

Barriers and opinion of buildres regarding green building and the extent of greenness of the buildings constructed by them: A study of their interrelationship

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ABSTRACT : The global environment is affected by the irreversible damage caused by the human activities. The increasing rate of real estate industry everywhere is creating pressure on its natural resources and environment. When a building is constructed it effects environment right from excavation of construction sites, construction process, to operation of buildings which requires significant input of energy, water, raw materials also responsible for lots of waste and emissions. Escalating concern for the environmental impact of real estate has compelled the formulation of sustainable solutions by adopting the concept of constructing green buildings. It is considered as integrated approach towards minimising the negative impacts of construction and its operations on the environment. Green buildings are designed and constructed in such a way that it increases the whole lifecycle performance as well as conserve resources. It has been observed that Vadodara city has witnesses a remarkable growth in the construction of commercial as well as residential sectors. Hence, a study was conducted firstly, to find out the opinion of the builders regarding adoption of green building concept in their construction of residential sectors and the barriers faced in adopting the same and secondly to find out the extent of greenness of the selected houses constructed by these selected builders. The data were gathered through a questionnaire from a sample of 75 builders through convenience sampling. The data were also gathered through an observation check list from a sample of 220 existing residential buildings which were constructed between January, 2005 to December, 2013 selected through purposive sampling. The findings of the study revealed that majority of the builders were middle aged. Majority of the builders faced lack of technical knowledge amongst their project team, contractors and clerk and lack of interest in implementing green building concept as high extent of barrier in adopting green building design and construction. Majority of the builders had somewhat favourable opinion regarding green building. Majority of the houses had moderate extent of greenness for all the sub aspects. Nearly three fourth of the respondents' houses had moderate extent of greenness on the overall scale. The results of mean scores were found highest for the sub aspect "Indoor Environment Quality" and lowest for "Innovative Ideas" sub aspect. The builders can be made aware through an educational programme given by the educational institution about the impact of the buildings on the health of the occupants and to construct a building which incorporates features of green building.

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During the late 20th century, awareness of the impact of technology and the expanding human population on the earth increased. More people are moving to the city causing a significant increase in the construction of buildings and skyscrapers and hence, a booming in the city economy but with great repercussions in the environment (Conte and Yepes, 2012). Buildings started to be recognized as major contributors to the world's energy usage, landfill waste and diminishing green space (IFMA Foundation, 2010).

Buildings are one of the heaviest consumers of natural resources and account for an important portion of the greenhouse gas emissions (Yi-Kai *et al.*, 2010). The construction and operation of buildings, specifically residential buildings, require significant input of energy, water and raw materials. Buildings are also responsible for considerable quantities of waste and emissions (Winter, 2008). Buildings not only use resources such as energy and raw materials but they also generate waste and potentially harmful atmospheric emissions (Alnaser *et al.*, 2008). The built environment has a vast impact on the natural environment, human health, and the economy. Significant increases in chemical sensitivity have been linked to volatile organic compounds (VOCs) found in building materials and consumer products (Indian Green Building Council, 2013). This illustrates that humans face a range of negative impact linked to the way buildings are designed, built and maintained. People started to expand their efforts to reduce their environmental impacts.

Over the last several years, there has been a rapidly growing concern about environmental issues and a rising interest in sustainable practices. Sustainability is one of the basic concept that interest people in the field of construction who are trying to apply its technology and strategy according to the architects and industrial progress (Matar *et al.*, 2015).

“Green buildings” are one of the answer to these challenges by integrating the key areas of environmental and human health, protection of ecosystems and preservation of natural resources (including water, agricultural land, timber, minerals, ore, quarry products and fossil fuels), reduction of atmospheric pollutants associated with energy use and materials manufacturing and creation of safe, non-toxic indoor environments. Green building is not a matter of choice or luxury but a necessity for the

environmentally conscious industry professionals, owners, developers, government officials and rest of the stakeholders (Pedini and Ashuri, 2010).

