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STUDYING ENVIRONMENTAL AWARENESS IN THE SELECTION OF BUILDING MATERIALS

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Abstract: The main objective of the research is to highlight the extent of considering environmental impacts of building materials when making choices about the selection of building materials. The research object was achieved through two stages, the first stage included a theoretical study to identify environmental impacts of buildings construction and the importance of building materials for a construction project, while the second stage included a practical study to collect the necessary data and information to realize the reality of the process of selecting building materials for buildings construction. The practical study included personal interviews with engineers that have experience in buildings design, and then a closed questionnaire was conducted in order to achieve research object. (45) Questionnaire forms were distributed. the results showed a clear interest from the research sample in the importance of considering environmental impacts when selecting building materials as well as a clear weakness in the application of it on the ground because of the absence of instructions and motivating factors on one hand and the absence of data concerning environmental impacts of building materials on the other hand.

Keywords: *building materials, building construction, environmental impacts, environmental awareness*

دراسة الوعي البيئي في اختيار مواد البناء

الخلاصة: يهدف البحث الى تسليط الضوء على مدى اخذ الاثار البيئية لمواد البناء بنظر الاعتبار عند اختيارها في تصميم المباني .تم تحقيق هدف البحث على مرحلتين تضمنت المرحلة الاولى دراسة نظرية للتعريف بالاثار البيئية المصاحبة لتشييد المباني واهمية مواد البناء للمشروع الانشائي ، في حين تضمنت المرحلة الثانية دراسة عملية لجمع البيانات والمعلومات للتعرف على واقع حال عملية اختيار مواد البناء في تشييد المباني . شملت الدراسة العملية اجراء المقابلات الشخصية مع المهندسين ذوي الخبرة في مجال تصميم المباني و القيام باستبيان ميداني مغلق لتحقيق هدف البحث اذ تم توزيع 45 استمارة استبيان . اظهرت نتائج البحث اهتماما واضحا لدى افراد العينة بضرورة اخذ الاثار البيئية بنظر الاعتبار عند اختيار مواد البناء فضلا عن وجود ضعف واضح في تطبيق ذلك على ارض الواقع لعدم وجود التعليمات و العوامل التشجيعية من جهة وعدم وجود البيانات المتعلقة بالاثار البيئية لمواد البناء من جهة اخرى.

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

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

2. Environmental Impact Of Construction

The construction industry considered one of the most resource-intensive industries. There is a growing Concern about the effects of building activities on human and environmental health. There is no doubt that there is an urgent need to make the construction environment more sustainable [2]

The effects of Construction activities on the environment are throughout the life cycle of a construction project. Life-cycle concept refers to all activities from extraction i.e. ‹of resources through product manufacture and use and final disposal or recycle from "cradle to grave" Figure (1).Generally construction buildings affect the environment in two main ways by consuming resources and creating pollutants and wastes. [3]

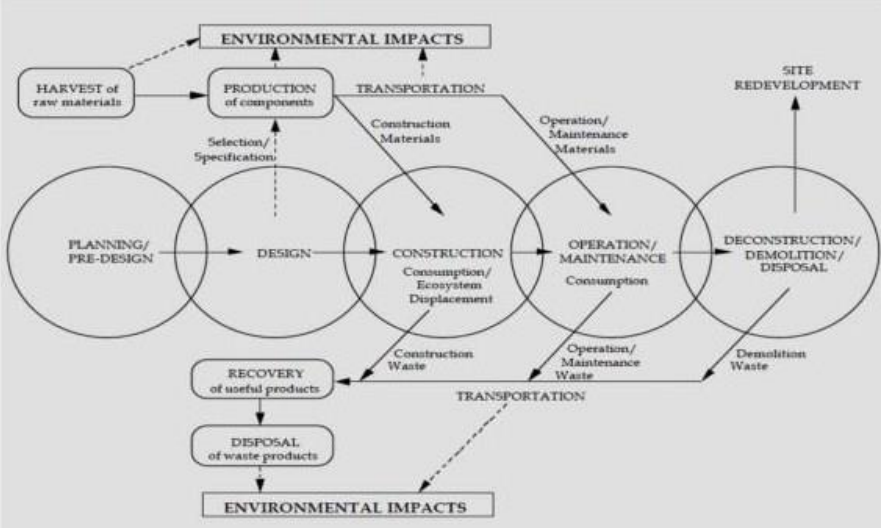

Figure (1): Environmental Impact through the Life Cycle of a Building Construction [3]

2.1 Resource Consumption

The physical environment principally linked to the construction sector by the demands made by the construction sector on global natural resources, and this assumes huge environmental significance with the rapid growth in global population and the attendant implications for natural resources.

