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Barriers in Application of Passive Strategies to Multifamily Residential Buildings in Hot and Dry Climate of Aurangabad

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ABSTRACT

The population and economic growth has resulted in the increase of, India's energy consumption. Specially in hot and dry climate significant amount of energy is utilized for cooling. Passive building strategies play an important role in reducing solar heat gain, which reduces cooling demand and overall energy consumption. This paper conducts in-depth research and discussion on the main obstacles to the use of passive strategies in the design of multifamily residential buildings in hot and dry climate. The online survey method was used to conduct this research. A questionnaire was created by reading relevant literature and combining expert opinions. It was sent to architects, developers, civil engineers, and students of architecture who work or study in the city who were the respondents for the study. The questionnaire was distributed to 190 people, and 60 responses were collected and analysed. The results showed that cost was the primary barrier among all four groups of respondents in application of passive strategies to multifamily residential building in Aurangabad. However lack of awareness among occupants was also identified as the second major barrier. Other barriers identified were lack of awareness among designers and developers, Lack of availability of materials and Unskilled labours.

Keywords: Passive strategies, Barriers, Multifamily buildings, Awareness

1. INTRODUCTION

For human life to continue on Earth in a sustainable way, combating global climate change and ensuring resource efficiency are constant requirements. Building energy use generates considerable carbon dioxide emissions, which are linked to the factors contributing to climate change, as well as a significant demand for the use of limited energy resources.[1] Energy consumption in the building sector is very high, and it is expected to rise further as living standards rise and building typologies change. [2] Climate, particularly in hot and dry climates, is another major factor that influences energy consumption. There is large temperature fluctuation in such a climate, resulting in increased use of air conditioning systems and thus increasing energy consumption. [2]

Aurangabad, a city in the Indian state of Maharashtra, has a comparable climate. With 1,175,116 people, it is the fifth-most populous urban area in Maharashtra (according to the 2011 census). Even though it's one of Maharashtra's largest emerging cities, the majority of its buildings lack proper consideration for the local temperature, which necessitates a substantial amount of energy for cooling during climate extremes. Between February and May, climate is characterised by high temperatures and low relative humidity. The daily mean maximum outdoor temperature between these months is around 38°C [3] with low indoor air velocity. Due to the high indoor temperature, the majority of building occupants experience on going and escalating problems with the indoor environment.

There are currently over 3 lakh (As per 2011 census) households in urban areas, with a large number of people living in multifamily residential buildings. As the population in metropolitan area of city is rising with time, demand for the housing units are at its peak due to which new housing schemes are introduced by builders and developers in this area almost every day. As construction activities are increasing in city, conventional building materials and practices are replaced by new materials and technologies. Requirement of new houses is only increasing with the time and causing more demand of energy. Many buildings may drastically cut their

energy use by implementing passive measures. The secret to creating a passive building is to make the most of the local climate. [4]

The aim of this research was to identify the barriers to the use of passive design strategies in the construction practise of multifamily residential buildings in Aurangabad. The objectives of this research were to investigate the existing passive strategies for multifamily residential building in the city's hot and dry climate, as well as to investigate and analyse barriers to incorporating the same into conventional multifamily residential building construction practises. This research will aid in the identification of problems encountered by professionals in practise, as well as providing a base for further studies to address these barriers.

2. LITERATURE REVIEW

There is an increasing need to install energy saving measures due to the low replacement rate of older structures. [5] The practises used in buildings to reduce energy use include both passive and active approaches. Active measures include things like upgrading HVAC systems, using energy-efficient appliances, lighting systems, and renewable energy sources, as well as distributing energy as effectively as feasible while ensuring occupant comfort. In contrast, passive measures minimise energy losses through the building envelope and maximise the use of natural heating, cooling, and lighting potentials in order to lower energy demand. [6] With the help of solar and wind energy, as well as the natural qualities of building materials, passive architecture ensures that interiors stay warm in the winter and cool in the summer, creating a comfortable environment all year long. It is claimed that using these techniques will make the building more comfortable while using less energy.[4]