Green buildings are designed to meet certain objectives such as protecting occupant's health, improving employee productivity, using energy, water and other resources more efficiently and reducing overall impact to the environment (Zigenfus, 2008 and Mathew, 2015). It maximizes the use of efficient building materials and construction practices, optimizes the use of onsite sources, uses minimum energy to power itself, uses efficient equipment to meet its daily consumer consumption, maximizes the use of renewable sources of energy, uses efficient waste and water management practices and provides comfortable and hygienic indoor working conditions (Mohanty *et al.*, 2010). By adopting green building strategies, both economic and environmental performance can be maximized. Green construction methods can be integrated into buildings at any stage, from design and construction, to renovation and deconstruction (Cassidy, 2003).

Green building construction has taken off significantly over last decade in India. Several institutional and government bodies have come forward to build sustainable buildings (Mehta and Porwal, 2013). The green building movement in India started with the establishment of the IGBC in 2001, which was an initiative of the Confederation of Indian Industries (CII) along with the World Green Building Council and the USGBC (Roy and Gupta, 2008).

India, too, faces the environmental challenges of the construction sector. Due to the fact that the construction industry is traditionally a largest user of natural resources, the necessity to design buildings with a low environmental impact is increasing. This augurs well for the country and now there is an imminent need to introduce green concepts and techniques in this sector, which can aid growth in a sustainable manner. With the technological advancement in the construction industry, invention of new building materials and scarcity of space these concept of “environment friendly” houses had been overlooked. This has had a negative impact on the indoor and outdoor environmental conditions. Therefore, it is the “Green Homes” which would play a critical role towards averting major ecological crises. Green building is accepted worldwide in the recent past.

There is still a vast community that either is unaware of sustainable design concept, indifferent to its cause, or unconvinced of its advantages. To convince owners, builders, and designers and other stakeholders about the benefits of sustainable design, it is necessary to make them understand the numerous advantages of green building concept.

Vadodara city has witnessed a remarkable growth in the construction of residential units during the later part of the twentieth century and during the early year's twenty first century. At that time all the builders might not have paid much attention to its influence on the residents and environment. Now the upcoming buildings are made "green" but the existing building can also be improved to make them environment friendly. A study was, hence, planned encompassing various aspects in relation to Green Building. Some of the houses constructed by selected builders of Vadodara city were considered for assessing the extent to which they are green (eco-friendly). It was considered important to study the opinion of the builders regarding green buildings and the barriers they face in adopting green building concepts / features.

The findings can prove to be highly useful to the architects and builders or contractors who are the key person behind the construction of the house; so that they can consider the guidelines given by LEED and GRIHA to make the houses that have low impact on the environment which is the need of present era. With this background the present study was conducted.

Statement of problem :

The present research aims to assess selected houses of Vadodara city with regards to the extent they are "Green". It also aims to find out the opinion of builders of Vadodara city about green building and the barriers faced in adopting green building features in their construction.

Objectives of the study :

- To find out the opinion of the selected builders of Vadodara city regarding the concept of green building.
- To find out the extent of barriers faced by the builders of Vadodara city in adopting green building design and construction.
- To assess the extent of greenness of the selected existing houses.

EXPERIMENTAL METHODOLOGY

The research design for the present investigation was descriptive. The data were collected from Vadodara city through convenience sampling. A list of builders of Vadodara city was obtained from 'CREDAI' (an association of builders of Vadodara city). Out of 300 builders of Vadodara city, seventy five were selected who had adopted some aspects of green building in their construction of residential colonies. The housing colonies which were constructed by the selected builders between 2005 and 2013 were selected through Snow ball sampling method, the housing units (houses) were selected from these colonies. Houses from each of the colonies ranging from 1 to 3 were selected. Thus, 220 houses were considered as sample for present study. The tool to collect data was a questionnaire which contained three Likert type scales (1) A scale to find out the extent of barriers faced in constructing a green building. The barriers were classified as 'Lack of technical knowledge', 'Availability of funds, space and materials', 'Green certification process', 'Lack of expected returns' and 'Lack of interest'. The responses were 'Major barriers', 'Minor barriers' and 'Not a barrier' where the scores ascribed were from 3 to 1, respectively. (2). Opinion scale for of builders regarding green building. It had 5 point continuum for the responses 'Strongly agree', 'Agree', 'Neutral', 'Disagree' and 'Strongly disagree'. The responses were given scores of 5 through 1, respectively. The possible maximum and minimum scores were divided in three categories having equal intervals. Higher scores indicated most favourable opinion of builders regarding green buildings. The data were collected through observation check list for the assessment of the selected houses which contained items indicating the greenness of the house in various aspects of the green building *viz.*, sustainable site selection, water efficiency, energy efficiency, material and resources, indoor environment quality and innovative ideas. The factors were assessed through observation and for some factors equipments were used. The presence and absence of the factor were assessed by response "Followed" or "Not followed", "Present" or "Not present", "Applied" or "Not applied" but in order to maintain consistency and clarity in the responses the responses are presented here in the form of "Yes" and "No". Each factor was assigned marks. For each positive response the marks assigned were given and for negative response 'zero' was assigned. The

