JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Selection criteria for Energy efficient Building materials in India's Affordable housing

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Abstract : There are many factors that guide the selection of building materials for housing. The stakeholders of the project - the users, engineers, architects and builders have a decisive role in the selection of material palette. Most of the sustainability criteria focus on environmental impact of the building whereas in housing, there are many other factors like social, economic, technological and perceived sustainability and perceived aesthetics in addition to environmental impact. This study analyses the criteria that guide holistic selection of sustainable materials in affordable housing in India. It also highlights the barriers that prevent and strategies which can accelerate the adoption of energy efficient building materials for affordable housing in India.

Keywords: Sustainable building materials, Energy efficient building materials, affordable housing, low energy, low carbon

1. INTRODUCTION

Housing is one of the fundamental rights of human beings. As per the technical committee report of Ministry of Housing and Urban Affairs (MoHUA), it is estimated that housing shortage at 18.78 million during the 12th Five Year Plan period of which over 95% of this housing shortage is estimated in the Economically Weaker Sections (EWS) and Low-Income Group (LIG) categories. Accordingly, to address this shortage, intensive efforts are required to substantially increase affordable housing stock. MoHUA has also initiated the Global Housing Technology Challenge - India (GHTC-India) which aims to identify and mainstream a basket of innovative construction technologies and materials from across the globe for housing construction sector that are sustainable and affordable.

2. SHIFT FROM TRADITIONAL TO MODERN BUILDING MATERIALS

The introduction of modern construction technologies and materials like concrete and steel caused a setback for traditional building materials like mud, bamboo etc. According to Akande O K et al (2021), based on a study in Nigeria, native dwellers have settled for the high taste of fashion, modernity, show of affluence and status in place of the sustainability that local and low impact material have to offer. Affordable housing can be achieved through sustainability by incorporating environmentally friendly and community-based principles through the choice of construction material (Gilkinson, N and Sexton, M 2007). The construction materials can be grouped as 1) Short term renewable origin (timber, wool, straw) 2) Extracted or mined (earth, sand and gravel) 3) Extracted and further processed (lime, cement, plaster, slate, stone, brick) 4) Extracted and highly processed (steel, glass and plastics) 5) Recycled or reclaimed (reused timber, brick, aggregate, steel, glass, insulation). Each category has different impacts on the environment in terms of its energy usage and emissions.

3. SELECTION CRITERIA FOR SUSTAINABLE BUILDING MATERIAL

The selection of a building material based on its sustainability depends on its environmental, social and economical impact. All tangible impacts that cause harm in terms of carbon emissions and utilization of resources are accounted in environmental impact. The factors involving people and their perception comes in social impact. Economical impact includes the affordability and economic sustenance of the materials.

3.1 Environmental impact

To analyze the environmental impact of the building materials and technology, it is important to define the basic concepts of energy use and carbon emissions in buildings.

3.1.1 Initial Embodied Energy (IEE)

This is the energy consumed in the production process of a product, from the extraction of raw materials and processing of natural resources to the manufacturing and transport of products to building construction sites. It also includes the energy that is directly associated with the construction activities. IEE is thus all the energy that is consumed in the pre-use phase of the building's lifecycle (Dixit, M.K and Singh, S 2018).

3.1.2 Recurrent Embodied Energy (REE)

This refers to the energy required to maintain, repair, and/or refurbish the buildings during their service life. REE is a function of how a building is used by its occupants, the maintenance demands of the occupants, the service life of the building, and the life span and quality of the materials and components. (Lotteau, M et al, 2017).

In affordable housing, if the building is designed as low energy building with natural lighting and ventilation, the demand for operational energy becomes insignificant. In a study conducted by Deepak, B et al, (2022)122 numbers of Indian affordable houses of chosen typologies were analysed for its initial embodied energy and recurring embodied energy. It was found that the REE is equal to 86% of IEE, based on only three major construction materials (Fired clay bricks, cement and steel) in only three building components like Terracing, Flooring with skirting and Plastering/Rendering.

