PORT SAID ENGINEERING RESEARCH JOURNAL
Faculty of Engineering - Port Said University
Volume 17 No. 1 pp: 68:78

Waste Minimization in Infrastructure Projects in Egypt

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ABSTRACT

Waste is one of the most sophisticated problems which adversely affect the construction sector in Egypt. Substantial amounts of materials have been over consumed in different project stages. Examples of these stages are; design, documentation, procurement, handling, transportation storage, operation and inspection. Improper waste management and lack of concern given for waste minimization leads to excessive wastage of materials. The scope of this study covers the construction companies which possess experience in infrastructure field. Infrastructure projects are huge concerning capital and importance. It also includes big variety of activities which can be considered as a representative to the hole construction industry. This study aims to identify the main factors that cause waste in infrastructure projects in Egypt. It aims also to identify the severity of these factors.

Questionnaire was designed to collect data in order to carry out the objectives of this study. The questionnaire includes 67 main factors causing waste divided into 10 categories representing all project stages. Out of 180 questionnaires distributed, only 51 have been responded. Data has been analyzed using *"Statistical Package For Social Science"* (SPSS) software. Analysis of data shows that the main causes of material waste are: Delay in taking decision by the project manager, Low technical level of labors, Low level of project manager in managing the work and Poor planning of project layout.

A program was designed using *"Visual Basic"* to help the project team parties to predict the waste in an infrastructure project. It also help them to make a price bid. The program considers 12 of construction materials where the user define the price and quantity of each material. These construction materials are the most consumed in infrastructure projects. Then, the user answers 99 questions which represent all project characteristics. The program gives the user the probable waste percent for each material and estimated waste quantity. Finally, the program offers some advices in accordance with user answers to minimize waste.

1-INTRODUTION

The Egyptian construction industry has achieved a significant development. Buildings, roads, bridges, infrastructure and water supply projects were implemented on a large scale in recent years. This progress will attract investments, increase the standard of living and provide different kinds of job opportunities. The establishment of new cities in the wide open spaces of desert will redistribute the overpopulation in Nile delta stripe.

There are several conditions that must be achieved for the project success such as finishing on time, according to specifications and within budget. Several factors could negatively affect the project's success. Due to lack of concern given for these factors, the construction sector in developing countries is usually suffering from losses. These factors could happen during different project stages like design, documentation, procurement, handling, transportation, storage, operation and inspection.

Many of materials' industries have evolved with the development of construction industry. The construction industry consumes huge amounts of raw materials. There are two main disadvantages of waste. First, it has a very negative financial impact on construction sector as it is one of the serious reasons which cause high prices. Moreover, waste is one of the most environmental polluters but this factor is considered only in developed countries of Europe and United states.

Construction management is no longer an option but a necessity. It contributes strongly to the development of construction industry. Management application on construction projects will contribute in avoiding many problems that lead to losses. Reworking of finished activities, reordering of materials, rent equipment and labor before or after the required time, storing the materials for long time are examples of poor performance which will strongly cause losses.

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1.1 Background of Research

Waste is a global phenomenon associated with the progress of the construction sector in any place. Many researches discussed this problem from different points of views. Some researchers discussed the "4R" concept which represent the four methods used for controlling waste; reduce, reuse, recycle and recovery. Reduction or prevention of waste factors was selected by many researchers as the best technique for controlling waste as it try to solve the problem before happening. Other researchers discussed causes of poor performance in construction sector. Several researches discussed each method of those "4R" used for controlling waste separately.

1.2 Problem Statement

One of the main reasons that lead to growth of construction sector is reasonable unit price of construction activities. Price analysis consists of two main components, namely direct and indirrec cost. The contractor will consider the waste cost in bid using previous experience in a similar project. For example, if the contractor found from his experience by working in one of the infrastructure projects that waste in pipes is about 15%. As a result, the contractor will raise unit price of pipes by the same percentage. There is another problem caused by the transfer of waste to landfills. Some countries have specific areas as landfill and these spaces will expire with the increase of amount of waste. Some developed countries have focused on the impact of construction waste on the environment. As a result, these countries have to raise taxes on the transfer of waste to landfills.

Finally, the purpose of this research is to identify the main reasons which leads to waste to be avoided and therefore the percentage of waste and price will be reduced. If there aren't any actions to reduce the high value of the waste there will be no control on prices.

1.2 Objectives of the Study

The objectives of this work could be drawn as:
(1) To identify the factors that cause waste in construction projects in Egypt,
(2) To determine the severity of these factors and there priority order or rank,
(3) Develop computerized checklist to help project team players to avoid these factors, and
(4) Propose guidelines to project team players to minimize waste.

1.4 Scope of Study

This research will focus on investigating waste management techniques in infrastructure projects as a result of increasing size of these projects in egypt in recent years because of its priority as it precedes other civil works. Therefore, this paper aims to focus on determining factors causing waste in this kind of projects.

2. LITERATURE REVIEW

2.1 Definition of Waste

Construction material wastes refer to materials from construction sites that are unusable for the purpose of construction and have to be discarded for whatever reason (Yahya and Boussabaine, 2006) [1].