2.1 PASSIVE STRATEGIES

In order to make a building more comfortable to live in or work in, passive cooling implies lowering the temperature variations between the inside and outside of the structure. Correct window placement and daylight design, the choice of appropriate glazing for windows or skylights, the proper size of glass shading when heat gains are avoided, the use of light or reflective-colored materials for the building envelope and roof, careful siting and wise orientation decisions and appropriate landscaping design are just a few passive cooling strategies that can be used in hot and dry climates. [4] These design strategies can be used to reduce the need for mechanical cooling systems. Hanam Taleb (2014) has further proven in their research which looks at the use of passive strategies to improve thermal performance and reduce energy consumption of residential buildings in U.A.E. buildings that by adopting these eight passive cooling strategies, 9% reduction in cooling load has been achieved in real case study building selected as a sample. It was further claimed that if the building used passive cooling strategies, total annual energy consumption could be reduced by 23.6%. [4]

n a hot and dry region, mechanical systems account for the majority of the energy load; however, this load could be decreased by including components in the building, such as louvered shading devices, which can drastically reduce energy usage while allowing light to enter. Another consideration could be selecting an appropriate glass type for windows, which will prevent harsh radiation from entering the building while still allowing the room to be naturally day lit. Numerous studies and experiments have demonstrated that some passive design techniques, such as the use of suitable building materials, an ideal building orientation, sufficient natural ventilation, and specific design elements, can provide natural cooling and/or heating while consuming less energy. [7] These methods may not necessitate any additional capital investment.

Despite all of the study that has been done to date, many regions of the world still lack practical application of the results. It is important to recognise the importance of Passive House and other low-energy building design principles. The greatest low energy designs, in example, give occupants the option of better environments and more steady and controllable levels of thermal comfort while also lowering energy expenses. These co-benefits should be extensively leveraged to promote energy efficient design when governmental legislation and regulation are not setting the standard. [1] It is noted in one of Adrian Pitts' (2016) research that the UK government's enthusiasm for upholding prior pledges to low energy design has decreased. Another important conclusion from the same study was the possibility for UK design experts involved in low energy design to profit from the opportunity.

If accurate data on the advantages over time were easier to access, the use of Passive House and low energy requirements may be increased. [1] Adoption of energy-efficient housing is not hindered by a single factor. Instead, there are a variety of problems that need to be resolved as part of the obstacles. The implementation of passive design projects within construction businesses has been significantly influenced by internal pressure, and the findings indicate that personal dedication is a key and arguably the most important driver. [8]

Research has been done in various ways to identify the major barriers to the development of passive buildings. One such a research has been done by (Shengkai et al. 2019) in China in which survey method was used. By reviewing pertinent literature and aggregating expert comments, this survey assembled a total of 18 independent and non-subordinated influencing factors from the four dimensions of technology, economy, policy, and environment. It was noted that a significant barrier to the promotion of passive buildings is the general public's lack of awareness. The key barriers range from minor to major in terms of climate

characteristics, scientific research power, emphasis, incentive programmes, supervision, and mandatory rules. Four indicators, including "the degree of emphasis of designers," are part of the policy dimension in addition to the objective aspect of China's climate characteristics. [9]

Most South-East Asian countries are dealing with growing environmental issues as a natural consequence of economic development. South-East Asian countries face very different sustainable development challenges, but they also face common challenges typical of industrialising and urbanising economies. These and other obstacles make the pursuit of sustainable development and construction in South-East Asia especially difficult. The region's major barriers to sustainable construction include a lack of awareness, training, and education, as well as ineffective procurement systems.[10]

2.2 BARRIERS IDENTIFIED

Following are the major barriers identified in the study by Shafii (2006) that could contribute to construction of passive buildings:

- **A lack of knowledge regarding environmentally friendly construction:** Sustainability is still a relatively new notion in developing countries. In general, the region is becoming more aware of sustainable building and construction, although not across the entire construction sector.
- **A lack of education and skills in sustainable design and construction:** Because they are unfamiliar with the idea of sustainable building, many important stakeholders are naturally reluctant to change. The biggest obstacle is hence a lack of knowledge of the significance of sustainable design.
- **The increased cost of sustainable construction:** Many interested parties think that the building sector won't become green until it offers them some sort of financial benefit. Other than energy efficiency, which is believed to yield quick returns, the majority of customers are not interested in any sustainable elements.
- **Regulatory obstacles:** Government policies and regulatory frameworks do not promote the development of the construction industry.
- **Lack of designers/professional abilities:** Future architects and engineers may not be adequately prepared to grasp these roles and duties by current school architecture and design curriculum or construction education.
- **Disincentives to Local Material Production**

These barriers may differ for the Aurangabad region. As a result, identifying barriers for a specific region is critical. It is also necessary to identify which are the primary and major barriers that must be addressed first. As a result, the purpose of this study is to identify barriers to the use of passive strategies in the hot and dry climate of Aurangabad.

