’. It is not the skill only; it is the game spirit that wins the game.

Mantra 2: ‘Continuous persistence’ overcomes the obstacles and shows the door to possibilities. Persistence tides over fears and negativity which is common in the beginning, but makes it ‘possible’ to go ahead with ‘renewed vigour’.

Mantra 3: The Government alone cannot succeed in Technology Mission just by making laws; it also requires an overhauling of the people’s mind set.

Mantra 4: For success, no strategy can be a ‘Formula’, but as an ‘Ingredient’ it can definitely improve the chances of success.

With decades of overcoming all odds, the learning is that one may encounter many setbacks but one must not be defeated.

Development of Appropriate Technologies for quality affordable housing have to pass through various stages of improvement which require a dedicated passionate approach and positive thinking and involve the (i) Production process, (ii) execution process, (iii) quality control, (iv) cost reduction, (v) durability, (vi) safety, and (vii) acceptance by community.

Case Studies

A few case studies are briefly given. They are based on the 50 Alternate Technologies which have been used to design and deliver more than 50,000 Sustainable Affordable houses at minimum cost using cost effective design, materials and technologies – green and energy efficient ‘yet’ affordable.

Case Study 1: Housing at Bawana, Delhi for Workers (4634 houses). Load bearing walls with perforated modular (190 x 90 x 90 mm) mechanised bricks, earthquake resistant provisions of vertical reinforcement, plinth and lintel bands, under reamed piles, floor/ roof 60mm thick using precast RC planks and joists system, precast ferrocement steps, sunshades, shelves, and water tanks, (Figures-1 & 2).



Figure - 1



Figure - 2

Case Study 2: Affordable houses at Inno Geocity, Oragadam, Chennai (500 houses). Load bearing walls, 150 and 200mm thick with mortarless interlocking cement fly ash blocks technology, exposed finish, floor/ roof with precast RC planks and joists system, precast shelves, sunshades, floating foundation in black cotton soil, (Figures-3 & 4).



Figure - 3



Figure - 4

interlocking blocks technology, exposed finish, precast RC planks and joists system, precast shelves, sunshades, precast ferrocement stairs, (Figures-5, 6 & 7). Figure-6 shows ferrocement steps and Figure-7 shows the roofing system.



Figure - 5



Figure - 6



Figure - 7

Case Study 4: Brick Arch foundation for a building, (Figure-8).



Figure - 8

Case Study 5: Housing at Mawana, Meerut for Shriram Group. 190mm thick stretcher bond, exposed finish, floor /roof precast R. B. panels, (Figure-9).



Figure - 9

Housing at Surajpur, Greater Noida for DCM Toyota group. Walls in stretcher bond, floor/ roof RC ribbed thin slab, (Figure-10).



Figure - 10

Housing at Gurdaspur & Zira (Punjab), (124 houses, Govt. of Punjab) walls in stretcher bond, precast RC planks and joists floor/roof, cement lime plaster, external exposed, (Figure-11).



Figure - 11

Case Study 6: EWS housing at Bhopal (BDA, 120 houses). Under reamed piles for foundation in black cotton soil, precast stone block masonry walls 200 and 150mm thick, (Figure-12).



Figure - 12

Case Study 7: Staff Housing at Anjar (Bhuj) and Vapi (Gujarat), for Welspun Group. Foundations with precast plum concrete blocks, superstructure with fly ash mortarless interlocking blocks, precast RC planks and joists floors/ roof, precast ferrocement stairs, shelves, sunshades, concrete door and window frames, (Figure-13).



Figure - 13

Case Study 8: EWS housing (3024 houses), Kalkaji, New Delhi. S+14 Storeyed, CLC block walls, combined footings, (Figure-14).



Figure - 14

Case Study 9: Housing at Mawana and Pinjore: Row lock bond wall, grit pile foundations, precast panel slabs, (Figures-15 & 16).



Figure - 15



Figure - 16

Case Study 10: Housing at Daurala for DCM group. 190mm stretcher bond wall, precast ferrocrete panels B & P System floor/ roof, (Figures-17 &18).



Figure - 17



Figure - 18

Case Study 11: Housing at Bhopal, Community building Ambala. Roof/ floor in RC hollow slab with 'Kulars', (Figure-19).



Figure - 19

Case Study 12: EWS Housing at Poothkhurd, Delhi. 14,700 houses, 5 storeyed, framed structure, precast RC planks and joists floors and roof, modular flyash brick walls, (Figure-20).



Figure - 20

Case Study 13: Affordable Housing at Sector Pi, Greater Noida. 800 houses, Row lock bond brick walls, Filler slab floors/ roof, (Figure-21).



Figure - 21

Case Study 14: Demonstration housing at Amethi. Row lock bond brick walls, filler slab, (Figure-22).



Figure - 22

Case Study 15: Units at Jammu for Railways. Precast ferrocement stack panels in precast columns, ferrocement channel roof, (Figure-23).

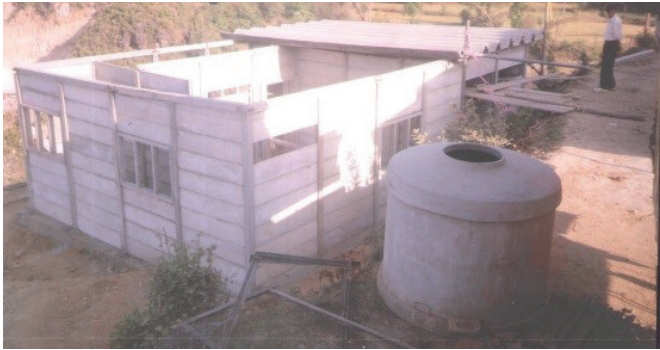


Figure - 13

Case Study 16: Affordable housing at Lucknow (2000 houses): RCC monolithic shear wall technology (Figure-24).



Figure - 24

Case Study 17: Housing at Gandhinagar, Rajasthan. Technology: Confined masonry technology wherein, direct load is taken by masonry walls and earthquake horizontal load by confining columns and beams, (Figure-25).

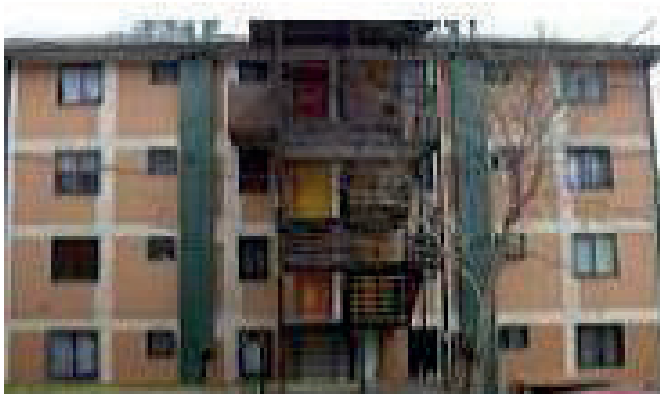


Figure - 25

Case Study 18: Housing for HPC, Assam with load bearing Reinforced Hollow Concrete Block (RHCB) masonry, (Figure-26).



Figure - 25

Case Study 19: Housing at Nagpur, structural hollow clay blocks masonry (Figure-27).



Figure - 27

Case Study 20: Author's farm house near Manesar: with Vernacular technologies: row lock bond, stretcher bond, flat arched lintels, Flemish modular wall, barrel arch, Nubian arch, filler slab, precast R.B. panel roof, corbelled roof, catenary, Dome (Figure-28 to 35).



Figure - 28



Figure - 29



Figure - 30



Figure - 31



Figure - 32

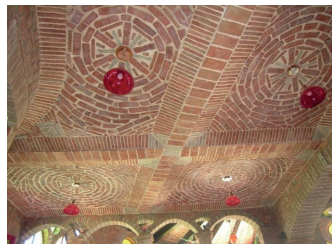


Figure - 33

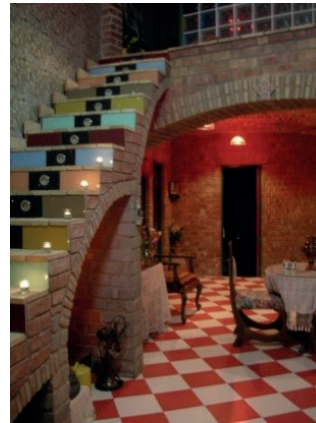


Figure - 34



Figure - 35

Conclusion

The thinking that alternative technologies are meant only for a 'poor man's housing' needs to change. The green and cost-effective technologies can be used for all types of housing to make them sustainable as well as more affordable. Besides housing, these technologies have been used in projects for institutional, industrial, hospital, educational, hotels and even commercial buildings leading to cost effectiveness.

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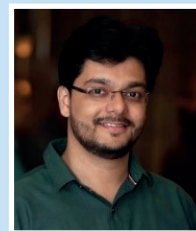
Affordable Mass Housing Schemes – Case Study from Navi Mumbai



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Introduction

As per the census of India in 2001, around 72% of the total population used to live in rural areas, and 28% in urban areas. Those figures changed to 69% and 31% respectively by 2011. The growth figures show a considerable rise in the urban population as compared to the rural population, mainly driven by the migration from rural areas to the urban centres within a short period of time.

According to estimates, a population of approximately 600 million is expected to live in urban areas by 2030¹, indicating a further rapid urban growth. That would result in an increased demand for affordable housing in the urban centres.

