EVALUATION FOR THE MANAGEMENT OF WASTES RESULTED FROM DEEP EXCAVATIONS RELATED TO PROJECTS IN JORDAN

Dr. Orabi Al Rawi
Faculty Member/Isra University
JORDAN

Nawzad Al Kharabsheh
Civil Engineer/CC Co.
JORDAN

ABSTRACT

This research aims at conducting evaluations for the management of wastes resulted from deep excavations in addition to identify the methods used to dispose those wastes for projects in Jordan. The idea of this research proposed that there are poor management for the wastes generated during conducting deep excavations, and therefore these wastes could potentially be hazardous to environment and public safety. The implemented methodology in performing this research comprised four phases. The first of these focused on the literature review for previous studies related to deep excavations and their wastes. The second phase concentrated on designing a survey questionnaire regarding attitudes for executing deep excavations and controlling their wastes in Jordan, then distributing this survey to several construction companies. The third phase was the analysis of the collected data using SPSS program. The last phase concerned with developing guidelines and preparing for conclusions. Based on the analysis of the field survey for this research, the results indicated that there is a lack in the application of the engineering management for the excavation's wastes, and that was clear through the existence of some wrong practices such as a lack of commitment to conduct a study of the general location of the project, and the in determination for the location of the output storage pits in case of non-compliance with the specifications of the backfill, in addition to other results that had been fixed in the conclusions of this research. Out of the conclusions of this research, it is recommended that Jordanian's construction companies should accurately perform the Jordanian Construction Code related to how to deal with construction's wastes, and this may be one of the responsibilities of the Jordan Engineers Association to enforce those companies to conduct the intended requirements.

Keywords: Deep Excavations, Construction's Wastes, Excavation's Work Planning, Workers Health and Safety, Waste Management.

INTRODUCTION

The urban development that involves performing large scale projects may be recognized now in many countries, including Jordan. This type of projects often entails the need for carrying out deep excavations, and therefore leading to the accumulation of large amounts of wastes. In general, the need for deep excavations may arise to construct basements, or a cut-and-cover tunnel, to maximize the use of ground space for car parking or for transit system or else, especially with densely populated and lack of land (Ahmed H., 2007). However, every development may contain pros and cons. Although deep excavation could contribute to the exploitation of the land area, but it has many problems if the appropriate engineering management for this activity is poor or not available. Generally, a lot of engineering problems could be encountered because of performing deep excavations. Some of these are represented by increasing the bending moments along retaining walls and sliding collapses of existing geological formations, especially with the presence of ground water, leading the site to be unstable and uncontrolled.

Poor planning and management leaded several large-scale projects in Jordan to be stopped or postponed during the previous decade. On the other hand, poor control for the wastes resulted from deep excavations is also recognized in many construction projects in Jordan, whether through using these materials incorrectly or placing them at inappropriate locations; therefore, poor management and control for these materials could create site randomness, and then could affect the project time and cost, and probably could lead to some risks. Accordingly, this research reviews and includes all preventive measures that dealing with excavation's wastes and their controls.

LITERATURE REVIEW

Different investigations had been carried out by researchers to study deep excavations and the management of wastes resulted by them for construction projects, some of these are briefly presented below.

Iacoboaea C. et al. (2010) studied the risk of environmental pollution as humanity is alarmingly close to the moment of environment degradation irreversibility. An important contribution to environment pollution is construction and demolition waste. Romania, and particularly big Romanian cities, are facing asphalt works, changing curbs, residential construction/renewal, chaotic urban development and construction and demolition debris that cannot be ignored any longer and thrown away on the wayside. According to The Romanian National Institute of Statistics, in 2006 the amount of municipal wastes that collected by the companies in Romania was about 6.8 million tones, out of which 6.96% represents construction and demolition wastes. On the other hand, construction and demolition waste is eliminated without being weighed on old landfills or free spaces. Following this observation, a consortium of three universities and two research institutes elaborated a research proposal that was accepted to be financed by The Romanian National Research Authority. The project has several goals. One of them is to create a database containing analytical forms for every material/equipment used in construction and demolition, which can be considered potential waste. Another goal would be to elaborate new solutions regarding waste storage in the urban environment.

