Al-Azhar University Civil Engineering Research Magazine (CERM)
Vol. (40) No. (3) July, 2018

Managing the construction waste to reduce medium size residential and commercial project cost in Egypt

El-Desouky1 A.M. ,Ibrahim 2 M.E. , ElDieb 3 A.S.
1, Overseas Deputy Department Manager at ECG (Cairo- Egypt),
2, Professor, construction and management Faculty of Engineering, Cairo Univ. (Giza, Egypt),
3,Assistant Professor, construction and management Faculty of Engineering, Cairo Univ. (Giza, Egypt).

ملخص

عرف المخلفات الإنشائية : بانها مخلفات صلبة غير خطرة تتولد من نشاطات البناء ،الهدم ،الإنشاء والتطوير والتصليح هدم المنشآت والأبنية ، الطرق ، الجسور ، تنظيف الأرض ، إنشاء المجاري ، المنازل ،وان المواد المتخلفة في المواقع تتضمن: اسفلت ، خرسانه، خشب ، زجاج ، ألمنيوم ، حديد ، عبوات الصبغ ، عوازل أنابيب المراجل ، أسلاك ، سقوف ثانوية وغيرها.

بسبب التزايد السريع لعدد السكان والإنشاءات تتولد في البلد ملايين الأطنان من مخلفات الإنشاءات والهدم وان هذه المخلفات تتزايد طبقاً إلى المعلومات المتوفرة ويجب التخلص منها وان السماح لهذه المواد التي من الممكن إعادة استخدامها او تدويرها ان تذهب الى المدافن.

هذه المخلفات بطبيعة الحال تختلف من موقع بناء الى أخر ولكن المنافع في التقليل وإعادة الاستخدام وإعادة التدوير تبقى كما هي وحيث ان إعادة استخدام او تدوير المخلفات الإنشائية والهدم هي احد اكبر مكونات التنمية المستدامة. عند إدارة مخلفات الهدم والإنشاءات فان الخيار الاول الذي يؤخذ بنظر الاعتبار هو التقليص والخيار الأخير هو الطمر الصحي.

Abstract

Construction waste is defined as solid, non-hazardous waste generated from building, demolition, construction, development and repair activities, demolition of buildings and structures, roads, bridges, cleaning of land, construction of sewers, houses, and the following materials: asphalt, concrete, wood, glass , Aluminum, iron, pigment packaging, boiler pipe insulators, wires, secondary ceilings and others.

Due to the rapid increase in population and construction, millions of tons of construction and demolition waste are generated in the country. These wastes are increased according to the available information and must be disposed of, and allowing these materials that can be reused or recycled can go to the landfill.

These residues naturally vary from one site to another but the benefits of minimization, reuse and recycling remain as they are, and the reuse or recycling of construction waste and demolition is one of the major components of sustainable development. In the management of demolition and construction waste, the first option to be considered is reduction and the last option is landfill

Key words: construction waste, waste management, waste percentage, Waste materials, Waste cost.

1. Introduction

Construction waste is in between 15 and 30% of the urban waste, Prevention of the construction waste generation on site is an important element in the integrated chain management policy. Waste can occur due to different construction processes and due to many factors including the external factors such as accidents and others(Forsythe and Marsden, 1999).

In fact, the values of mistakes that occur in these factors are governing waste quantities. As increasing of mistakes in these factors will increase the quantity of waste.

For example, if the mistakes due to transportation process of the materials inside the site are minimum, the waste due to this process will be minimum. In addition, a mistakes caused by warehouses conditions are minimum by applying a good storage system, the waste due to this process will be minimum and so on. Therefore, understanding and identifying of these factors is recommended. In addition, Bossink and Brouwers (1996) identified the relative importance of each factor toward the construction materials is not same i.e , the factor concerning cutting and forming has effect for some materials such as steel, and marble, while it has no effect for others such as sand, and gravel. Therefore, it is also recommended to determine the relative importance of each factor versus the used materials.

