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Influence of Client in Adopting Energy Efficiency in the Design Process of Building

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Abstract
Building only consumes 20.1 percent of the total energy in the world [1]. So, the use of energy within the limits of basic requirements and shifting the early design to more green and sustainable approaches can have a significant impact on energy resource management. It is crucial to find out the major reasons that define the limit of energy use in buildings so that any minor to major action plan can be outlined to decrease the energy demand by building sector of Nepal. Client's influence in the design process can be seen as significant from the early design stage. However, changes in the design process can adopt energy efficiency from the initial phase. For this, it is required to understand the parameters where design is influenced by the client.

Keywords
design process, client, energy efficient building, passive design, simulation tools

1. Introduction

Building only consumes 20.1 percent of the total energy in the world. The building sector is a major energy consumer and contributor to the greenhouse gases emission and ozone layer depletion [1]. Another research suggested that the global average of energy used in the building is about 36 percent [2]. The proportion of households using cement bonded bricks/stones or concrete is 61 percent compared to 17 percent in rural areas [3]. But this percentage will vastly increase as around 755,549 residential buildings, 4000 government offices, and 8200 school buildings are damaged due to the earthquake, as the promotion of concrete buildings suggesting them safer and better than traditional ones are bringing shift on construction aspect of reconstruction.

In Nepal, there is a very high urban growth rate. This means people's choice of living standard changes with the time to urban lifestyle with access to modern technologies most of which are a consumer of energy. It is estimated that an additional 1 million houses will be constructed between 2011-21. For this, 55 billion bricks i.e. more than 2300 tera-joule energy will be consumed [4]. Both client and architects have an equal role in making of energy efficient building. To build such an energy efficient building, it is required to understand the thought process of an Architect and what all parameters go into the decision making of the design in its early phase. For this, it is required to understand the parameters where design is influenced by the client.

2. Literature Review

14.5 percent of the total residential sector energy consumption is by the urban residential sector. About 52 percent of the urban energy is used for cooking purposes followed by electric appliances (14 percent), lighting (13 percent), heating and cooling (10 percent) animal feeding (8 percent) and agricultural processing (3 percent). Furthermore, the author analyzed that the overall growth rate of energy consumption is about 2.3 percent per annum. This suggests that a small fall in energy use by buildings would result in a marginal impact on the energy use of nation [5]. So, the use of energy within the limits of basic requirements and shifting the early design to more green and sustainable approaches can have a significant impact on energy resource management. However, it is crucial to find out the major reasons that define the limit of energy use in buildings so that any minor to major action plan can be outlined to decrease the energy demand by building sector of Nepal.

Owners of buildings or buyers of new buildings may mistakenly believe that the efficiency of a certain

building is very good even if it is not. In particular, buyers may mistakenly believe that new constructions automatically are so much more efficient that there is no need to take any further action [6]. This might hamper increased efficiency in new buildings because more efficient buildings and products will not penetrate the market since consumers believe that the existing products and building are already efficient enough. The concept of design phases is related to a set of consecutive actions that guide the development process. These actions are grouped in stages by their level of priority, shaping each phase of the project. It is important to consider the value of each action/goal/objective, predicting its importance on buildings performance and its influence on the projects final cost in order to implement each one at the adequate moment. A performance approach is essential to manage the life cycle requirements of a building during its conception [7].

