© 2017 IJSRST | Volume 3 | Issue 6 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Integration of Energy Efficiency in Early Design Stage-Architects' Perspective

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ABSTRACT

In the wake of growing concerns of energy issues, the architects are also being looked upon for designing energy efficient buildings. This paper attempts to gain an insight into the various factors affecting the design decision making by architects in this regard. The research is further extended to identify the various related issues. The aim of this paper is to highlight the role of architects in integrating energy efficiency in the early stage of a building design and to understand the expectations of architects for design aids. The methodology adopted in the research was to collect data through an Online survey method using "Google Forms" in which a questionnaire was sent to 300 architects in India. The responses gave a clear indication towards the need of design aids which could help the architects in achieving energy efficiency targets in the buildings. The responses also established the characteristics of such design aids so that these could be integrated smoothly into the existing design process adopted by the architects. The findings of this research can be used in future research for the development of design decision making aids or tools for the architects, so that the global issues of energy deficiency can be addressed at large.
Keywords: Energy, Energy Efficiency, Design, CO_2 emissions, Buildings

I. INTRODUCTION

Buildings, Energy Demand And Environmental Impact

In present scenario, the world population is approx. 7 billion which has been projected to reach the figure of 10 billion by 2100. Corresponding to the needs of this population growth, the building sector is also expected to expand. [1] It is estimated that almost 40% of all energy within a country is consumed by its building sector only. [2] In 2007, IPCC had highlighted the fact that the energy demand in buildings had grown at an annual rate of 2 percent between the years 1971 to 2004 and this growth rate was in tandem with the rate of increase of related CO_2 emissions. Considering the regional scenarios, it was reported that the developing Asia was responsible for around 30 percent CO_2 emissions due to the electricity consumption. [3] During its entire life cycle, a building consumes approx. 80%-90% of energy for its operations of heating, cooling and other installations whereas the rest of 10%-20% is consumed for the purposes of construction, manufacturing of materials and finally demolition. [4]

Hence, it can be established that the building sector, energy demand and CO_2 emission cannot be dealt with in isolation to each other. Buildings consume energy for their operation to maintain thermal comfort conditions and the outcome in the production of this energy requirement is in the form of CO_2 emissions. Thus, in a way, buildings can be held responsible for climate destabilization.

II. METHODS AND MATERIAL

Building Sector In India

Being a developing country, India's economy is at a rise with an annual growth rate of 7.1% in GDP for the year 2016. At the same time, India has world's second largest population of 1.324 billion which is growing at an annual rate of 1.1%. Due to the driving forces of growing economy and population, the urban population is also growing at a fast pace of 2.3% annually. It implies that more and more people shall be moving to urban areas and more buildings shall be needed, which shall lead to expansion of building sector. Due to these key indicators, the electric power consumption in kWh

per capita has increased by 3 times from 1990 to 2016. [5]

Scope of Energy Efficiency In Buildings

When the buildings are being seen as the key causes of energy concerns, they can also be considered as the prime candidates for implementation energy efficiency measures. There are a few promising facts regarding the scope of energy efficiency in buildings with special reference to India. In 2010, Mckinsey reported that India has still to build approx. 70% to 80% of its buildings which shall exist in 2030. It indicates that still there is a scope of integrating energy efficiency into the design of these new buildings which have still to come up. In the same report it was highlighted that by improving the energy efficiency of buildings, industry, appliances and transportation sector, India can reduce its energy demand by almost 20% in 2030. In this way, India can reduce its CO_2 emissions by 50 million tonnes till 2030. [6]

The integration of energy efficiency in building design ensures an energy saving potential ranging from 20% to 50%, depending upon the measures/strategies adopted. In this way, the floor area electricity consumption of a fully air-conditioned building can be brought down from 200 kWh to 120-160 kWh. [7] The energy efficient design strategies ask for using appropriate climate responsive architectural design, building materials and appliances for the overall reduction of energy demand of a building in maintaining indoor comfort conditions. By the adoption of Passive controls, i.e. climate–responsive building design, the requirement for any Active controls, i.e. Mechanical means of HVAC can be minimised to a great extent. [9]

Present Building Design Trends

The buildings as being designed today seem to challenge the climate rather to go hand-in-hand with it. [10] Most of the Modern buildings are coming up as aluminium and glass boxes which need an enormous amount of electricity for maintaining indoor comfort conditions. [4] In that way, they not only have high operational costs but also have lasting environmental impacts for years. Therefore, there is an urgent need to incorporate energy efficiency in new buildings to come up in India, and architects need to reconsider their design approaches. [11]