In fact, estimating of the mistakes that will be occurred in these factors during the project lifecycle prior to the project starts is difficult. Accordingly, it is suggested to establish a methodology or a tool to use in performing such estimation. The suggested methodology is through the project characteristics, which can be controlled, identified, and planned, prior the project starts. However, determining of these factors and their relative importance toward the different construction materials, and the related Project characteristics. Factors affecting waste quantities and the relative importance of each factor for each material of the most widely used in construction are identified. Moreover, the project characteristics related to each factor, which are used in estimating the value of mistakes for different factors is investigated.

2. Identification of the factors affecting waste

2.1 The initial list of Factors

Three unstructured interviews have been carried out with three experts to determine and identify of the factors affecting the waste quantity. The experts have been selected based on the following criteria. This fact favorably agrees with the study conducted by (Chua D.K.H. et al, 2001) that contractors behavior have no clear rules while delivering a bidding decision as these decisions are commonly based upon intuition and past experience.

The interview with each expert was opened to allow the expert to explore his opinion with reference to the identification of factors affecting the quantity of waste. i.e. no previous or initial determination for these factors has been given to the expert as shown in table 2.1. The results of such interview with each expert have been collected, and then results from all experts are summarized together with that detected from the literature review in order to establish a proposed list or initial !fat of factors.

Table 2.1 indicates the initial list of the factors affecting waste quantity in general and regardless to the material type.

Factor	Identification
Contract document mistakes	Represent the mistakes due to the errors in contract documents or one of it.
Incomplete contract document	Represent the mistakes due to the errors in contract documents or one of it.
Purchase order mistakes	Represent the mistakes due to errors in purchase process.
Vendor's mistakes	Represent the mistakes due to errors generated from project vendors.
Vendor's mistakes	Represent the mistakes due to errors generated from project vendors.
Storage and Transportation mistakes	Represent the mistakes due to problems in storage of materials, handling, preservation or warehouse facilities.
Labour mistakes	Represent the mistakes due to labour's errors.
Equipment mistakes Accidents	Represent the mistakes generated by equipment such as using the unsuitable equipment.
Mistakes due to activities consequence	Represent the mistakes due whether conditions, theft, or careless. Represent the mistakes due to execution of activities, where some activities cause damage to the previous one.
Cutting and forming	Represent the mistakes due cutting of incorrect lengths, and forming irregular shapes due to several reasons.
Wrong amounts	Represent the mistakes due the using of extra amount of material due to many reasons.

2.2 Final list of factors

The percentages of the respondents who consider the factor as reason for the waste, For example, 17 respondents which represent 29.3% of the questionnaire· respondents indicated that the "Contract document" affect the waste quantity.

It can be seen that the frequency of the factor "Cutting and forming" represents about 60.3 % while, "labour mistakes" represent 63.7% .These two factors represent the highest percentages , however it seems logic since construction industry in Egypt is suffering from the shortage of good labour. The next two highest factors are "storage and material

transportation" and "wrong amounts" 48.2 % and 39.6 % respectively. However, it seems also logic where the material transportation whether at site or to site cause a recognized waste.

A frequency between 20 to 30 %, is about Accidents, Equipment mistakes, contract document mistakes, and incomplete mistakes. Only two respondents reported extra factors (two different factors) , however it represent a small frequency (3 %),therefore it can be neglected . Therefore, the eleven factors, which includes in the initial list will be considered as a final list. (Alberta Environment, 2006)

2.2 Relative importance of the affecting factors

The factors that affect the material waste quantity have been identified in general in the previous section. However, there is a need to find the percentage of waste generated by each factor for each material. The relative importance expression will be used to represent such percentage. In a deep investigation for each factor and its effect on the waste of different construction materials, it was found that the effect of a certain factor is high on certain material and low for another material (Lanting 1993).. For example, the factor titled "Cutting and forming" has high effect on waste produced from steel or wood ,Yost and Lund (1997) estimated that by weight or by volume, wood, dry wall and cardboard combined make up between 60 and 80 percent of job site waste in construction projects. and has low effect on waste generated from the sand and gravel.

In order to determine the relative importance of each factor relating to a specific material, the second questionnaire has been introduced. This questionnaire has been designed to include two sections.

The first section is the general information section, which includes the organization or the firm name, address, the legal form, rank of the company in the Egyptian federation for construction contractors and the relevant activities. These items indicate the position of the company in the Egyptian construction industry market.