The housing deficit in India which was around 18.78 million units as per 2012-2017 data, has increased to 29 million units in 2018². It is anticipated to further rise to 38 million by 2030² if appropriate actions are not taken in time. Most of the deficit is in regards to the LIG (Low Income Group) and EWS (Economically Weaker Section) of the society.

Presently, a large part of the urban population lives in cramped, poorly constructed houses owing mainly to the lack of affordable housing options. Those dwelling spaces also lack basic amenities such as clean water,

sanitation, electricity supply as well as sewage and waste disposal. Thus, providing affordable housing is inevitable for sustainable urbanization and is one of the topmost priorities for a government.

Affordable housing in India refers to housing that is priced at a level that is affordable to low and middle-income households. The Government of India has defined affordable housing as housing units with a carpet area of up to 60 sqm in metro cities and up to 90 sqm in non-metro cities.

As per the Government guidelines affordable housing projects should constitute at least 60 percent of the overall Floor Area Ratio/ Floor Space Index (FAR/ FSI) of the project. In addition to the 60 sqm for the development of affordable housing, 35 percent of the overall dwelling units constructed should have a carpet area of 21-29 sqm (EWS) category. Such projects would thus have a mix of EWS / LIG / Higher Category residential units and commercial units.

Some of the prominent Affordable Mass Housing schemes in India are:

1. Aranya Community Housing, Indore (M.P.)
2. The Stanwood Residency, Halol (Gujarat)
3. Tara Housing, Delhi

4. Housing for Mahouts & their Elephants, Jaipur (Rajasthan)
5. Sublimes Ordinaries Housing project, Vasind (Maharashtra)
6. Sheikh Sarai Housing Complex, Delhi
7. Chengalchoola Housing, Trivandrum (Kerala)
8. Atira Staff Housing, Ahmedabad (Gujarat)
9. Incremental Housing in Belapur, Navi Mumbai (Maharashtra)

Key Architectural Considerations/ Elements in Affordable Mass Housing Projects

Mass housing schemes especially for the lower income groups of the society, requires that the socio-economic structure be considered and given the due share in the architectural design.

People from low-income groups tend to be more oriented towards community life and events, and thus need spaces for social gatherings and other common activities. Besides, their lower income leads them to look for proximity to the public transport hubs, for saving their 2-wheeler or 4-wheeler fuel costs.

Their dwelling structures need to allow ample natural light and ventilation for maximum day time for health purposes as well as to keep the power consumption and associated expenditure to a minimum.

The factors mentioned above are used to guide the planning and design which help to make them a success.

Objectives of Affordable Housing Policy are:

- To establish mechanisms for slum prevention and including creation of housing stock for the affordable.
- Public Private Partnership (PPP) modes to cater to housing shortage.
- Encouraging activities of the Housing Boards and Development Authorities.
- To provide incentives for facilitating accelerated growth of affordable housing stock to state governments and union territories.

Growing Need for Housing in & around Mumbai Metropolitan Region

Mumbai, the financial capital of India and a major economic centre in South Asia, has been seeing an influx of people from all over the country since many decades, owing to the employment opportunities, ease of commutation, communication, and overall standard of life.

To ease the load on Mumbai, the twin city of Navi Mumbai developed across the Vashi creek, has rapidly developed into an urban centre and is well-connected to the parent city by means of road and rail.

Navi Mumbai is witnessing great pace in infrastructure development including an international airport. That has resulted in a growing need for housing and allied amenities.

CIDCO Mass Housing Scheme

To cater to the housing needs, the City & Industrial Development Corporation (CIDCO) has proposed to construct affordable housing units for LIG and EWS of the society at various locations across Navi Mumbai. The locations include Kharghar, Panvel, Vashi, Kalamboli, Navade, Talaja, Bamandongri, etc. M/s Hafeez Contractor is the Project Architect for these projects. Most of the sites are have transit-oriented development, in proximity with railway stations, bus depots and train terminuses, etc. That has led to a greater demand for housing the from Lower Income Group. A mass housing project that was conceptualised by CIDCO is under construction.



Figure 1: Aerial view of CIDCO's Bamandongri site, Navi Mumbai; The site is in front of Bamandongri Railway station and along a creek

Design Requirements

The affordable housing campuses are located at easily accessible locations and the residential towers had to be planned for optimum utilization of the available space and the plot area as per the prevailing norms. The large number of residents on these blocks also needed to be supported by basic amenities within the premises to optimize their commutation time and cost for living, for daily needs.

Challenges

Some of the sites are located near water bodies or airport zones, hence they had to be planned as per the specific Building Byelaws which restrict the building heights and permissible FSI's were restricted.

The Kharghar Station site is situated near a creek, and a considerable portion comes under the Coastal Regulatory Zones (CRZ) norms. That restricted the number of floors of the towers coming within the CRZ zone.

The challenges at another site included the requirement of a mixed-use building, wherein a Bus Depot was to be provided on the Ground floor and Residential apartments on the upper floors. The site is located at a road junction and thus, has good commercial potential.

Different planning and design approaches were adopted depending upon building type. For the commercial cum residential one, Shops have been proposed facing the external road, while in case of the Bus Depot, which is located in the inner part of the site, the access for the buses is given from a separate dedicated gate. The entire area has a Podium above. The entire area has a Podium above,



Figure 2: Kharghar Station site

which the 22 storied Residential tower rises. The Podium slab is designed to cater to Fire Tender movements.

The structural columns on the Ground floor, are located so that they do not obstruct the vehicular movements in the Bus Depot level. The circulation zones have been segregated to avoid clashes of different functional activities.

Highlights

- The sites being situated next to the transport hubs, provide the occupants of the housing campuses easy access to various parts of the city, thus reducing time and fuel for daily commutation. The sites are well connected to the nearest essential services as well as work centres.
- The multi-storeyed residential apartment towers have been proposed in cluster formations, which fosters better community living. Vertical development has also enabled more free land area within the campuses for open spaces or green zones.
- The residential towers are designed with pre-cast construction technology and engineered formwork system (Aluminium Modular Formwork). Their standardized design has helped in facilitating rapid and quality construction work, plus saving time. Construction of high-rise towers has facilitated better views and ventilation especially on the upper floors, which is a privilege for the dwellers.
- The areas for LIG units are between 50-55 sqm, while those for EWS units are between 25-29 sqm as per PMAY norms.
- The towers vary from G+7 to G+29 structures depending upon the permissible FSI and height restrictions depending upon the development zones. Vehicular parking spaces have been proposed on the lower floors and residential units on the upper floors.
- The floor wise configuration varies from 8 to 38 residential units per floor based on the utilization of FSI. The buildings have sufficient vertical circulation core areas, viz. staircases and elevators provisions are as per Fire norms.
- A uniform floor height of 2.90 m has been proposed

- for the residential floors, and the commercial spaces to be of double heights (i.e., 5.80 m).
 - The sites having shops, of sizes ranging from 200 to 500 sqft, facing the external roads. The residential grid is planned around a central core area and consists of similar grids with shear walls, all planned in conjunction with the architectural layout requirements.
 - The elevations of the towers have been designed keeping in mind the cost-effectiveness of the materials, durability as well as the aesthetics of the building.
 - The campuses are equipped with basic amenities such as Common spaces, Convenience shopping, Playgrounds / Gardens, Gymnasium, Club House, etc.
 - The campuses have been planned and designed keeping in mind the differently abled people. Provisions have been made for their convenience, which include Toiletries, Ramps for wheelchair access, Car parking spaces for differently abled, etc.
- Some of the salient planning and design aspects are given in the table.