Debris is solid waste from construction, remodeling, repair or demolition of buildings, roads or other structures. Examples of debris are: rest of wood, concrete, drywall, masonry, roofing, siding, structural metal, wire, insulation, asphalt, packaging materials related to construction or demolition and other materials applied in construction.(CRISTIANO,2007) [2].

Construction waste was defined as any material apart from earth materials, which needed to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess or non-use or which cannot be used due to non-compliance with the specifications, or which is a by-product of the construction process. (Ekanayake and Ofori, 2004) [3].

2.2 Waste Measurement

In united kingdom (Rohit Bhagwat,2008) [4] summarized statistical information about waste which shows that 335 million tones of waste was generated included approximately 100 million tones of minerals waste, and 220 million tones of controlled wastes from households, commerce, and industry which also includes construction and demolition wasted. About 60% of total waste sent to landfill, 6% incinerated, 10% recycled and 22% treated using various methods. Due to high percent of waste sent to landfill the united kingdom government goes to rise the landfill taxes. This decision was taken as the available landfill sites have very limited life span. The following figure (2-1) shows the rise in landfill taxes from year 1996 to 2009.

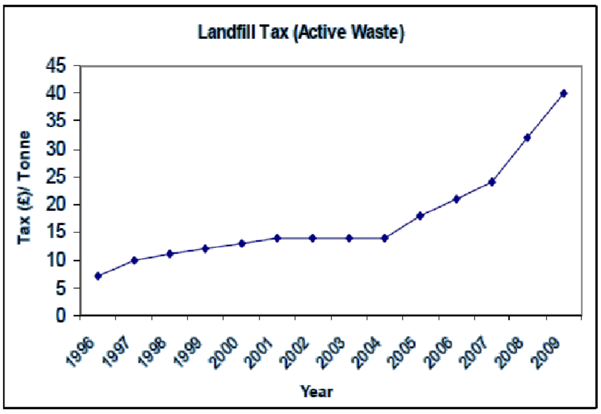

fig. no.(2-1) increase in landfill taxes from year 1996 to 2009 (Rohit Bhagwat,2008) [4]

The amount of waste in Brazil is between 20 to 30% of material weight entered a construction site (Pint and Agapyan, 1994) [5]. 25% of materials in construction process waste (Hamassaki and Neto ,1994) [6], 20% of material entered the site are wasted (Formoso et al., 1994) [7],

(Wong Xiao Wen, 2007) [8] indicated that the construction sector in united stated of America produced 136 million tones of construction and demolition waste. The annual production rate of construction and demolition waste from the whole planet is around 3 billion ton (Mohd Fidaus,2009) [9]

2.3 Waste Management

2.3.1 Waste management hierarchy

Fig.no.(2-2) Waste management hierarchy,

Reduction:

Reduction of waste was chosen by many researches as the best strategy to control waste. Reduction of waste at source is very helpful as it try to solve the problem before it becomes complex. Reduction is better than reuse, recycle and recovery as it avoid the generation of waste. It could be the best strategy for countries with minimum financial resource. Reduction could be implemented during design, documentation, handling, storage, supervision and …etc.

(Wong Xiao Wen,2007) [8] summarized the benefits of waste reduction such; increase profit, increase landfill life, reduce environmental impact, conservation of natural resources, cleaner and safer construction site and improve company image..

Reuse:

Reuse techniques is defined as re-employment of materials to be reuse in the same application or to be used in lower grade applications in the project. Materials such as wood, earthworks, steel, concrete, masonry, tiles, plasterboard, insulation materials, paints, solvent and carpets can be profitably reused on the construction site (Mohd Fidaus,2009) [9].

Recycle:

Concrete, plastic, asphalt and brick are some of main materials which must be utilized in any infrastructure project. Recycling mean these previous waste materials in other different ways such as using the crushed concrete in protection of levee, sub-base, backfilling and foundation material. The main precaution when using recycling is to make the required tests to ensure the quality of recycled materials.

Recovery:

A recovery technique is a process of generating energy from waste materials that cannot be reduced, reused or recycled. (Mohd Fidaus,2009) [9]. Hauling and disposal costs, the value of recovered materials, and labor costs contribute to whether materials recovery is more or less cost-effective than disposing of materials. Recovery of low value materials may be cost-effective if disposal costs are high and removal and sorting are not labor intensive. The added labor necessary to remove items for reuse may be offset by savings from both the avoided costs of purchasing new materials and avoided disposal costs. (Said Saker,2006) [10].

3.DATA COLLECTION METHODOLOGY

There are different ways to collect data such as interviews, books, standards, E-mail survey and questionnaire. This study will use questionnaire to accomplish the aim of this research. Close-ended questions and likert scale can strongly achieve quick and accurate analysis. In likert questions the respondent will be asked to express his agreement or disagreement according to a scale as shown in the following table.

Table no. (3-1) Degrees of agreement

Least important	1
Less important	2
Moderate important	3
Very important	4
Most important	5

The questionnaire consists of three main parts. Part (A) includes information about the respondent company like experience, classification, number of employees and number of projects implemented by the company in the last five years.
In section (B) the respondent is asked to show his company strategy to control waste. Different kinds of waste strategies were listed and the respondent selects the strategy he usually uses in his company.
Section (C) includes 67 factors causing waste. The respondent would state his opinion for each factor according to the previous scale.

