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ANALYSIS OF FACTOR AFFECTING FEASIBILITY ASSESMENT OF INTELLIGENT BUILDING CONCEPT IN CONSTRUCTION SECTOR WITH CONTEXT OF CENTRAL GUJARAT

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Abstract: ***A building that uses both technology and process, to create a facility that is safe, healthy, and comfortable and enables productivity, well-being of its occupants is called intelligent building. It exhibits key attributes of environmental sustainability to benefit present and future generations. The notion of the Intelligent Building is the modern civil engineer's big idea of tackling these deficiencies. Therefore, it is necessary to analyze the intelligent building in the construction industry. However, past research has been done on intelligent building are mostly qualitative and there is a lack of quantitative research. Due to this lack of quantitative research, there is no good-developed framework of factors affecting intelligent building (I.B) in the construction industry. This paper presents the analysis of the factors affecting Intelligent Building ranked in accordance with the most affecting factors based on the survey.***

Keywords: **Factors, Intelligent Building, Construction**, Relative Importance Index (RII), Importance Index (IMPI).

I. INTRODUCTION

An intelligent building can be defined as "the building that combines the best available concepts, designs, materials, systems and technologies in order to provide an interactive, adaptive, responsive, integrated and dynamic, intelligent environment for achieving the occupants' objectives over the full life span of the building."

An intelligent building has an implicit logic that effectively evolves with changing user requirements and technology, ensuring continued and improved intelligent operation, maintenance and optimization. It exhibits key attributes of environmental sustainability to benefit present and future generations. The notion of the Intelligent Building is the modern civil engineer's big idea of tackling these deficiencies. An intelligent building must be smart enough to vary the environment to suit the users and also to provide various means of communication or network regardless of whether it is internal or external.

II. OBJECTIVES OF STUDY

This paper has an objective to act as a foundation for future studies and its results will become an important information in efforts to improve the design of an Intelligent Building practices in the construction sectors. To rank the main factors related Intelligent Building by Relative Importance Index (RII) and Importance Index (IMP.I) method.

III. RESEARCH METHODOLOGY

The data collected to determine the most influential factors on Intelligent Building was done through a survey by explorative questionnaire to the respondents involved in the daily activities of construction firms in various central regions in the Gujarat. The questionnaire was designed so that respondents can give the rank to their answers based on the Likert scale. The analysis of these data was done by a method named relative importance index (RII) method as well as statistical methods using the statistical package for the social sciences (SPSS) Software.

IV. DATA COLLECTION

The target population included civil engineering and building firms of central region of Gujarat. The Architects, Engineers, Clients and Contractors of various city of Gujarat were targeted for the survey. The details of various stakeholders and total numbers were collected through the internet. These details were considered as size of the population to decide the sample size of the study. To obtain a statistically representative sample of the population, the formula shown in Eq. (1) used.

$$n = \frac{m}{1+[\frac{m-1}{N}]} \quad \ldots\ldots\ldots (1)$$

Where n, m and N = the sample size of the limited, unlimited and available population, respectively. m is estimated by Eq. (2)

$$m = \frac{z^2 * p * (1-p)}{e^2} \quad \ldots\ldots\ldots (2)$$

Where z = the statistic value for the confidence level used, i.e. 2.575, 1.96 and 1.645, for 99%, 95% and 90% confidence levels, respectively; p = the value of the population proportion that us being estimated, and e = the sampling error of the point estimate. Because the value of p is unknown, Sincich et al. (2002) [14] suggest a conservative value of 0.50 be used so that a sample size that is at least as large as required be obtained. By using 90% confidence level, i.e., 10% significance level, the unlimited sample size of the population, m, is approximated as follows:

$$m = \frac{1.645^2 * 0.5 * (1-0.5)}{0.1^2}$$

m = 67.65

Accordingly, for the total number of stakeholders as per detail available through the internet, i.e., N = 1129, the representative sample size of the population required, is determined as shown below:

$$n = \frac{67.65}{1+[\frac{67.65-1}{1129}]}$$

n = 63.88

$n \approx 64$

As the response rate is always low, the questionnaire was distributed to various stakeholders more than the sample size requirement. Total 106 questionnaires were distributed to different respondents in Ahmadabad, Vadodara, Anand and Nadiad. They were sent the reminder for sending their feedback after 10 to 15 days of sending the questionnaire. This study received 88 responses. So, the response rate (as compare to sample size = 64) is in this research is 137%, which is considered as very good in this kind of survey research.

The followings two types of approach should be used for data analysis.

A. Relative Importance Index technique

Relative Importance Index method is used determine the relative importance of the various factors related Intelligent Building. The same method is going to be adopted in this study within various groups (i.e. Architects, Engineers, Clients and Contractors). The four-point scale ranged from 1 (No impact) to 6 (Very high impact) is adopted and transformed to relative importance indices (RII) for each factor as follows:

$$RII = \frac{\sum W}{A \times N} \quad \text{.....(5)}$$

Where, W is the weighting given to each factor by the respondents (ranging from 1 to 6), A is the highest weight (i.e. 6 in this case), and N is the total number of respondents. Higher the value of RII is more important.