This is especially the case with housing and infrastructure, which are very resource-intensive. The call for sustainable construction is in realizing the construction industry's capacity to make a significant contribution to environmental sustainability because of the huge demands it exerts on global resources [4].

2.2 generation of Pollution

Pollutants are produced during different phases of construction in many forms .Pitt defined Pollution from construction as "particles, noise, vibration and vaporous discharges" [5] The construction industry considered as the biggest effector on the environment due to the quantities of materials it use in construction. Environmental effects caused by building materials are resulted from raw materials extraction which contributes in pollutants accumulation to the atmosphere. [6]
Also materials production and transportation as well as site activities release Dust and other emissions include some toxic substances which causing a serious threat to the natural environment [7].

2.3 Waste Generation

The construction industry has been characterized as one that produces the highest amount of solid waste among all industries. Waste incurs additional cost either through it being carted away, or that which results from the actual rework.[8]
Waste results from the production, transportation and use of materials [9]
According to the economic nature of the building industry, every stage of the construction period is minimized. In addition, time and quality are critical and virgin materials are considered superior to second hand products for these reasons alone Screening, checking and handling construction waste for recycling are time consuming activities and the lack of environmental awareness amongst building professionals may create significant barriers to the usefulness of recycling [10].

Most construction waste is unnecessary many construction and demolition materials have a high potential for recovery and reuse, implementing a waste management plan during the planning and design stages can reduce waste on-site by 15 percent, with 43 percent less waste going to the landfill through recycling, and it delivers cost savings of up to 50 percent on waste handling [11].

2.4 Energy Consumption

Construction industry consumes energy at each phase of its life-cycle. Energy is and the operation of a ،consumed during Material production, construction phase completed building for heating, lighting, power and ventilation. Many techniques may be used to improve energy performance in construction building such as using insulation methods and development of an advanced energy monitoring and control [6].

2.5 Health And Well Being

The internal environment of buildings is responsible for human's quality of life. People spend about 90% of their Life in buildings. The World Health Organization (W.H.O.) indicated that bad internal environment of buildings is responsible for many health problems; they called this situation as "sick building syndrome". The W.H.O.

estimates that about, 30% of service buildings and industrial buildings worldwide have the SBS. [12]

The environmental protection agency in the United States (EPA) defined (SBS) as " a term used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified. The complaints may be localized in a particular room or zone, or may be widespread throughout the building". [13]

Because of buildings long life they affect the environment and the public health for many years such as producing Carbon dioxide emissions by The operating systems of the buildings like heating, cooling, electricity and lighting . There is an urgent need to improve Construction industry's methods of operating to make it more environmental friendly. [14]

3. The Importance Of Building Material For A Construction Project

Materials constitute a considerable proportion of a project total cost. It is ranged between (20-50%) according to some studies. Others indicated that materials proportion of a project total cost can increase up to (60%) sometimes. [15]

In Iraq building and construction sector considered one of the most important sectors to the national economy. It plays a major role in the preparation of GDP (gross domestic product) and employment and providing the key indicators of national accounts. According to Central Statistical Organization in Iraq (CSO), the value of building materials that was actually used in building and construction during 2013 accounted (69.7%) from the total cost of building and construction projects. [16]

Table (1): values of building materials from 2000 to 2013[16]

Year	*The total spent cost except contractors returns(million dinars)*	*Value of Building materials (million dinars)*	*Percentage of building materials %*
2000	21,628	14,872	68.70
2001	32,025	18,281	57.00
2002	50,515	37,763	74.70
2003*	-	-	-
2004	57,703	39,186	67.90
2005	65,181	42,793	65.70
2006	204,570	137,420	67.17
2007	531,050	382,791	72.10
2008	1,338,535	1,008,075	75.30
2009	1,191,784	851,475	71.40
2010	1,069,228	767,525	71.78
2011	1,447,761	1,015,063	70.10
2012	1,665,978	1,144,798	68.70
2013	2,656,910	1,853,826	69.70

*there was no report available for the year 2003 because of the war condition and data burning

Materials are pivotal in any type of industries .building materials can affect a construction project in two ways:

1. Shortage or unavailability of materials can interrupt or even stop the work in the project which will cause extra costs due to the delay.
2. Too much quantities of materials can cause serious problems, thus it increases the cost of storing and handling materials.