marks obtained were counted for each sub scale for each of the house. Higher scores indicated high extent greenness of the house. The minimum and maximum possible scores of each of the scales were divided into 3 categories having equal interval for all the scales which determined the extent of greenness of the selected existing buildings. The scale was subjected to establishment of content validity. The reliability coefficient derived were 0.647, 0.746 and 0.786, respectively through test – retest method of establishing reliability.

EXPERIMENTAL FINDINGS AND DISCUSSION

The findings of the study obtained through the analysis of the data, their interpretation supported with discussion are presented here.

Section I : Background information of the respondents :

This section consists of the background information about the selected builders of Vadodara city.

Background information :

The age of the builders ranged between 21 and 51 or more years with a mean age of 43.01 years. Nearly three fourth of the respondents were between the age group 36 to 50 years. It was found that more than one third of the builders had diploma in civil engineering. More than one fourth of the builder's were Bachelor's degree holder in Arts. Less than one fourth of the builders had bachelor's degree in civil engineering. It can be concluded that two third of the respondents were graduate

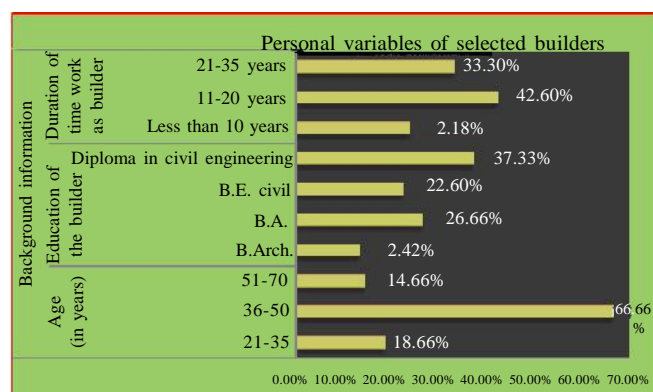
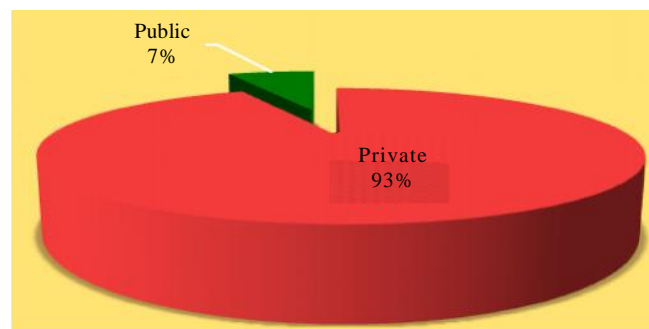


Fig. 1 : Percentage distribution of the builders according to their age, education and duration of time working as a builder

and one third were diploma holder in Civil Engineering. Nearly two third of the respondents were from field related to construction (B.Arch., B.E. Civil and Diploma in Civil Engineering) and one fourth were from arts field. Less than one half of the respondents were working as builders since 11 to 20 years. One third of the builders were in the field of building construction since 21 to 35 years (Fig. 1).

Kind of projects undertaken by builders in which green building elements were incorporated :

In this section the builders were asked to reflect the kinds of building projects in which they had incorporated green building elements. The projects identified were public or private projects in which the builders had worked so far. The results indicated that majority of the builders had incorporated green building elements in Private projects. Only 6.66 per cent of the builders had incorporated green building elements in public projects. It can be concluded from the findings that the builders might had felt freedom in implementing green building elements in their private projects (Fig. 2).