3.3 Pilot test

The purpose of pilot test is to make sure that the respondent understands the questioner and to find out the shortcomings and ambiguities. The questioner was translated into Arabic to help the respondent to understand it. Ten contractors were asked to fulfill the questionnaire and add any other factor that may cause waste from their point of view. The questionnaire will be reliable when the respondent answers don't include indecisiveness answers.

3.4 Research sample

The research sample should represent the opinion of companies working in infrastructure field. Great care should be taken in choosing the sample to ensure that it represents the actual population. According to the Egyptian Federation of Construction and Building Contractors, the numbers of construction companies working in infrastructure field are as following:

Table (3-2) Number of construction companies in each class in infrastructure field, the Egyptian contractor's federation for construction and building

Classification	Number of companies
First	65
Second	36
Third	56
Fourth	96
Fifth	258
Sixth	197
Seventh	2648

The following equation was used by (Said Saker, 2006) [10] and many other researches

$$SS = \frac{Z2 \text{ x } (p) \text{ x } (1-p)}{C2}$$

Where:
SS = Sample size
Z = Z value (e.g. 1.96 for 95% confidence level)
p = percentage picking a choice, expressed as decimal (0.5 used for sample size
needed)
C = confidence interval, expressed as decimal (e.g., 0.05 = $\pm$5)

$$SS = \frac{(1.96)2 \text{ x } (0.5) \text{ x } (1-0.5)}{(0.05)2} = 384$$

Correction for finite population

$$\text{New SS} = \frac{SS}{1 + \frac{SS - 1}{pop}}$$

Where:
pop = population

$$\text{New SS} = \frac{384}{1 + \frac{384 - 1}{3356}} = 344.7$$

To ensure good representation of each stratum, the following number of each category of certain class has been selected:

First class = 344.7 x 65/3356 = 7 contractors

Second class = 344.7 x 36/3356 = 4 contractors

Third class = 344.7 x 56/3356 = 6 contractors

Forth class = 344.7 x 96/3356 = 10 contractors

Fifth class = 344.7 x 258/3356 = 26 contractors

Sixth class = 344.7 x 197/3356 = 20 contractors

Seventh class = 344.7 x 2648/3356 = 272 contractors

The following table shows the result of sample size:

Table no. (3-3) Sample Size

companies classification	Number of companies (population)	Number of companies of sample
First	65	7
Second	36	4
Third	56	6
Fourth	96	10
Fifth	258	26
Sixth	197	20
Seventh	2648	272
Total	3356	345

For accurate results companies from sixth and seventh class will be excluded because these companies have less experience and efficiency. This study will focus on companies classified as first, second, third and fourth.

In previous studies the researchers faced a problem when many companies refused to fulfill the questioner. (Mohd Fidaus, 2009) [9] reviewed that the respondent percentage was 33%. 40 companies only agreed to answer the questionnaire out of 120. Some companies don't trust that these data will be used for research purpose only. They fear that these data could be used to impose taxes or something else. This is the result of many years of lack of confidence with the governmental authorities. In this study, the same problem has been faced. Out of 180 questioners, only 51 responded.

3.3 Data Analysis

After collecting data, the answers of questionnaire were coded to enable them to be computer processed. The questionnaire is analyzed using statistical package for social science (SPSS). This program provides important data such as mean, median, mode and other statistical methods which are suitable in achieving the objectives of the study.

4- Result

4.1 Company profile and waste strategies

4.1.1 Years of experience

Fig.(4-1) shows the years of experience analysis of the surveyed companies. About (31.8 %) of the surveyed companies were established in the last five years while the rest have experience more than five years.

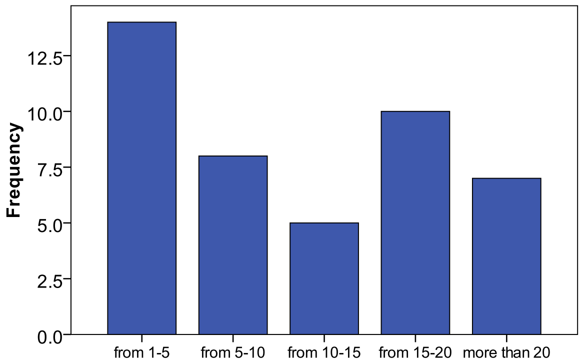

Fig. (4-1) Years of experience

4.1.2 Respondent position

Fig.(4-2) shows the respondent position for the surveyed companies. The site engineer has the highest percent (35.3%). While projects manager has the lowest percent (9.8%).