4. Materials Life Cycle

Materials affect the environment severely through its life cycle from "extraction of row materials through processing, manufacturing, using and demolition" [17].

An ideal life cycle of a material is explained in Figure (2). At each step of the life cycle there is energy and resources consumption, and waste and pollutants generation to the environment. Yet, transporting materials require transport during their life cycle require more energy and produces more emission to the atmosphere. Environmental impacts of materials can be reduced through the recycling and reusing of materials which will reduce the need for manufacturing new materials [18].

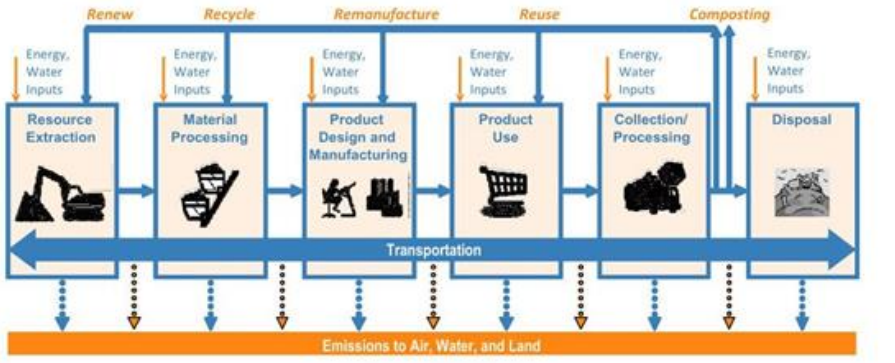

Figure (2): the life cycle of materials [18]

5. 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

5.1 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.

5.2 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 sustainability awareness of designers concerning the selection of building materials. The sample was taken were engineers who had experience in buildings designs.

5.2.1 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:

- Determining the researcher dependency (Inter Examiners) and the reliability of the respondents (Intra Examiner).
- 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) (19):

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

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)

5.2.2 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 the environmental awareness in the selection of building materials was designed to comprise two major parts as the following:

Part one: contains general information about the respondents

Part two: environmental awareness in the field of building construction, which includes three main questions as following:

1) Exploring the extent of respondents agreement to the statements about the environmental impact of buildings
2) The achievement of project goals when developing the designs and plans of building projects.
3) The factors that affect the selection of building materials in building projects, which were divided into three groups as following:

- Environmental impacts
- Functionality
- The cost

5.3 Statistical Analysis

The following statistical data analysis approaches were used in order to analyze andassess 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

Scores	*Scales*	*Interval*	*A.D.* (*)
Never	1	20 -	TL
Rarely	2	36 -	L
Sometimes	3	52 -	M
Often	4	68 -	H
Always	5	84 - 100	TH
Strongly disagree	1	20 -	TL
Disagree	2	36 -	L
Neutral	3	52 -	M
Agree	4	68 -	H
Strongly agree	5	84 - 100	TH
Not important	1	20 -	TL
2	2	36 -	L
3	3	52 -	M
4	4	68 -	H
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): [19]

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

5.4 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:

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

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.

6. Results Discussion

The findings of data analysis will be presented systematically in tables and these correspond with the objectives of the practical study, and as explained in the following:

Part 1: distribution of socio-demographical characteristics variables

Table (5) shows 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 Degrees

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: Environmental awareness in the field of building construction:

1. Table (A-1) shows statistical analysis and basic assessments for "Environmental impact in the design and construction of buildings". Sub domain consists of five items, all of them reported either high or too high degrees of assessments indicating that studied respondents were aware the importance of studying the environmental impacts of construction sector in general and building.
2. Table (A-2) shows statistical analysis and basic assessments for Achieved project objectives sub domain, which consists of five items. Three of them are reported moderate degrees of assessments, and they are accounted (60%), while leftover items had high assessments. Achieving the client requirements got the first priority among project goals (RS=81.6%), then achieving building regulation in Iraq (RS=81%) ,while minimizing the potential environmental impacts of building projects got the last priority (RS=60%) , which indicates that applying sustainable building aspects needs can be enhanced through making them a part of building instruction and specifications.
3. Table (A-3) shows summary statistics and basis assessments for asking about "Do you consider the following factors when selecting building materials in your projects", which consists of three sub domains, that were named (Environmental Impacts, Functionality, and The Cost), they consists of (9, 8, and 3) items respectively. All items related the reusing or recycling of building materials at the end of their life cycles got a low assessment. Also the consideration of material embodied energy got a low assessment with (RS=45.6%)

