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Benchmarking Energy Efficient Design Practices in Pakistani Construction Industry

Rizwan U. Farooqui
Professor, NED University of Engineering & Technology, Karachi, Pakistan
rizulhak@neduet.edu.pk

Tahir Khan
Research Scholar, NED University of Engineering & Technology, Karachi , Pakistan
tahirkhan5720@gmail.com

Abstract
Energy saving is a high-priority around the globe due to depleting sources of energy production. Pakistan is amongst one of the major victim of Energy crisis. It is the matter of substantial fact that most of the buildings in Pakistan are not designed by keeping in mind the energy efficient principles. For this reason, energy-efficient measures are being increasingly implemented in all sectors. The building sector is responsible for an important part of the energy consumption in the world. Most of this energy is used in heating, cooling, and artificial ventilation Systems. But there are lots of parameters, if taken into account while designing buildings can significantly reduce energy consumption. A survey conducted indicates that the architects in Pakistani Construction industry somehow take into consideration different energy efficient parameters while designing buildings.

Keywords
Energy Efficient Design, Reduce Energy Consumption, Energy Efficient Parameters.

1. Introduction

World mostly relies on oil & gas for electricity production but these sources are not sustainable. If oil production remains constant until it's gone, there is enough to last 42 years. Oil wells produce less as they become depleted which will make it impossible to keep production constant. Similarly, there is enough natural gas to last 61 years and there is enough coal to last 133 years (Global Energy Crisis, 2010). Due to these eye opening facts, currently significant efforts are being made to improve energy efficiency and to reduce energy consumption.

Since buildings are responsible for the major portion of the energy usage, so by efficient use of energy in buildings can reduce significant amount of energy consumption. The conceptual design phase of a building is the best time to integrate sustainable strategies. When these mechanisms are put into action at

the very beginning of the construction phase, this reduces implementation costs as compared to when they are installed in subsequent stages of construction (Wang et, al. 2006). The energy efficiency of buildings is significantly influenced by architectural design aspects, such as orientation, shape of the building structure, where the openings of windows are located, etc.

Energy crisis is hindering economic development of the Pakistan. The problem of energy crisis is due to the electricity demand being more then the production capacity of the national power grid (The Energy Crisis in Pakistan and its solutions, 2011). As buildings account for a major portion of total energy & since buildings in Pakistan are not designed by keeping in mind the energy efficiency measures, energy consumption is climbing day by day. So this study intends to benchmark the practices of the architects in Pakistani construction industry, that how much they incorporate the energy efficient design principles in their design while designing buildings.

2. Literature Review

Omer (2008) has considered appropriate heating and cooling design as one of the best methods to achieve desirable environmental conditions that reduce energy consumption and cost in buildings required, due to which, significant efforts have been made in recent years in improving energy efficiency and cost reduction.

However, an existing study has demonstrated that the improvement of energy performance in buildings is possible by focusing on appropriate building parameters, despite the negative effect of mandatory decisions (Wilde P et, al, 2002). Increasing energy demands and decreasing energy availability throughout the world are leading to the compulsory efficient usage of energy in every sector. One of the main sectors of high energy consumption is buildings. Thus, the design process and the energy performance of buildings are critical issues for designers (Petersen S & Svendsen S, 2010).

Complex buildings like office buildings have to experience/undergoes through the process of performance evaluation. In spite of this, performance evaluations is mostly implemented in the late stages of design because architects hardly ever have the familiarity with the performance evaluation or hardly realize the significance of energy simulation tools for this purpose. Architects have general knowledge about form, materials, and preferred HVAC systems in buildings; if the impacts of these parameters on energy performance are known by architects then this knowledge can be used to improve energy performance during the early stages of design (Schlueter A & Thesseling F, 2009).Though architects have relatively limited information about the effects of building parameters on energy performance in the early stages of building design, they have to deal with several uncertain and sensitive parameters (Morbitzer C et,al , 2001).