Takeshi K. (2013) presented three issues on the reuse of materials in geotechnical applications in Japan. First, status of reuse of excavated soils is presented. Since natural contamination has been a concern these years, several efforts including experimental studies to evaluate the environmental suitability of these materials have been conducted. Second, traceability in environmental geotechnics has been becoming an important consideration. One joint project, in which the excavated soils generated from shield tunnel excavation are utilized as a soil material for reclamation, utilizes the electronic toll collection (ETC) system to track the soil materials. Third, utilization of disaster wastes caused by the 2011 East Japan earthquake and tsunami is required. Challenges include the proper treatment to separate soils from waste mixture and to utilize these soils in geotechnical applications.

Alison M. and Kieran R. (2015) studied waste management concerning the results of excavations. The authors stated that the contractor should test the results of drilling to verify their validity. As an example, if the soil resulting from the drilling was clean, free of organic materials, therefore, it may be used as a backfill, but if the soil is not suitable; therefore, the contractor must dispose them outside the project location, and that may be useful to improve resource efficiency and environmental performance; and reduce cost. However, the authors showed that there was a lot of bad practices that were carried out by the contractor such as placing the resulting soil randomly on the streets that may cause accidents, or do not testing the soil to make sure of their validity.

Simon (2015) submitted a development method in a form of a conceptual model for the urban flow of excavated soil and rock, and studied the management of excavated soil in construction projects. The conceptual model was subsequently used to clarify the different perspectives of the scientific literature and knowledge gaps. The author concluded that the excavated materials are often disposed at landfills and the recycling rate for high quality purposes is low, and therefore there is a need to evaluate the potential for an increased use of excavated soil and rock as construction materials.

METHODOLOGY

During this research, a questionnaire survey had been designed (consisted of several items related to executing deep excavations and their wastes) and then distributed to practicing and professional engineers at construction companies in Jordan (especially those who carried out deep excavations) to evaluate:

a- General requirements in implementing deep excavations.

b- Methods used in deep excavations "waste management and disposal".

RELIABILITY

In this research, the equation of internal consistency (Cronbach's alpha) was conducted to calculate the stability of the questionnaire survey, and the results are shown in Table 1. These results showed that the values of Cronbach alpha for the studied variables were generally higher than 60%, which are acceptable in the research, and the overall reliability coefficient is ranging between 0.88% and 0.90%.

$$\textbf{Cronbach Alpha} = \frac{Kr}{1+(K-1)r} \quad \text{.... (1)}$$

Where: K:is the number of items in the test.

r: is the mean of the correlations between items.

Table 1: Cronbach's Alpha for the Studied Variables

Variables	Statements	Cronbach Alpha
General Requirements in Implementing Deep Excavations	15	0.88
Methods Used in Deep Excavations "Waste Management and Disposal"	14	0.90

(Cronbach Alpha: According to Abebe A., Daniels J. and et al, 2002)

RESEARCH SAMPLE SIZE AND CHARACTERISTICS

The study population was the civil engineers in Jordanian construction companies, and therefore the data had been collected from companies that perform projects including deep excavation, which represented all the study population. Accordingly, (80) questionnaire had been distributed, (65) of them were received, while (15) of them had been excluded from the analysis due to their unfinished information. So, the questionnaires that valid for analysis were (65), and the response rate was (81%).

The field survey for this research showed that more than half of the respondents have experience exceeding 10 years. Therefore, the responses are valid for the research since they were based on an extensive experience of respondents in management of deep excavations and their wastes in Jordan. However, the Sample's demographic variables are shown in Table 2.

Table 2: Sample's Demographic Variables

Variable	Category	Jordan	
		Counts	**%**
Type of Organization	Consultant	31	47.4
	Contractor	27	41.5
	Sub-Contractor	7	10.8
	Total	**65**	**100**
Qualifications	Master Degree	12	18.5
	Bachelor Degree	51	78.5
	Diploma Degree	2	3.1
	Total	**65**	**100**
Years of Experience	1-5 Years	16	24.6
	6-10 Years	11	16.9
	More than 10 Years	38	58.5
	Total	**65**	**100**
Number of Projects	1-5 Projects	16	31.4
	6-10 Projects	5	9.8
	More than 10projects	8	15.7
	Total	**65**	**100**
The Excavation Depth of the Current Project	7-10 m	18	27.7
	11-20 m	41	63.1
	>20 m	6	9.2
	Total	**65**	**100**