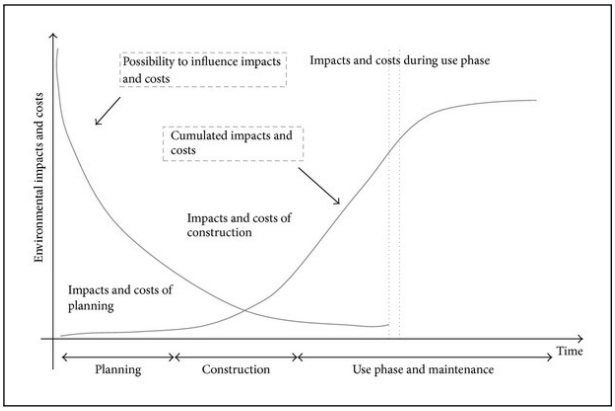

Figure 1: Impact and Cost of Planning

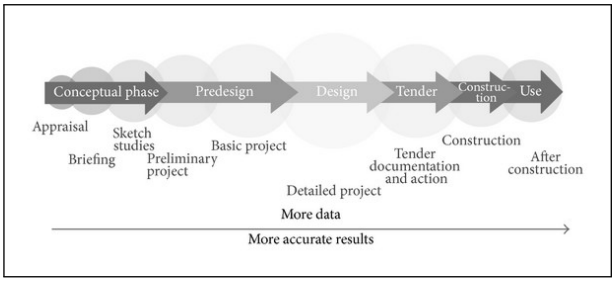

Figure 2: Architecture Design Process

The building materials can be classified in terms of use in building components i.e. foundation, wall material, upper floor/Attic, Seismic resistant elements. Various types of materials can be used in various components. For e.g.: stone, bricks, concrete block, soil stabilized block for wall materials. Altogether Nepal reconstruction authority has listed 13 no of materials for walls and 5 types of materials for roofs. For the wall, there are stone, brick, earthbag local softwood timber planks, interlocking brick, Hollow Cement Concrete Block, compressed stabilized earth block, debris block, light gauge steel, cellular lightweight concrete tiles, cement fiberboard, gypsum board, calcium silicate board. Likewise, for the roof, there are slate, stabilized mud, RCC slab, CGI sheet and clay tiles. For the production of different kinds of materials, different kinds of organic and inorganic raw materials are required.

Expectant architects lack sufficient knowledge and skills to analyze building energy. They always make decisions based on personal experience and do qualitative analysis. Energy performance of windows is influenced by a variety of design parameters such as WWR (window-to-wall ratio), SHGC, U-value, VT, shadings, daylighting control, etc. These parameters affect occupants' thermal and visual comfort as well.

For example, the International Energy Conservation Code specifies the criteria for SHGC considering climate zone, orientation, and projection factor of solar shadings. U.K. Building Regulation Part L2A [8] limits the effects of solar gain in summer by specifying the criteria for the solar gain through the glazing compared to that through the reference glazing. Building Code of Australia specifies the criteria for the aggregate air-conditioning energy value with regard to SHGC, U-value, glazing area, energy constant for the specific orientation, and heating and cooling shading multiplier.

There are some government policy interventions regarding energy efficiency. The 2010- 13 Three Year Plan mentioned the need for energy efficiency and the government's commitment to move further towards better efficiency in the energy sector. Given the lifespan of most buildings, the relative, energy efficiency of new buildings will influence energy consumption for many years. Energy efficient improvements can reduce the demand for and costs of cooling and heating systems. Moreover, a well-designed building with consideration of climate and energy can give a diverse solution to overcome energy demand and sustainable and efficient building performance. The combination of various solar passive design aspects can easily be integrated into new buildings based on the site, orientation of the building and local climatic conditions. Similarly, the use of proper design of day lighting can lead to a tremendous reduction in the use of artificial lights

during daytime and thereby reduces the energy consumption by building for lighting. And the use of energy in a more improvised way can reduce the cost also. However, in Nepal, there are no codes written on building energy. Any available codes only cover the areas of safety. So, a better outline for policy making in the sector of building energy is an essential aspect to mitigate any future energy crisis. The space heating energy consumption of a building can be reduced by up to 80 percent if the orientation, building shape, insulation, and ventilation are optimized in the design process [9].

3. Methodology

The research is located within post-positivist paradigm and hence correlational research strategy was used to carry out the study to understand the influence of client in the early design process, we conducted a survey among the architects who are working professionally to investigate their existing practice, needs, and limitations in an early design stage. Using a structured questionnaire, an online sample survey was carried out. The sample frame of 570 respondent architects was taken from the election of Society of Nepalese Architects held in 2019. Using Cochran's formula [10] for determining the sample size, a total of 234 respondents were selected with considering confidence level of 95 percent and margin of error as 5 percent.