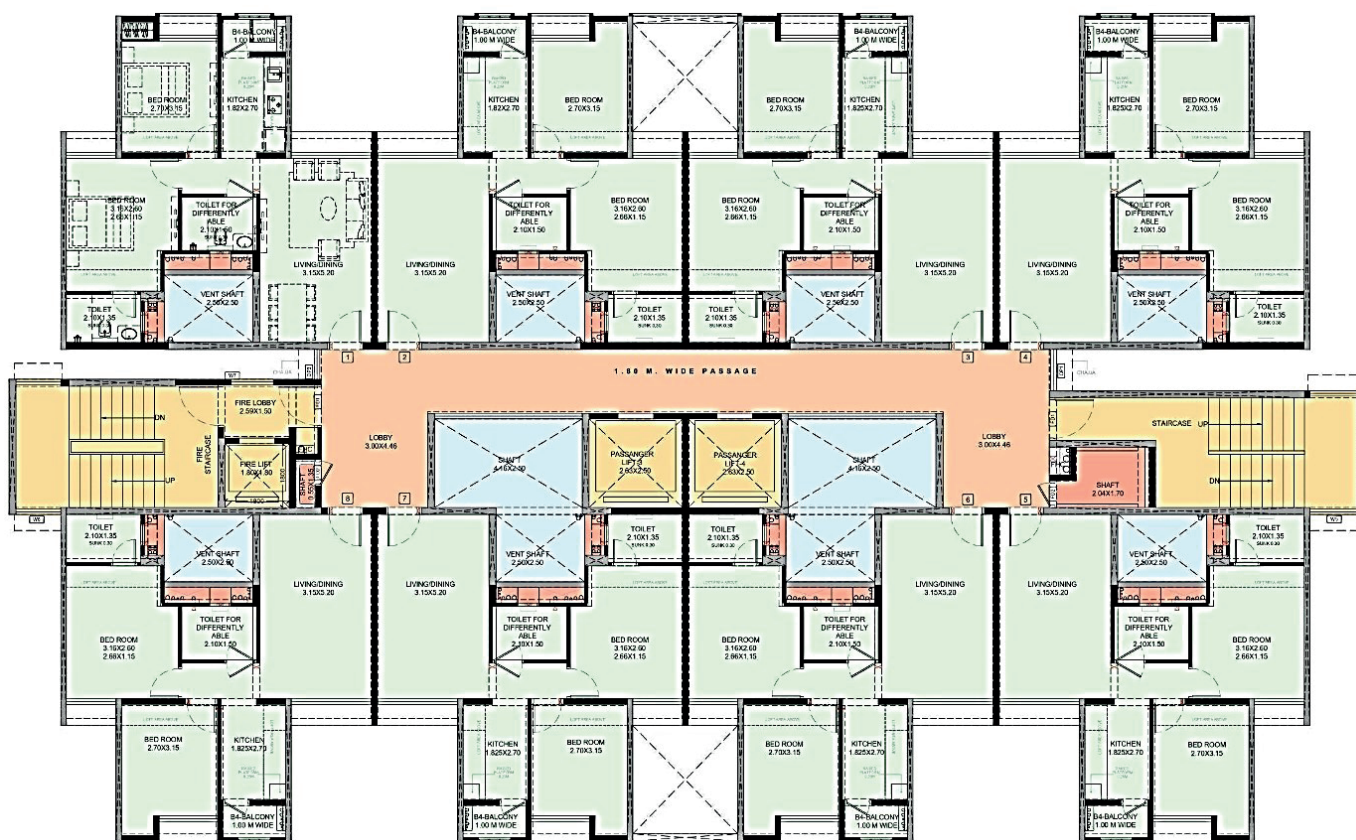
Planning & Design Aspects		
1	Massing	- Primarily, the towers are divided into Ground floor (Shops or Parking) with Typical Residential floors (8 nos to 30 nos) on the upper levels. - Few sites have Bus Depot with Commercial spaces on the Ground floor, Podium parking on the First floor and standalone Residential tower on the upper floors. Public transport system have been kept at walking distance or within the premises of all these housing clusters thus avoiding traffic and bottlenecks while commuting.
2	Circulation and Evacuation – Typical Residential floor	- Dwelling units are arranged around horizontal circulation areas – Passages, and integrated with the vertical circulation components - Staircases and Elevators. - The emergency exit points & Fire towers are easily accessible from all areas on the floor with travel distances within 22.50 m. - Refuge areas are constructed, as per NBC norms, on the 8th, 13th, 18th & 23rd floors. Based on the effective utilization of the building layout and ease in access, a single dwelling unit has been converted into a refuge area which is equivalent to approximately 12% of the total habitable floor area. - Vertical and horizontal circulation spaces have been planned in an efficient manner, wherein they occupy approximately 20% of the total floor plate area.
3	Façade treatment	- Since the sites are in Navi Mumbai, an area which receives heavy rainfall, weatherproof exterior paint has been proposed to suit the local climatic conditions. - Entrance areas on the Ground floor have been distinguished and identified with decorative Jali's.
4	Location of Utilities, Arrangements of Ducts, and distribution	- Compactly planned Services and Utility shafts to cater to the Electrical, HVAC, Plumbing, Fire Fighting & Building Management System requirements. MS chequered plates has been provided at each floor level inside the shafts for the ease of maintenance. - The ducts are easily accessible from the common spaces, yet they have been segregated from the Residential units and protected by Fire resistant doors. - Electrical rooms and Meter rooms on the Ground floor are located in such a way that they do not cause disturbance to the Parking movements as well as pedestrian circulation. - The Plumbing shafts, are proposed on the inner sides of the towers; they are open to sky for facilitating natural light and ventilation not only in the Toilets but also in the Common corridors.
5	Structural grid	- Key Structural elements – The Shear walls are integrated into the core and staircase which simplifies the architectural design. - The columns have been planned such that there are minimum offsets in the rooms of dwelling units.



CIDCO Kharkopar site deploys Pre-Cast construction technology



The housing clusters have been provided with amenities such as Club House, Health Centre, and Garden area



Typical floor plan for LIG type housing units tower, Kharghar Station site.

Total floor area	627 sq.m.
No. of dwelling units per floor	8 no.s (2 BHK) per floor
Area under dwelling units	496 sq.m. (79% of floor plate area)
Area under circulation core	131 sq.m. (21% of floor plate area)
Occupancy per floor	40 pax. (5 persons / unit)



Typical floor plan for EWS type housing units tower, Bamandongri site.

Total floor area	440 sq.m.
No. of dwelling units per floor	8 no.s (1 BHK) per floor
Area under dwelling units	360 sq.m. (78% of floor plate area)
Area under circulation core	80 sq.m. (22% of floor plate area)
Occupancy per floor	32 pax. (4 persons / unit)

Conclusions

In developing countries like India, one of the basic human needs for housing needs to be catered on priority basis, and especially where migration for jobs and other reasons is seen.

Since a major portion of the society in the urban areas belong to the Low-Income Groups, the housing projects focus on providing low maintenance and energy efficient shelters, while keeping in mind the socio-economic

structure of the Indian society. Affordability needs to be incorporated in the planning, design, construction, and use stages so that the users derive the benefits not only during the purchase of such properties but can sustainably live in these places and meet their economic and social needs.

Affordable housing schemes are thus seen as the driving factors to address these needs which will stand as the role models not only in the country but also worldwide.

TCE's Involvement

TCE is the Project Management Consultant for the housing projects coming up at Taloja, Kharghar Station & Navade and Bamandongri. The scope of work includes detailed review of the Tender and Good For Construction (GFC) documents. Total scope was approx. 88,000 EWS and LIG units being executed under 4 packages. TCE has been entrusted with PMC services for 3 packages having approx. 65,000 units.

TCE has suggested value additions from Functional, Economical, Safety and Statutory points of view in the project.

Acknowledgement

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[Home News](#) Affordable housing

AFFORDABLE HOUSING



June 13, 2024 10:19 AM IST

A multi-pronged approach, not mere targets, can boost affordable housing

The present PMAY scheme and the faltering pace of affordable housing that fell short of its earlier targets has evoked a great deal of criticism

Source: <https://www.moneycontrol.com/news/tags/affordable-housing.html>

A Study To Standardise Affordable House Design For A Public Sector Organisation



Anusha Thati

Architect, Scientific Officer-E
General Services Organization, Kalpakkam

Affordability is a subjective concept that is connected to an individual's earnings, spending, savings, debts. The perception of affordability will vary from person to person.

Recently, there has been an increasing focus on the topic of affordable housing in various sectors. Architecture plays a pivotal role in determining key variables such as the minimum area required, housing densities, living space, natural light, and ventilation, building materials, availability of amenities such as green spaces, social places, scenic vistas, etc.

This case study examines various housing models in the DAE township at Kalpakkam that adhere to the GPRA standards for Type I and II housing. The models fall under the MIG housing policy in India, meeting the required area specifications. The study also includes the impacts of introducing MIG housing in multi-storeyed buildings.

Introduction

According to the Pradhan Mantri Awas Yojana (PMAY), affordable housing is defined as follows. *"In metropolitan areas, a dwelling is considered affordable if it is priced at Rs 45 lakh or less and has a carpet area of 60 square meters (646 square feet) or less. Over the years, with varying schemes, there has been an evolution in housing affordability"*.

Table-1: Evolution of Affordability in Housing

Scheme		Dwelling Unit Size
Deepak Parekh Committee 2008	EWS	Upto 30 sqm of carpet area
	LIG	30-60 sqm area
	MIG	Above 60 sqm area (120 to 150 sqm)
MoHUA Taskforce on Affordable Housing 2012	EWS	21-27 sqm of carpet area
	LIG	28-60 sqm of carpet area
Pradhan Mantri Awas Yojana 2015	EWS	30 sqm of carpet area
	LIG	60 sqm of carpet area
	MIG-I	160 sqm of carpet area
	MIG-II	200 sqm of carpet area

a. Type Housing Based on Income

As per the CPWD norms, the types of houses are categorised based on Employee's income and Grade.

Table-2: Plinth Area Norms for General Pool Residential Accommodation GPRA (in sqm)

Type	Before 2000	2012	2013	2024
I (A)	34	40.80	49.5	No new construction
II (B)	45	54	63	75

b. Design Guidelines Followed While Planning The Dwelling Units

- Minimum floor-to-floor height kept at 3,000 mm.
- No room or space to be less than 1,800 mm width.
- Minimum size of toilets to be 1,500 mm x 2,100 mm, but it is desirable to provide bigger toilets. All water closets to have a wash basin.
- Utility Balcony to be provided in all types of units. The utility balcony to be avoided on the front side of the building.

Methodology

The methodology adopted was a study of the housing focused on the DAE Township at Kalpakkam, situated 80 km from Chennai. It also comprised an analysis of the housing standards published by CPWD and GRPA in 2024.

The study classifies the CPWD affordable housing background into three developmental phases: the early period (1970–2000), the growth period (2000–2010),

and the time of extensive construction (2010–2020). The approach offered valuable perspectives for the future development and execution of the housing policy. The selection of case studies was determined by utilizing specified criteria or those that are illustrative of typical housing, taking into account the availability of floor plan drawings and development data for analysis.

From 1970 to 2000, buildings were normally limited to the ground level but some were of G+2 structure. The layout plans were based on row housing, in which the walls between housing units were common and thus shared, which resulted in cost savings. Majority of the structures were constructed as load-bearing structures, with sloped roofs. Open yards in the front and rear of the buildings allowed for increased flexibility and utility.