B. Importance Index technique

In this technique, for each cause/factor two questions were asked: What is the frequency of occurrence for this cause? And what is the degree of severity of this cause on project delay? Both frequency of occurrence and severity were categorized on a four-point scale. Frequency of occurrence is categorized as follows: always, often, sometimes and rarely (on 4 to 1 point scale). Similarly, degree of severity was categorized as follows: extreme, great, moderate and little (on 4 to 1 point scale).

1) Frequency index: A formula is used to rank causes of delay, based on frequency of occurrence as identified by the participants.
   Frequency Index (F.I.) (%) = $\sum$ a (n/N) * 100/4 .....(4)
   Where, a is the constant expressing weighting given to each response (ranges from 1 for rarely up to 4 for always), n is the frequency of the responses, and N is the total number of responses.
2) Severity index: A formula is used to rank the factors based on severity as indicated by the participants.
   Severity Index (S.I.) (%) = $\sum$ a (n/N) * 100/4 ..... (5)
   Where a is the constant expressing weighting given to each response (ranges from 1 for little up to 4 for severe), n is the frequency of the responses, and N is the total number of responses.
3) Importance index: The importance index of each cause is calculated as s function of both frequency and severity indices, as follows:
   Importance Index (IMPI) (%) = [F.I. (%) * S.I. (%)]/100 ..... (6)

A total number of 80 respondents were surveyed from the Gujarat region, namely cities like Ahmadabad, Vadodara, Anand and Nadiad out of which 18 respondents were Architects, 24 were Engineers, 22 were Clients and 24 were contractors. A ranking of the factors was

achieved from the Relative Importance Index (RII) method and statistical package for the social sciences software (SPSS). Also ranking comparison between Architects, Engineers, Clients and contractors are shown below.

V. RESULTS AND FINDINGS

The all ranking indices explained earlier were used to rank factor affecting Intelligent Building from the viewpoints of the Architects, Engineers, Clients and contractors. These respondents included Architects, 24 were Engineers, 22 were Clients and 24 were contractors.

A. Top 10 causes ranked by the Relative Importance Index (RII) technique (based on all respondents):

The relative importance index, RII, was computed for each cause to identify the most significant causes. The causes were ranked based on RII values. From the ranking assigned to identify the most important factors of Intelligent Building in Indian construction industry.

Based on the ranking, the 10 most important causes of Intelligent Building by RII were:

(1) Lift Management.[RII=0.824]
(2) Parking.[RII=0.824]
(3) Lighting Control.[RII=0.816]
(4) Use of light emitting diode (LED) and compact fluorescent lamp (CFL) Lighting.[RII=0.803]
(5) Efficient Use of Water.[RII=0.775]
(6) Sourcing Local Construction Materials.[RII=0.769]
(7) Maintaining Air Quality.[RII=0.769]
(8) Optimum Use of Day Light.[RII=0.767]
(9) Natural Air Flow.[RII=0.759]
(10) Heating, Ventilation ,Air Conditioning And Cooling (HVAC) System.[RII=0.759]

B. Top 10 causes ranked by Importance Index (IMPI) technique (based on all respondents)

The importance index of each cause is calculated as a product of both frequency and severity indices. Based on the ranking, the 10 most important factors of Intelligent Building by IMPI were:

(1) Lighting Control. [IMPI=75.058]
(2) Lift Management [IMPI=75.058]
(3) Parking.[IMPI=74.547]
(4) Sourcing Local Construction Materials.[IMPI=61.184]
(5) Efficient Use of Water.[IMPI=58.219]
(6) Maintaining Air Quality.[IMPI=57.231]
(7) Programmable Logic Controller, Supervisory Control And Data Acquisition (PLC SCADA) Software.[IMPI=56.867]
(8) Heating, Ventilation, Air Conditioning And Cooling (HVAC) System.[IMPI=56.003]
(9) Use of light emitting diode (LED) and compact fluorescent lamp (CFL) Lighting.[IMPI=55.843] (10) Natural Air Flow.[IMPI=54.744]

VI. SUMMARY

It is studied through field survey. It should frequency, severity and importance of the Intelligent Building. The importance index of each cause is calculated as a product of both frequency and severity indices of each factor. 33 factors were identified through research. The field survey included 18 Architects, 24 Engineers, 22 Clients and 24 contractors. Data collected were analyzed by frequency, severity importance and relative importance. Results shows that out of top 10 factors total 7 factors were common in ranking by both methods. They were Lift Management, Lighting Control, Use of light emitting diode (LED) and compact fluorescent lamp (CFL) Lighting, Natural Air Flow, Sourcing Local Construction Materials, Parking, Heating, Ventilation, Air Conditioning and Cooling (HVAC) System. It is hoped that the findings of the paper will help the stakeholders to act on Intelligent Building to raise awareness and feasibility study in their projects.

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