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IDENTIFYING BARRIERS TO THE USE OF SUSTAINABLE BUILDING MATERIALS IN BUILDING CONSTRUCTION

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Abstract: The research aims at examining the barriers to the use of sustainable building materials in the construction of buildings despite the environmental awareness of the designers in the field of building construction. In order to achieve the research objective a scientific methodology consists of two phases was followed, the first phase included a theoretical study to identify the reasons that prevent the use of green building materials in building construction, while the second phase included a practical study to collect the needed data and information related to research subject. The practical study included personal interviews and open questionnaire with experienced engineers in the field of building design and conducting a closed questionnaire to achieve the research objective. The results showed that the gap between the environmental awareness of the designers in the field of building construction and the realistic application is due to many reasons which were classified into two categories: administrative reasons and technical reasons.

Keywords: *Sustainable building materials, Building construction, Sustainability.*

تحديد المعوقات التي تحول دون استخدام مواد البناء المستدامة في تشييد المباني

الخلاصة: يهدف البحث الى دراسة معوقات استخدام مواد البناء المستدامة في تشييد المباني على الرغم من توفر الوعي البيئي لدى فئة المصممين في مجال تشييد المباني .لغرض تحقيق هدف البحث تم اتباع منهجية علمية تمثلت بمرحلتين شملت المرحلة الاولى الاطلاع على المصادر النظرية المتعلقة بموضوع البحث في حين شملت المرحلة الثانية اجراء دراسة عملية لغرض جمع البيانات و المعلومات عن موضوع البحث. الدراسة العملية تضمنت اجراء المقابلات الشخصية مع المهندسين ذوي الخبرة في مجال تصميم المباني و القيام باستبيان ميداني مغلق لتحقيق هدف البحث. اظهرت نتائج البحث بان الفجوة الكبيرة بين توفر الوعي البيئي لدى المصممين في مجال تشييد المباني والتطبيق الواقعي تعود الى مجموعة اسباب تم تصنيفها الى صنفين : اسباب ادارية و اسباب تقنية.

1. Introduction

Construction industry considered as one of the most resources consumers. It is well-known that this sector is a key one for environmental protection and for a sustainable resource management.

At the global scale we are currently consuming about 150% of the resource that the Earth can renew in one year Thus, the existing patterns of production and consumption are unsustainable The construction industry plays an important role, since it consumes more raw materials than any other economic activity, approximately 50% of the global

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consumption. Furthermore, it is expected that this industry will grow in the next years. [1]

2. Building Materials and Sustainability

Building materials have a basic role in achieving sustainability of buildings. They also participate in the economic growth. The use of construction materials affects the environment in many ways, basically due to the big consumption of the non-renewable resources and the amount of waste and pollutants that are generated through the life cycle of materials [2]. In general, construction stakeholders began to recognize the importance of controlling the environmental impacts caused from construction industry. Selecting construction materials has got big attention to be improved so that the sustainability suitability of materials is considered while in fact factors like cost, availability and appearance were more efficient in the selection process of materials [3].

(Huberman) stated that sustainable building materials are materials that "respect the limitations of non-renewable resources, work within the pattern of nature's cycles and inter-relationships of ecosystems, are non-toxic, are energy and water efficient, are made from recycled materials and are themselves recyclable".[4] (Kibert,) stated that "Sustainable products may not necessarily be manufactured from sustainable materials. For example low-e glass is considered a sustainable product because it reduces building heat gain. However, float glass is considered a sustainable material because it is highly recyclable unlike low-e glass, which is not, or is poorly, recyclable".[5]

Another opinion supposes that "sustainability represents a system not a material or product and there are no sustainable materials but materials that are used sustainably. We may create outstanding environmentally preferable materials, but if we do not use them in a way that supports their use in line with sustainability principles (if wastes cannot become food for future materials for example), we fail" [6].

3. Characteristics of Sustainable Building Materials

Many attributes distinguish sustainable building materials depending on materials life cycle. Materials or products can be considered sustainable if they have one or more of the following attributes (7) and (8):

1. Enhancing the quality of indoor air by reducing emissions of VOCs.
2. Durability and low maintenance requirements.
3. Having recycled content which is partially or entirely produced from post-industrial or post-consumer waste.
4. They are manufactured from renewable resources.
5. Having low "embodied energy" which is "the energy required for materials production and transportation".
6. Free of ozone depleting substances such as Chlorofluorocarbons (CFCs), Hydro chlorofluorocarbons HCFCs.
7. Having less toxic compounds.
8. They are local materials.
9. They have the ability to be reused.

