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Performance Evaluation of Green Buildings

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ABSTRACT: Much of the emphasis to date in green building development has been on optimizing energy and resource efficiency. Little was known about user perception and satisfaction in green buildings. It is widely believed that sustainable building design strategies create improved indoor environmental quality and be associated with improved occupant comfort, satisfaction, health, and work performance relative to buildings designed around standard practices. Yet, this belief remains a hypothesis with little empirical support. This study tries to assess the indoor environmental quality of Green buildings in Chennai by conducting Occupant survey. A questionnaire survey for occupant satisfaction was conducted in Anna centenary library building, Kotturpuram which is a Green building and the results are analyzed to assess the satisfaction level of the occupants.

KEYWORDS: Green buildings-Satisfaction-Comfort-Forgiveness-Occupant survey

I. INTRODUCTION

Aim of the study:

The objective of this study is to assess the performance of a green building using selective parameters, Conduct an occupant survey for Indoor Environmental Quality(IEQ) and Assessing the comfort and satisfaction level of the occupants in Green buildings situated in Chennai.

Scope of the study:

This study is concentrated on assessing the comfort and satisfaction level of occupants in green building. The scope of the project is limited to the study of Indoor Environmental Quality(IEQ) in green buildings situated in Chennai.

II. REVIEW OF LITERATURE

A range of green building rating systems, protocols, guidelines and standards has been developed in the past 20 years that respond to the need to evaluate and benchmark levels of building achievement in the green revolution [1]. Lawrence Berkeley Laboratory and Capital E Group observed on cost data for 40 green projects and did an in-depth review of a hundred existing studies in buildings(Kats, Alevantis, Berman, Mills, & Perlman, 2003) [2]. The later financial gains of steps to improve employee comfort and productivity are greater than the cost of construction. U.S. Green Building Council conducted a survey which showed sustainable building design would become a more common practice once the human benefits had been identified (Heerwagen, 2000) [3].

In the study of green buildings, emphasis should be given for the human benefits and occupant comfort is to be given a main preference than other features(Reeder,2010) [4]. There are two large-scale studies concerning green buildings' occupants: one is the Occupant Indoor Environmental Quality (IEQ) Survey and Building Benchmarking by the Center for the Built Environment (CBE) at the University of California Berkeley in North America (Abbazadeh, Zagreus, Lehrer, & Huizenga, 2006; Brager& Baker, 2008). This project identified that on average, occupants in green

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buildings were more satisfied with thermal comfort and air quality in their workspace, while they were less likely to be satisfied with lighting and acoustic quality. On Comparing complaint profiles of those dissatisfied with lighting and acoustic quality, a higher percentage of occupants were dissatisfied with light levels and sound privacy in green buildings [5].

The other large-scale study on green building occupants is the Post-occupancy Review of Buildings and their Engineering (PROBE) carried out by BUS (Building Uses Studies)Ltd. in the U.K. (Leaman&Bordass, 2001, 2007; Leaman, Thomas,& Vandenberg, 2007) [6]. This study disclosed that although tended to be tolerant of these minor shortcomings; this phenomenon was called “forgiveness” which showed occupants’ capability of extending their comfort zone by overlooking inadequacies of their ambient environments. The two studies have succeeded in their initial effort to compare green building and conventional building from occupants’ point of view (Leaman&Bordass, 2007) [7]. The above studies showed that the relationship between green buildings and occupant comfort should be studied.

Occupant survey:

- Preparation of questionnaire for assessing occupant comfort of the building
- Survey of occupants
- For questionnaire survey, the green building “Anna Centenary Library ” in Kotturpuram was selected
- The results of the survey are analyzed using IBM SPSS and “Comfort Index” and “satisfaction index” are found out from the data.

Details on ANNA CENTENARY LIBRARY BUILDING:

The Anna Centenary Library (ACL), a state-of-the-art library in the Chennai is a State library building which is a LEED certified Green building [8]. The construction of the building started on August 16, 2008, completed in a short span and declared open to the public from 20 September 2010.

The built up area of this centralized air-conditioned library is 3.75 lakh sq. ft., encompasses ground and eight floors. At present, it hosts five lakhs books covering wide range of subjects to serve the information needs of the public, academic and corporate community. ACL has a Braille Section, Own Books Reading Section, Children Section, Periodicals and Newspapers Section, Tamil books Section and English Books Section. In addition, the library has a Conference Hall that can facilitate 200 members [9]. One of the special features of this library is that, it is a partner of the World Digital Library (WDL). The networking of Connemara Public Library with 31 district central libraries is under way. All these libraries will be linked with Anna Centenary Library in course [10].

