

Reducing Waste of Construction Materials in Civil Engineering Projects In Iraq

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ABSTRACT

There is no doubt there is waste of construction materials in projects. So it is the responsibility of project managers to minimize these wastes. This study aims to determine the major causes of construction materials wastage, to test the willingness of those who are engaged in the building and construction industry towards waste management and to estimate the percentage of wastage in the main building materials used in construction sites in Iraq. To achieve the aims of this study, a form of questionnaire prepared, which include three sections that question about the causes of wastage, factors that influencing the application of waste management in the country and the wastage's estimated percentages for more common fifteen types of used materials in Iraqi construction sites and compare the results gained with other countries data. The study found that the most important causes of materials wastage at construction projects in Iraq are lack of on-site waste management plans; frequent changes to design, time pressure, lack of supervision, improper storing of materials; lack of possibilities to order small quantities; lack of skilled workers; theft and vandalism and poor contract documents. Moreover, the study found that both the private and public in the construction sector do not really considered in their plan and given an adequate attention to the management of waste in a construction site in Iraq, in addition, the study revealed that the wastage percentage of materials are ranged between 5% to more than 11% in the Iraqi construction sites.

Key words: causes of wastage; waste management; construction materials; waste minimization.

1. INTRODUCTION

The construction industry known by its production to a considerable amount and a large variety of waste, the quantity and kind depend on different factors, such as the type of construction, level or stage of construction, labors and their activities on site. Construction and demolition wastage are generated throughout the construction process, renovation course and demolition of different structures that mostly contain bulky, heavy materials, and salvaged building components and contribute substantially to the environmental pollution. A wide range of projects for instance commercial building, residential projects, office, and shopping malls, basically, generate waste in the industry of construction (Yap, 2011).

The production of construction-waste known as a major issue due to its direct influence on the efficiency of the construction industry as well as the environment and in recent years, a serious concern increased about the negative influence of the waste of construction materials on the environment (Formoso et al., 2002). Construction waste also stands as one of the major issues that face developing countries in the sector of the economy (Gulghane and Khandve, 2015).

The construction industry is one of the greatest waste producer industry in the world, but this industry sector still a major economic business among other sectors. The pollution generated due to construction activities create a great threat to the environment (Shen et al., 2007). It can be a pressing issue when there is a lack of resources to cover the building industry's demand. Iraq since the early nineties faces a serious problem in providing resources in general including construction materials, due to the economic siege enforced by the united nation after the first gulf war or as known "the desert storm war." Since then, Iraq passes through hardship in all life aspects that force the government to consider recycling materials and uses different alternatives to keep the progressing cycle flowing on the right path. But that was almost an impossible mission to accomplish due to the acute deficiency, and for that waste materials appeared to be a serious problem in the country. Later, in 2003, the American invasion on Iraq occurred, and that occupation has a destructive impact on all the country's sectors including the economy, health education and for sure the construction industry sector. It stopes all the construction project at once for a long period, and the deconstruction took place instead of generating a considerable amount of demolishing waste materials, (Fawn and Hinnebusch, 2006).

Recently, the war against terrorists and terrorism has a destructive impact on all the cities of the country specially Al-Mosul and Al Anbarcity. The initial statistics show that in the final weeks of the battle in Al-Mosul city, more than five thousand sites destroyed. Ninety-eight percent of the destruction covered the residential buildings, especially in the Old City. The Great Nuri Mosque also destroyed. With over 80% of the healthcare centres have demolished, about 130 kilometres of roads, 100 kilometres in the western section of Mosul, were also damaged with all the bridges that connect city parts across the river, producing a large amount demolishing waste. However, these numbers are certainly likely to rise after the survey and field assessment of the damage. All that with not mentioning the Damage in the other parts of the country (UNDP, 2017). All that create serious environmental issues and economic burden for the country to deal with and created a huge challenge to the country to reconstruct and built the destroyed cities again. For that reason, reducing waste in materials comes as an essential activity to take place in the building industry(UNDP, 2017).