10. They have the ability to be recycled "preferably in a closed-loop recycling system".
11. They are biodegradable.
12. Reducing waste generation during manufacturing or construction process
13. They are energy efficient and they "contribute in reducing the operation energy during building occupancy".
14. They contribute in water conservation.

Sustainable materials characteristics may vary according to material type. For example the green features of a concrete mix may involve using fly-ash "as a post-industrial recycled content material", but when we talk about an interior paint; its green features may concentrate on containing low VOC to improve the quality of indoor air. In general, evaluating sustainable materials needs to [8]:

1. Knowing environmental impact related to different types of materials.
2. Knowing government regulations, and third-party standards for green products, if they exist.
3. Knowing available sustainable materials in local markets and what are their green features

4. Benefits of Using Sustainable Building Materials

(Kibert) stated that selecting sustainable material can be one of the most difficult duties to be done in a construction project. Partially, this can be because:[5]

1. A Construction project involves various products that needed to be evaluated
2. Assessment parameters can vary according to material categories and manufactured countries
3. There is lack of sufficient information about manufacturing processes.
4. There is no agreed method to evaluate materials and products universally.

Despite that, using sustainable products for buildings can be useful to the triple bottom (TBL) which explained in figure (1), for many reasons [9]:

1. In environmental term, using sustainable materials can reduce the environmental impacts of construction industry.
2. Economically, the use of sustainable products can reduce the operation costs.
3. Socially, using sustainable products and materials can improve the well-being of building occupiers and protect the natural environment

Figure (1): TBL description

5. Barriers to the Use of Sustainable Materials

Barriers to using sustainable building materials and products can be [10] and [11]:

1. Construction practitioners that are not aware how important it is to prevent the environment from being polluted by the waste generated from construction industry.
2. The absence of well-known sustainable building products to be used in construction.
3. The lack of sufficient environmental information about structural materials to make adequate comparison between alternatives.
4. The absence of regulations and codes that encourage the use of green building.

6. Practical Study

The practical study included the following stages:

1. Personal interviews and open questionnaire
2. Closed questionnaire: included two parts:
   - Examining the content validity and Pilot study
   - Main survey

6.1. *Personal Interviews and Open Questionnaire*

This phase included personal interviews with engineers having experience in the field of buildings design in order to determine the outline of the research path. These engineers were top managers, architect engineers, civil engineers, electrical engineers, and environmental engineers; they all have more than ten years' experience in the design of buildings and the process of selecting building materials.

6.2. *Closed Questionnaire*

Depending on the results obtained from personal interviews and open questionnaire process and literature review, the researcher developed a closed questionnaire. The closed questionnaire was designed to investigate barriers to the use of sustainable building materials. The sample was taken were engineers who had experience in buildings designs.

6.2.1. *Examining the content validity and pilot study*

In order to ensure the validity of the questionnaire content, it was presented to a group of (10) experts in the design of buildings and sustainable buildings issues. They were asked to review the questionnaire whether its content was comprehensible in studying the research problem.

The experts agreed with the questionnaire items. Minor changes were taken place to improve the questionnaire and make it clear and adequate in investigating the research problem.

A pilot study was made by randomly selecting a convenient sample of (10) engineers concerned with the studied problem .The objectives of the pilot study were as follows:

1. Determining the researcher dependency (Inter Examiners) and the reliability of the respondents (Intra Examiner).
2. Identifying the time needed for data collection through each single interview.

Identifying the difficulties that might be faced through the questionnaire process

Table (2) explains the determination of reliability of the pilot study where the reliability of intra examiner (test & pretest), and the reliability of inter examiner recorded high and adequate in the pilot study.

Reliability Coefficient (actual value) for the pilot study was calculated by equation (1) [12]:

$$\text{Actual value} = \left(1 - \frac{\text{no. of non coincidences items}}{\text{no.of all items} * \text{sample size of pilot study}}\right) * 100\% \ldots (1)$$

Table (2): Reliability Coefficients of the Pilot Study

Groups	*Reliability Coefficients*	*Actual values %*
Students	Inter Examiners	93.23 (63:930)
	Intra Examiner	91.94 (75:930)

6.2.2. *Main survey*

The questionnaire form was designed according to the theoretical literature review and personal interviews carried out by the researcher with engineers having expertise and practice in designing building and selecting of materials. (45) Questionnaire forms were distributed while (39) were filled and analyzed.