III.INFRASTRUCTURE

Built on 8 acres of land, the 9-floor library houses a total area of 333,140 sq. ft and has a capacity to accommodate 1.2 million books [11]. ACL has planned to adopt an integrated library management system that includes automated issue and return of books, user smartcards, access controls, Radio Frequency Identification (RFID) technology and self-check counters. The library is designed to accommodate a total of 1,250 persons. An auditorium of 50,000 sq. ft. with a seating capacity of 1,280, and an amphitheatre on the terrace that can accommodate more than 800 persons and two conference halls with capacities of 151 and 30 persons respectively, are some of the facilities available. A dedicated children's section, spread over 15,000 sq. ft. has a fun-filled theme-based reading area with multimedia kits and storybooks [12]. The library also boasts a high-tech section for the visually-impaired, with talking books and Braille displays. Parking space exists for about 420 cars and 1,030 two-wheelers. A separate power substation with a capacity of 32 kV has been built on the premises. CCTV cameras have been installed in 493 locations in the building. A food court in the building is capable of serving 180 persons at any given point in time. The library was designed by C.R.N ARCHITECTS. The entrance to the building showcases a 5 ft bronze statue of C.N. Annadurai. The library employs 200 staff, including 96 permanent and 40 contract employees, and has a collection of 550,000

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books. It is visited by about 2700 persons every day. The library has a special section for Braille, children's books and manuscripts etc. The building is designed in such a way that the reading area receives good daylight. The western end is flanked by the service areas to prevent solar radiation. The seven-storey atrium allows in abundant natural light.

In July 2010, the library building received the LEED NC Gold rating from IGBC becoming the first library building in Asia to reach this. This project has achieved 43 LEED points, highest amongst any government buildings in Tamil Nadu thus far.

Work done to assess the Indoor Environmental Quality :

Questionnaires are a valuable way of collecting data from a large group of people .It is important to consider whether a standard or tailored questionnaire is required. Standard questionnaires offer the advantage of being able to gather consistent data across your facilities. The benefit of this is that you can benchmark buildings, or parts of buildings against each other. A standard questionnaire that is available from expert consultancies enable benchmarking a building project against others in the sector. Tailored questionnaires enable examination of issues specific to the building or institution. However, it is possible to combine the two approaches and use a standard questionnaire with a section that is specific to your circumstances.

The questionnaire was prepared on the base of the guidelines of Occupant Indoor Environmental Quality (IEQ) Survey and Building Benchmarking by the Center for the Built Environment (CBE) at the University of California Berkeley in North America (Abbazadeh, Zagreus, Lehrer, & Huizenga, 2006)

Analysis of results:

A total of 100 survey responses were collected, 50 were transient users and 50 resident users. This represents an overall response rate of around 20% of the total number of regular building users which is at an acceptable level. Survey results were processed by the Usable Buildings Trust as part of the licence agreement. The consolidated results for the whole sample and those for the two distinct user groups are summarised in Table 1.

Parameters	Mean scores	BUS benchmarks
Temperature in summer(TS)	3.30	3.31
Temperature in winter(TW)	3.44	3.23
Air in summer (AS)	3.32	3.01
Air in winter(AW)	3.34	3.04
Noise (NS)	3.56	3.23
Light (LT)	3.60	2.96
Overall comfort(CO)	3.52	3.40

Table 1. Mean scores for parameters

From the data, comfort index can be found for the building,the equation is as follows (Zhonghua Gou,2013)

$$1... \text{comfort index} = (Z - TS + Z - TW + Z - AW + Z - AS + Z - LT + Z - NS + Z - CO) \quad ..$$

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Z- normalized mean scores

Using the formula, the comfort index of the building is found to be 0.72. Positive value indicates that the occupant are comfortable in the green building.

IV.DISCUSSIONS

Lighting does not appear to satisfy occupants with the exception of natural lighting. Glare from both external and internal sources is a problem for some, with Glare from lights being one of the few variables to show a substantial difference in perceptions between residents and transients. Lighting overall was perceived by both groups to be acceptable but not completely satisfactory. Occupant comments identified specific issues of concern. The occupants complained that that some areas were not properly illuminated and appear to be dark in evenings.

Noise

Users were quite satisfied with the Noise isolation provided. Mean score(3.56) is much higher than BUS benchmark

Temperature

Overall temperature in winter and summer returned satisfactory scores.

Overall Comfort

The Overall comfort score was a healthy 3.52. This suggests that although there are some concerns in regard to particular aspects of comfort, both resident and transient users are generally comfortable in the building.

V.CONCLUSION

The study confirms the continuing challenges associated with evaluating and benchmarking occupant satisfaction with comfort conditions in green buildings. The historical evidence is that not all green buildings perform well, while some have been rated better than conventional ("non-green") buildings the buildings most poorly rated by occupants are also green buildings. However, in terms of occupant comfort the Anna centenary building performs well in its design. The survey results identify a handful of specific areas where occupants perceive that there are problems - variables relating to noise, lighting and thermal comfort which cannot be ignored. The study has justified occupant ratings that run generally true to form for green buildings. Scores for summary variables such as Overall comfort were slightly better than specific variables under the same heading, while noise intrusion, lighting quality and sensor control were the problematic areas. The results for lighting also point to the complex task of balancing natural light, artificial light and glare in design in order to deliver optimum lighting conditions to a majority of building occupants. Improved occupant satisfaction and performance may be less about green design intent but occupant knowledge of how to manage the situational constraints presented by this new type of built environment in order to deliver the outcomes required.

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