Optimizing early design green parameters in an architectural design contingent on the building types and climatic conditions is a significant task, because climatic conditions are different in different areas/localities and it is very much a challenging scenario to judge, predict and control the climatic conditions. Furthermore, it affects amount of the energy consumption in buildings (Lam JC et, al , 2010)

The various sensitive building parameters that have an important influence on the thermal comfort in naturally ventilated office buildings (de Wit MS,2001). Some parameters in terms of architectural points of view have been selected and are assumed to be the main variables that influence the annual heating and cooling energy loads in apartment buildings: the building shape, the window-to-external-wall area, the envelope color, the thermo-physical properties of building materials, the thermal insulation, the natural ventilation, and the air infiltration (Yusuf Yıldız & Zeynep Durmu Arsan, 2011).Now the furthermore parameters are divided from early described parameters are the length and width of the apartment building; the air infiltration rate; the natural ventilation rate; the window areas in the South, North, East, West directions; the U-value and solar heat gain coefficient (SHGC) of the windows based on their orientations; the thermal conductivity of main external wall material; the thermal conductivity of the thermal insulation material on the external wall, roof and ground; the specific heat of the external wall; the thickness of the thermal the insulation on external wall depending on the orientations; the thickness of the thermal insulation on the roof and ground; the color of the external wall based on the orientation and the color of the roof. (Yusuf Yıldız & Zeynep Durmu Arsan, 2011).

3. Scope and Objectives

The present study is limited to conduct questionnaire survey from building Architects of the Pakistani construction industry and benchmarking their practices associated with energy efficient design.The present study was initiated with following objectives in mind.

- To study the international best practices of the building architects regarding energy efficient design.
- To Benchmark the local practices of the building architects regarding energy efficient design.

4. Methodology

The following steps were taken to achieve the desired objectives:

- After relevant literature collection, literature review was conducted to assess international / global best practices regarding energy efficiency measures in the building's design.
- In the second phase questionnaire / survey was designed to assess energy efficient design practices in the local construction industry.
- In the last phase survey was conducted from buildings designers & responses were analyzed to benchmark local practices of energy efficient design of buildings.

5. Data Collection Methodology

The questionnaire was developed in such a pattern that the answer given to us by the architects, was in terms of importance and in terms of usage of the energy efficient (green) parameters in the Pakistani construction industry. Questionnaire survey was carried out in the local construction industry. Survey audience included was the architects. Questionnaire was distributed in audience through personal contacts. 32 questionnaires were distributed among selected professionals while 20 responses were received. After scrutinizing 15 responses were found valid.

Table 1: Response Rate

No. of Questionnaires Distributed	No. of Questionnaires Received	Valid No. of Questionnaires	Response rate
32	**20**	**15**	**47%**

6. Data Analysis

In survey, parameters that can create energy efficiency in buildings were assessed by their importance & usage in the construction industry of Pakistan for benchmarking energy efficient design practices. Results of data analysis are shown in subsequent sub-sections.

6.1 Building shape

Initially five parameters under Building shape (***width of the building, height of the building, external wall area, external door area & total floor area***) were analyzed in terms of their importance & usage as shown in Figure 1. Analysis of aforementioned parameters exhibit that 47% of the architect rated width of the building as highly important & 47% revealed that they often used / consider width of building in their architectural design.40%, 33% & 40% rated height of the building, external wall area & total floor area as highly important but on the other side 53% occasionally, 33% always & 47% occasionally consider / used these parameters in their design. For external door area 33% consider it as least important parameter & 33% consider it rarely in their design.