The sample size was distributed among senior Architects (10+ years of experience), Mid-level Architects (5-10 years of experience) and Junior Architects (1-5years experience) covering the entire Nepal. The table below shows the distribution of samples among aforesaid three groups.

Table 1: Sample Distribution

Category	Sample Distribution
Architects (10+ years of experience)	86
Mid-level Architects (5-10 years of experience)	50
Junior Architects (1-5years experience)	98

A covering letter describing the study and its purpose was included with the survey form to explain the answers from the respondents would be anonymous and that their contact information would not be used outside of the study. The survey was conducted for 3 weeks starting March 1, 2019. The questionnaire consisted of 28 measurements that were either yes/no questions, multiple choice or the ratings that are weighted on a scale of 1 to 5. Details of the sections are below:

- Part A: General information, the background of the respondent and experiences were included in this part.
- Part B: This section included the knowledge of architects and workflow. It also inquired about client influences in design decision making.
- Part C: This section inquired about the knowledge of energy modeling tools and its workability. It also included the energy efficiency adaptations taken in considerations and the influences of the client.
- Part D: This section inquired about the reasons for not adopting energy modeling into their design process and the possibility of use of such tools for bringing energy efficiency in design.

4. Analysis and Findings

The sample of 234 architects who responded the survey is fairly diversified in terms of background (age, experience, ethnic group). Out of the 234 architects who responded to the survey, 42 percent are young architects with 1-5 years of professional experience, 21 percent are intermediate architects with 5-10 years of experience and 37 percent are experienced architects with 10+ years of professional experience. Most of the architects who responded to the survey are commercial architects with 35 percent of them that handle less than 50 percent residential projects. About 65 percent of the respondents handle more than 50 percent of commercial projects and about 2.7 percent of them handle commercial projects below 25 percent.

When questioned about the sequence of their design process, the majority of the architects said that they first do zoning of spaces (42 percent), followed by orientation (32 percent), followed by assessing the building structure and designing of building form. Once all this is decided, they choose the building materials. 60.8 percent architects replied that the designed area is depended on clients' requirement with only 2 percent replied it depends on Floor Area Index. 41.5 percent replied that the cost of the building is discussed in the conceptual design phase and 26.8 percent replied it is considered in the first

meeting with a client. Only 4.9 percent replied it is decided in the construction phase.

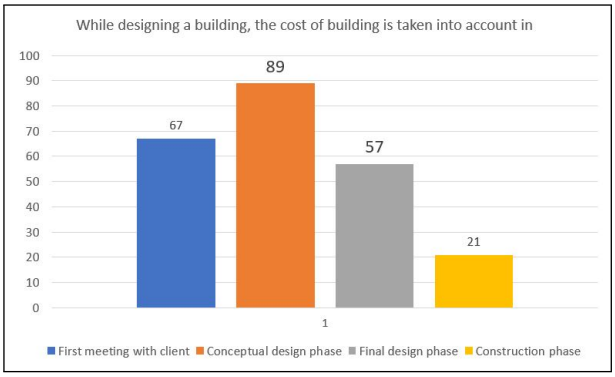

Figure 3: Priorities with respect to Service Quality of Consultants

When questioned about when the material of the building is taken into account, 7.8 percent architects replied it is decided in a first meeting with the client, and also 7.8 percent answered it is all decided by the client and not influenced by the architect. But 47.1 percent replied it is decided in the conceptual design phase and 33.3 percent replied it is decided in the final design phase. The table below shows the understanding of energy efficient building related with the knowledge they acquired based on any training in energy efficient building or green building technology. It can be observed that the experience of architects has a sound influence in the knowledge and understanding of energy efficient building.