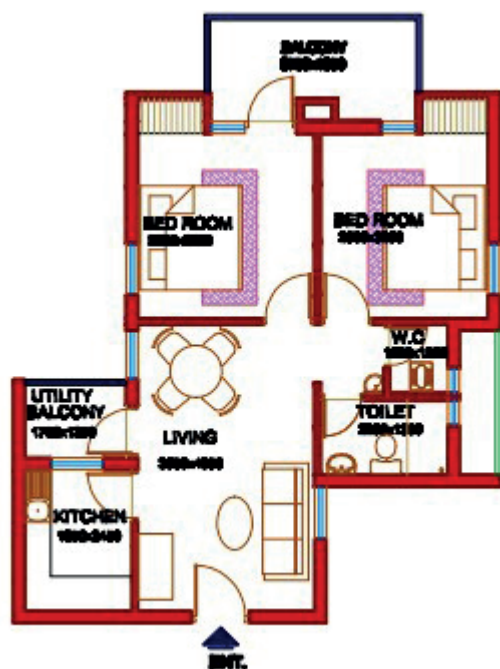


Figure-1: CPWD Housing Model

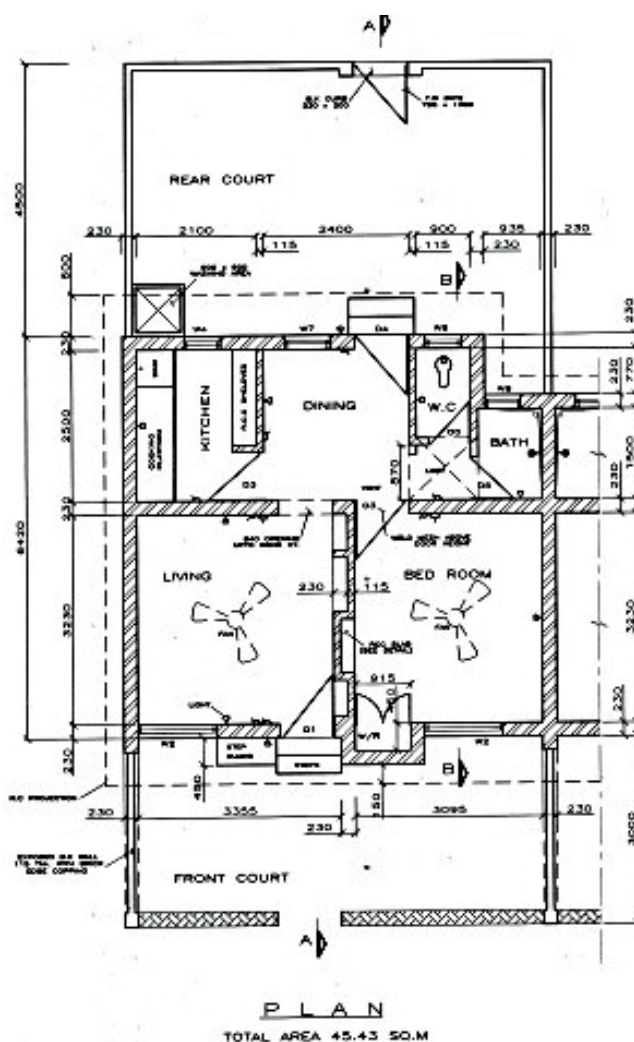




Figure-2: Row Housing

From 2000 to 2010, structures with G+2 floors were designed using RCC beams, columns and slab. However, there was significant variation since the minimum area requirement for the dwelling units progressively increased over time. There was a significant focus on designing diverse layouts in the same area to accommodate the specific requirements and varying lifestyles of the people.

For instance, Type II describes a residence with a living area, kitchen, and one bedroom, with the potential to expand to include two bedrooms within the same spatial boundaries.



Figure-3: G+2 Floor Apartment

Present Scenario

In the period 2010 to 2020, due to the rising cost and limited availability of land, it became necessary to construct houses in a multi-storey form. Priority was placed on sustainability and energy efficiency. To enhance and meet the demands of modern lifestyles, additional power points are installed to accommodate the increase in electrical appliances and electronic devices. To meet the requirements, two tower blocks, each of seven floors, were constructed in Reinforced Cement Concrete (RCC). Each block included 58 quarters.

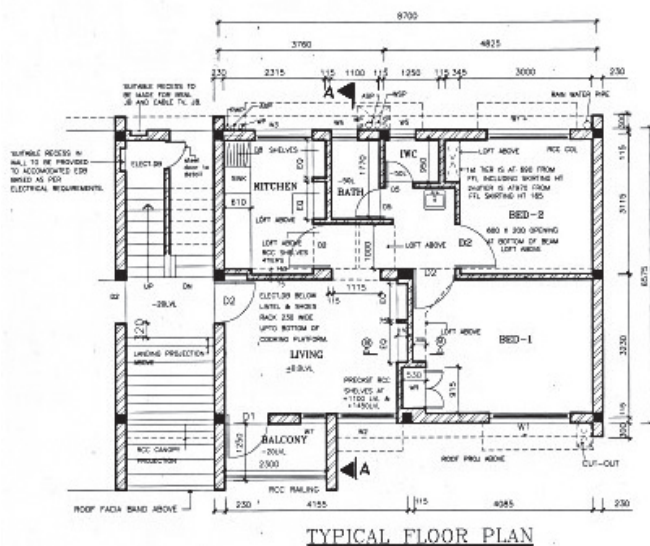
The allocation of quarters over different levels was as follows:

- The ground floor has 6 quarters and two stilts,
- The 1st floor to 6th floor has 8 quarters on each floor, and
- The 7th floor has 4 quarters and the remaining area is for an open terrace.

All the building services/ utilities were provided.

The key features of those schemes were:

- Orientation of the houses was in the North-South direction so that they would get natural lighting,



- Existing trees on the site were retained to the maximum extent,
- Reflective cool roofing tiles were provided to reduce the heat transmission,
- Eco-friendly materials such as Fly ash bricks, Low VoC paints were used
- Dual flush tanks to conserve water, and
- Recycled water was used for flushing.

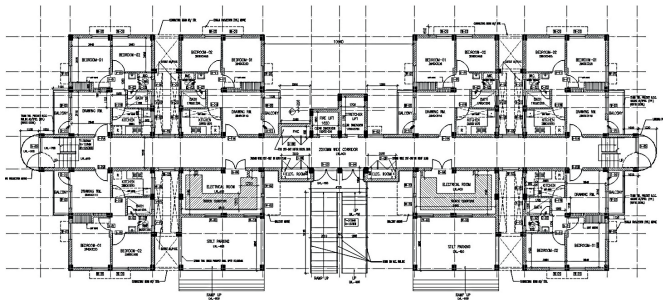


Figure-3: G+7 Tower Block with 8 quarters per floor

Results and Discussions

- The analysis revealed that combining dwelling units to create a multi-storeyed structure enhances comfort for inhabitants and promotes sustainability

by providing shared amenities such as parks and parking.

- The orientation of a dwelling is crucial for low-income households, as they prefer natural ventilation and light to minimize energy usage and thus decrease expenditure.
- The building's height was restricted to a G+2 structure during the growth phase to reduce costs by avoiding installation of elevators for vertical movement.
- Later the height of the buildings were limited to G+7 throughout the construction phase to minimise costs associated with elements such as refuge area, wet risers, and other firefighting requirements.

Conclusions

To make the most of limited resources while still providing adequate housing for growing populations, multi-story buildings have become increasingly popular. A focus on water management, energy-efficient materials, and improved public areas should be among the design's environmental priorities. Substantial changes were made over time in line with the constraints and requirements. The shift is symbolised by the transition from row houses to multi-story structures and from single-bedroom to double-bedroom residences with the necessary services and utilities, to suit the evolving lifestyle, albeit with optimised cost.

Acknowledgement

The author is thankful to IGCAR for allowing the submission of this article for publishing in ViewPoint.

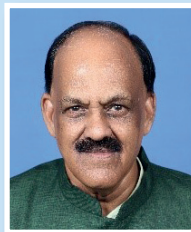
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Business Responsibility and Sustainability – Energy & GHG Reporting



Madhusudhan Naik
Founder and CEO



M. R. Moorthy
Advisor and Mentor

iCapo Tech Pvt Ltd - Living Things

The Business Responsibility and Sustainability Report called (BRSR Core) was introduced in 2021 and it replaced the earlier BRR (Business Responsibility Report)

The Securities and Exchange Board of India (SEBI), the monitoring agency, made it mandatory for the top thousand listed companies in India “by Market Capitalisation” to file BRSR from the financial year 2023 by including the same in their respective Annual Reports. It is being made Mandatory and is being implemented in phases.

It all started in the 2011 based on the United Nations guidelines for protecting the environment from pollution and thereby adopt sustainability processes, procedures, etc.

The Ministry of Corporate Affairs, Government of India, came out in 2018 with the National Guidelines on Responsible Business Conduct, (NGRBC). SEBI has been entrusted to ensure mandatory implementation and compliance to BRSR as per NGRBC.

Accordingly, SEBI introduced a voluntary framework which provides formats for listed business organisations to prepare the BRSR. It is mandatory for many companies to disclose information about their Environmental, Social and Governance (ESG) data.

Nine Principles form the basis for BRSR core disclosures relating to ESG and it is mandatory based on Market Capitalization for the organisations to report them by responding to 140 questions, divided into 98 Essential Indicators (mandatory) and 42 Leadership Indicators (voluntary).