Ding et al. (2018)from China mentioned that the negative impact on the environment due construction waste has become a serious issuethat should be solved as fast as possible with the accelerated process of urbanization in the country. Their research provides guidance to both designers and construction professionals to measurewaste reductionlike reduced design modification during the design phase, application of prefabricated components, on-site classifying materials and reuse them during the construction phase.Also, to help governments in the assessment of waste reduction management by providing references to the outcomes of construction plans and the benefits to the environment. On the other hand, Gao et al. (2018)stated that over the past decades a huge amount ofconstruction and demolition waste (C&D) had been generated, and it gradually arouses people’s attention towards the environmental threats and health issues that caused by C&D Waste. This study concluded that the popular C&D Waste reduction measureswere “Design for disassembling” besides “use of recycled materials such as metal scaffolding, metal formworks” in both design and construction stage respectively.

Bekr (2014)studied the causes and amount of construction waste on building construction projects sites in Jordan.The analysis revealed that the most important sources of materials wastageon construction sites were design change orders, poor contract documents, lack of skilled workers and bad site conditions, also the percentage of construction waste materials were between 15% - 21% on Jordanian construction sites.

Muhwezi et al. (2012)aimed to determine the major points that cause wastes on building construction projects in Ugandaand to present the possible ways to reduce their occurrences.The study showed that Lack of skills of workers, purchased materials that do not match qualifications, inappropriate storage at site leading to products damage, terrible weather conditions, Changes on the design while the building is in progress were the top significant factors of waste generation.The study made byAl-Hajj and Hamani (2011)revealed that the main causes of wastage in construction material were poor design, lack of awareness, and rework and variations. The most effective practices on material waste minimization were sufficient storage, training the staff, just- in time delivery of materials. They mentioned that to achieve the target of minimization of material wastage, more effective implementation is needed regarding waste segregation and waste measurement.Swinburne et al. (2010)attempts to measure the wastage of material occurring on selectedhighway construction sitesand to do so, a review has been undertaken to define the main points of awareness in construction waste generation, sustainable construction, and waste minimization.The paper discussed that Waste generation on construction sites is often occurring due to bad storage and inadequate protection, poor handling, poor site control, over ordering quantities of material, the absence of training, and damage to the material during transportation and delivery.

Poon et al. (2004)mentioned that Greater consideration to waste production and waste management should be taken at the planning phase of a building improvement to reduce wastage levels.They found that the most essential waste type used in the framework that requiring disposal were timber boards directly followed by waste resulted from wet trades.The major causes of wastes were improper handling and preparation, misuse, and improper processing. They suggested that using of precast building system can significantly reduce the production of construction waste. Also mentioned that appropriate planning with the preparation of a detailed waste management plan is an essential factor for an effective waste minimization process.In addition, they suggested that the waste monitoring data should publicize to help future studies on waste estimations.

Aim of study

The objective of this paper is to determine the major causes of wastage of construction materials on building construction sites in Iraq based on the perceptions of consultants, contractors, and owners. also, to estimate and evaluate the magnitude of wastage in the main building materials used in the Iraqi construction sites and compare the results with other countries data. Also, to form an idea about the willingness of stakeholders to adopt waste management and what factors affecting the Practice of Construction Waste Management.

3. METHODOLOGY

To achieve objectives of this paper, a questionnaire will be adopted as the main source of data. The questionnaire form prepared and designed according to the theoretical study of the topic including literature reviews, published articles, and other resources, and from face-to-face interviews with engineers, experts involved in the process of building and construction.

The questionnaire consisted of three main sections, each one represented by a separate table. The first section of the questionnaire is committed to the causes of wastage in construction materials; it contains twenty-seven factors categorized into seven groups. The answers would be telling the impact of each factor given rated from 1 which stands for no effect to 5 for higher impact. The second section of the survey questioning is made to test the desire and the willingness of those who are involved in the construction industry towards the idea of waste management and waste planning and how fare does they support it. Also, to form a view of why there is a lack of such planning in the construction industry in Iraq. A face-to-face interview will involve in this part, and YES or NO would answer the questions. The third part of the survey requested respondents to give their answers depending on their experience in the field of construction by scoring the percentage for each type of the selected materials as follows: 0 - 2%, 3 – 5 %, 6–8%, 9–11%, and 11< %. And the selected materials are Sand, Aggregate, Cement, Concrete block, Bricks, Steel reinforcement, Concrete, Tiles, PVC water pipes, wood, roofing materials, Asphalt, Glass, Gypsum, and Paint.