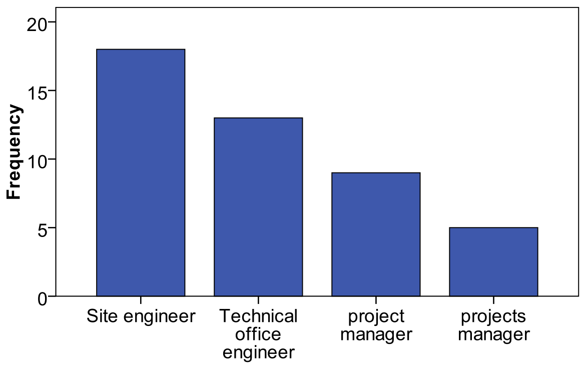

Fig. (4-2) Respondent Position

4.1.3 Respondent experience

Fig.(4-3) shows the respondent experience for the surveyed companies. About (52.9%) is the percent of respondents have experience form 1-5 years. It also represents the case of the Egyptian construction sector. After the prosperity of construction sector in Arab countries like Saudi Arabia, United Arab Emirates and Arabian gulf in general. That lead to immigration of skilled workers, including engineers, we have a shortage in Egypt in experience between 5 and 20 years.

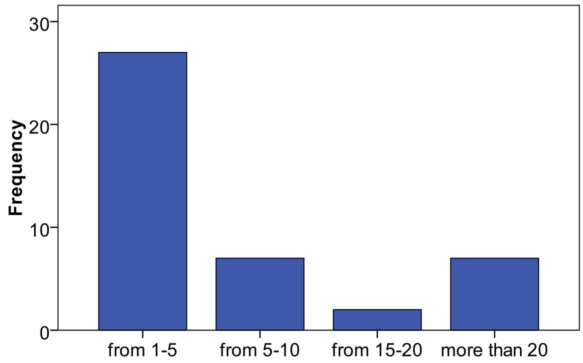

Fig. (4-3) Respondent experience

4.1.4 Number of projects in last 5 years

Fig. (4-4) shows the number of projects for the surveyed companies. The category from 5 to 10 years has the highest percent of projects (35.3%).

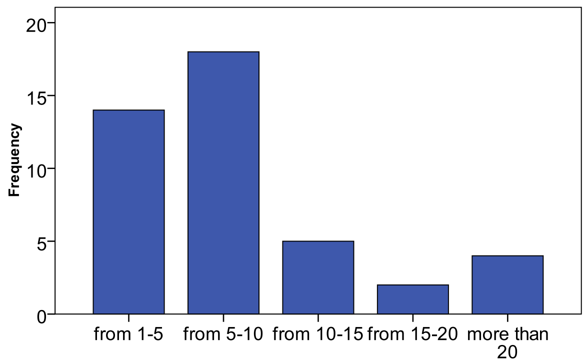

Fig. (4-4) Number of Projects

4.1.5 Value of projects in last 5 years

Fig.(4-5) shows the value of projects in the last five years. About (15.7%) didn't answer this question. The highest percent was (41.5%) for projects with value from 1 to 10 millions.

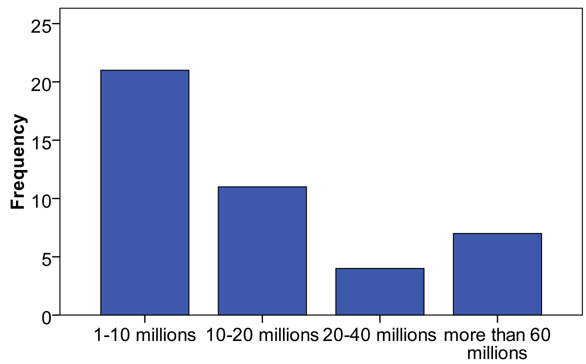

Fig. (4-5) Value of Projects

4.1.6 Classification of companies

Fig.(4-6) shows the classification of the surveyed companies. From 180 questionnaires distributed, only

51 responded. Only 39 respondents answered this question. Many companies were wary of revealing any financial information. About (23.5%) didn't answer this question. This is a real challenge to most researchers who faced difficult in obtaining financial data as most companies consider it top secret.

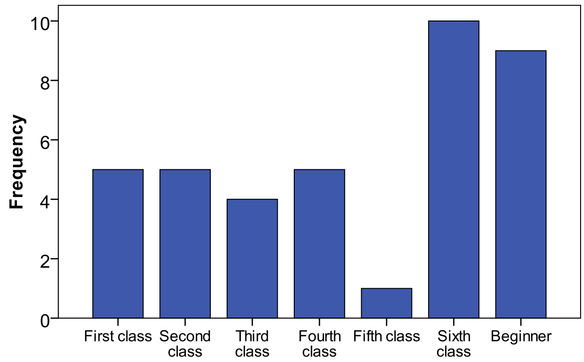

Fig. (4-6) Classification of companies

Table. (4-1) Classification of companies

		Frequency	Percent	Valid Percen	Cumulative Percent
Valid	First class	5	9.8	12.8	12.8
	Second class	5	9.8	12.8	25.6
	Third class	4	7.8	10.3	35.9
	Fourth class	5	9.8	12.8	48.7
	Fifth class	1	2.0	2.6	51.3
	Sixth class	10	19.6	25.6	76.9
	Beginner	9	17.6	23.1	100.0
	Total	39	76.5	100.0	
Missing	System	12	23.5		
Total		51	100.0		

4.1.7 Plan to control waste

Fig.(4-7) shows the surveyed companies plan towards waste. Only (41.2%) have a strategy to control waste, while (43.1%) didn't have any plan.