Role of Architects

The newer materials, technologies and increased demands for comfort conditions of the built environment have posed challenges for the current generation of architects. [10] Buildings are no longer seen as shelters only but have to be comfortable against all odds of outside climate. Therefore, it becomes imperative to design them as per the common design principles of energy efficiency, i.e., the building design is optimised for orientation, form and shading of windows. [3] The architects can use various energy saving materials to insulate the building components i.e. Walls, Roof and Windows to further increase its energy efficiency. Due to such a magnitude of requirements of comfort, energy efficiency and environmental concerns, the role of an architect has gained immense significance. [11] The architects need to adopt to this new phase of design expectations whose they have to integrate newer methodologies and tools in their design process.

Design Process

A typical design process can be divided into the phases of Analysis and Plan development. The specifications for the climate performance of a building are considered in the analysis stage to arrive at a sketch design which is more qualitative in real sense. Thereafter, precise specifications of building components (i.e. Walls, Roof, Windows etc.) are finalised in the Plan development stage, which are quantitative in nature. In other words, the building design moves from the early / sketch stage to the construction stage. The 20% of design decisions taken during the early design stage have a major impact on the rest 80% of decision making. [12] Moreover, setting the targets in the early design stages lead to more efficiency in overall design process. [4] To gain an insight into the various factors affecting the design decision making to achieve energy efficiency in buildings, an online survey method was chosen to send questionnaire to the architects.

III. RESULTS AND DISCUSSION

Survey Methodology

The questionnaire was designed and created in "Google Forms" and sent to 300 architects for the collection of data related to energy efficiency issues w.r.t design of buildings. The responses were received from 82 architects from all over India (from 11.7.2015 to 31.7.2015). Out of 82 respondents, 38% were young architects with 1-8 years of experience, 42% were from middle age group with 9-15 years of experience and 20% were above 40 years of age, with a professional experience of more than 16 years.

Survey Design

The questionnaire consisted of a total of ten questions and had been divided into three major sections – Section-I, II and III. The aim of Section-I (questions 1-3) was to establish the role of climate and energy efficiency in the design process. It also enquired about the reasons for including them in the design and the stage at which they would like to integrate them in the design process. Section-II (questions 4-6) inquired to identify the particular elements of climate which influenced the built form, as accounted by them. It also asked for the elements of built form (walls, roof, windows etc.) taken into consideration in response to the climate and energy efficiency. The questions further expanded to explore the design techniques adopted by the respondents for achieving energy efficiency in the built form. Section-III (questions 7-10) intended to identify the barriers in adoption of available design techniques. It also extended to inquire about the need of any design aid in the form of guidelines to be used in the design process. Finally, the expectations of architects regarding the design and guidelines were identified.

Survey Results

Section-I

In response to the important factors in a design process, a large majority of the respondents mentioned "Function" of a building as the most important factor followed by "Climate and Energy Efficiency" as a criteria in their design. The other important factors based on the responses included "Structure", followed by "Site", and finally "Cost" and "Aesthetics" (Fig. 1).

Since Climate and Energy Efficiency were the focus of this questionnaire, the next question inquired about the reason of inclusion of climate and energy efficiency in their designs. Majority of the respondents (70%) described "Improved building designs", as the reason of inclusion, followed by 25% who said they did it for "building certification" and 5% mentioned that it was done for "prestige and fame" (Fig. 1).

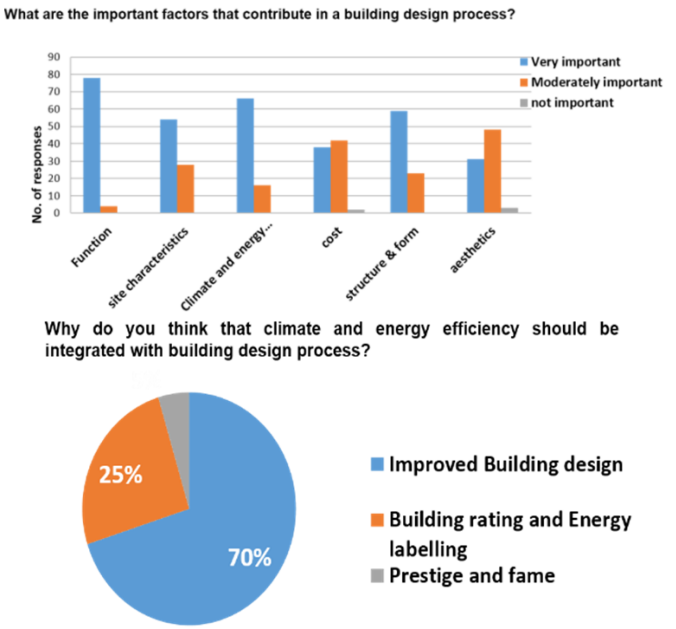

Figure 1. Responses for questions related to contributing factors in design process, and need for integration of climate and energy efficiency