The questionnaire require that the respondent select a range from the five intervals of relative importance ranges for each factor versus each material. Table 2.3.1illustrates those five intervals (ranges) for the effect of each factor relative to each material, which have been suggested and introduced in the questionnaire. Data from respondents have been collected and analyzed as follows an intermediate values is selected for each interval to represent the interval in order to perform the calculations. If the respondent select the second range" Small" the, then the midpoint of this respondent will be 7.5.

Table 2.3.1 Intervals boundaries for Questionnaire two.

Interval	Very small	Small	Average	High	Very high
Percentage	0-5%	5-10%	10-30%	30-50%	> 50%

A mean (average) value for each factor has been calculated using equation three.

$$\sum X / N$$

Where,

N= sample size

X = The mid-point range selected by the respondent.

Table 2.3.2 indicates the different values for the relative importance in relating to the selected construction materials. Standardization has been made (correction) for the calculated percentage so that the total amount for all factors in relating to a specific material must be 100% or one.

Table 2.3.2 Relative importance (weight) of Factor versus different Materials.

Material / Factor	STEEL	CEMENT	WOOD	SAND	GRAVEL	MARBLE	CERAMIC	MORTAR	R. OFF TILES	PLASTIC&PIPES	BRICKS	CONCRETE
Contract documents Mistakes	0.07	0.05	0.06	0.06	0.06	0.08	0.08	0.06	0.05	0.08	0.07	0.07
Incomplete documents Mistakes	0.07	0.05	0.05	0.06	0.05	0.07	0.07	0.04	0.04	0.05	0.05	0.05

Material / Factor	STEEL	CEMENT	WOOD	SAND	GRAVEL	MARBLE	CERAMIC	MORTAR	R. OFF TILES	PLASTIC&PIPES	BRICKS	CONCRETE
Purchase order Mistakes	0.11	0.12	0.10	0.12	0.14	0.11	0.11	0.10	0.10	0.11	0.11	0.13
Vendor Mistakes	0.08	0.08	0.10	0.10	0.09	0.08	0.09	0.07	0.09	0.10	0.11	0.09
Storage and Transportation Mistakes	0.09	0.14	0.11	0.14	0.13	0.10	0.11	0.15	0.18	0.10	0.17	0.12
Labour Mistakes	0.15	0.15	0.14	0.13	0.15	0.14	0.15	0.17	0.15	0.16	0.15	0.13

Equipment Mistakes	0.06	0.08	0.09	0.10	0.10	0.08	0.08	0.08	0.07	0.08	0.09	0.09
Accidents	0.05	0.07	0.07	0.06	0.05	0.06	0.05	0.05	0.07	0.07	0.05	0.06
Activities Consequence Mistakes	0.05	0.06	0.05	0.07	0.07	0.09	0.07	0.09	0.08	0.05	0.07	0.06
Cutting and forming Mistakes	0.17	0.04	0.16	0.04	0.03	0.11	0.13	0.06	0.11	0.15	0.07	0.06
Wrong amount Mistakes	0.10	0.16	0.07	0.12	0.13	0.08	0.06	0.13	0.06	0.05	0.06	0.14
Total	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

It can be seen from table 2.3.1 that the effect or the relative importance of the factor" cutting and forming" with respect to some materials such as "Steel", 'Marble", and "Wood" is high as 17% , 11%,and 16% respectively. On the other hand, it has small effect for other materials such as "cement"," Sand", and "Gravel" which are 4%, 4%, and 3% respectively .Also, It can be seen from the table that the labour mistakes.

Factor represents high relative importance for all materials, where it ranged from 13% to 17% of the total effects. The same for the factor "Wrong amount mistakes", where it has a recognized relative importance varying from 5% to 16%.However, these results confirm that those two factors have a recognized effect on waste quantity.

2.4 The project characteristics.

As indicated in the introduction of this chapter, the value of the mistakes in the different factors is occurred all over the project lifecycle and estimating of this value is difficult prior the project starts. In addition, leaving the estimation of the mistakes values to the experience of the estimator could lead to wrong result. Therefore, it is recommended to find a methodology or a tool to estimate the factor mistakes. The project characteristics. Could be used to such purpose, therefore identified, planned, and controlled of such characteristics are leading to determine the factor mistakes prior the project starts.