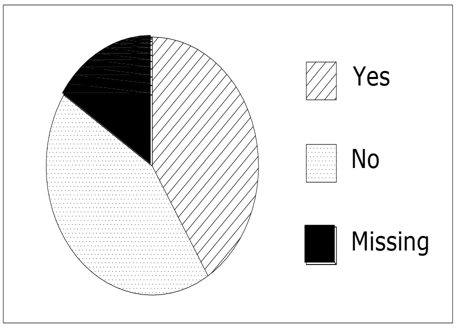

Fig. (4-7) Companies plan to control waste

4.1.8 Training labors

Fig.(4-8) shows the surveyed companies strategy to train labor. Only (27.5%) take training labor into consideration, while (54.9%) have no strategy for such purpose.

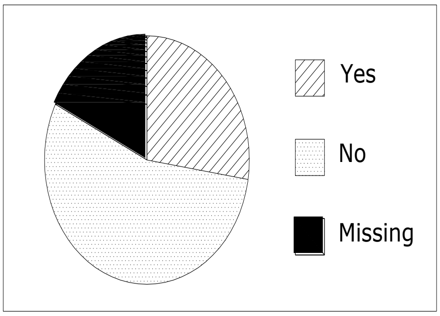

Fig. (4-8) Companies program to train labor

4.2 Material waste percentage

An analysis was obtained for 51 questionnaires and the mean was calculated for the following materials. Table (4-1) shows the mean value within the rating scale as below

1 = range (0-5) (average index < 1.5)
2 = range (5-10) (1.5 < average index< 2.5)
3 = range (10-15) (2.5 < average index< 3.5)
4 = range (More than 15) (3.5 < average index< 4)

Table (4-2) ranges of waste

Materials	Mean	Rang
Cement waste	1.3404	0-5
sand waste	1.8085	5-10
aggregate waste	1.7872	5-10
brick waste	1.933	5-10
Asphalt waste	1.3077	0-5
Plastic pipe waste	1.3333	0-5
Cast iron waste	1.4878	0-5
Precast manholes	1.2683	0-5
Precast manholes	1.2195	0-5
Ready mix concrete waste	1.2727	0-5
Pipe fitting waste	1.155	0-5
Manholes cover waste	1.2558	0-5

4.3 Factors causing waste

Table (4-2) shows the mean of factor causing waste for the surveyed companies. Design, documentation, equipments, procurement, handling, transportation, operation in site, supervision and unexpected condition are all the project phases which were described by 67 question in the questionnaire.

Table no. (4-3) Factors causing waste

No.	Factor	Mean
1	Designers' low experience	3.72
2	Lack of awareness of the designer about the construction procedure	3.96
3	Lack of information about the best materials types	3.74
No.	**Factor**	**Mean**
4	Using low price materials with low quality	3.82
5	Design errors	4.22
6	Inaccurate information from site investigation	4.20
7	Shortage in dimensions and specifications on drawings	4.14
8	Designer not aware of what is available in Egyptian market of construction materials	3.84
9	Errors in calculating quantities of contract items	3.46
10	Contract doesn't clarify the responsibilities of owner and contractor	4.02
11	Shortage in contract duration and occurrence of waste because of speed in construction	3.86
12	Lack of interest in the contract terms of safety and occupational health	3.80
13	Lack of attention in contract to ways of resolving disputes	3.76
14	Rise in prices of materials	4.02
15	Contractors raise prices in bid prices	3.82
16	Delay in drawings approval	3.84
17	Delay in construction materials approval	3.74
18	Making quality control test in laboratories which are not reliable	3.68
19	Errors in contractor bid	4.04
20	Delay of payment to the contractor	4.10
21	Poor schedule	4.04
22	Slow in obtaining the necessary permits to start work	3.86
23	Assignment of work to the contractor with the lowest price without considering the quality	4.30
24	The poor condition of the company's equipment	4.06
25	High price of rental equipments	3.96
26	High maintenance costs	3.90
27	Slowdown in the calibration of sensitive equipment	4.10
28	Poor productivity of the equipment	4.04
	due to the mode of the operator	
29	Using of equipments not mentioned it the contract	3.90
30	Fuel high prices	3.88
31	Damaged pipes and cables duo to lack of a good map for infrastructure	4.21
32	Purchase from the supplier who has lowest price regardless of quality	3.92
33	Purchase materials do not confirm to contract specifications	4.02
34	Buy from a supplier which is not reliable by the owner	4.04
No.	**Factor**	**Mean**
35	Purchase of materials greater or less than the required	4.02
36	Lack of good description of the required materials in purchase order	4.17
37	Making schedule for supplies	4.04
38	Delay caused by modification in purchase order	3.75
39	Lack of attention to examine the materials when supplied	4.10
40	The inability of supplying small quantities	4.13
41	Using wrong way in handing each materials	3.98
42	Lack of attention to safety procedure and occupational health	3.96
43	Road accidents	3.74
44	Long distance between project and supplier	4.15
45	Overloading the truck with material or using wrong way in loading	4.02
46	Arrangement of the stoke and separation of each kind of materials	4.00
47	Using wrong way in storing materials	4.13
48	Storage protection	4.13
49	Making database on the quantities used and remained in the stoke and remained materials in purchase order	4.15
50	Cutting materials in wrong way	4.08
51	Lack of harmony between teamwork	4.02
52	Lack of motivation of labors duo to low salaries	4.19
53	Lack of manpower	4.22
54	Lack of experience of site engineer	4.20
55	Low technical level of labors	4.33
56	Low experience of project manager in managing the work	4.33
57	Delay in taking decision by the project manager	4.48
58	Poor planning of project layout	4.33
59	Acceptance of defected work	3.86
60	Low experience of the supervisor engineer	4.12