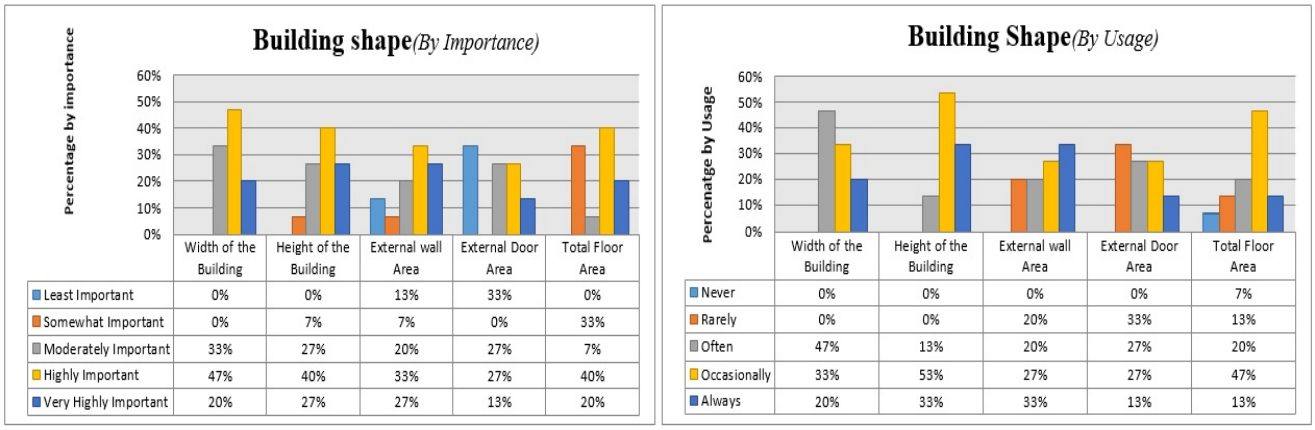

Figure 1: Building Shape *(By Importance & Usage)*

Furthermore five new parameters under Building shape (***shading on building façade, wind direction, path of the sun, natural ventilation & day lighting***) were analyzed in terms of their importance & usage as shown in Figure 2. Analysis of aforementioned parameters exhibit that 33% of the architect rated shading on building façade as very highly important & 47% revealed that they often used / consider shading on building façade in their architectural design.40% rated wind direction & path of the sun as highly important but on the other side 53% & 33% of architects always consider / used these parameters

in their design. For natural ventilation 33% & day lighting 53% consider it as very highly important parameter & 53% of architects consider these parameters always in their design.

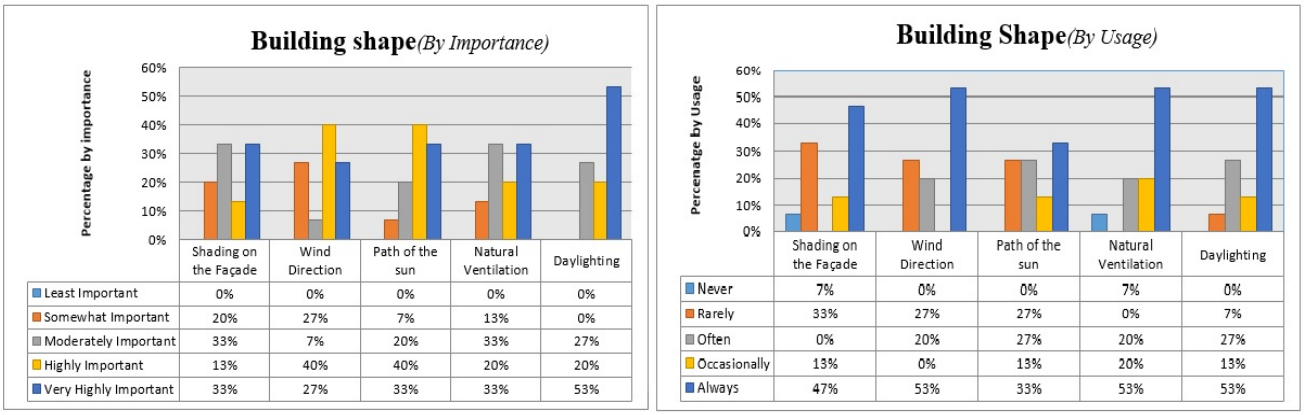

Figure 2: Building Shape *(By Importance & Usage)*

6.2 Windows

For Windows, Figure 3 shows the results of parameters (***placement of windows, U-value, SHGC, thickness of windows and type of windows***) considered under windows. Result reveals that 53% of architects considered placement of windows and U-value as moderately important to be consider in their design but for usage point of view 53% of architects always consider & 27% occasionally consider it in their design. For solar heat gain coefficient (SHGC) 60%, thickness of windows 33% of architects rated it as moderately important but on the other side 33% of architects never used SHGC & 47% rarely used thickness of windows in their design.33% of architects rated types of windows as very highly important and 40% rated it as they used/consider types of windows always in their design.