Market Capitalization

Market capitalization, (Market Cap), is the total value of publicly traded company’s outstanding common shares owned by stockholders. The Market Cap is equal to the traded market price per Common Share multiplied by the number of Common Shares outstanding in the market.

Common Shares are given to business owners and other members as proof of the money they have invested in the company; they are the Shareholders and they are free to trade those shares in the stock exchange. The Management Team cannot trade their shares even if the share price go sky high. These Common Shares shareholders have the least claim on the company’s assets.

It is now a common practise for individuals as well as Financial Investment organisations to look at sustainability reports before investing their money. Thus, an organisation which files its BRSR indicating

their various achievements and initiatives, attracts more investments. Thus, reporting a Company's performance on sustainability related factors through its BRSR has become as Vital and Important as reporting on Financial and Operational performance.

The SEBI designed format addresses BRSR requirements by collecting information based on nine Principles, as listed below.

Business Responsibility & Sustainability Reporting Format

Section A: General Disclosures

Section B: Management and Process Disclosures

Section C: Principle wise Performance Disclosure

Principle 1: Businesses should conduct and govern themselves with integrity, and in a manner that is Ethical, Transparent and Accountable

Principle 2: Businesses should provide goods and services in a manner that is sustainable and safe

Principle 3: Businesses should respect and promote the well-being of all employees, including those in their value chains

Principle 4: Businesses should respect the interests of and be responsive to all its stakeholders

Principle 5: Businesses should respect and promote human rights

Principle 6: Businesses should respect and make efforts to protect and restore the environment

Principle 7: Businesses, when engaging in influencing public and regulatory policy, should do so in a manner that is responsible and transparent

Principle 8: Businesses should promote inclusive growth and equitable development

Principle 9: Businesses should engage with and provide value to their consumers in a responsible manner

This article, focuses on the Energy related reporting required by BRSR as per Principle 6. The focus for that is the monitoring of emissions, reducing emissions and also look at more renewable green energy consumption by installing small captive hydro power projects, solar, wind, waves geothermal, etc. power generating systems. These organisations need to look at other devices and methods which can reduce power consumption with a live monitoring mechanism through a dashboard, etc.

Some of the issues to understand the relevance of detail disclosures vis-à-vis Energy in BRSR centre on the difficulties faced by Banks, Corporates. etc. in complying with the norms. The difficulties arise since a Bank may have many branches spread all over India in addition to stand alone ATMS. Similarly, Telecom Tower Operators and Corporates with many regional and local offices. In every organization over 40% of carbon dioxide CO₂ emissions are due to electrical power consumption since the electricity is being generated by burning fossil fuels - coal, oil and gas. Since the Power generation is done for End Users to sustain their business activities as well as for domestic needs, the responsibility for reduction of the Green House Gas (GHG) emissions, dwells both on the Power Generation companies as well as on the commercial end users.

In the 9 Principles of the BRSR, Energy Consumption is the first Essential Indicator in Principal 6 of the guidelines: The other Essential Indicators are – Water, Air Emissions (other than GHG emissions), Green House Gas emissions, Waste Management, and, Environmental approval/ clearance for operations/offices in/ around ecologically sensitive areas,

The details pertinent to this article are reproduced below for ready reference.

From Serial No.1 of Principle 6

Essential Indicators

1. Details of Total Energy Consumption (in Joules or multiples) and Energy Intensity, in the following format:

Parameter	FY _____ (Current Financial Year)	FY _____ (Previous Financial Year)
Total Electricity Consumption (A)		
Total fuel consumption (B)		
Energy consumption through other sources (C)		
Total energy consumption (A+B+C)		
Energy intensity per rupee of turnover (Total energy consumption/ turnover in rupees)		
Energy intensity (optional) – the relevant metric may be selected by the entity		

Note: Indicate if any independent assessment/ evaluation/assurance has been carried out by an external agency? (Y/N) If yes, name of the external agency

2. Does the entity have any sites / facilities identified as designated consumers (DCs) under the Performance, Achieve and Trade (PAT) Scheme of the Government of India? (Y/N) If yes, disclose whether targets set under the PAT scheme have been achieved. In case targets have not been achieved, provide the remedial action taken, if any.

From Serial No.6 of Principle 6.

6. Provide details of greenhouse gas emissions (Scope 1 and Scope 2 Emissions) & its intensity, in the following format.

Parameter	Unit	FY _____ (Current Financial Year)	FY _____ (Previous Financial Year)
Total Scope 1 emissions (Break-up of the GHG into equivalent CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆ , NF ₃ , if available)	Metric tonnes of CO ₂ equivalent		
Total Scope 2 emissions (Break-up of the GHG into equivalent CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆ , NF ₃ , if available)	Metric tonnes of CO ₂ equivalent		
Total Scope 1 and Scope 2 emissions per rupee of turnover			
Total Scope 1 and Scope 2 emission intensity (optional) – the relevant metric may be selected by the entity			

Note: Indicate if any independent assessment/ evaluation/assurance has been carried out by an external agency? (Y/N) If yes, name of the external agency.

7. Does the entity have any project related to reducing Green House Gas (GHG) emission? If Yes, then provide details.

From Serial No.12 of Principle 6.

Leadership Indicators

1. Provide break-up of the total energy consumed (in Joules or multiples) from renewable and non-renewable sources, in the following format:

Parameter	FY _____ (Current Financial Year)	FY _____ (Previous Financial Year)
From renewable sources		
Total electricity consumption (A)		
Total fuel consumption (B)		
Energy consumption through other sources (C)		
Total energy consumed from renewable sources (A+B+C)		
From non-renewable sources		
Total electricity consumption (D)		
Total fuel consumption (E)		
Energy consumption through other sources (F)		
Total energy consumed from non-renewable sources (D+E+F)		

Note: Indicate if any independent assessment/evaluation/assurance has been carried out by an external agency? (Y/N) If yes, name of the external agency.

The matter relating to the collection of data for GHG emissions is discussed below.

Addressing the Issue of Reducing GHG Emissions

Many listed organisations have to collect monthly electricity bill payment details, consumption details, power factor analysis, etc., then consolidate the same to arrive at the total energy consumption for the year. That amounts to a lot of data collection to prepare the energy related.

The Low Carbon Emission Economy can be synchronized with the Green Ecological Economy based on low energy consumption and low pollution by measuring and recording all the necessary parameters.

To start with therefore from the energy point of view there is an increasing need to collect, measure and analyse the energy related data. In this growing digital world, organisations listed on stock exchanges and having pan India operations must turn to digital services

for automatic real time gathering, collection and analysis of measured data. That clubbed with Artificial Intelligence would be the best way to find goal-oriented objectives, namely lowering carbon emissions and collated data for reporting in the BRSR.

Energy is at the heart of climate change and addressing this issue is the key to the solution for reduction in Carbon Emission. Generating Electricity and Heat by burning Fossil fuels like Coal, Oil or Gas which produce a large portion of the Green House Gases such as carbon dioxide (CO₂) and nitrous oxide (N₂O) that cover or blanket the earth and trap the sun's heat. These methods of power generation also emit long list of harmful pollutants.

Improving business performance taking into account sustainability is a key concern of every corporate entity. With energy efficiency demanding the use of lesser energy to perform the desired task, management teams are making the transition from preventive to predictive maintenance with the help of tools like Artificial Intelligence (AI) and IoT (Internet of Things) enabled

solutions. Predictive maintenance enables reduction in the cost of maintenance as the principle is “as per need of requirements” thus saving cost and time.

For long term sustainability decarbonisation is necessary but a very complex issue. Digitalisation will be a key enabler in this transformation from preventive to predictive. AI and IoT can redefine the way that energy is produced, distributed and consumed.

A case study to illustrate the complexity of collecting and collating the data required for reporting is given below. It is based on a case with which a company incubated by the Indian Institute of Technology Bombay was associated.

BSBR Case Study

The case relates to a big commercial bank for which the senior author was involved to help them file the BRSR report relating to Energy.

Problems Addressed for the bank:

BRSR Reporting

The Bank has 1300+ branches all over India, and they were finding it problematic to quantify the unit consumption per branch for the entire year. A study showed that they lacked the hygiene of collecting utility bills and were extracting values manually from them.

Since they had branches all over the country, 23% of the bills were in regional languages. That made it difficult for them to always translate the bills so as to understand the data that could be extracted from them.

The task therefore was to help the bank to solve the problems relating to:

- Data mapping and cleaning
- Data Quality checks
- Data extraction using DocAI
- Consolidation of extracted data

- Data analysis and dashboarding
- BRSR reporting

Plan

After studying the operations relating to energy, a plan was evolved for:

- **Data Collection** - created a routine of collecting utility bills for each branch
- **Data Extraction** - 20+ key metrics to be extracted and a detailed analysis be done to identify the sites that were performing poorly
- **Language Translation** – deploying Large Language Models (LLM) and Document Artificial Intelligence (IDoc AI) to translate and extract key metrics from the bills which were in regional languages.
- **UBA platform** - the User Behaviour Analytics (UBA) platform was used for auditing 35 sites randomly selected all over the country. The UBA platform gave reasonable assurance to showcase the original bills against the value extracted and thus gave confidence

Result of Implementing the Plan

With the above put in place, basic information like electricity unit consumption, and amount for each site location was made available for auditing and the results were very satisfying.

- **Comprehensive Electrical Data Analysis** - access to detailed information on the sanctioned load and contract demand for every branch across the nation.
- **Improved Cost Management** – provided a clear understanding of the penalties being paid at a national level.
- **Efficient Financial Management** – the data enabled making informed decisions to mitigate penalties and optimize operational efficiency.