61	Lack of supervision by the supervisor engineer	4.24
62	Low number of supervisors	4.22
63	Slow in taking decision by the supervisor	4.27
64	Bad relation between owner and supervisor and contractor	4.10
65	Bad weather conditions	3.85
66	Strike actions and demonstrations	3.92
67	Disruption of water and electricity supply	3.94

5. PROPOSED PROJECT MODEL

This study is aiming to develop a tool to predict the percent of waste for the most common materials in infrastructure projects. Previous studies showed that each material has a very wide rang of performance (Said Saker, 2006) [10]. So, this software is developed for infrastructure projects only. CCCW "Computer Checklist for Calculating Waste" is the name of this developed software.

5.1 Procedure of project model

Based on data analysis, this program goes through four steps to predict value of waste:

1- Estimation of waste factors weights; This study considers two ways for this objective. The first way used the mean value of waste factors from the survey analysis to estimate the weight of each factor. Then, a checklist is developed including 99 questions.

Table (5-1) shows some question of design stage. This method considered the percent of mean as a weight.

Table (5-1) weights of first method

Code	Questions to consider	Weight
1.1.1	Is the designer has the required experience in design of infrastructure	1.38
1.2.1	Is the designer aware about the construction procedure	0.74
1.2.2	Is there coordination between the designer and site engineer during design	0.74
1.3.1	Should the designer know required kinds of materials	1.39
1.4.1	Will the designer choose high quality materials regardless cost	1.42
1.5.1	Is there enough consideration given for site investigation	0.78
1.5.2	shouldn't the designer depend on these data taken from a near project	0.78
1.6.1	Is there a person responsible for revising design with drawings	0.78
1.6.2	Is the designer keen to check the output data from computer design programs	0.78
1.7.1	Are all dimensions illustrated on the drawing clearly	0.77
1.7.2	Are all materials well specified	0.77
1.8.1	Is the designer familiar with materials available locally	1.43

The second way use *person correlation coefficient* to find the relation between waste factors and waste in construction materials. Then, all these relations which have negative relations or significance <=.05 have been executed. Finally, the accepted relations have been used to find the weights of each factor.

Table (5-2) shows some question of design stage. This method considered the percent of each relation as a weight.

Table (5-2) weights of second method

Code of questions	cement	sand	aggregate	brick	Asphalt	Plastic pipe	Cast iron waste	Concrete pipes	Precast manholes	Ready mix concrete	Pipe fitting waste	Manholes cover waste
1.1.1	0	3.78	0	0	0.13	6.99	5.73	0	4.66	5.08	1.01	0
1.2.1	0	0	0	0	0	0	0.91	0	0.42	1.10	0	0
1.2.2	0	0	0	0	0	0	0.91	0	0.42	1.10	0	0
1.3.1	0	0	0	0	5.82	3.68	2.95	0	1.61	4.91	3.05	0
1.4.1	0	0	0	0	0	0	0	4.04	0	0	0	0.07
1.5.1	0	0	0	0	0.80	0.35	2.19	0	0.21	0	0	0
1.5.2	0	0	0	0	0.80	0.35	2.19	0	0.21	0	0	0
1.6.1	0	0	0	0	0	0	0	0	0	0.31	0	0
1.6.2	0	0	0	0	0	0	0	0	0	0.31	0	0
1.7.1	0	0	0	0	0.54	0	0.64	0	2.77	0.87	2.49	0
1.7.2	0	0	0	0	0.54	0	0.64	0	2.77	0.87	2.49	0
1.8.1	0	0	0	0	3.45	0	0	0	0	3.57	2.63	0

1- Ranges of constructions materials waste;

Table (5-3) material waste range

Class	Range of waste	Materials
First (W1)	(5-10)%	Sand, Aggregate and Brick
Second (W2)	(0-5)%	Cement, Asphalt, Plastic pipes, Cast iron pipes, Concrete pipes, Pre-cast manholes, Ready mix concrete, Pipe fittings and manholes covers

2- Efficiency of controlling waste;

After the user inputs the prices and quantities of project materials, he goes to the second part of the checklist which consists of 99 *"yes or no"* questions. When the user check *"no"*, he losses the percent or weight of this questions. Finally, the software cumulates the weight of questions answered by *"no"*. Efficiency of controlling waste could be estimated by subtracting the cumulative negative questions from 100%.

3- Probable waste value;

In order to find the probable waste value, this thesis produces two methods. The first method is obtained by using the E-W chart. By finding the efficiency of controlling waste (E) as illustrated before, the user could enter this chart and get the value of W1 & W2 which represents the probable waste percentage for these materials shown in the previous table.

