

AN ANALYTICAL STUDY OF THE IMPLEMENTATION OF SUSTAINABILITY PRINCIPLES IN SELECTING BUILDING MATERIALS IN SAUDI ARABIA

Saleh Baharetha

Research Scholar, Department of Architecture and Building Sciences, Faculty of Architecture and Planning, King Saud University, Riyadh, Saudi Arabia

ABSTRACT

In the last few decades, raw materials consumption and production has risen dramatically due to the rapid growth of world population and global energy consumption. Furthermore, construction materials generate huge amounts of waste annually all around the world and consume large amounts of embodied energy. There has been recently considerable economic growth in Saudi Arabia due to strong oil prices and ongoing reforms. So, there is a need to use natural resources in an efficient manner and provide a better environmental, social and economic life. This paper aims to explore the current practice of selecting sustainable building materials in Saudi Design/Consultant offices and investigate the main obstacles facing Designers and Engineers when selecting sustainable building materials. To perform this task, a series of interviews was conducted and a questionnaire survey was distributed to a representative sample of Architects/Engineers working in different private and public organizations in the Eastern Province of Saudi Arabia. Data analysis revealed that there is a lack of the awareness in selecting sustainable building materials. It also emphasized the absolute responsibility of owners in the selection process. Results also revealed that most agreed barrier facing Designers and Engineers is that clients do not care about demanding sustainable building materials. Finally, this paper puts forward a set of recommendations in order to incorporate sustainability principles in selecting building materials in Saudi Arabia.

KEYWORDS: *Raw Materials Consumption and Production, Building Materials*

Article History

Received: 31 Oct 2019 | Revised: 09 Nov 2019 | Accepted: 25 Nov 2019

INTRODUCTION

Recently, the government of Saudi Arabia has promoted several initiatives toward implementing sustainability principles and strategies especially with its limited number of natural resources and the absence of the use of renewable energy resources. Such initiatives include wastewater treatment and the positive trends toward increasing the awareness of the population about water scarcity in Saudi Arabia (Hanan, 2010). Also, it has been a number of years since many agencies in Saudi Arabia have played a valuable role in the field of sustainable construction such as The Presidency of Meteorology and Environment (PME), The National Commission for Wildlife Conservation and Development (NCWCD), The Ministry of Water and Electricity (MoWE) and The Ministry of Municipal and Rural Affairs (MoMRA). These agencies have many responsibilities such as providing a healthy environment, managing waste and raising environmental awareness (Al-Yami, 2005).

Current Practice of Sustainability in Saudi Arabia

There are several researches which have discussed implementing sustainability principles in building construction in Saudi Arabia. Hanan (2010) investigated energy and water consumption in residential buildings in Saudi Arabia in order to achieve more sustainable buildings in the future. A residential building situated in Jeddah city was selected as a case study. The building energy and water consumption was investigated using simulation software packages. The study concluded by suggesting some guidelines which would lead to the construction of sustainable buildings in Saudi Arabia. Such guidelines include improving thermal insulation of exterior walls, placing windows properly to maximize natural daylight and promoting waste recycling.

Al-Yami (2005) explored sustainable construction principles in Saudi Arabia and emphasized the great efforts made by the Saudi government towards obtaining a good and better environment. Furthermore, he indicated that there was a lack of awareness of establishing sustainable construction principles in Saudi Arabia. Also, he made semi-structured interviews with twelve experts working in different public sectors and explained the obstacles of implementing sustainable construction in Saudi Arabia.

Siddiqui (2012) investigated the impact of sustainable building design from the construction management point of view. An existing building design was analyzed and a variant design was modified to increase LEED certification points. The impact of sustainability costs was identified by conducting Life Cycle Cost Analysis (LCCA). The study indicated that although green buildings have substantial initial costs, they gain more benefits than conventional buildings during the buildings' useful life.

Susilawati and Al-Surf (2011) conducted a current study to explore obstacles facing implementation of sustainability in the housing sector in Saudi Arabia and investigate the level of people's knowledge. They said that the harsh dry climate, water scarcity and the rapid urbanization are major challenges facing the implementation of sustainable housing in Saudi Arabia. They conducted a web-based survey distributed to 693 engineers chosen from the Saudi Council of Engineers. 52.2% of the respondents were not aware of sustainable housing issues. The study suggested many sustainable methods to be implemented in Saudi Arabia including passive solar design and natural ventilation. Moreover, the authors suggested some recommendations to encourage the implementation sustainable housing in Saudi Arabia. Such recommendations include applying sustainable codes in construction, organizing several workshops for Architects and Stakeholders, and using media to inform people of the importance of sustainability.