2.5 Identification of the project characteristics.

The methodology that has been applied to determine and identify the project characteristics is extended in two directions. The first one is to examine the literature concerning this point to explore -the project characteristics that represent each factor or control these factors. In fact, the quality management system was a good source to formulate the initial list of the project characteristics in addition to the literature. The second direction is to explore the opinion of the experts concerning these characteristics in

the Egyptian construction industry. However, interviews with four experts have been carried out, in order to formulate an initial list of these project characteristics.

The results of such interviews with experts and the literature have summarized to formulate this list of the project characteristics.

Finally, this list initial list has been presented to other 12 experts through a questionnaire to find out the final project characteristics. A statistical analysis to finalize the initial list has been carried out.

2.5.1 Interviews with Industry experts

The first interview produced an initial list of the project characteristic in relative to each factor of that factors affect the waste quintet These interviews were unstructured interview Le the no previous items or proposed project characteristic have been introduced.

2.5.2 Initial project characteristics

The results of the interviews in addition to the literature review and the IS09001-2000 have been collected to establish an initial list. Table 2.5.2.1 illustrates the initial project characteristics and there identification. It can be seen from table 2.5.2.1 that the factors have been grouped into six groups. The first group (documents) includes contracts mistakes and incomplete documents, while the second group (purchasing) include purchasing order and vendor mistakes. The third group (storage) has only the storage and mistakes factor while the fourth group is the accident factor. The fifth group is the process, which contains the labour, equipment, cutting and forming, and wrong quantity. Final group is the management.

It can be seen from the table 2.5.2.2 that the project characteristics in relative to each factor could be panned, and controlled before the project starts. For example, the factor titled "purchase order mistakes", five project characteristics can be determine, however, each character could be planned and controlled by the project engineer, which can establish a good process for purchasing, complete all the necessary information with respect to the product, and the vendor. In addition, the project engineer can control the presence of the small order based on the project environment. Another example, there are four characteristics can be used to determine the mistakes associated with "Storage" factor, these characteristics represent the condition of the warehouse, handling system, possibility of the unpacked materials, and the site layout. Finally, it can be seen from the same table that factor tilted "Labour mistakes" include one characteristic about physical and metal conditions. However, physical and mental condition for labour plays a major rule in productivity and the quality of work, which affect waste generation. .Project engineer could make the good plan for each of the previous characteristics, even the characteristic concerning the possibility of unpacked material which can be mange through specific preparation.

Table 2.5.2.1 **Initial Project characteristics versus Factors**

NO	FACTORS	CHARECTERSTICS
	Documents	
Fl	Contract documents mistakes.	1. Drawing mistakes. 2. Specifications mistakes. 3. General condition mistakes

F2	Incomplete documents	1. Incomplete documents. 2. Incomplete specifications. 3. General condition mistakes.
	Purchasing	
F3	Purchase order mistakes	1. Existence of purchasing process.
NO	**FACTORS**	**CHARECTERSTICS**
		2. Quality of purchasing Information (Take Off QTY/ Specifications). 3. Existence of verification process for Purchased product. 4. Presence of change orders 5. Presence of small orders.
F4	Vendor mistakes.	1. Presence of evaluation process for vendor relevant experience. 2. Presences of validation process for vendor performance against competition. 3. Application of QMS (IS09001-2000) by the vendor in his/her organization, applying QMS Audit by the organization. 4. Availability of good vendors in the project.
	Storage	
F5	Storage and transportation mistakes.	1. Condition of warehouse facilities. 2. Existence of handling system, packaging, storage, and delivery. 3. Possibility of Unpacked materials 4. Condition of site layout and site organization.