Kinds of projects undertaken by the builders

Fig. 2 : Percentage distribution of respondents according to incorporation of green building elements in various kinds of project undertaken by them

Section II: Extent of opinion of builders regarding green buildings :

The data in Fig. 3 revealed that more than one half of the builders strongly agreed that “Due to the deteriorating environmental quality of Vadodara city, the green building design and construction should be promoted” (56.0%) followed by “Green building design and construction helps in balancing the negative effect of various kind of pollution, hence, should be implemented in Vadodara city”

(50.7%) and “Green building design and construction is a tool which enables the designer to apply green concepts and criteria, so as to reduce the environmental impacts” (49.3%). Less than one half of the builders agreed that People of Vadodara city are environment conscious so Green Building design and construction is encouraged by them (49.3%) and “As the city of Vadodara is witnessing tremendous growth in infrastructure and construction development, Green building design and construction can aid growth in a sustainable manner” (46.7 %).

Less than one half of the builders were neutral about the concept that “Constructing a green building proves to be costlier than ordinary building” (45.3%). Less than three fourth of the builders disagreed that it is difficult to design the building as per the standards and recommendation of LEED than designing the simple houses (61.3%). Less than one half of the builders strongly disagreed that people at present are not aware of green building design and construction, therefore, they do not opt for such housing (40.0%). It can also be concluded from the data that majority of the respondents had “somewhat favourable” opinion regarding green building. Less than one fourth of the respondents had “most favourable” opinion regarding green buildings (Fig. 3).

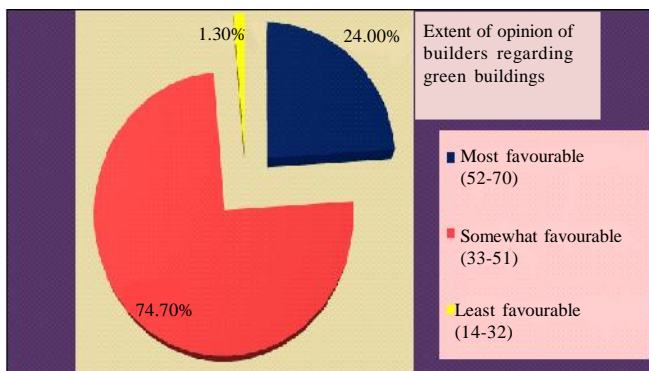


Fig. 3 : Percentage distribution of the respondents according to their extent of opinion regarding green buildings

Section III: Barriers faced in adopting green building design and construction in the projects undertaken by the selected builders :

It was found that lack of technical knowledge of the builders, contractors, clerk and the other project team was found to be at high extent as barrier faced by majority of the respondents amongst all other categories. More than three fourth of the respondents faced moderate

extent of barriers in availing funds, space and materials for constructing green buildings (Fig. 4). Mean weighted scores for each item and category were computed which ranged between 1 and 3. It was found that lack of technical knowledge of the builders, contractors, clerk and the other project team was found to be at high extent as barrier faced by majority of the respondents amongst all other categories. More than three fourth of the respondents faced moderate extent of barriers in availing funds, space and materials for constructing green buildings. The mean weighted score computed for the each category of reason supported this finding (Fig. 5).

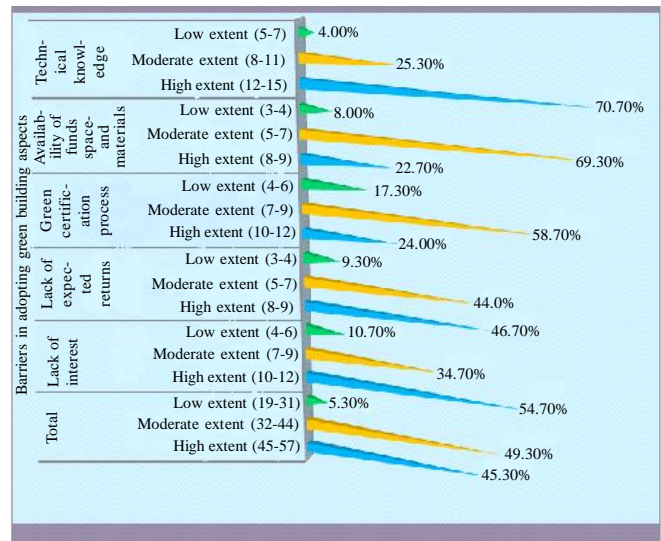


Fig. 4 : Percentage distribution of the respondents according to the barriers faced in adopting green building design and construction