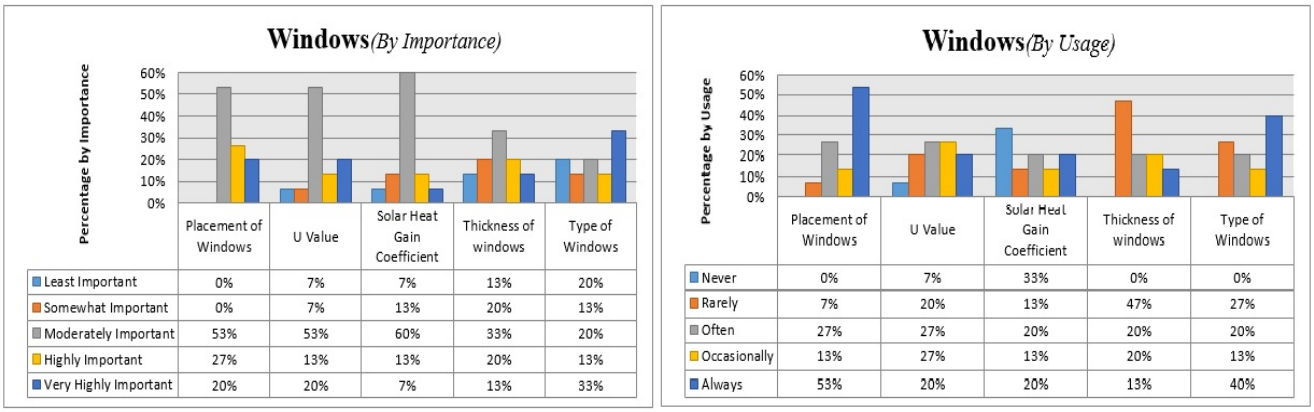

Figure 3: Windows *(By Importance & Usage)*

6.3 Insulation

Underneath insulation six parameters (***thermal conductivity of external wall material, specific heat of external wall, thermal insulation material on the external wall, insulation on roof, insulation on floor & insulation on windows***) were considered. As shown in Figure 4, 40% of architect's rated thermal conductivity of external wall material as moderately important and on the other side 47% of architects always considers it in their design. Architects rated 47% specific heat of external wall &40% thermal insulation material on the external wall as highly important parameters and for usage 40% & 33% consider these parameters in their design.