In this research, SPSS Software (Statistical Package for Social Sciences) had been conducted to analyze the collected data. However, the following statistical techniques were used for data analysis:

a. Cronbach's Alpha reliability is a measure of internal consistency, that is, how closely related a set of items are as a group **(Mohsen T., 2011).**

b. Descriptive Statistical Techniques: including means and standard deviations. These techniques can be calculated using Equations (2) and (3):

$$\text{Mean} = \Sigma X / N \quad \dots (2)$$

Where:
ΣX: is the sum frequency of the sample.
N: is the total number of samples.

$$\text{Standard deviation} = \sqrt{\frac{\sum_{i=1}^{N}(X-\bar{X})^2}{N}} \quad \dots (3)$$

Where:
Xi: is frequency of each sample.
$\bar{X}$: is mean of sample.
N: is the total number of samples.

One (T-test) sample was used to test the hypotheses, therefore the researcher used (t value = 2). It is to be noted that in (T-test) the value of (t calculated) should be within the solution of the area which is (±1.96) in which the Sample will be located at two trail areas, however the (t calculated) is shown in Equation (4):

$$t = \frac{\bar{X}-\mu}{\frac{\sigma}{\sqrt{N}}} \ldots (4)$$

Where:
$\bar{X}$: is mean of sample.
μ: is t-value(tabulated)=2.
σ: is standard deviation of sample.
N: is the total number of sample.
The responses are tabulated in accordance with a five-point Likert Scale, as shown Table 3:

Table 3: Five Point Likert Scale

Very Low	Low	Medium	High	Very High
1	2	3	4	5

The relative importance is measured through the application of Equation (5):

$$\text{Class Interval} = \frac{(\text{Maximum class} \quad - \quad \text{Minimum class})}{\text{Number of level}} \quad \ldots (5)$$

$$\text{Class Interval} = \frac{5-1}{3} = \frac{4}{3} = 1.33$$

It is to be noted that:
- The Low degree of class interval is in the range of 1.00- 2.33
- The Medium degree of class interval is in the range of2.34 – 3.67
- The High degree of class interval is in the range of3.68 – 5.00

RESULTS

The mean, standard deviation, ranking, and importance level for each item in the questionnaire are shown in Tables4 through 7:

Table 4: Attitudes Towards "General Requirements in Implementing Deep Excavations"

No.	Statements	Mean	Std. Deviation	Ranking	Importance Level
9	Project management monitors continuously the weather conditions and their effect on the deep excavation performance.	3.48	1.06	1	High
7	Project management choses the suitable equipment for soil analyses, measurement of deep excavations loads expected and others.	3.17	1.14	2	Medium
13	The contractors are complying with the deep excavation dimensions as it is stated in the Site plans.	3.17	1.21	3	Medium
12	Workers in deep excavation projects in Jordan are always subject to dangers from the side collapsing of the soil and others.	3.15	1.20	4	Medium
11	Work orientation: Do you think that there is an active and constructive communication between project manager and workers, and between workers themselves?	3.09	1.28	5	Medium
4	Project management undertakes procedures necessary to support the building and roads surrounding the deep excavations in a proper way.	3.00	0.95	6	Medium
	There is a follow-up on the contractors to fix				

14	and strengthen the side support walls before start of the foundation construction.	2.97	1.20	7	Medium
2	A special department is established in the project site with experienced staff in practical eye sighting and practical experience for soil and materials.	2.89	1.15	8	Medium
15	The contractors are obliged to the side walls support according to the prepared designs.	2.88	1.29	9	Medium
1	Project general administration conducts a presides for all aspects regarding the project site.	2.86	1.29	10	Medium

Table 4: Continued

No.	Statements	Mean	Std. Deviation	Ranking	Importance Level
3	Project general administration relay on a specialized third party to continuous inspection for the neighboring areas of the	2.78	1.04	11	Medium
5	Project management relies on specialized third party to determine the proper way to support the deep excavation sides and provide the necessary protection	2.92	1.08	12	Medium
8	All construction material, machines, excavation equipment, earth-moving equipment are stored in previously identified locations not to affect the deep excavated area.	2.75	1.21	13	Medium
10	Deep excavated areas are left open for a long time without making any necessary precautions for their sides or with machinery inside.	2.74	1.20	14	Medium
6	Hiring project supervisors to monitor the possibility of water overflow or flooding in deep excavation and to monitor the stability the structure.	2.49	1.06	15	Low
Total		2.81	0.72		**Medium**