The data for this paper was gained using a questionnaire. The questionnaire, which has been written in English with Arabic translation to make it more clear and easy to answer. The questionnaire was distributed either personally or via e-mail to 50 members of the top and middle management in different construction companies, sight engineers, consultant, and other specialists in the field of construction industry. Only 45 valid questionnaires were received for the analysis with a response rate of 90% as shown in the table below.

To analyse the data collected in this survey, a descriptive and frequency statistical analysis techniques will be used. On the other hand, to analyse the data in a fast, systematic, and reliable way, an accurate and advanced method is required. To do so, Microsoft Excel and the computer software Statistical Package for Social Science (SPSS 25) selected.

The collected data from the survey were analysed by using the severity index and the frequency index method (Assaf and Al-Hejji, 2006), and they are both explained below with details.

Depending on Assaf and Al-Hejji (2006), the formula shown below was used to rank waste in materials based on severity index as indicated by the participants, which is called the Severity Index (S.I).

$$Severity\ Index(S.I)(\%) = \frac{\sum a(n/N)}{5} \quad 100 \dots \dots \dots (1)$$

Same as the next formula shown below, it is used to rank causes of wastage in materials grounded on the occurrence frequency as recognized by the contestants, which is called Frequency Index (F.I).

$$Frequency\ Index(F.I)(\%) = \frac{\sum a\left(\frac{n}{N}\right)}{5} \quad 100 \dots \dots \dots (2)$$

Where:(a) represent the constant weighting that is given to each response ranges from 1 for never up to 5 for very high impact,(n) represent the frequency of the responses, and (N) represent the total number of responses.

The Importance Index of every cause of wastage calculated as a function of both severity index and frequency index, as shown below:

$$Importance\ Index(I.I)(\%) = \frac{F.I(\%) \times S.I(\%)}{100} \dots \dots \dots (3)$$

4. RESULTS and DISCUSSION

The analysis of Causes of Wastage of participant’s response and the ranking of 27 considered factors that cause wastage in construction materials in building projects in Iraq is shown in Tab. 2, while Tab. 3 shows the ranking of the groups of factors.

Table 1. Ranking of causes of wastage.

Cause of wastage	SI %	FI %	I.I %	Rank
Lack of on-site waste management plans	74.67	75.11	56.08	1
Changes to design	74.31	73.35	54.51	2

Lack of on-site material control	69.78	68.89	48.07	3
Time pressure	68.44	70.22	48.06	4
Lack of supervision	66.67	67.11	44.74	5
Improper site storage space leading to damage or worsening	66.22	66.67	44.15	6
Improper storing methods	67.56	65.33	44.14	7
Lack of possibilities to order small quantities	65.33	66.67	43.56	8
Lack of contractor experience and lack of knowledge about construction	66.67	64.89	43.26	9
Use of incorrect material, requiring replacement	67.11	63.11	42.35	10
Ordering error, under ordering, and so on	63.56	65.78	41.81	11
Lack of attention to sizes of used materials	65.78	60.89	40.05	12
Materials supplied in loose form	64.44	61.78	39.81	13
Use of products that do not fit	64.44	60.44	38.95	14
Accidents due to negligence	62.17	60.44	37.58	15
Inadequate material handling	60.44	60.89	36.90	16
Poor craftsmanship	60.89	60.43	36.80	17
Equipment malfunction	58.67	60.89	35.72	18
Materials stored away from the point of application	59.11	59.56	35.20	19
Unknown quantity of required products due to imperfect planning	60.43	57.78	34.92	20
Vandalism	58.67	59.11	34.68	21
Inefficient methods of unloading	58.22	59.11	34.42	22
Stealing of materials	59.56	57.78	34.41	23
Weather	56.00	58.22	32.60	24
Error in contract documents	57.78	55.56	32.10	25
Designer is not familiar with possibilities of different products	50.22	48.70	24.46	26
On-site transportation methods from storage to the application point	44.89	45.33	20.35	27

Table 2. Severity, Frequency, and Importance indices rank of the factor groups.