- **Benchmarking of Electrical Parameters** – the energy consumption per square feet of the area could be benchmarked.
- **SoP preparation** – a standardized operating procedures was developed for selection of sanctioned load and the contract demand. The SoP will help enhance the overall operational effectiveness.
- **Strategic Planning and Resource Allocation** – the client can strategically plan for future energy requirements and allocate resources effectively.

BRSR Reporting

At the end of the assignment the process implemented provided

- reasonable assurance for 80% of the bank branches/offices, and
- confidence for filing BRSR reports for auditing

Conclusions

SEBI having laid down the reporting format to provide a thrust to sustainability and reduction of GHG emissions it is necessary that organisations monitor the initiatives taken by them. India has committed to the world for carbon neutralisation and therefore attention is drawn from various quarters to ensure that GHG issues are well addressed. The reason for publishing the data through BRSR is that the Investors can see as to where the organization is plying their money in order to adhere to accepted standards relating to GHG emissions.

About iCapo Tech Pvt Ltd - Living Things

It is a SINE- IIT Bombay incubated company, providing Energy Management Solutions that help large enterprises to accelerate their Net Zero Journey.



From The Economic Times

AFFORDABLE HOUSING



Union cabinet approves government assistance for constructing three crore PMAY houses

"It has been decided in the Cabinet meeting today to provide assistance to three crore additional rural and urban households for the construction of houses to meet the housing requirements arising out of the increase in the number of eligible

Source: <https://realty.economictimes.indiatimes.com/tag/affordable+housing>

CEAI NEWS

WEBINAR - "USE OF AI FOR AUTOMATION OF MATERIAL TAKE-OFF"

CEAI and FIDIC Asia Pacific organised a webinar on *"Use of AI for Automation of Material Take-off"* for all types of buildings including the services - electrical, mechanical, plumbing and other works on 26th April 2024. Beam AI is changing the way quantity take-offs are done. From concrete and rebar to utility services it takes off quantities for 16 trades, delivering pinpoint accurate quantity take-off calculations in 3 simple steps.

With Beam AI, one can now save 90% of the time typically spent on manual, time-consuming quantity take-offs and accurately process upto 30% more estimates, translating to more bids and faster business growth. Streamlined workflows on a user-friendly, cloud-based AI platform means that one can focus on refining estimates and provide value engineering

Youtube link: <https://youtube.com/live/GaWgC-Cw3A08?feature=share>

Upload your plan docs on Beam AI → Type in your scope of work → Hit "Proceed"

BEAM Estimators & Project Managers spend about 30-50% of their time on takeoffs

This leads to following challenges in bidding cycle:

- Focus shifts away from coordinating with customers & vendors
- Inadequate time to refine estimates & for value engineering
- Slower turnaround of estimates

Beam AI helps estimators with 100% automated takeoffs

Webinar on Use of AI for Automation of Material take off 26 April 2024

Webinar on Use of AI for Automation of Material take off 26 April 2024

Webinar on Use of AI for Automation of Material take off 26 April 2024

Webinar on Use of AI for Automation of Material take off 26 April 2024

TRAINING COURSE ON FIDIC CONDITIONS OF CONTRACTS

a) Open House Training in Delhi

CEAI organised an open house-training courses on the *"Practical use of FIDIC Conditions of Contract"* in Delhi on 10th and 11th May 2024. 31 engineers attended the training.

Mr. Bogdan Oprea, FIDIC accredited trainer from Romania conducted the training course.



Training in progress



View of participants

b) In-house FIDIC Training for MPMRCL Bhopal

An in-house training on FIDIC Conditions of Contract was conducted for the employees of **Madhya Pradesh Metro Rail Co Limited** from 13th to 16th May 2024 at the office of MPMRCL, Bhopal.

The training was conducted by Mr Bogdan Oprea.



WEBINAR ON “BUSINESS ETHICS AND CORPORATE GOVERNANCE”

CEAI organised a webinar on *"Business Ethics and Corporate Governance"* on 14th June 2024.



Mr. JVL Narayana, Vice President

CEAI welcomed all the speakers and the participants to the webinar. He briefed participants on the activities of CEAI and said that the

Ethics & Quality Committee of CEAI works on advocating ethical principles

and practices through various forums to create a value based culture amongst the consulting engineering fraternity.



Mr. Umesh Shrivastava,

Chairperson of the Ethics Subcommittee of CEAI introduced the theme of the webinar. Business ethics refers to the principles and standards that guide the behaviour

in the world of business. Corporate Governance refers to the system by which companies are directed and controlled. It involves the company's management, its board, its shareholders, and other stakeholders. Corporate governance provides the structure through which the objectives of the company are set and the means of attaining those objectives and monitoring the performance are determined. It ensures accountability, transparency, and ethical practices.



Prof. Rohit Varman, Professor, Birmingham Business School, University of Birmingham, made a presentation on “**Corporate Social Responsibility and Ethical Challenges for Business**”. He

focussed on the issue of corporate social responsibility because it is at the heart of business ethics. He briefed about Corporate Social Responsibility and said that the idea of corporate responsibility according to the World Business Council in 2005 framed “the commitment of business to contribute to sustainable economic development working with employees, their families, the local community and society at large to improve their quality of life”.

Prof Varman focussed on how there is often a gap between some of these claims and what is being actually done and he shared case studies to illustrate his point.

One of the case studies he shared was the gap between the claim of Coca Cola and what they actually deliver to the community. The claim of being a frontrunner in corporate citizenship and sustainable development, making considerations for customers and employees striving to enhance the quality of life for the societies and neighbourhoods they operate in. He mentioned how in 1999, at a site near Varanasi, Coca Cola started a bottling plant in Mehendi Ganj. Initially villagers were very happy as they thought that they would get employment. But from 2002 onwards there was consistent and sustained protest against Coca-Cola due to heavy usage of water every day, as this region was primarily dependent on Agriculture and hence harmed their livelihood. Prof Varman said that such violence / protest does not come in media reports or in the Annual report of such corporations.

He reflected on Modern Slavery by Corporations. The Global Slavery Index's 2018 report, published by the Walk Free Foundation, states that \$127.7 billion worth of garments is imported annually by G20 countries, a group of nations which account for 80 percent of world trade. These imports help underwrite a global economy

that traps 40.3 million people in modern slavery in their supply chain. In 2016, 71 percent of whom were women. There are more slaves today than ever in the last 500 years.

Further, we are witnessing a specific regime of sovereignty under neoliberalism in which management of different population groups requires varied modalities of government and rights of citizenship. Following the pandemic in 2019/ 2020, the bottom 50 percent of the population have continued to see their wealth chipped away. By 2020, their income share was estimated to have fallen to only 13 percent of the national income and have less than 3 percent of the total wealth. Its impact has been exceptionally poor diets, increase in debt and deaths etc. The wealthiest 10 percent own more than 72 percent of the total wealth, the top 5 percent own nearly 62 percent of the total wealth, and the top 1 percent own nearly 40.6 percent of the total wealth in India. The country still has the world's highest number of poor at 228.9 million. On the other hand, the total number of billionaires in India increased from 102 in 2020 to 166 billionaires in 2022.



Prof A Venkat Raman, Dean, Faculty of Management Studies, University of Delhi made a lecture on ‘**Values, ethics and managing people in organizations**’. Ethics and governance are not just legal or technical aspects of doing business.

They are human decisions reflective of personal values at the individual level and organizational values at the corporate level. Ethics, integrity, and societal concerns are shaped in the formative stages of an individual's life or early stages of their corporate life.

High focus on performance and achievements and the adulation for only high achievers can sow seeds of unhealthy values. If there is a widespread belief that ends justify the means and all means are fair can become the death knell for an organization's health and sustainability. Even as society evolves, the younger workforce i.e., Millennials and Gen-Z, are often not in sync with the values with which successful

organizations were built. But value based human resource management practices, can help nurture organizational values that can foster ethical behaviour among employees. Senior managers have to espouse and exemplify organizational culture and values of integrity in everything they do and every HR decision they take. Mere rhetoric on ethics and integrity will not suffice.

It is necessary to hire ‘organizational culture fit’ employees; onboard new employees while testing their value congruence; focus on consistency of communication and role modelling. If the performance appraisal system focuses on results and targets (KRAs) and penalizes those who ‘don’t cut corners’ to achieve targets, then the system may be breeding unethical business practices. Management needs to ask itself if employees who ‘cook books’ are passively tolerated or even promoted?

Employee engagement strategies could also foster socially responsible behaviour among employees (e.g., volunteering for a social cause). Besides, organizations should promote gender parity, opportunities for socially discriminated groups, and have a humane approach towards contractual employees at project sites in order to promote organization wide behaviour that is ethical, humane, and socially mindful.



Mr. M Lakshmanan, Chief Human Resources Officer of L&T Technology Services (LTTS) made a presentation on **“Building a Value-Centric Organization Culture: The LTTS Journey”**. In

his presentation Mr Lakshmanan focused on building an ethical organization through strong values, particularly within LTTS, highlighting the transformative initiative known as Project Avatar. Project Avatar was launched to redefine LTTS's mission, vision, and values, creating a cohesive and growth-oriented culture. The initiative aimed to internalize this culture among all employees, fostering a shared sense of purpose and ethical behaviour. LTTS successfully articulated its Vision, Mission, and Values, with active

participation from all employees. One notable initiative was the creation of **Painting Value Walls** at each LTTS location, ensuring that every employee resonated with the newly defined values. The **Avatar Awards** were also instituted to recognize employees who exemplified LTTS's values, particularly Ethics and Integrity.