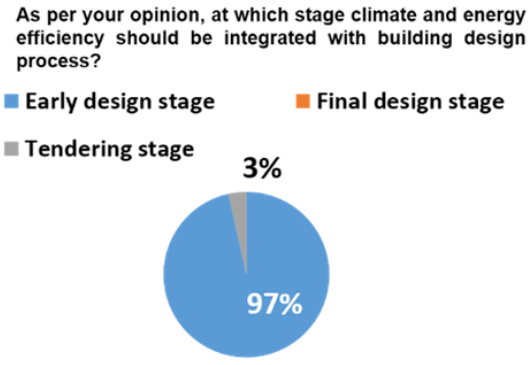

Figure 2. Responses for questions related to climate, energy efficiency, design stages and building envelope

The third question was regarding the stage at which energy efficiency should be incorporated in the design process. Most of the respondents (97%) answered for inclusion of energy efficiency in "early design stage"

and 3% asked for this inclusion at "tendering stage" (Fig. 2).

The responses of the first section had revealed that "Climate and Energy Efficiency" are considered almost as important as "Function" in order to achieve improved building designs.

Section-II

In response to the dominating element of climate influencing the design process of architects, "Solar radiation" was mentioned as most important by respondents, followed by "air movement", "rainfall" and finally, "humidity" (Fig. 3). When inquired about the particular element of built form taken into consideration by them for energy efficient design, then a majority of respondents identified "Roofs" as major design component of built form, followed by "Windows and skylights", "Walls", "Shading devices", "Material u-values" and finally, "surface colour and texture" (Fig. 3).

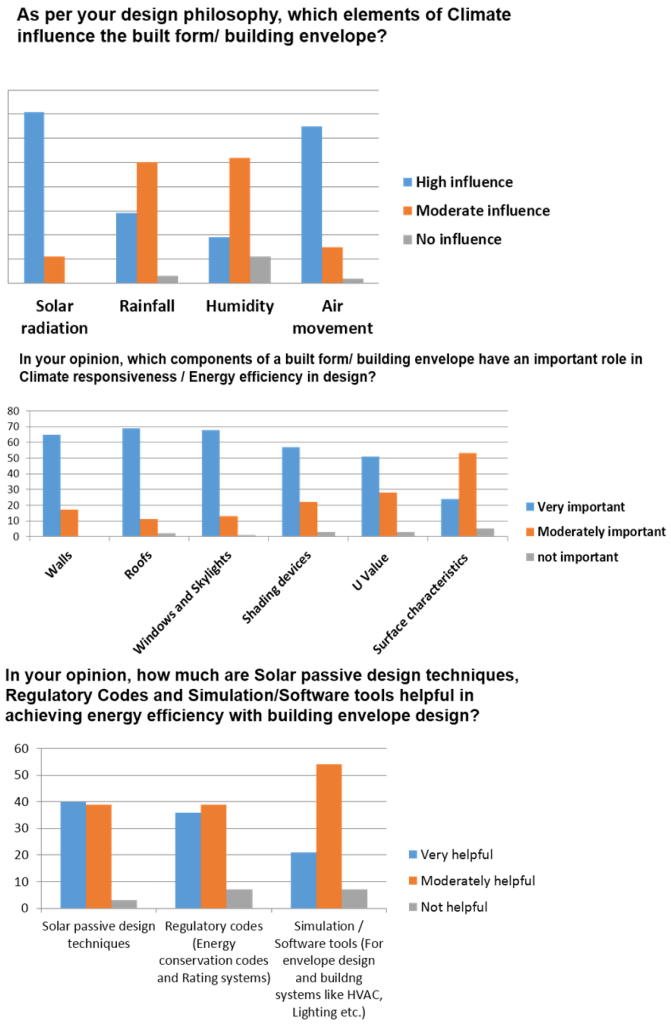

Figure 3. Responses related to envelope components and design approaches for Energy efficient envelope design

In response to the design techniques adopted by the architects for energy efficiency, the "Solar Passive Design" techniques led the design scenario, followed by the "Regulatory codes/rating systems" and finally "Simulation / Software tools", which were favoured by a small number of respondents (Fig. 3).