Factors group	SI %	FI %	II%	Rank
ON-SITE MANAGEMENT AND PLANING	70.37	70.37	49.63	1
SITE OPERATION	65.89	64.11	42.37	2
STOREAGE	64.00	64.74	41.50	3
DESIGN AND DOCUMENTS	62.58	60.32	38.34	4
PROCUREMENT FACTORS	61.99	61.19	37.96	5
EXTERNAL FACTORS	58.07	58.37	33.90	6

MATERIAL HANDLING	54.81	55.55	30.96	7
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The influencing factors on the Practice of Construction Waste Management are shown in Tab.4. The results of the survey show that 100% of the participants supporting the idea of the waste management and they all agreed that construction waste should be reduced, and managed and providing more training on waste management, but surprisingly most of them do not apply waste management plan in their work. That shock is gone and turns to seem reasonable after analyzing the data because the survey showed that there is no support for waste management in the construction industry in both governmental and private sectors. On the other hand, over 90% of the participants in the survey believe that using recycled materials and imposing penalties will not influence the practice of waste management in the present time. In addition, the same percentage believe that material prices do not have much impact on that area of management.

Table 3. Factors Influencing the Practice of Construction Waste Management.

Influencing Factors	YES%	NO%
Do you agree with the idea of Waste Management?	100	0
Does your organization take Procedures for Waste Management?	12.4	87.6
Do you agree that the waste in construction must be reduced?	100	0
Is there any encouragement or support from your company or government to practice Waste Management?	0	100
Do you agree that there must be more care to apply Waste Management on building sites?	100	0
Do you believe applying Waste Management will help reducing construction waste?	83	17
Do you think that more training on Waste Management is important?	100	0
Do you agree that penalties must be charged against contractors who don't have a waste management plan?	8.89	91.11
Do you think that using recycled material will reduce waste?	6.67	93.33
Does the low price of materials have an influence on not considering waste management plan?	4.44	95.56

Wastage in construction materials due to application, vandalism, theft, bad storage, and transit, to the fifteen selected types of materials used in the construction sites in Iraq is revealed in Tab.5 shown below. The table points out that sand had the highest percentage of waste of about 11.24% directly followed by aggregate with the percentage of waste of about 11.00%. Cement has 9.80% close to the wastage in Gypsum with 8.60%; Concrete has 8.16% while Concrete blocks and bricks have close percentages with 7.31% and 6.98% respectively. On the other hand, roofing materials, Paint and PVC water pipes have the lowest percentage of waste with about 5.40%, 5.11%, and 5.07% respectively.

Table 4. Survey results, percentages of wastage of materials.

Material	Percentages of wastage of materials					Mean%
	0-2%	3-5%	6-8%	9-11%	11%<	
Sand	0	0	2	12	31	11.24
Aggregate	0	0	1	20	24	11.00
Cement	0	3	11	10	21	9.80
Gypsum	3	5	12	10	15	8.60
Concrete	1	9	12	15	8	8.16
Concrete block	5	12	8	10	10	7.31

Bricks	6	10	12	10	7	6.98
Tiles	5	15	7	10	8	6.89
Steel reinforcement	5	15	13	10	2	6.22
Wood	9	13	11	9	3	5.87
Glass	10	16	9	5	5	5.49
Asphalt	10	13	15	4	3	5.40
roofing materials	10	13	15	4	3	5.40
Paint	15	11	9	6	4	5.11
PVC water pipes	15	10	11	6	3	5.07

For the causes of wastage in materials. The results shown in Tab.2 highlights that the lack of on-site waste management plans, changes to the design, lack of on-site material control, time pressure, lack of supervision. Inappropriate site storage space leading to damage or deterioration, improper storing methods, lack of possibilities to order small quantities, lack of contractor experience and lack of knowledge about construction. Use of incorrect material requiring replacement and ordering error were ranked in the first ten positions as the most effective waste causes on sites.

The outcomes shown in Tab. 2 exposed that “Lack of on-site waste management plans” ranked first with Importance Index of 56.08. From the author’s experience, discussions and interviews with survey’s respondents, only large contracting companies, which are very few in the country, having a plan for managing the materials in building projects. These strategies represented in managing materials purchasing, materials supply, making lists, material stocking, material handling, and transport. In their study, Jaillon et al. (2009) exposed that the absence of waste minimization strategy was the major source of waste in construction sites in Hong Kong.

The same table also shows that “Change to the design” ranked second with Importance Index of 54.51. When these changes to design happen during construction progress, can result in different ways wastage. There will be waste resulted in materials that cannot be returned to the seller if changes to design happened during the construction phase and after purchasing the materials already. In the same way, if the building has constructed already, any change to design will May results in demolition act depending on the change order causing wastage in materials. In their study, Ekanayake and Ofori (2000) stated that changes to design were major factors of construction waste as it ranked the highest.