3. METHDOLOGY

The research commenced with a thorough review of the literature to identify the recent global trends of passive homes. It was investigated whether any relevant information on this subject has already been published. Literature survey was also done to identify earlier research done regarding the topic. Various literature was identified through online survey method to conduct research on this specific topic.

The questionnaire was developed through a review of the literature and factors identified form it, as well as through face-to-face discussions with experts in the field. The first step in preparing a questionnaire was to understand the local climate type and to list suitable passive strategies. For hot and dry climate passive strategies based on natural ventilation (cooling) and natural lighting (Day-lighting) were selected. Face-to-face discussions with experts helped to understand current housing scenario, building typology, materials and technologies used for construction and it also helped to understand design procedure of multifamily residential buildings.

Based on the gathered information, stakeholders who were involved in executing multifamily residential projects were identified as respondents viz. architects, civil engineers, developers and students of architecture. The identified professionals are currently working or studying in Aurangabad city and have in depth knowledge about construction scenario in that particular region.

Questionnaire was divided into several parts. The first part contained personal information regarding profession and year of experience. Second part of questionnaire gathered information about thought process of respondents while executing multifamily housing projects. It also involved understanding the respondents' knowledge regarding passive strategies and green building certification. The last part of the questionnaire asked the respondents what they thought were the primary barriers and which were the barriers frequently faced by professionals in applying passive strategies.

The questionnaire was sent administered via online messaging application and other social media platforms from 1st January 2023 to 5th January 2023. The questionnaire was circulated among 190 people who were working or studying in Aurangabad city. Out of the total forms administered, 60 responses were collected and considered for analysis.

4. RESULTS

60 responses were considered for analysis and the distribution of the respondents consists of 31 architects, 9 developers, 11 civil engineers and 9 students of architecture. Distribution of responses are shown below in Figure 1.

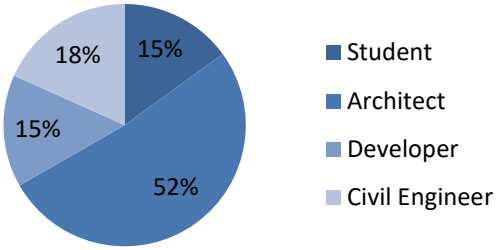
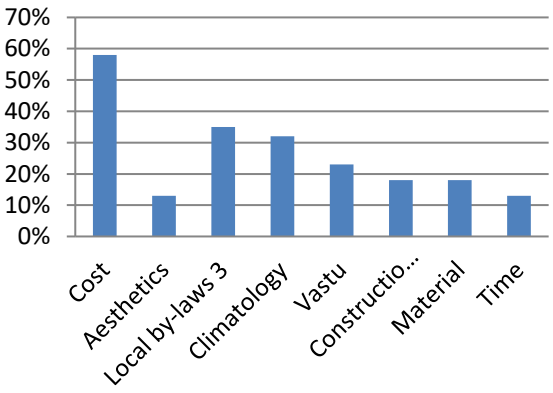


Figure 1 Distribution of responses collected from various professions

Respondents were given eight parameters to choose from: cost, aesthetics, local by-laws, climatology, vaastu shastra, construction technology, material, and time required for construction. Results show that Cost is a primary consideration for 58% of respondents among all professions and all age groups when designing multifamily residential buildings, while priority to climatology were given by only 32% of the respondents. Figure 2 below shows statistics about priority given to each parameter by respondents.



among respondents about passive strategies that can be used in Aurangabad's hot and dry climate. According to the findings, 75% of respondents were aware of the passive strategies that can be used in hot and dry climates.

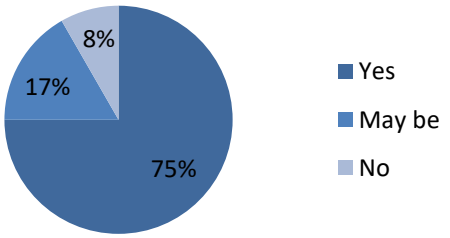


Figure 3 Awareness about Passive Strategies among Respondents.