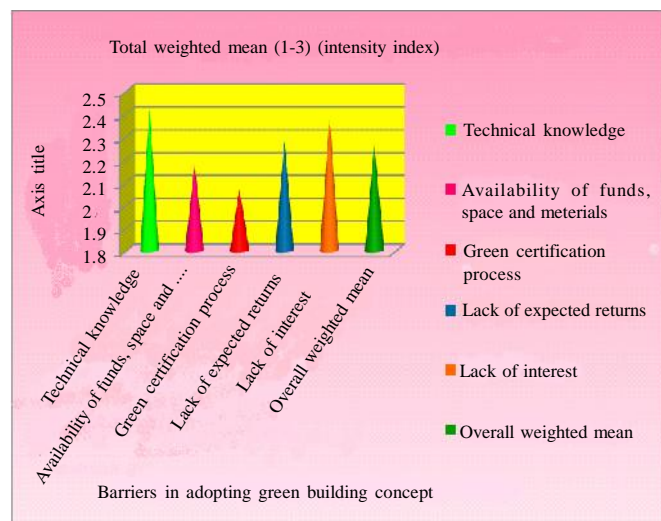


Fig. 5 : Weighted mean for the barriers faced by the builders in adopting green building concept

Section IV: Extent of “Greenness” of the selected houses:

The extent of greenness was analysed in terms of high, medium and low scores obtained on sub-scales viz., sustainable site, water efficiency, energy efficiency, Material and Resources and Indoor Environment Quality and on the entire checklist. The scores on each of the item of the scale were summated and possible range of minimum to maximum scores was divided into three categories having equal intervals. The high scores were considered as high extent of greenness. The possible score on the scale was 0 to 183 (Fig. 6).

Analysing the entire scale, it was observed that none of the houses were found having high extent of greenness. Majority of the houses were green to moderate extent. Low extent of greenness was reflected in less than one fourth of the cases. Regarding the sustainable site less than three fourth of the houses had moderate extent of greenness. More than one third of the houses had low extent of greenness (Fig. 6). On the aspect of water efficiency, more than three fourth of the houses had moderate extent of greenness and one half of the houses had low extent of greenness. About the energy efficiency, more than one half of the houses had low extent of greenness while less than one half of the houses had moderate extent of greenness. Regarding the material and resources, majority of the houses had moderate

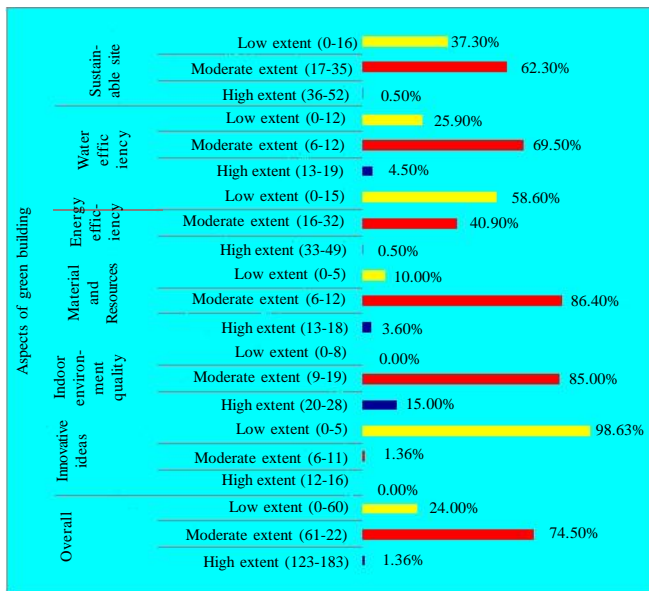


Fig. 6 : Percentage distribution of according to “Extent of greenness” of the selected houses

extent of greenness. Majority of the houses had moderate extent of greenness on indoor environment quality aspect while only 15 per cent had high extent of greenness. Regarding innovative aspects, low extent of greenness was found in all of the houses. The weighted mean (item intensity) for each of the statement and for each of the factors for assessing the existing selected buildings was found.

The weighted mean computed for each factors for assessing the existing selected buildings reflected that the scores for “Indoor Environment Quality” was found to be the highest amongst all the aspects. The aspect of “Innovative Ideas” scored the lowest. The overall weighted mean on all the factors was 0.327 (Fig. 7).