Assessing Sustainability Awareness in Saudi Design/Consultant Offices

To achieve the main goal of this study, a pilot-tested questionnaire survey was distributed to a representative sample of Designers/Engineers in the Eastern Province of Saudi Arabia to explore their sustainability awareness and investigate the main barriers they face.

The respondents were firstly asked to specify their role in their organizations by choosing one of the three main categories: "Engineer/Architect", "Manager", "Supervisor", or any other position they are holding. As illustrated in Figure 1, the results indicated that the majority of respondents 66 % (28 Architects/Engineers out of a total of 42) are either practicing as Architects or Engineers. It was also noticed that 23.8 % (10 respondents out of a total of 42) are practicing as Project Managers, and 9.52 % (4 respondents out of a total of 42) are practicing as Supervisors.

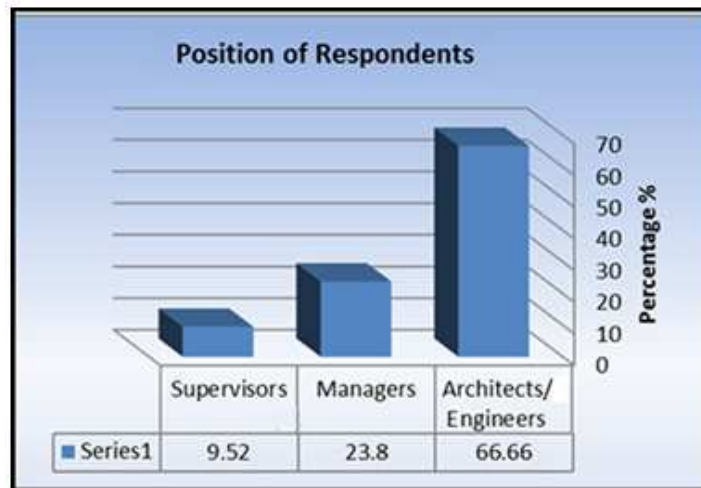


Figure 1: Respondent's Positions in their Organizations.

The study also considers the respondents' years of experience. The years of experience were classified into four main categories: “1-5 years”, “6-10 years”, “11-15 years” and “more than 15 years”. The results showed that 21.42 % of the respondents (9 Architects/Engineers out of a total of 42) had been practicing for more than 15 years, 30.59 % (13 Architects/Engineers out of a total of 42) have experience ranging between 11-15 years, 21.42 % (9 Architects/Engineers out of a total of 42) have an experience ranging between 6 -10 years, while 26.19 % (11 Architects/Engineers out of a total of 42) have at least 5 years or less as shown in Figure 2.



Figure 2: Respondents Years of Experience.

The sample of respondents who filled the survey and assessed the identified sustainable building materials criteria was determined using the following equation (kish, 1995):

$$n = no / [1 + (no/N)]$$

Based on the above equation, the sample size was calculated as follows:

$$\text{Sample size } (n) = 25 / [1 + (25/145)] = 21$$

About 69 questionnaire surveys were distributed, out of which the received questionnaire were 42, which are more than the sample size calculated above.

To calculate the Agreement Index, respondents were requested to rank their level of agreement or disagreement on a scale of (1-4), where (one) refers to the least level of agreement and (four) refers to the highest level of agreement. The agreement index (AI) was calculated by using the following equation.

$$\text{Agreement Index AI} = \frac{\sum_{i=0}^3 a_i x_i}{3 \sum x_i} \times 100 \%$$

Where:

i = Response category index where $i = 0, 1, 2, 3$

a_i = Weight given to i response where $i = 0, 1, 2, 3$

x_i = variable expressing the frequency of i as illustrated in the following:

x_0 = frequency of “extremely Important” response corresponding to $a_0 = 4$.

x_1 = frequency of “very Important” response corresponding to $a_1 = 3$.

x_2 = frequency of “not Important” response corresponding to $a_2 = 2$.

x_3 = frequency of “extremely not important” response corresponding to $a_3 = 1$.

The importance index of (0 - < 25 %) is classified as “extremely not important”; (25 - < 50 %) is classified as “not Important”; (50 - < 75 %) is classified as “very important”; and (75 - 100 %) is classified as “extremely important”.