3.1.3 Demolition Embodied Energy (DEE)

This is the energy consumed to destroy the building at the end of its lifecycle, recycle and re-use some components, and dispose of others by transporting the debris and waste to landfills or incinerators (Azari, R., and Abbasabadi, N 2018).

3.1.4 Operational Energy (OE)

It is described as the energy used in keeping the indoor environment within the acceptable range and other human activities (Chen, T et al, 2000). Operational energy can vary depending on the level of luxury essential to occupants, the predominant climatic environments as well as the operational plan (Ezema, I et al, 2016). Since the operational period of a building is around 30 to 50 years, conserving operational energy can reduce the energy emissions to a great extent.

3.1.5 Embodied Carbon (EC)

Embodied carbon is the carbon dioxide (CO2) or greenhouse gas (GHG) emissions associated with the manufacture and use of a product or service. For construction products, this means the CO2 or GHG emission associated with extraction, manufacturing, transporting, installing, maintaining and disposing of construction materials and products. The majority of embodied carbon for a construction product is CO2 emitted from the use of fossil fuels in extraction and manufacturing of construction materials and as a result of process emissions from manufacturing (Cao, C 2017).According to Jennings, M et al, 2011, 8.1 Gt of carbon dioxides is added to the global system as a result of high impact buildings. The global system experiences a harsh impact because of high emission of carbon dioxide (Mohad, H.A et al, 2018). The Durban, South Africa, International Union of Architect (UIA) conference held in 2014 by the Architecture profession, jointly projected 2050 as year from which building will experience zero carbon emission. Though developed countries are known to generate the greatest emission, the impact is maximum in developing countries. Hence for countries like India with a huge housing shortage, it is high time to adopt low energy and low carbon strategies in an affordable way to meet housing demands.

3.2 Social impact

Perception of people about the building material's aesthetics and functionality is a significant factor in the decision of material selection. To analyse the low energy building materials with respect to the perception of community /occupants, it is important to understand the factors that influence the choice. Durability, structural performance, sustainability, reduced total cost of building, buildability, aesthetics, ready availability, ease of maintenance, accessibility, sustainability, lack of knowledge about other materials are some factors inferred from a study by Akande O K et al (2021).

3.3 Economical impact

The affordability of building materials against its longevity is a significant factor in material selection. Some materials may be more affordable and sustainable but fails in durability (e.g. Bamboo, Mud etc). Some materials may have more embodied energy, and emissions but may be very durable and affordable (For e.g. Concrete block). Hence it is important to choose materials which are economically viable at the same time environmentally sustainable and aesthetically appealing to the user.

4. Barriers preventing the adoption of energy efficient materials

Lack of awareness by the users, mindset of seeing low energy materials as an indicator of been poor, occupants low-income class, the poor outlook of the finished product, the life span of the material, clients preferred choice as regards the materials, lack of database on the impact placed by high impact materials on the environment are some of the findings identified in the same study as the barriers preventing the integration of low energy materials.

5. Strategies to adopt energy efficient materials for housing

If the biases towards low energy materials have to be lessened, there is a need for public awareness towards the environmental impact of the conventional materials. Building professionals and developers should use these materials frequently to increase the familiarity and popularity. The Govt. can have maximum standards set for embodied energy for different housing types. The outlook of the low energy building materials need to be improved to increase the aesthetics of the finished product. The compressive strength of the materials should be improved so as to improve durability, structural performance and life span of the material. The public should be enlightened on maintenance policies and strategies that will make the use of these materials sustainable. High impact materials should be reused or recycled to reduce the embodied carbon emission as well as embodied energy emitted (Akande O K et al, 2021). Societal enlightenment as against the mindset that low impact materials is for the poor who cannot afford expensive high energy materials is a major strategy required to increase popularity of low energy materials.

6. Conclusion

If the huge housing demand is met by using energy efficient building materials, it will result in significant reduction in the environmental impact caused by the buildings. Hence it is important to incorporate energy efficient building materials which has better environmental performance in terms of embodied energy and operational energy. At the same time, the biases of these materials should be positively changed so that users are more aware and motivated to use energy efficient materials in their housing.

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