In the above Figure 3, it was observed that 8.3% respondents were unaware of passive strategies; however, when a list of suitable passive strategies based on cooling, natural ventilation and natural lighting for hot and dry climates were given to respondents, it was observed that only 3.3% respondents were not aware of any passive strategies (as seen in fig. 4 below) while at least one passive strategy from list given was known to the respondents. The majority of respondents were aware of ventilation as a passive strategy.

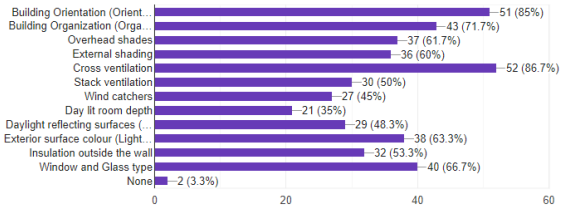


Figure 4 Passive Strategies known to respondents

Further, respondents were asked to rate on a scale of 0 to 5 (where 0 - never and 5 - always) the frequency of considering passive strategies while designing. As per the responses, results show that, 41% of respondents frequently considered passive strategies for multifamily housing as seen in Figure 5 below.

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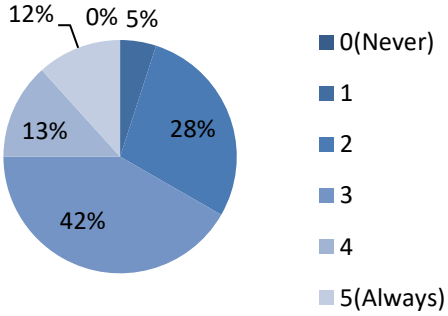

Figure 5 Frequency of consideration of passive strategies while designing

Based on face-to-face discussions with experts and literature study, a list of barriers was identified, and respondents were asked to select the options that they perceived to be a barrier. Figure 6 below shows the repose to this question. It was seen that cost, awareness among occupants and unskilled labour were mostly recognized barriers by the respondents.

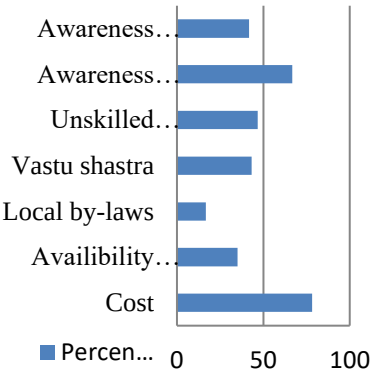

Figure 1 Barriers in application of passive strategies

Respondents were also asked to select the primary barrier they face while designing and constructing a project, and the findings as seen in figure 7 below show that the majority of respondents faced cost as the primary barrier.

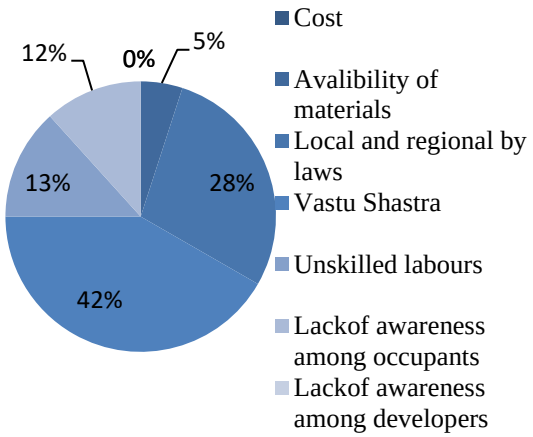

Figure 7 Primary Barrier faced by respondents

When asked if respondents faces any other barrier not mentioned above while designing passive multifamily residential building it was found that, other barriers faced by respondents were lack of trust on architect or designer by the clients and fancy demands by the clients for their buildings without any background knowledge. Sometimes a restricted plot area creates a barrier because of occupants needs are greater than plot areas. It can be difficult at times to meet all of a client's needs while also implementing various strategies.

5. DISCUSSIONS

After collecting responses from all four respondent groups, responses were also analyzed separately each group by profession. Each profession has a unique role to play in the project's execution, and the problems encountered by each type of professional may differ. Also, knowledge and awareness among each respondent group may differ. The responses collected were compared based on three factors: design priority, awareness of passive strategies, and the primary barrier encountered when implementing passive strategies.

5.1 PRIORITY GIVEN TO CLIMATOLOGY WHILE DESIGNING A PROJECT:

When design procedure wise priorities are compared, it was found that 59% of architects gave priority to cost while designing a project. This number is greater among developers. Cost was the preliminary factor in design for 80% of developers. Among students and engineers this percentages are 30% and 41% respectively. When the responses for the climatology parameter are examined, it was seen that only 25% of architects mentioned this as a first preference. This figure is slightly higher among students, with 30% prioritizing climatology as a primary factor in design. None of the developers and engineers considered climatology as a primary factor.