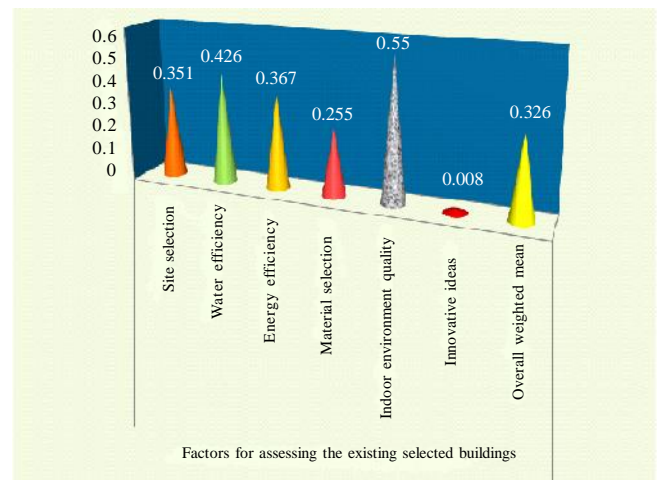


Fig. 7 : Weighted mean for the “Extent of greenness” of the selected houses

Testing of hypotheses :

In order to test the hypotheses formulated for the present investigation, as per the nature of variables t-test, Chi-square, co-efficient of correlation, analysis of variance were computed. For the purpose of statistical analysis, the hypotheses were formulated in Null form. The results are presented in this section.

Ho₁ : There exists no relationship between the opinion of builders regarding green building concept and their selected personal and situational variables :

The results revealed no significant relationship between the opinion of builders regarding green building concept their age and duration of time working as builder

(Table 1). Hence, the Null hypothesis was accepted.

Ho_{2.2}: There exists no variation in extent of influence of reasons for adopting green building design and construction of the builders due to kind of construction projects undertaken by them :

Chi-square value was found to be significant only for private projects undertaken by the builders and extent of influence of reasons for adopting green building design and construction (Table 2). Thus, the Null hypothesis was partially rejected. It can be because builders might have had freedom to express their environmental concern in the construction in private projects undertaken by them.

Ho₃: There exists no relationship between the extent of barriers faced by the builders in adopting green building design and construction and their selected personal and situational variables :

A number of sub-hypotheses were framed for the purpose of statistical analysis.

Ho_{3.1}: There exists no relationship between the extent of barriers faced by the builders in adopting green building design and construction and their age, duration of time working as builder and sources of information on green buildings :

The results revealed no significant relationship between extent of barriers faced by the builders in adopting green building design and construction and their age and duration of time working as builder (Table 3). Hence, the Null hypothesis was accepted.

Ho_{3.2}: There exists no variation in the extent of barriers faced by builders in adopting green building design and construction due to kind of construction projects undertaken by them :

Chi-square value was not found significant for any kind of projects undertaken by the builders and the extent of barriers faced by them in adopting green building design and construction (Table 4). Thus, the Null hypothesis was accepted.

Table 1: Co-efficient of correlation showing relationship between opinion of builders regarding green building concept and their age, duration of time working as builder and sources of information on green buildings

| Sr. No. | Selected variables | n | r-value | Level of significance |
|---------|-------------------------------------------------------------------------------------|----|---------|-----------------------|
| 1. | Opinion of builders regarding green building concept Age of the builders | 75 | -0.018 | NS* |
| 2. | Opinion of builders regarding green building concept Duration of time as builder | 75 | 0.012 | NS* |

Note: *NS =Not-significant

Table 2: Chi-square values for selected variable

| Variables | Chi-square values | df | Level of significance |
|-------------------------|-------------------|----|-----------------------|
| Kind of projects | | | |
| Residential | 5.456 | 4 | NS* |
| Commercial | 1.683 | 4 | NS* |
| Institutional | 8.716 | 4 | NS* |
| Renovation | 8.437 | 4 | NS* |
| New construction | 6.212 | 4 | NS* |
| Private | 8.647 | 2 | 0.05 |