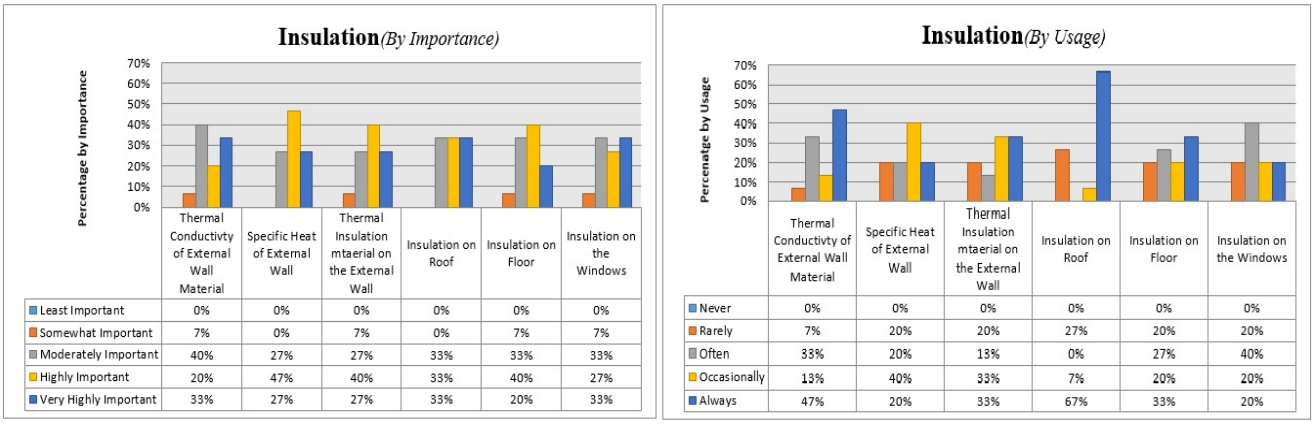

Figure 4: Insulation *(By Importance & Usage)*

6.4 Envelope Colour

Envelope colour contains three parameters (***colour of external wall, colour of roof, colour of internal wall)*** underneath it. As shown in Figure 5, architects rated 33% colour of external wall as moderately important and on the other side 47% of them often consider it in their design. 33% rated colour of roof as somewhat important & 27% rated colour of internal wall as moderately important but for consideration these parameters into their design architects often consider it (67% colour of roof & 40% colour of internal wall) as shown in Figure 11.

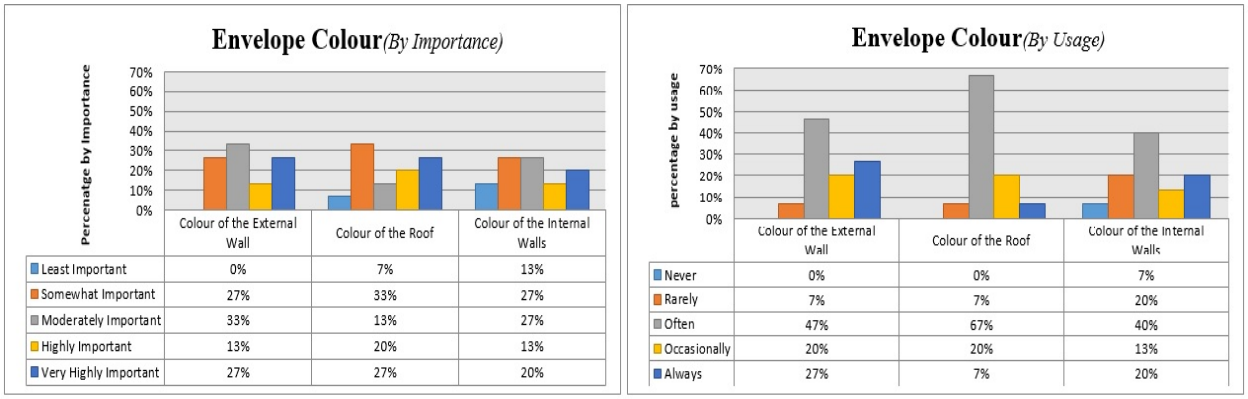

Figure 5: Envelope Colour *(By Importance & Usage)*

7. Conclusions

As sustainable /energy efficient design concept is at its infancy stage in Pakistani construction industry and the awareness graph is also at rather lower side, so, it can be concluded from above facts mentioned in results that somehow architect in Pakistani Construction industry take into account the different energy efficient parameters while designing buildings. Like factors based on the importance 47% of the architect rated width of the building as highly important, 53% of the architects rated day lighting as very highly important and for specific heat of external wall 47% of architects rated it as highly important. And on the other end factors based on their usage 47% of the architect often used/consider width of the building in their design, 53% of architects occasionally consider/used the parameter height of the building, 53% of architects always consider/used placement of windows in their architectural design. The above survey targeted just the architects, so for more strengthen results more studies should have to focus/target to all the stakeholders (architects, constructors, structural engineers and MEP) of a project to benchmark the energy efficient design parameters. This is just further evidence that energy efficiency in a building sector requires a lot of improvements as building sector is responsible for an important part of the energy consumption in the world.

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