Table 2: Priorities with respect to Service Quality of Consultants

		Have you received any training in energy efficient buildings or green building technology?			
	Row Labels	No	Not sure	Yes	Grand Total
Years of experience	10+ years	21	6	59	86
	5-10 years	31	8	11	50
	1-5 years	62	12	24	98
	Grand Total	122	24	88	234

	Row Labels	No	Not sure	Yes	Grand Total
What do you understand by energy efficient building?	Both	35	12	108	155
	Passive and solar responsive building	51	12	16	79
	HVAC efficient building	0	0	0	0
	Grand Total	122	24	88	234

		The requirement of mechanical heating/cooling system is guided by		
	Row Labels	Client's requirement	Design requirement	Grand Total
Years of experience	10+ years	38	48	86
	5-10 years	34	16	50
	1-5 years	73	25	98
	Grand Total	145	89	234

Furthermore, 62.75 percent respondent replied orientation is the most important criteria for energy performance and 66.67 percent replied artificial control is the least important criteria. When questioned about the requirement of the mechanical heating/cooling system, 61 percent replied it is all decided by the client and only 39 percent replied that it is decided by design requirement. Mixed replies were encountered when questioned about client's priorities in design with cost, function, aesthetics on the highest order but 78 percent ranked energy performance in the lowest order of priority of client. It was observed that 96.1 percent architects do not use any energy modelling tools in design process and when asked for the reason for not using, 42.5 percent replied as it is not demanded by client followed by 22.5 percent for lack of knowledge to use energy modeling and 12.5 percent for not being aware of such tools. When questioned about the reason of affecting client's preference of energy efficient building, 47 percent replied that it's due to lack of government bylaws and codes followed by 46 percent due to lack of knowledge in public sector. 62.74 percent respondent agree that client's choice can be the reason for which energy efficient technology is implemented and 82.35 percent agree it depends on the architect's choice.

5. Discussion

Client's influence in the design process can be seen as significant from the early design stage. 60.8 percent of respondents agree that the designed area is dependent on the client's requirement. And also, the discussion for building material is considered in the early design phase mostly. However, the result shows that although the materials are considered in the early design phase, the aesthetics and cost overtook the priorities as energy performance being the least in the priority order. As 96.1 percent of respondents do not use any energy modeling tools, the significance of material choice in energy performance might not be confirmed. It was observed that the use of mechanical heating and cooling is mostly guided by client's choice and also only 25.4 percent respondent gave positive response for the requirement to consider an active heating/cooling system with 45.1 percent gave a neutral response and 29.4 percent gave a negative response. As 78 percent respondents ranked energy performance in the lowest order of priority in design discussion, it might signify that although the design discussions and design process consider aesthetics, cost, and safety, the energy performance of the designed building is not prioritized by the client. This

is also verified by the response regarding the use of energy modeling in the design phase where most of the respondent replied that it is not required by the client. The responses show abundant possibilities that the preference of energy efficient building is mostly guided by the client's preference followed by government bylaws and codes. However, the implementation of energy efficient technologies is dependent on the architect's choice as 82.35 percent respondent. agreed upon this which is followed by the client's choice with 62.74 percent agreed upon this.

6. Conclusion

It is noticeably seen that there is active participation of the client in design discussion and design process and an architect's perception of the building is more or less in line with the communicative references made by the client. It is well observed that the architect takes into account most of the client's preferences but energy efficiency and energy optimization being the least preferred criteria in design discussion, it is always considered minor in the design process. If energy efficiency does not rise as the requirement of the client, the market will not invest in energy efficiency options. Geller stated that minimum efficiency standards can be a very effective strategy for stimulating energy efficiency improvements on a larger scale [11]. However, changes in the design process can adopt energy efficiency from the initial phase. For this, energy modeling tool might be required to have reasonable communication between architect and client for energy optimization and adaptation. For cost optimization, a project needs to be analyzed for its performance from initial design phase to building operation phase.

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