RESULTS AND DISCUSSIONS

Respondents were asked to indicate their level of awareness of sustainability issues in selecting building materials by choosing one of the following levels of awareness: extremely aware, moderately aware, slightly aware and not at all aware. The results stated that 66.66 % of the respondents (28 Architects/Engineers out of a total of 42) were moderately aware of sustainability issues in selecting building materials, 16.66 % were strongly aware, 9.52 % were slightly aware and 7.14 % were not aware at all as shown in Table 1. According to similar studies done by Crawley (1999) and Ding (2008), it was observed that paying more attention to sustainability issues during earlier Design stages is very important to design more sustainable building projects. Also, Elhag (2001) indicated that considering sustainability issues will contribute significantly in decreasing the overall cost of buildings.

Table 1: Levels of Sustainability Awareness

Extremely Aware	Moderately Aware	Slightly Aware	Not At All Aware
Percentage %	Percentage %	Percentage %	Percentage %
16.66	66.66	9.52	7.14

Respondents were asked to investigate the way through which they had heard about the term “Sustainability”. The results showed that 40.74 % of the respondents (17 Architects/Engineers out of a total of 42) had heard about it by reading journals and magazines, 9.52 % by reading building materials brochures, 26.19 % by surfing the Internet, 14.28 % through the media or by studying at universities, while 5.52 % of the respondents had not heard about the term “sustainability” as shown in Table 2.

Table 2: The Way by which Respondents Heard about the Term “Sustainability”

Journals and Magazines	Brochures	Internet	Other	Never Heard about Sustainability
Percentage %	Percentage %	Percentage %	Percentage %	Percentage %
40.74	9.52	26.19	14.28	5.52

Respondents were then asked to indicate the source from which they collect information when selecting building materials as shown in Table 3. According to the data obtained, it was found that 66.66 % of respondents (28 Architects/Engineers out of a total of 42) select building materials based on the information they have found in brochures. This is in line with a similar study conducted by Tas (2008), where respondents ranked “brochures” as a second source of information for selecting building materials. However, brochures are not updated continuously when new building materials are brought onto the market. The study also showed that 21.66 % of respondents select building materials depending on gaining knowledge from websites, and only 16.66 % select building materials based on meeting LEED requirements. Despite the fact that 66 % of respondents indicated that they were moderately aware of sustainability principles, it was surprising that only 16.66 % were guided by meeting LEED building materials requirements when selecting building materials.

Table 3: The Source of Collected Information Used in the Selection Process

Manufacturing Brochures	Internet	LEED Rating System
Percentage %	Percentage %	Percentage %
66.66	21.66	16.66

Respondents were also asked to indicate the factors according to which they make decisions when selecting building materials as shown in Table 4. The survey responses showed that the majority of respondents 76.19 % (32 Architects/Engineers out of a total of 42) select building materials based on their clients' desire. This is in line with a study conducted by Gann and Salter (2002) and Akadiri (2011) which emphasized clients' highest degree of involvement in selecting building materials. The results also showed that 11.9 % of respondents select building materials based on their own decision, 7.14 % based on the contractors' decision and 4.76 % based on meeting building codes. A few number of respondents indicated that they consult other companies when selecting building materials.

Table 4: Decision Making When Selecting Building Materials

Based on Clients Desire	Based on Contractors Decision	Based on Meeting Building Codes	Based on Your Own Decision
Percentage %	Percentage %	Percentage %	Percentage %
76.19	7.14	4.76	11.90

An interesting observation is that the survey responses showed that only three respondents have been involved in selecting building materials in building projects. Two of these experts have been practicing for less than three years, while the third one has between 3-5 years of experience. The percentages of sustainable projects for all of them were less than 30 % of all their building projects and all of them were using LEED rating system in selecting building materials. Another interesting observation is that only one respondent has been practicing in a LEED certified building.

Sustainability Consideration Issues

To investigate on what extent Architects and Engineers are practicing sustainability issues in selecting sustainable building materials, respondents were asked to score their level of agreement or disagreement, where 1 represents ‘strongly disagree’ to 4 which represents ‘strongly agree’ as shown in Table 5.