Mr Lakshmanan further discussed the role of leadership in emphasizing the importance of ethics, highlighting statements from leaders about ethical standards at LTTS. It then addresses the Ethics Line, a dedicated communication channel for employees to report unethical behaviour confidentially. The number of whistleblowing cases from the previous year is reviewed, illustrating the effectiveness of the Ethics Line in maintaining transparency and accountability.

Mr Lakshmanan summarized the key points and reiterated the importance of maintaining an ethical culture; how LTTS inculcated ethical behaviour through its values, underscoring that a collective commitment to ethics is essential for the organization's success. This comprehensive approach ensures that ethics remain at the forefront of LTTS's operations, driving sustainable growth and integrity.

A lively Q&A and discussions followed.



Ms Sayona Philip, Chairperson of Ethics and Quality Committee of CEAI moderated the Webinar. In her concluding remarks she summarised that the objective of the webinar was to create an awareness amongst the professional fraternity

about the importance of Ethics and Integrity; The webinar covered several aspects including corporate social responsibility, the need for sustainable economic development for all stakeholders including employees and the local community; It cautioned that corporations are at the risk of evolving into self-servers for the interests of whoever controls them, at the expense of whoever does not.

Speakers lucidly brought out the need for a process to

educate and train professionals through HR practices such that they imbibe the values of ethics and integrity in their professional formative years to take over as managers and ultimately top management in an organisation. The top leadership sets the tone for ethical behaviour and practice and the mid-level leadership is key to dissemination.

Responsible Corporates or business entities internalise an ethical culture in multi-phasic stages of diagnosing/ designing/cascading or disseminating and bringing to life an ethical culture. In the long run, socially responsible conduct by Individuals or Corporates and ethical practices pay off – it enhances credibility of the profession and organisation and engenders trust and will prove to be indispensable for the success and longevity of the organisation.



The webinar was well received. The participants were appreciative of the speakers and described them as 'Excellent', 'Very insightful', 'Informative', 'Amazing', 'Very lucid and very clear', 'forthright exposition of the issues', 'Very impactful', 'brilliant', 'bringing out the truth of many organisations', 'aptly brought out the underlying agendas', etc.

You Tube Link: <https://youtube.com/live/qve6kOX-GA54?feature=share>

ACTIVITIES OF CEAI FOUNDATION

PVR Nest, - 3 Pink Toilet Projects – Vikas Puri, Lajpat Nagar & R. K. Puram, New Delhi



*Inauguration of Pink toilet at Vikas Puri
(Shri Sudhir Dhawan and Shri R S Sharma attended)*

Romila Palliative Care Center in Mumbai

Water tank and pump house were repaired.





26 April, 2024

To,
Mr. Sudhir Dhawan
Chairman CEAI Foundation (WRC)
New Delhi 110070

Respected Sir

(Sub: Letter of appreciation and acknowledgment)

Greetings from Romila Palliative Care!

We are pleased to share with you that the repair work of the water pump, the water tank and the entire pump house has been completed.

At the outset, we would like to thank you warmly and express our heartfelt gratitude to your esteemed foundation for this generous gesture which has made such a big difference for us. There was always a risk of the entire structure crumbling down and as an NGO we would have been able to do only minimal repair. Besides the basic repair work, the tiling of the water tank has also been done to prevent future leakage. Additionally, the tiling of the walls and the entire pump house is making it look very aesthetic. The work done is of extremely good quality. Attaching some photographs for your perusal.

Thank you once again!

Your sincerely,

Pouruchisti Wadia
Associate Program Director
Romila Palliative Care
SNEHA, Mumbai

Cc Dr. Harshwardhan Subbarao Hon. Chairman CEAI WRC,
Mr. A. P. Mull Hon Co-Chairman CEAI WRC
Mr. Jeffrey Nambiar, Hon. Secretary cum Treasurer

SNEHA (Society for Nutrition Education and Health Action)

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WEBINAR ON “WAYS & MEANS TO ACHIEVE CARBON NEUTRALITY IN CONSTRUCTION INDUSTRY”

Young Professional Forum of CEAI organised a webinar on “*Ways & Means to Achieve Carbon Neutrality in Construction Industry*” on 24th May 2024.

The presentation was made by Ms. Anamika Kadam, DGM-L&T, an individual member of CEAI.

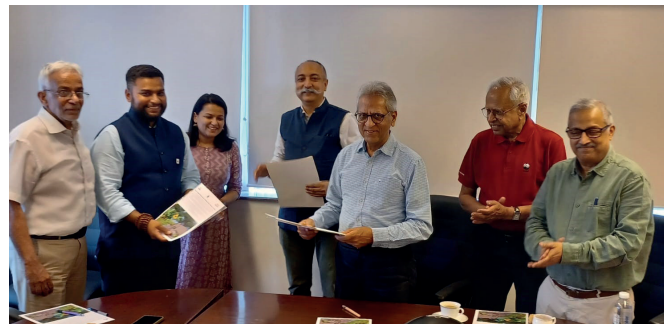
Carbon management in construction is important for several reasons, as the construction industry is a major contributor to Greenhouse Gas emissions, and managing carbon can help reduce its environmental impact. Hence, for sustainable development, the construction industry needs to implement eco-oriented principles and reduce the carbon impact. These can be achieved through improved tools for quantifying and managing the carbon footprint of buildings.



The speaker in her presentation explained various tools and technologies which are built by the construction industry to play their essential role in achieving net zero carbon in the built environment.

CEAI SIGNED MOU WITH WWF - INDIA

CEAI has signed an MoU with World Wide Fund for Nature – India (WWF – India) on 20th May 2024 at the CEAI office. The objective of the engagement between WWF- India and CEAI is to create a platform for cross learning opportunities between stakeholders with a motivation to contribute towards Natural Resources Safeguards in Linear Infrastructure Development.



MEMBER NEWS

CEAI Member Honoured

Aarvee Associates received the “Achievement Award for Best Professionally Managed Company” at the 15th CIDC Vishwakarma Awards 2024.



CEAI GC Member appointed as FIDIC CC Member



CEAI is happy to announce that Mr. Gagan Anand, a Member of the Governing Council of CEAI has been appointed as Member of FIDIC Contracts Committee (CC), Geneva for term of 3 years March 2024 – March 2027. He is the only Indian to have been appointed as a Member of the FIDIC Contracts Committee.

Pursuant to his appointment as Member of FIDIC Contracts Committee, he has been appointed as the Contracts Committee Liaison for Task Group 18, which is working for developing FIDIC's PPP form of contract.

Mr. Gagan Anand, Managing Partner, Legacy Law Offices LLP, admitted as solicitor of England & Wales and as an advocate in India, earlier worked as the Chief Legal Adviser of the Punjab Infrastructure Development Board headed by the Chief Minister of Punjab for a decade, and made immense contribution to establish the regulatory framework for infrastructure development including PPPs. During his tenure, the State started adopting FIDIC Lump-sum Turnkey based EPC mode of contracting.

Gagan's more than 28 years of work experience as a construction lawyer spans across projects in India, Bangladesh, Ghana, Kenya, Kingdom of Saudi Arabia, Mongolia, Vietnam, Yemen, Zambia and Zanzibar. He was awarded the National Law Day Award 2010, with the citation – *"remarkable achievements and leadership in the practice of corporate laws including immense contributions for the development of PPPs"*. Legacy Law Offices LLP under his guidance has continued to excel in the field of constructions laws and regularly executes work in relation to developmental projects under the aegis of World Bank, ADB, UNDP and JICA. As a fifth generation lawyer, he leads a team of lawyers to successfully represent clients in high-stakes construction arbitration and litigation cases and enjoys a high success rate.

OBITUARY

MR. SUBHASH CHAND MEHROTRA



Mr. Subhash C Mehrotra, former President of CEAI and Chief Executive & Principal Consultant of Mehro Consultants passed away on 4th May 2024 at the age of 74. He had done his B.Tech (Civil Engineering) from IIT Delhi in 1972 and M.Tech (Structural Engineering) from IIT Delhi in 1979.

He was President of Consulting Engineers Association of India for the years 2004-2005. He was a member of FIDIC Board from 2005 to 2009 and also a Member of the FIDIC Business Practices Committee, and Chairman of the FIDIC Task Force on Guarantees and Bid Bonds.

He won the Overhead Water Tank competition prize organized by Delhi Urban Arts Commission. The overhead tank for the Rajiv Gandhi Bhavan, New Delhi, India, was adjudged as the best structure.

MR. YADUVENDRA MATHUR



Mr. Yaduvendra Mathur, Governing Council Member of CEAI passed away on 4th May 2024.

Mr. Mathur was an Indian Administrative Service Officer of the 1986 batch. He had retired on 30th November 2019 from the rank of Secretary to Government of India. After obtaining a degree in Economics and an MBA in Finance, Mr. Mathur worked with a Tata Company (Associated Cement Companies, 1982-1984) before joining the IAS in 1986, topping his batch.

As Chairman and Managing Director of Exim Bank (2014-17) he was part of the initiative of Prime Minister to promote project exports from India by engaging friendly nations through concessional Lines of Credit extended by the Bank. From February 2017 till his retirement, he was heading the Knowledge

and Infrastructure Verticals of National Institution for Transforming India (NITI Aayog) as Special Secretary.