Table (2.5.2.2**) Causes Of Waste Generation as indicated by Respondents**

Causes of Wastes 1	F(70-100) 2	T(40-69) 3	S(0-30) 4	% of(F+S) 5	Rank 6
Information					
Late Information	8	14	11	61.1%	5
Unclear Details	2	15	16	47.2%	. 10
Ignorance of Specifications	1	9	22	27.8%	13
Uncompleted design	7	20	8	75.0%	2
Inadequate Information	7	11	12	50.0%	9
Substitution of materials	4	16	14	55.6%	7
Management					

Poor Planning	5	14	15	52.8%	8
Poor Control	7	17	11	66.7%	4
Excessive Control	2	16	14	50.0%	9
Bureaucracy	4	10	18	38.9%	11
Unnecessary people moves	9	18	9	75.0%	2
Waiting Resources(idle)	3	14	18	47.2%	10
Resources					
Equipment misuse	5	12	18	47.2%	10
Poor Distribution	3	14	18	47.2%	10
Untrained Labor	9	19	8	77.8%	1
Resources Shortage	2	19	13	58.3%	6
Recourses Surplus	3	8	21	30.6%	12
work not done	7	17	11	66.7%	4
Poor technology	7	17	10	66.7%	4
Unpredicted Situations					
Changes to design	8	20	8	77.8%	1
Theft or Vandalism	2	8	25	27.8%	13
Damage during Transportation	7	15	14	61.1%	5
Poor handling- storage	4	16	16	55.6%	7
Materials defects	4	21	11	69.4%	3

3. Conclusions and recommendations:

The results of materials waste percentages in the Egyptian Construction Industry gathered in are consistent to those developed by Ragab et al (2001) & Garas et al (2004) . While comparing the absolute values of these 2 Egyptian studies with those of other countries, a great difference between the values is recognized due to the different procedures of gathering the data as well as the variation in the building traditions.

- Uncompleted designs, changes to design, substitution of materials, late information, unnecessary people movements, and untrained labor were among the highest dominant causes of materials waste generation in the Egyptian Construction Industry.
- While ignorance of specifications, waiting (idle) resources, bureaucracy, and theft actions were of least effect on materials waste amounts.
- The study is limited to the three prevailing types of projects: "Residential", "Non Residential or Building", and "Engineering".
- Although small case base with 20 case, it is expected that it will increase gradually. This will be achieved by adding (retaining) the new case (using the "query as case" option) that fits the users' requirements to the case base.
- Problems related to projects of type Residential "PR' which consist of repetitive units and typical floors are almost similar to each other. They only differ in the on-site management level according to the experience of the members of the teamwork and the conditions of each site. This makes each project regarded as a new experience.

It is recommended that future work on material waste minimization would cover the following areas:

1- To integrate other building materials in the study after identifying their effect on the overall project cost.
2- To collect data on materials waste percentages and its causes using site-measured data.
3- It is highly recommended to make this application available for contracting companies to integrate all the cases of various projects inside it to be used as a decision-supporting tool, as well as a learning tool for estimating and minimizing the amount of waste in materials.

4. References:

- Alberta Environment. (2006). Construction, renovation and demolition waste materials: Opportunities for waste reduction and diversion. Retrieved Sept. 15, 2007, from http://environment.gov.ab.ca/info/library/7703.pdf
- Bossink, B. A. G., and Brouwers, H. J. H. (1996). Construction waste: Quantification and Betts, M., Robinson, N. and Santhanam, J. (1993). "Multi-purpose expert system prototype in Construction Law." Australian Institute of Building Papers, 4, pp.57-74.
- Chua, D. K. H. and Godinot, M. (2006). "Use of a WBS matrix to improve interface management in projects." Journal of Construction Engineering and Management, 132(1), 67-79. Chung, J. K. O. (1999). Monitoring of Solid Waste in Hong Kong 1998. Environmental Protection Department, Hong Kong, China.
- Forsythe, P., and Marsden, P. K. (1999). Modeling construction waste performance-an

arising procurement issue. Profitable Partnering in Construction Procurement, CIB W92 (Procurement Systems) and CIB TG23 (Culture in Construction) Joint Symposium, London, UK, pp. 679-688.

- Lanting, R.W. (1993). "Stofstromen in debouw en het milieubeleid." Ketenbeheer in de bouw, The Netherlands, pp. 25-38 (in Dutch).
- Yost, P., and Lund, E. (1997). "Residential Construction Waste Management: A builder's Field Guide (National Association of Home Builders)NAHB,p.6.