Table 5: Sustainability Assessment Consideration

Statement	Strongly Agree 4	Agree 3	Disagree 2	Strongly Disagree 1	Agreement Index	Mean Value
	Percent %	Percent %	Percent %	Percent %		
Selecting sustainable building materials is very important to construct more efficient buildings	59.52	40.47	0.00	0.00	89.88	3.59
Some building materials have negative impacts to the environment and human health	69.04	28.57	19.04	7.14	77.97	3.11
Buildings contractors and owners should be aware of the importance of selecting building materials	69.04	30.59	0.00	0.00	97.02	3.88
Building materials initial cost is more preferred to life cycle costs.	69.04	30.59	16.66	16.66	71.42	2.85
Sustainable building materials criteria should be incorporated in building codes?	69.04	21.42	30.59	26.19	59.52	2.38

The results showed that the biggest concern in implementing sustainability in the selection process is to increase the contractor's and client's awareness of the importance of selecting sustainable building materials, with agreement index of 97.02 %. This was followed by the importance of selecting sustainable building materials to construct more efficient buildings (AI= 89.88 %), the emphasize of the negative impacts of some building materials to the environment (AI= 77.97 %) and the preference of the initial cost when compared to the life cycle cost (AI =71.42 %). The incorporation of selecting sustainable building materials in the local building codes was rated last with an agreement index of (59.52 %). This reflects that respondents are unaware of the advantages of implementing sustainable building materials.

Barriers against Selecting Sustainable Building Materials

The findings revealed that the current practice of sustainability in building projects in the Eastern Province is facing lots of problems. Such problems are summarized below in Table 6. Respondents were asked to score their level of agreement or disagreement where '1= strongly disagree' to '5 = strongly agree'.

Table 6: Barriers of Selecting Sustainable Building Materials

Barriers	Strongly Agree 4	Agree 3	Disagree 2	Strongly Disagree 1	Agreement Index %	Mean Value
	Percent %	Percent %	Percent %	Percent %		
Lack of Information of sustainable materials specification	69.04	26.19	4.76	0.00	91.07	3.64
Financial cost	73.80	19.04	7.14	0.00	91.66	3.66
The clients do not care about selecting and demanding sustainable building materials	80.59	14.28	4.76	0.00	94.04	3.76

Table 6 Contd.,

Unawareness of the requirements of selecting sustainable building materials	64.28	19.04	9.52	7.14	85.11	3.40
No governed or municipal code requires selecting sustainable building materials	59.52	26.19	14.28	0.00	86.30	3.45
Culture (accustomed to use materials)	19.04	19.04	40.47	21.42	58.92	2.35
Construction techniques are limited	19.04	21.42	45.23	14.28	61.30	2.45
It is difficult to use unconventional materials	45.23	35.71	19.04	0.00	81.54	3.26

The findings indicated that the lack of available information that describes the properties and specifications of sustainable building materials constitutes a major obstacle against selecting sustainable building materials. Most of Designers and Engineers do not know what types of sustainable building materials are available in the market and what the technical properties of these materials are. In addition, the lack of experienced people in this field also constitutes a major obstacle. Some respondents suggested that government should provide funding for training and educational activities to allow the public to gain more knowledge about the specifications of sustainable building materials.

The financial cost was rated secondary with an agreement index of 91.66 %. Building projects normally have certain budgets which make Designers and Engineers move toward decreasing the initial costs of building materials. According to Akadiri (2011), Kunzlick (2003), Ofori (2004), the biggest concern of respondents was the cost of building materials. This is also in line with a study done by Demkin (2008) which observed that controlling buildings budgets is a major concern for all building team members including owners, Clients and Designers. However, this barrier can be overcome if Designers took into consideration that selecting sustainable building materials will decrease operation costs and save huge amounts of energy.

The results showed that most of Clients do not care about selecting and demanding sustainable building materials. This was rated first by the respondents with an agreement index of 94.04 %. This barrier can be overcome if the government provides a special market for sustainable building materials, so that clients could investigate the huge difference between sustainable and non-sustainable building materials.

The results indicated that about 85.11 % of the respondents claimed that the unawareness of sustainable building materials requirements including installation and implementation constitutes a major concern. According to Edward (2006), the lack of experiencing sustainability issues is the main reason for the incorrect implementation of sustainability in the construction of buildings.

The local building code in Saudi Arabia does not include the specification of sustainable materials. Consequently, about 86.3 % of the respondents claimed that this constitutes a major barrier against selecting sustainable building materials. In addition, some respondents indicated that sustainable building materials criteria shouldn't be included in the specification of sustainable materials because they believe that this will increase building costs. According to Cabugueira (2004), incorporating sustainability in building regulation will encourage people to select sustainable building materials.