7. Conclusions

According to the theoretical and practical studies, the following results can be concluded:

1) Prioritizing building construction projects goals showed that satisfying the Clint's requirements and building regulation within the country gets the highest priority with (RS=81.6% and RS=81%) respectively .
2) Minimizing the potential environmental impacts of construction gets the least priority with (RS=60%) in spite of the high reorganization of responders to the importance of reducing the environmental impacts of construction projects.
3) Avoiding the use of materials that are classified as hazardous or toxic under local or international regulations was one of the most affected factors in the selection of building materials
4) There was a shortage in considering some factors like embodied energy, and the ability of material to be reused or recycled at the end of its life cycle.
5) The selection of building materials mostly based on the initial cost of them.

8. Recommendations

In the light of previous conclusions, the research proposed the following recommendations:

1) Increasing stakeholders awareness about the environmental impacts of some building materials and the importance of using sustainable building materials
2) Making the minimization of environmental impacts of building materials a priority within building regulations and specifications.
3) Giving attention to the benefits that can be obtained from recycling the waste of building materials
4) Considering the life cycle cost of building materials including the disposal cost.

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Appendix –A

Table (A-1): Distribution of studied responding concerning Environmental awareness in the field of building construction items axis

Statements	MS	SD	RS %	A.D.
Part two: Environmental awareness in the field of building construction				
1. To what extent you agree to the following statements about the Environmental impact in the design and construction of buildings				
Construction activities have various negative impacts on the environment	3.95	0.72	79	H
Environmental Assessment for construction projects is important in the success of the project economically	4.33	0.77	86.6	TH
Is necessary to study the environmental impacts of materials during their life cycle	4.31	0.61	86.2	TH
It is important to take into consideration the environmental impacts when selecting building materials	4.41	0.55	88.2	TH
There is a need to change some traditional building materials used in our country	3.95	1.02	79	H

Table (A-2): Distribution of studied responding concerning achieved specific objects when developing designs and plans of building projects

Statements	*MS*	*SD*	*RS %*	*A.D.*
Part two: Environmental awareness in the field of building construction				
1. *Do you achieve the following goals when developing the designs and plans of building projects*				
Achieving the project at minimum cost	3.38	0.91	67.6	M
Achieving the project at minimum time	3.13	0.98	62.6	M
Satisfy client requirements	4.08	0.84	81.6	H
Minimize the potential impacts of project to environment	3	0.97	60	M
achieving building regulation within the country	4.05	0.94	81	H

Table (A-3): Distribution of studied responding concerning considering environmental factors in the selection of building materials

Statements	MS	SD	RS %	A.D.
Part two: Environmental awareness in the field of building construction				
1. Do you consider the following factors into consideration when selecting building materials in				

your projects				
Environmental Impacts				
Geographical location of the project area and the type of materials that are available in that region	3.51	1.12	70.2	H
The climate within the project area	3.79	0.98	75.8	H
potential negative impacts on the health and safety of building users	3.28	1.1	65.6	M
Expected pollution of the environment (water, air, soil)	3.59	1.27	71.8	H
Avoid using materials classified as hazardous or toxic under local or national regulations	4.28	0.97	85.6	TH
Produced from renewable resources	2.77	1.22	55.4	M
Don't consume natural resources	2.79	1.22	55.8	M
embodied energy (energy expended during manufacturing operations, transfer and use of the material)	2.28	1.17	45.6	L

Continue...

Statements	MS	SD	RS %	A.D.
Part two: Environmental awareness in the field of building construction				
Possibility of environmentally sound disposal of material at the end of its service life (reuse or recycling)	2.03	0.87	40.6	L
Functionality				
Suitability of material for the required job	4.05	0.94	81	H
possibility to be recycling	2.1	0.91	42	L
possibility to be reused	2.33	1.06	46.6	L
Maintainability	3.92	1.01	78.4	H
contribution in reducing operational energy	3.44	0.97	68.8	H
Fire resistance	4	0.95	80	H
Durability	4.15	0.81	83	H
Strength	4.28	0.86	85.6	TH
3. Do you consider the following factors into consideration when selecting building materials in your projects				
The Cost				
Initial Cost	3.9	1.05	78	H
Maintenance Cost	3.69	1.26	73.8	H
Disposal Cost	2.21	1.1	44.2	L