He was posted by Department of Economic Affairs to the office of Executive Director for India in the African Development Bank, Abidjan, Tunis (2001-2003). Prior to that international assignment representing India, he was a Senior Deputy Director teaching Public Administration at the Lal Bahadur Shastri National Academy of Administration at Mussoorie, from 1998 to 2001.

He had long stints in various positions in the Finance Department including Principal Secretary Finance Budget, Government of Rajasthan. As Energy Secretary of Rajasthan (2004-2007) Mr. Mathur spearheaded three new greenfield super critical sized power plants and renewable energy in the state. He served as Planning Secretary, Drinking Water Secretary and also Director General Revenue Intelligence in Government of Rajasthan. He had experience as Managing Director of a Textile Mill at Bhilwara (1990-91) and as the Chairman of Indira Gandhi Canal Board. Mr. Mathur was Collector & District Magistrate of Bhilwara (1993-97) and Bharatpur (1997-98).

Mr. Mathur joined the Consulting Engineers Group Ltd. as a Director in December 2020 and was head of international business till his last date. His international exposure and vast knowledge of corporate affairs were instrumental in successful execution of many international projects. His sad and untimely demise has left a great void in the organization.

The Governing Council of Consulting Engineers Association of India (CEAI) at its meeting held on 7th May 2024 paid homage to them and recalled the immense contributions of Mr. Mehrotra and Mr. Mathur to the cause of CEAI and the consulting engineers in India.

On behalf of members of CEAI, the Governing Council conveyed their sense of loss to the members of the families of Mr. Mehrotra and Mr. Mathur and prayed to the Almighty for eternal peace of the departed Souls.

FORTHCOMING EVENTS OF CEAI

- July 12th and 13th 2024: Seminar on “*Urban Mobility -Emerging Technologies*” at Bhopal
- August 7th 2024: SAIL-CEAI Seminar on “*Advantages of Parallel Flange Sections over Conventional Indian Steel Sections*” at Mumbai
- August 12th and 13th 2024: Seminar on “*Quality of Design and Construction for Sustainable Infrastructure*”, at New Delhi
- September 20th 2024: SEPC-CEAI Conclave, “*Export of Services- Opportunities and Challenges*” at New Delhi
- October 18th 2024: Seminar on “*Legal Matters Relating to Construction*” at Mumbai
- November 8th 2024: Seminar on “*Environment and Climate Change Sustainability – Challenges and Opportunities*” at New Delhi

VIEWPOINT

The theme for the September 2024 issue of CEAI's quarterly magazine “**ViewPoint**” is “**Energy Transition**”. The Guest Editor for the issue is Dr. S Sakthivel, Deputy General Manager, Technology Team, TATA Consulting Engineers Limited.

Energy is one of the biggest contributors to the carbon emission issue that is at the forefront as a cause for air pollution and climate change. To stem that, different ways and means have been developed to generate electricity from non-fossil fuels. These range from Nuclear and the renewable sources - Solar, Wind, Hydro, Tidal, Geothermal and Biomass. Other than electricity generation per se, sources of carbon emissions include buildings, transportation, and industries in the final energy demand. Energy efficiency is an important part of building design. Electric Vehicles are now replacing Internal Combustion Engine Vehicles. Electric traction through Metros and High-Speed Rails is on the upswing. Focus is now slowly shifting from just

electricity generation to industrial decarbonization as well.

Consulting Engineers have been engaged on projects to produce energy from alternative sources. They are invited to share about their projects set up to decarbonization through any of the renewable sources.

Articles could also be on expressing one's thoughts on new ways of doing design, construction, repairs, maintenance, etc. or even on adoption or development of new technology.

A number of consulting engineers and smaller organisations are engaged in these works which do not receive the recognition they deserve since their works do not get publicized. CEAI's ViewPoint provides an opportunity to all those engaged in such activities to share case studies of their achievements, how they addressed the challenges faced, practical issues experienced and the solutions to those, etc. in the various disciplines of engineering. Photographs, charts, diagrams, drawings, etc. would benefit readers for a better appreciation of the issues encountered and the manner in which they were addressed.

The articles for an issue need to reach CEAI at least 3 weeks prior to the end of the month of the ViewPoint issue. Articles need to be in Times New Roman 12 with single line spacing with before and after 6 pt and normal margin, on A4 size. A recent clear and bright passport size photograph of the author(s) is to be sent along with the article. For details of formatting please refer to "*Format for Articles for CEAI Viewpoint*" on CEAI's website, under '*Publications*'.

We urge all Professionals to use CEAI's ViewPoint to showcase the capabilities and achievements of the Engineers in India plus educate and guide new engineers.

The theme for the December 2024 issue is "Recycling & Reuse of Building Materials in Construction Industry".

The articles for an issue need to reach CEAI at least 3 weeks prior to the end of the month of the ViewPoint issue. Articles need to be in Times New Roman 12 with single line spacing with before and after 6 pt and normal margin, on A4 size. A recent clear and bright passport size photograph of the author(s) is to be sent along with the article. For details of formatting please refer to "*Format for Articles for CEAI Viewpoint*" on CEAI's website, under '*Publications*'.

Advertisement in ViewPoint

ViewPoint is circulated to all CEAI Members, FIDIC, Ministries of the Government of India, Ministries of the State Governments, Administrations of Union Territories, Public & Private Sector Undertakings, Construction Firms, Contractors, Consultants, Foreign Missions and Funding Institutions in India and other organisations related to or dealing with the engineering profession. Thus, all stakeholders partnering development and progress are its readers.

Catch the Customers Eye
Get Wide Exposure → **VIEWPOINT**
Improve Visibility

Support from CEAI members and stakeholders are sought for increasing the number of advertisements, so that ViewPoint gains in its stature as a unique Technical Publication for the fraternity and the public at large to spread information of how Consulting Engineers are helping society for improving the quality of life and doing so sustainably.

The rates for advertisements in **VIEWPOINT** are given below:

Item	Rate Per issue* (Rs)	Discounted rate at 10% for 2 consecutive issues* (Rs)	Discounted rate at 20% for 4 consecutive issues* (Rs)
Back Cover	25,000.00	45,000.00	80,000.00
Inside Front Cover	18,000.00	32,400.00	57,600.00
Inside Back Cover	18,000.00	32,400.00	57,600.00
Full Page (Colour)	12,000.00	21,600.00	38,400.00
Full Page (Colour), if a specific page position is required.	14,000.00	25,200.00	44,800.00
Full Page (B&W) (such advertisements will be taken up for printing only when there are 4 or multiple of 4 advertisements for an issue)	8,000.00	14,400.00	25,600.00

Notes: *GST @ 5% or as prescribed will be added to the above rates.

bt Business Today

News

Union Budget

Budget 2024: Realtors demand Govt's focus on the affordable housing

As building affordable homes turned unviable for developers post-GST, its share has fallen sharply.



Arnab Dutta

• Updated Jun 28, 2024, 2:29 PM IST



As building affordable homes turned unviable for developers post-GST, its share has fallen sharply.

As the union budget is nearing, stakeholders of the country's real estate sector are increasingly putting forward their demand from the Finance Minister Nirmala Sitharaman.

While, their demands are wide-ranging - from reduction in goods & services tax (GST) to removal of regulatory hurdles, one of the key demands that is gaining chorus this time is aid for the faltering affordable housing sector.

Source: <https://www.businesstoday.in/union-budget/story/budget-2024-realtors-demand-govts-focus-on-the-affordable-housing-435050-2024-06-28>

Gen & Tech Quiz

1. What led to the concept of Affordable Housing?
 - a. Company townships
 - b. Proximity to workplace
 - c. Increase production
 - d. Industrial Revolution
 - e. All the above
2. Where can affordable housing for the public be first traced to?
 - a. USA
 - b. Germany
 - c. UK
 - d. Japan
 - e. India
3. Which category of urban population has maximum housing shortage?
 - a. Middle Income Group
 - b. Low Income Group
 - c. Economically Weaker Section
 - d. High Income Group
4. Which is the maximum usage of urban land in a city for?
 - a. Residential
 - b. Commercial
 - c. Industrial
 - d. Transportation
 - e. Green Areas
5. What are the main hurdles faced by the government in providing housing for all?
 - a. Affordability of a house
 - b. Appropriate faster construction technology
 - c. Land availability
 - d. Water & Sanitation
 - e. All the above
6. Which is a social infrastructure for the neighbourhood?
 - a. Parking facility
 - b. Swimming Pool
 - c. Mall
 - d. Play Ground
 - e. Cinema Hall
7. What is not part of sanitation and sewerage?
 - a. Sewers
 - b. Manholes
 - c. Piping
 - d. STP
 - e. Landfill
8. Building management involves?
 - a. Construction
 - b. Maintenance and Repairs
 - c. Planning
 - d. Designing
 - e. Obtaining Approvals
9. Which factor does not affect housing planning & design?
 - a. Climatic factors
 - b. Seismic activity
 - c. Socio-cultural factors
 - d. Technological factors
 - e. Proximity of social amenities
10. Which is a man-made issue?
 - a. Storm
 - b. Earthquake
 - c. Draught
 - d. Reclamation of water bodies
 - e. Tides

The first person who mails the correct answers to CEAI info@ceai.org.in will get a congratulatory mail and will be acknowledged by publishing the persons photograph in the next issue.

Contributed by A P Mull

Answers to Tech Quiz March 2024 issue

1. (c), 2. (a), 3. (b), 4. (a), 5. (e), 6. (d), 7. (e), 8. (c), 9. (d) 10. (a)



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