The results also indicated that 58.92 % of respondents claimed that the reason they did not select sustainable building materials was because they were not accustomed to using them locally. While 61.3 % of them claimed that the local construction techniques did not constitute a big obstacle against constructing sustainable building materials. In terms of the difficulties of using unconventional materials, the results indicated that 81.54 % of respondents said that implementing unconventional materials constitutes a big obstacle against selecting sustainable building materials.

Respondents were also asked to add any other obstacles that were not mentioned. The following barriers were added by respondents:

- Lack of incentives to apply sustainable building materials.
- Lack of people experienced in selecting sustainable building materials.

Guidelines for Implementing Sustainability Principles in Selecting Building Materials in Saudi Arabia

With the above in mind, the following are a list of summarized guidelines that would help in incorporating sustainability principles in selecting building materials in Saudi Arabia:

- More awareness needed to be raised on the significance of selecting sustainable building materials.
- Incorporating experienced policy makers in the process of selecting building materials.
- Promote more cooperation between Designers, Owners and Contractors.
- Government should provide academic programs and initiatives to encourage people to select sustainable building materials.
- Designers and Engineers are highly recommended to show the importance of sustainability in their designs.

CONCLUSIONS

This study examined the current practice and sustainability awareness of Saudi Design and Consultant offices in selecting sustainable building materials and investigated the main obstacles that Designers and Engineers face. A questionnaire survey was distributed to a representative sample of Architects and Engineers working in different firms in the Eastern Province of Saudi Arabia. The data collected from the questionnaire survey were analyzed and discussed. The results indicated that there is a lack of the awareness in selecting sustainable building materials. It also stated that clients have the highest degree of involvement in selecting building materials, and the cost is the biggest concern in the decision making process. The study also indicated that the main obstacles of selecting building materials is the lack of available information that highlight the positive aspects of sustainable building materials in decreasing operational costs, as well as the lack of experienced people in this field. Finally, the study puts forward a set of guidelines which could increase the awareness of selecting sustainable building materials in Saudi Arabia.

REFERENCES

1. Akadiri, O. (2011) "Development of a Multi-criteria Approach for the Selection of Sustainable Materials for Building Projects". A PhD Thesis, Wolverhampton University.
2. Al-Yami, A. and Price, A.(2005) "An Overview of Sustainability in Saudi Arabia". Loughborough University, Leicestershire.

3. Cabugueira, M.F.M. (2004) "Portuguese experience of voluntary approaches in environmental policy", *Journal of Management of Environmental Quality*, V 15, pp. 174-185.
4. Crawley, D. and Aho, I. (1999) "Building environmental assessment methods: application and development trends", in *Building Research and Information*, V 27, pp. 300-308.
5. Demkin, J. (2008) "The Architect's Handbook of Professional Practice, American Institute of Architects" 14th Ed. John Wiley and Sons.
6. Ding, G.K.C. (2008) "Sustainable construction – The role of environmental assessment tools" *Journal of Environmental Management*, V 86 No.3, pp.451-64.
7. Edwards, B. (2006) "Benefits of green offices in the UK: analysis from examples built in the 1990s" *Journal of Sustainable Development*, V 14, pp. 190-204.
8. Elhag, T. and Boussabaine, A.H. (2001) "Tender price estimation using artificial neural Networks" *Journal of Financial Management of Property and Construction*, Vol.6, pp 193-208.
9. Hanan, M. (2010) "Developing sustainable residential buildings in Saudi Arabia: A case study". *Journal of Applied Energy*, V 44, pp. 388–391.
10. Kish, L. (1995). "Survey Sampling." New York, Johan Wiley and Sons Inc.
11. Kunzlik, P. (2003) "Making the market work for the environment: Acceptance of (some) 'green' contract award criteria in public procurement" *Journal of Environmental Law*, V 15, pp 175-201.
12. Ofori, G. and Kien, H.L. (2004) "Translating Singapore architects' environmental awareness into decision making" *Journal of Building Research & Information*, V32 pp 1, 27 – 37.
13. Siddiqui, M. (2012) "Integrating Sustainability in the Curriculum through Capstone Projects : A Case Study" ASEE conference.
14. Susilawati, C and Al-Surf, M. (2011) "Challenges Facing Sustainable Housing in Saudi Arabia: A current study showing the level of public awareness".
15. Tas, E., Yaman, H. and Tanacan, L. (2008) "A building material evaluation and selection model for the Turkish construction sector" *Journal of Engineering, Construction and Architectural Management*, Vol. 15, pp.149–163.