5.2 AWARENESS ABOUT PASSIVE STRATEGIES AMONG DIFFERENT GROUP OF RESPONDENTS:

When data on awareness of passive strategies was analyzed, it was seen that the majority of respondents from each professional group were aware of passive strategies that are appropriate for the local climate of the Aurangabad region. For architects, students, developers, and engineers, the figures are 94%, 90%, 90% and 83%, respectively. It was observed that architects had higher levels of awareness than other professionals, while engineers have the lowest levels.

5.3 PRIMARY BARRIER FACED BY DIFFERENT RESPONDENT GROUPS:

From figure.8 below, cost and lack of awareness among occupants about passive buildings were identified as primary barriers faced by all respondent groups. It was also seen that architects had prioritized 6 barriers amongst which cost as the primary barrier was identified by 35% of architects. On other hand developers have recognized only 3 barriers amongst which cost was identified as the primary barrier. Through the analysis of responses given by civil engineers it was observed that they have recognized 4 barriers amongst which again cost remains the primary one and other barriers faced by them are unskilled labourers, availability of materials and lack of awareness among occupants. Students also identified cost as a primary barrier as seen from the results.

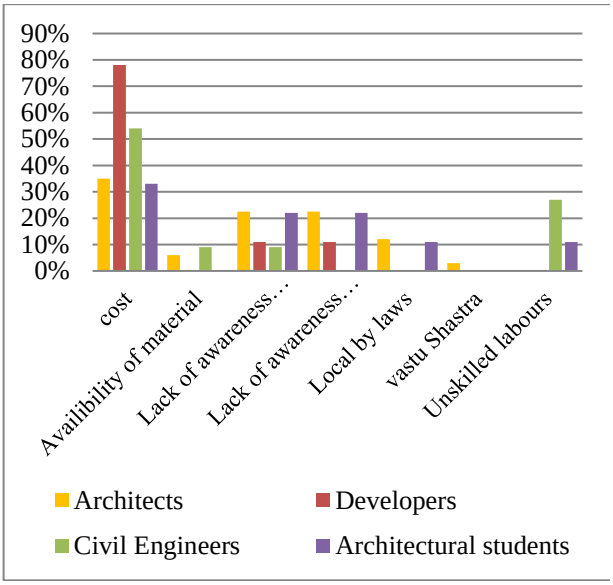

Figure 8 Comparative analysis of primary barrier faced by every respondent group

6. CONCLUSION:

While looking at the changing housing scenario and adverse impact of excessive energy consumption it is critical to design buildings with local climate and energy requirements in mind. For analysis respondents were categorized into 4 groups according to the profession that is architects, developers, civil engineers and architecture student. According to the survey, 75% of respondents are aware of passive strategies, and 16.7% believe they may be aware. In contrast, 8.3% of those who responded were completely unaware of passive strategies.

According to the findings, cost is considered as most important factor while designing any multifamily residential building among all groups of respondents. Because the majority of multifamily residences are built for commercial purposes, the preference order shifts, and the majority of respondents rank local climate as third or fourth parameter. When respondents were asked about the frequency with which they used passive strategies, it was seen that only 11% of them always used passive strategies while designing and only 41% of respondents consider passive strategies in their design on a frequent basis.

Primary barriers faced by all groups were analyzed individually as well. Findings shows that cost is the primary barrier faced by all respondents despite of profession and year of experience. The second most significant barrier identified was occupants' lack of awareness. The third most significant barrier was the lack of awareness among designers and developers. Local by-laws, vaastu shastra, material availability, and unskilled labour though were not identified as primary barriers.

This research has tried to understand the awareness amongst the various stakeholders in the construction industry as well as the barriers considered by them in designing using passive strategies but has not considered the users and their awareness about the same. The research can be taken further to understand strategies to reduce the initial cost required for application of passive strategies as well as ways to provide direct benefits to occupants or developers in terms of cost. However it is suggested that if some benefits in terms of tax is given by government to occupants or developers then people might think more positively about adopting passive strategies to multifamily residential buildings. Further research can also be undertaken to understand the awareness in occupants or users and evaluate if any difference in perception exists between the designers, developers and the users.

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