As the research was part of other study, the part of the questionnaire concerning Identifying barriers to the use of green building materials in building construction was designed to comprise two major parts as the following:

Part one: contains general information about the respondents

Part two: the reasons that prevent the use of new materials (environmentally friendly) instead of traditional materials in construction, they were divided into two main categories:

- administrative reasons
- Technical reasons.

6.3. *Statistical Analysis*

The following statistical data analysis approaches were used in order to analyze and assess the results of the study under application of the statistical package (SPSS) version. (14.0):

a- Tables (Frequencies, and Percent).

b- Summary Statistics tables including: Frequencies, percentages, Mean of score (MS),Standard Deviation (SD), Relative R Sufficiency RS%, as well as primarily assessment degree (A.D.) throughout selected specific categories of responding of different five measurement scales of Lekirt score, as illustrated in table (3):

Table (3): Different Scoring Scales of the studied Questionnaire's items with Assessment Degrees

Scores	*Scales*	*Interval*	*A.D.* (*)
Strongly disagree	1	20 -	TL
Disagree	2	36 -	L
Neutral	3	52 -	M
Agree	4	68 -	H
Strongly agree	5	84 - 100	TH
Extremely important	5	84 - 100	TH

(*) TL: too Low; L: Low; M: Moderate; H: High; TH: too High

Where Relative Sufficiency (RS %) are calculated by equation (2): [11]

$$R.S.\% = \frac{Mean\ of\ Score}{no.\ of\ Scoring\ Scales} * 100\% \quad \ldots\ldots (2)$$

6.4. *Reliability of the Questionnaire*

In order to determine the accuracy of the questionnaire , the reliability of the questionnaire was determined by using the major statistical parameter :Alpha Cronbach, as shown in table (4), where the results showed a very high level of stability and high consistency of the main axis of the questionnaire .

that results meant that the questionnaire was successful and valid in studying the problem of selecting building materials according to sustainability criteria on the same population at any time in the future under assumption of stationary conditions of the studied population.

Table (4): Reliability Coefficients of the Studied Questionnaire's

Reliability Coefficients of the studied Questionnaire	*Standard lower bound*	*Actual values*	*Assessment*
Alpha (Cronbach - α)	0.70	0.9130	Pass

Alpha Cronbach (α) for the reliability of questionnaire (Internal consistency)

Where Alpha Cronbach (α) was determined by the following equation:

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\sum_{i=1}^{K}\sigma_{ii}}{\sum_{i=1}^{K}\sum_{j=1}^{K}\sigma_{ij}}\right] \ldots\ldots\ldots (3)$$

Where K is the number of items (questions) and σ_{ij} is the estimated co-variance between items i and j. Note that σ_{ii} is the variance (not standard deviation) of item i.

7. Results and Discussion

The findings of data analysis are explained in the following:

Part1: Table (5) shows the distribution of studied sample concerning "Socio-Demographical Characteristics" variables (SDCv.), with comparisons significant.

The results has indicated that there has been a highly significant differences at $P<0.01$ among different levels of studied (SDCv).

Table (5): Distribution of the studied sample according to Socio-Demographical Characteristics variables (SDCv.) with significant comparisons

SDCv.	*Groups*	*No.*	*Percent*	*C.S. P-value*
Educational Degree	B.Sc.	26	66.7	K-S= 0.333 P<0.01 (HS)
	M.Sc.	9	23.0	
	Ph.D.	4	10.3	
	Total	39	100	
Years of Experience	5 - 10 years	9	23.1	P=0.000 (HS)
	more than 10 years	30	76.9	
	Total	39	100	
Specialist	Architect	19	48.7	K-S= 0.287 P<0.01 (HS)
	Civil	10	25.6	
	Mechanical	4	10.3	
	Electrical	4	10.3	
	Environmental	2	5.1	
	Total	39	100	

(*) HS: Highly Sig. at P<0.01; The Statistical Hypotheses are Based on one sample Kolmogorov-Smirnov and Binomial tests.

Part two: Table (6) shows summary of statistics and basis assessments for asking about the reasons that prevent the use of new materials (Environmentally Friendly) instead of traditional materials in construction, which consists of (2) sub domains, (Administrative Reasons, and Technical Reasons) and each consists of (8, and 5) items respectively. they obtained high and too high assessments, except for three items in the first sub domain have moderate assessment, which are (Decision-makers do not consider the issue of sustainability in buildings construction as a basic requirement), (The idea that the adoption of building materials environmentally friendly may be more expensive than traditional construction), and (The idea that the use of environmentally friendly materials may increase the duration of the project).