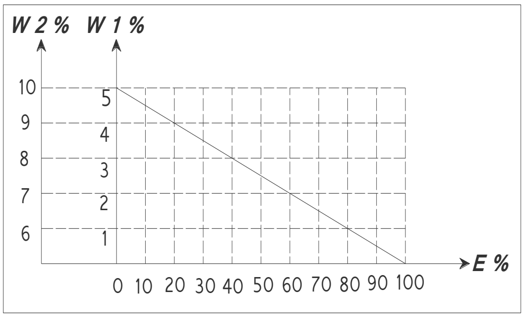

Fig. (5-1) Finding probable waste percentage using E-W chart

Where: E%: Efficiency of Controlling Waste

W1%: Probable Waste Percentage from 0% to 5% for first class materials

W2%: Probable Waste Percentage from 5% to 10% for second class material

For example; if the efficiency of controlling waste equals 50%, the probable waste value for first class materials (W1) will be equal to 2.5 % and the value for second class materials (W2) will be equal to 7.5% as shown in the following chart.

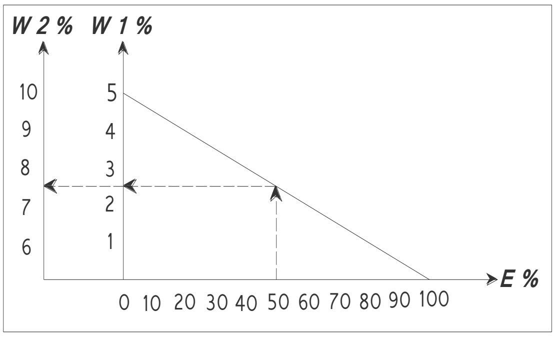

Fig. (5-2) How to use E-W chart

The second method is obtained by using equation. The following two equations are used for the same purpose.

W1 = 5 – E x .05

W2 = 10 – E x .05

Where W1, W2 and E as mentioned before

4- Final results

There are two outputs of CCCW. First output is probable waste values. The waste value could be calculated by using the following equation:

(Quantities) x (Price) x (Probable waste percentage) = (Probable waste value)

The second output that the user could minimize losses to the optimum waste value through commitment to advices offered by the software. The minimum waste percent is calculated using the following equation

(Quantities) x (Price) x (Minimum waste percentage) = (Minimum waste value)

5.2 Using CCCW program

The software consists of three sections. In the first section, the user input price an d quantities of project as shown in fig.no.(5-3). In the second section, the user answers 99 questions which describe all project aspects as shown in fig.no.(5-4). In the last section, the user could get the probable waste value in each kind of materials as shown in fig. no.(5-5).

	Units	Quantities	Price
Cement	Tons		
Sand	m3		
Aggregate	m3		
Brick	m3		
Asphalt	m2		
Plastic pipes	M		
Cast iron pipes	M		
Concrete Pipes	M		
Pre-cast manholes	Number		
Ready mix concrete	m3		
Pipe fitting	Number		
Manholes covers	Number		

fig. no. (5-3) price& quantities

Questions	Answer is NO
Is the designer aware about the construction procedure	
Is there coordination between the designer and site engineer during design	✓
Should the designer know required kinds of materials	
Will the designer choose high quality materials regardless cost	✓
Is there enough consideration given for site investigation	
shouldn't the designer depend on these data taken from a near project	✓
Is there a person responsible for revising design with drawings	
Is the designer keen to check the output data from computer design programs	

fig.(5-4) checklist

	Units	Probable waste percent	Price
Cement	Tons		
Sand	m3		
Aggregate	m3		
Brick	m3		
Asphalt	m2		
Plastic pipes	M		
Cast iron pipes	M		
Concrete Pipes	M		
Pre-cast manholes	Number		
Ready mix concrete	m3		
Pipe fitting	Number		
Manholes covers	Number		

fig.(5-5) final results

5.3 Case Studies

This program is studied for applicability using several miscellaneous case studies. The actual percent of waste was calculated in 6 projects for different materials. Then, these projects conditions were applied to CCCW program to predict the percent of waste.

The purpose of this section is to confirm correct application of two important items. The first item is to make sure that the values of waste in site are coinciding to what has been determined by the surveyed companies. For example, the quantity of sand waste is ranging from 5% to 10% according to the survey analysis. This section will try to find a way to determine the value of waste for the sand in site and compare it with the results of the survey. The second item, checking the correct application of the program and make sure that the results from project is close to the values of waste at site.

Determination of the value of waste in site is very difficult for two main reasons. The first reason is that contractors wary of revealing any financial information. The second reason is that most of contractors do not have a complete data base on quantities of materials to be implemented or purchased or values of waste for all project items. So, this section will focus on the main items of infrastructure project such as pipe lines.

The following cases calculate the waste by same way mentioned later. In each case there is a store in the project. The contractor receives the required material he needs form the store. At the end of every month the contractor will be paid according to what he has implemented and installed materials. So, the waste value will be the difference between what the contractor received and what he has implemented. The first three cases discussed waste in plastic pipes and the last three cases discussed waste in cement.

Table (5-1) shows the actual percent of waste in site and probable waste percent developed from CCCW for the same cases. The results show that the maximum difference is 2.28 % after exclusion of the results of the fourth case. The main cause of inaccurate results obtained in the fourth case was becau

se the ready mix concrete was delivered to site less than requested. When checking the volume of concrete in truck mixer it was found less than mentioned in the request policy with the truck mixer deriver. This may be due to an error in the mixer or may be illegal behavior by those responsible for the mixer.