Note: *NS =Not-significant, df=Degree of freedom

Table 3: Co-efficient of correlation showing relationship between extent of barriers faced by the builders in adopting green building design and their age, duration of time working as builder and sources of information on green buildings

| Sr. No. | Selected variables | n | r-value | Level of significance |
|---------|----------------------------------------------------------------------------------------------------------------------------|----|---------|-----------------------|
| 1. | Extent of barriers faced by the builders in adopting green building design and construction Age of the builders | 75 | 0.230 | NS* |
| 2. | Extent of barriers faced by the builders in adopting green building design and construction Duration of time as builder | 75 | 0.178 | NS* |

Note: *NS =Not-significant

Ho₄: There exists no interrelationship between the extent of barriers faced in adopting green building design and construction and opinion of builders regarding green building concept :

Computation of co-efficient of correlation indicated that no significant relationship was found between the extent of influence of reasons and extent of barriers faced by the builders in adopting green building design and construction and also between extent of barriers faced by the builders in adopting green building design and construction and opinion of builders regarding green building concepts. Thus, the Null hypothesis is accepted (Table 5).

Ho₇: There exists no relationship between the extent of greenness of the selected houses and barrier faced by the builders in adopting green building design and construction and opinion of builders regarding green building concept :

Computation of co-efficient of correlation reflected no significant relationship between the extent of barriers faced by the builders in adopting green building design

and construction and extent of greenness of the selected houses constructed by them (Table 6). But a significant relationship was found between the opinion of builders regarding green building concept and extent of greenness of the selected houses made by them. Hence, the Null hypothesis was partially accepted. Those builders who had favourable opinion, the house constructed by them had more “greenness”.

Conclusion and Implication :

The findings of the study revealed that builders had a mean age of 43 years, were graduate and were in the field of construction since 11 to 20 years with the mean of 16 years. Majority of them had “somewhat favourable” opinion regarding green buildings. The ‘Environmental’ reasons were more influential than other reasons for adopting green building design and construction. About two third of builders faced high extent of barriers in adopting Green building concept in their construction projects. The ‘Greenness’ of the selected houses reflected that they were green to a “moderate extent”. A positive relationship between opinion of the builders regarding

Table 4 : Chi-square values for selected variable

| Variables | Chi-square values | df | Level of significance |
|-------------------------|-------------------|----|-----------------------|
| Kind of projects | | | |
| Residential | 6.779 | 4 | NS* |
| Commercial | 3.974 | 4 | NS* |
| Institutional | 2.233 | 4 | NS* |
| Renovation | 0.864 | 4 | NS* |
| New construction | 3.965 | 4 | NS* |
| Private | 0.120 | 2 | NS* |

Note: *NS =Not-significant, df=Degree of freedom

Table 5: Co-efficient of correlation showing relationship between selected variables

| Sr. No. | Selected variables | n | r-value | Level of significance |
|---------|-------------------------------------------------------------------------------------------------------------------------------------|----|---------|-----------------------|
| 1. | Extent of barriers faced in adopting green building design and construction Opinion of builders regarding green building concept | 75 | -0.091 | NS* |

Note: *NS =Not-significant

Table 6: Co-efficient of correlation showing relationship between extent of greenness of the selected houses and barrier faced by the builders in adopting green building design and construction and opinion of builders regarding green building concept

| Sr. No. | Selected variables | n | r-value | Level of significance |
|---------|---------------------------------------------------------------------------------------------------------------------------------------|----|---------|-----------------------|
| 1. | Extent of barriers faced by builders in adopting green building design and construction Extent of greenness of the selected houses | 75 | -0.069 | NS* |
| 2. | Opinion of builders regarding green buildings concept Extent of greenness of the selected houses | 75 | 0.438 | 0.01 |

Note: *NS =Not Significant

green buildings and the extent of 'Greenness' of the houses constructed by them indicated that more favourable the opinion more was the extent of 'Greenness' of the existing houses. The study reflected clear implications for the need to overcome the barriers faced by the builders in adopting the concept of green building. There is a need to create awareness among the various stakeholders, so that the consumers that is potential house owners demand "green". The educational institution, Government, NGOs, LEED and GRIHA, Architects, Builders and Civil engineers need to meet the challenges and popularize the concept of green buildings for the sustainable development of the environment. The department of Family and Community Resource Management has a major role to play in creating the awareness among present and future homeowners through formal and non-formal education.

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