Table (6): Distribution of studied responding concerning the reasons that prevent the use of new materials (Environmentally Friendly) instead of traditional materials in construction

Statements	*Responding*	*No.*	*%*	*MS*	*SD*	*RS %*	*A.D.*
1. To what extent you agree to the following statements about the reasons that prevent the use of new materials (environmentally friendly) instead of traditional materials in construction							
Administrative Reasons							
Decision-makers do not consider the issue of sustainability in buildings construction a basic requirement	Strongly disagree	4	10.3	3.33	1.26	66.6	M
	Disagree	8	20.5				
	Neutral	4	10.3				
	Agree	17	43.6				
	Strongly agree	6	15.4				
Lack of available financial resources	Strongly disagree	3	7.7	3.41	1.09	68.2	H
	Disagree	6	15.4				
	Neutral	5	12.8				
	Agree	22	56.4				
	Strongly agree	3	7.7				
lack of adequate support for the implementation of projects where	Strongly disagree	1	2.6	3.97	0.84	79.4	H
	Disagree	1	2.6				

green building principles applied	Neutral	5	12.8				
	Agree	23	59.0				
	Strongly agree	9	23.1				
Non-availability of raw materials for the manufacture of local sustainable materials	Strongly disagree	1	2.6	3.44	1.19	68.8	H
	Disagree	11	28.2				
	Neutral	5	12.8				
	Agree	14	35.9				
	Strongly agree	8	20.5				
Lack of coordination among stakeholders	Strongly disagree	0	0.0	4.21	0.83	84.2	TH
	Disagree	3	7.7				
	Neutral	1	2.6				
	Agree	20	51.3				
	Strongly agree	15	38.5				
The idea that the adoption of building materials environmentally friendly may be more expensive than traditional construction	Strongly disagree	2	5.1	3.33	1.08	66.6	M
	Disagree	8	20.5				
	Neutral	8	20.5				
	Agree	17	43.6				
	Strongly agree	4	10.3				
The idea that the use of environmentally friendly materials may increase the duration of the project	Strongly disagree	3	7.7	2.72	1.05	54.4	M
	Disagree	17	43.6				
	Neutral	9	23.1				
	Agree	8	20.5				
	Strongly agree	2	5.1				
The lack of adequate information on sustainable building materials	Strongly disagree	0	0.0	3.79	0.8	75.8	H
	Disagree	4	10.3				
	Neutral	5	12.8				
	Agree	25	64.1				
	Strongly agree	5	12.8				
	Technical Reasons						
Lack of trusted materials suppliers	Strongly disagree	0	0.0	4.13	0.86	82.6	H
	Disagree	3	7.7				
	Neutral	3	7.7				
	Agree	19	48.7				
	Strongly agree	14	35.9				
Lack Of expertise required for the manufacture of environmentally friendly building materials	Strongly disagree	0	0.0	4.18	0.68	83.6	H
	Disagree	1	2.6				
	Neutral	3	7.7				
	Agree	23	59.0				
	Strongly agree	12	30.8				
Lack the skills required to build with such materials	Strongly disagree	0	0.0	3.97	0.87	79.4	H
	Disagree	4	10.3				
	Neutral	3	7.7				
	Agree	22	56.4				
	Strongly agree	10	25.6				
The lack of sufficient awareness to deal with these materials during the occupancy and maintenance period	Strongly disagree	0	0.0	4.26	0.68	85.2	TH
	Disagree	0	0.0				
	Neutral	5	12.8				
	Agree	19	48.7				
	Strongly agree	15	38.5				
Lack of adequate data on the potential environmental impacts of building materials used provide through their life cycle	Strongly disagree	1	2.6	3.54	1.05	70.8	H
	Disagree	7	17.9				
	Neutral	7	17.9				
	Agree	18	46.2				
	Strongly agree	6	15.4				
The difficulty of society acceptance for the use of new materials instead of traditional materials	Strongly disagree	1	2.6	3.92	0.98	78.4	H
	Disagree	4	10.3				
	Neutral	2	5.1				
	Agree	22	56.4				
	Strongly agree	10	25.6				

8. Conclusions

According to the theoretical and practical studies, barrios to the use of new building materials which are sustainable instead of traditional building materials were divided into two categories: Administrative reasons where Lack of coordination among stakeholders got the highest assessment, while The idea that the use of environmentally friendly materials got the last assessment which Reflects the awareness of the importance of using sustainable building materials and Technical reasons , where The lack of sufficient awareness to deal with these materials during the occupancy and maintenance period got a the highest assessment ,While Lack of adequate data on the potential environmental impacts of building materials used provide through their life cycle got the last assessment.

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