The findings of this section suggested that "Solar radiation" is considered to be tackled at the first instance and almost all the components of built form are taken into consideration by the architects in the design process. Mostly "Solar Passive Design" techniques are relied upon for achieving energy efficiency.

Section-III

In response to any barriers in adoption of design techniques of energy efficient design, the respondents mentioned the "difficulty of their interpretation" as the major barrier. The other reasons given were "high cost" for simulation tools and "lack of knowledge" for these techniques (Fig. 4).

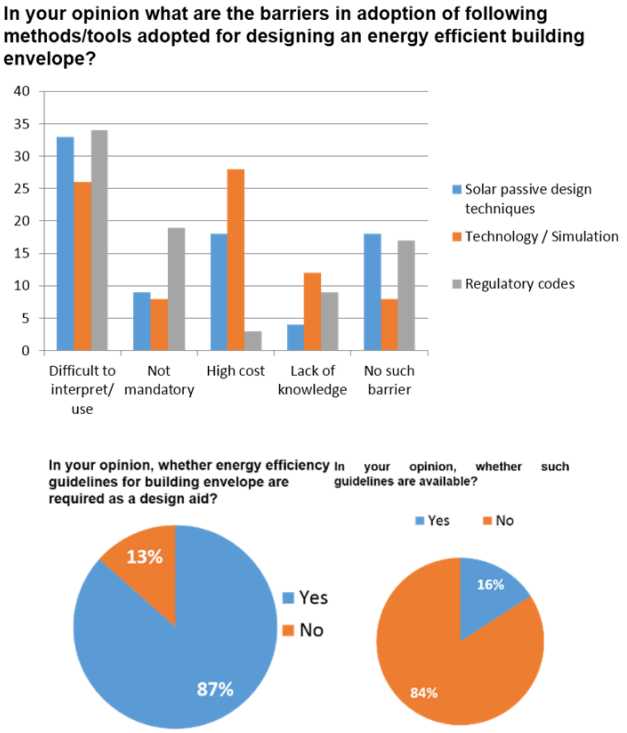

Figure 4. Responses related to barriers in adoption of methods/ tools for Building envelope design and availability/ need of energy efficiency guidelines

The fact to be noted in this section was that the architects have mentioned "Solar Passive design" techniques as "very helpful" in the design process in the

previous section, but in this section, most of them found their adoption as "difficult to interpret/use", which implies that the architects need some design decision making aid for incorporating these techniques. Moreover, the role of "Simulation tools" could also not be negated just because of "high cost" & "difficulty of use".

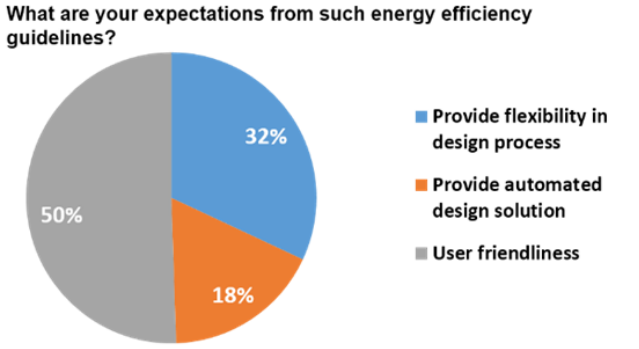

Figure 5. Responses for expectations of Architects from energy efficiency guidelines

The responses to next question regarding the need of any specific energy efficiency guidelines in this regard validated this need as 87% of the respondents that a design aid shall be helpful. The architects were inquired about their knowledge of any such guidelines, to which 84% showed their ignorance (Fig. 4).

Finally, the last question was put forward to find out their expectations from any such guidelines in future, and 50% of respondents want them to be "user friendly", 32% ask for providing them with "flexibility" in design process and the remaining 18% expect to get an automated design solution (Fig. 5). The findings of this section suggest that energy efficiency guidelines are required as a design aid for the architects so that they can incorporate the energy efficiency techniques early in their design process. Such design guidelines should allow for flexibility in design process and must be user friendly/easy to interpret.

IV. CONCLUSION

The energy efficiency can easily be integrated in the building design process at early stages of design so that maximum energy savings can be achieved. The role of architects has evolved over time but the basic principles of climatic design considerations hold importance and potential of achieving energy efficiency in present energy deficit scenario also. The research has established the need of development of specific guidelines for energy efficient design which can act as design aid for the architects. Such specific guidelines can have the capabilities of simulation tools embedded in them but have to be user friendly and must allow flexibility in the design process

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