Table (5-4) testing results

	Actual percent of waste %	Probable percent of waste %	Diff.
Case (1)	3.18	2.61	-0.57
Case (2)	1.49	2.11	0.62
Case (3)	4.78	2.5	-2.28
Case (4)	7.05	3.51	-3.54
Case (5)	2.08	2.74	0.66
Case (6)	4.99	3.55	-1.44

The correlation value between actual and probable waste percent is (.784).

6. DISCUSSION AND CONCLUSION

Table (6-1) shows the rank of the main factors causing waste in infrastructure in Egypt.

The factor that has got the highest rank in this thesis was project manager ability to take right decisions in the right time with average index of 4.48. This result is compatible with the findings of many researches as the project manager is the key for any project success. There should be an evaluation for the candidates for the project manager position.

Table (6-1) Rank of the main factors causing waste

No.	Factor	Mean
57	Delay in taking decision by the project manager	4.48
55	Low technical level of labors	4.33
56	Low experience of project manager in managing the work	4.33
58	Poor planning of project layout	4.33
23	Assignment of work to the contractor with the lowest price without considering the quality	4.3
63	Slow in taking decision by the supervisor	4.27
61	Lack of supervision by the supervisor engineer	4.24

Low technical level of labor was chosen by the respondents as the second causing waste factor with an average index of 4.33. Uneconomical cutting of materials by untrained labor consumes huge amounts of raw materials. Training courses should be performed to raise there technique level. This thesis shows that only 27.5% of investigated companies have a plan to train labor. If certifications showing technical level of labor must be submitted as one of any tender documents that will encourage construction companies to train there labor.

The following factor is more related to human management. The managerial capabilities of project manager was chosen by the respondent as the third factor. Many waste losses occur not only because of the technical level of project manager but also because of his managerial capabilities as well. Motivation of workers and keeping good relation with all project team parties is one of the main objectives of project leader. It is very useful to give project managers the required courses to improve their skills in human management.

Another important factor need to be given the required concern was poor design of project layout. Some notes should be taken into consideration while design the layout. Temporary road should coincide with the permanent road. Storage areas and labor housing should be away from the required work location to avoid need to move such facilities. Prevailing wind direction should be taken into consideration while detecting the position of workers housing, bathrooms and welding workshop.

Assigning of the work to contractor with the lowest bid regardless of the quality is a very important factor. It was chosen by the respondents as the fifth factor with an average index of 4.30. Quality and waste control should be taken into consideration beside price before assigning the work to any contactor. A detailed plan for controlling waste should be submitted with tender documents. This thesis shows that 43.1% of companies working in the infrastructure field didn't have any plan for waste reduction.

The following two factors associated with supervision. Being slow in taking decision by consultants was chosen by respondents with an average index 4.27. Lack of supervision by consultant or site engineer has a great effect on waste occurrence. It was chosen by respondents with an average index 4.24.

REFERENCE

[1] Yahya, K., Boussabaine, A.H., 2006. Eco-costing of construction waste. Management of Environmental Quality: An International Journal, Vol. 17 No. 1, pp. 6-19.

[2] CRISTIANO R. CASTELO BRANCO, 2007, AN EFFECTIVE WAY TO REDUCE RESIDENTIAL CONSTRUCTION, Master of science, Texas A&M University, USA

[3] Ekanayake, L.L, Ofori, G., 2004. Building waste assessment score: design-based tool. Building and Environment 39, 851–861.

[4] Rohit Bhagwat, 2008, Site Waste Management Practices in Construction Industry in United Kingdom, A dissertation submitted to The University of Manchester for the degree of Master of Science in Environmental Sciences, Policy, and Management jointly operated by the university of Aegean (Greece)

[5] Pinto,T. P., and Agopayan, V. 1994, "Construction wastes as raw materials for low –cost construction products." Sustainable construction (Proc. 1st Conf. Of CIB TG 16), J.Kibert,ed., Ctr. For Constr. and Envir., Gainesville, Fla., 335-342.

[6] Hamassaki, L.T., Neto, C.S., 1994. Technical and econo pects of construction / demolition waste utilization. Sustainable structure (proc. 1st conf of CIB TG 16), construction and environment, Gainesville Fla., 395-403.

[7] Formoso, C.T. Franchi, C., Soibelman, L., 1994. "A study on the waste of materials in the building industry in Brazil." Sustainable construction (Proc. 1 st Conf. of CIB TG 16) C.J.Kibert, ed., Ctr. For Constr. And Envir., Gainesville, Fla., 555-563.

[8] Wong Xiao Wen, 2007, Waste Minimization By Recycling Of Construction Waste, Master of science, University of technology, Malaysia

[9] Mohd Fidaus Bin Mustaffa Kamal,2009, Reduce, Reuse, Recycle and Recovery technique in sustainable construction waste management, Master of science, University of technology, Malaysia

[10] Said Saker Al-Moghany, February, 2006, Managing and Minimizing Construction Waste in Gaza Strip, Master of science, The Islamic University of Gaza – Palestine.