The study also shows that the “Inappropriate site storage space and Improper material storing methods’ were classified in the 6th and 7th ranking by Importance Index of 44.15 and 44.14 respectively. This cause can result in many ways. Faniran and Caban (1998) in their study found that inadequate storage and insufficient stacking of materials were one of the important factors of wastage. Similarly, Poon et al. (2004) reviled that one of the Maine causes of wastage was improper material storage. Moreover, in Gaza Strip, Enshassi (1996) stated that bad storage of materials was a considerable factor of wastage.

The analysis also showed that “inadequate material handling and Poor craftsmanship’ which related to not experienced workers, was ranked in the sixteenth and the seventeenth place with Importance Index of 36.90 and 36.80 respectively. Lack of experience can result in re-work due to work errors, which leads to wastage for sure. Alwi et al. (2002) from Indonesia Indicated that absence of skilled labours and staffs were a major cause of wastage in construction sites, and he mentioned that the contractors still have a problem of lack of skilled craftsmen to complete their projects adequately.

The ‘Weather’ factor ranked in the twenty-fifth in the position with Importance Index of 32.60. Poor weather can cause different types wastage in construction materials. Bad weather could cause disturbances to construction activity that could cause wastage if the work was done before the trouble has discarded and that can result in stating the activity again. In their study, Faniran and Caban (1998) revealed that bad weather could results in material wastage if the materials were left exposed to extreme conditions of cold and hot weather and exposed to rainfall connecting that with material storage facilities that should be considered to reduce waste caused by bad weather conditions.

For wastage of materials magnitude. The study concluded that construction wastage materials in Iraqi construction sites could exceed 11% of the materials used amount. Comparing these numbers with results gained from building sites in developed countries such as the UK and the USA, these results seem to be high. The statistics of wastage in the UK does not exceed 6% and 10% in the USA according to Poon et al. (2004).

Also, Chen et al. (2002) studied materials wastage for private residential structures in Hong Kong, the results of his study showed lower records than those in Iraq.

There are many other research studies like Shen et al. (2002) and Lu et al. (2011) that worked to find the reasons for wastage of each type of the aforesaid materials.

4. CONCLUSION AND RECOMMENDATIONS

To conclude, the analysis of the survey showed that both private and public sectors of construction in Iraq do not support the application of waste management in construction projects and this is a major cause in the increasing losses of construction materials. And this is also a reason for the contractors not paying attention to the wastage planning. Design changes during or after construction was also a major waste factor with importance index 54.51%, and the obvious reason behind it is poor decision making by the client and poor contract documents. Moreover, poor storage of construction materials comes with almost 44% of the importance index, and this happened of course by letting these materials exposed to bad weather conditions without protection, which may result in damaging the materials prominently. Bad storage is a major reason of waste in Iraq; this is because of the contractors not caring about the storage of the materials due to the lack of knowledge and experience in this field, or due to the lack of regulations in the storage methods in the contract bonds. Ordering errors come with 41.81% of importance index; this happens due to bad estimations of the needed amounts of materials during the design phase. Importance index 39.81% for supplying materials in loose form, this is common in Iraqi construction sites. Accidents in project site have 37.58% importance index, and this is related to lack of experience of labors and masons, for that inadequate handling and poor craftsmanship comes after with 36.9% and 36.8% of importance index respectively. Theft and vandalism represent a big source of loss in construction materials; this is sometimes to the lack of education and the financial state of the country with the bad security situation of Iraq.

To overcome construction waste issue, several important recommendations must be taken into consideration:

- Both private and public sectors in the field of construction should play an important role by supporting and applying a waste management plan in building and construction in Iraq.
- Improving contract documents to avoid wastage from design changes and changes in the requirements of the client and avoiding poor documents and design errors.
- Recommending preparing better storage facilities near the site to protect the materials and avoid wastage and avoiding unnecessary handling of materials.
- The contractors should hire qualified administrative staff to avoid mistakes in calculations of quantity, ordering errors, over-allowances and to avoid bad organization between construction and storehouse
- Good strategies for reducing waste in materials and more control on the project progressing and good communication and coordination between stakeholders is recommended to be done.
- Hiring trained and experienced labor and supervisors is very important.
- Having a good security system including fencing, lighting, and secured storage also recommended avoiding vandalism and theft.

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