Table 5: Attitudes Towards Methods Used in Deep Excavations "Waste Management and Disposal"

No.	Statements	Mean	Std. Deviation	Ranking	Importance Level
10	The contractors remove the remains and debris during the excavation such as old sewage and waste water pipes, old foundations, or old floors, if any.	3.75	1.03	1	High
9	The contractors receive legal permits to dispose the excavated soils outside the project.	3.35	1.16	2	Medium
3	The project management insists on testing the excavated soil in highly qualified laboratories.	3.25	1.09	3	Medium
13	If the excavated soil is not suitable for redemption, the contractor is obliged to supply the suitable type of soil for redemption from outside the project.	3.20	1.34	4	Medium
5	Do you think the contractor provides continuous follow-up of different kinds on fossils and artifacts discovered at the project	3.00	1.03	5	Medium

	site and controls what happens to them in the deep excavation projects in Jordan?				

Table 5: Continued

No.	Statements	Mean	Std. Deviation	Ranking	Importance Level
8	The contractors follow the rules and regulations of the disposal at authorized locations.	3.00	1.25	6	Medium
6	In the preliminary stage, before starting the project is there any estimation of types and quantities of soil that will be excavated from the project, and how to deal with it.	2.98	1.21	7	Medium
12	The site engineer will force the contractor to pay the fines in case of his negligence of handling with care the excavated materials	2.83	1.29	8	Medium
11	If the excavated soil is valid for agricultural use, the contractors will separate it to use it in proper locations.	2.78	1.22	9	Medium
7	The contractors follow the rules and regulations of the managing and dealing with extra excavated materials.	2.78	1.24	10	Medium
14	The contractors are committed to protect environment and to prevent disturbance to residents or traffic.	2.78	1.37	11	Medium
2	There is a special area at the project site to store the soil remnants that are not suitable to be used for the project, or if the re-use is not possible dispose or store it in locations at the site	2.75	1.28	12	Medium
1	The soil resulted from the excavation is collected within the project boundaries	2.68	1.23	13	Medium
4	If lab results proved that the soil is not suitable to be reused, then special technologies cure it according to the disposal procedures.	2.66	1.14	14	Medium
Total		3.20	0.81		**Medium**

Table 6: The Effect of General Requirements in Implementing Deep Excavations

Mean	St. Deviation	T- Tabulated	T-calculated	DF	Sig	Result
2.96	0.71	±1.96	10.76	64	0.000*	effect

(t) value = 2.00 * Significant at (0.05)

Table 7: The Effect of Methods Used in Deep Excavations "Waste Management and Disposal"

Mean	St. Deviation	T- Tabulated	T-calculated	DF	Sig	Result
2.98	0.81	±1.96	9.784	64	0.000*	effect

(t) value = 2.00 * Significant at (0.05)

DISCUSSION

In Table 4 the mean of this factor (General Requirements in Implementing Deep Excavations) ranged between (3.48 – 2.49), where the overall variable resulted of a total mean of (2.96), which was evaluated as in the Medium level. Variable (9) (Project management monitors continuously the weather conditions and their effect on the deep excavation performance.) has obtained the highest mean reaching (3.48), with standard deviation (1.06), which was evaluated as in the High level.

Variable (7) (Project management choses the suitable equipment for soil analyses, measurement of deep excavations loads expected and others) came in the second with a mean of (3.17), with standard deviation (1.14), which was evaluated as in the medium level. Variable (6) (Hiring project supervisors to monitor the possibility of water overflow or flooding in deep excavation and to monitor the stability the structure.) came in last with a mean of (2.49), and a standard deviation (1.06), and therefore was evaluated as in the Low level.

In Table 5 the mean of this factor (Methods Used in Deep Excavations "Waste Management and Disposal") ranged between (3.75– 2.66), where the overall variable resulted a total mean of (2.99), which was evaluated as in the Medium level. Variable (10) (The contractors remove the remains and debris during the excavation such as old sewage and waste water pipes, old foundations, or old floors, if any) has obtained the highest mean reaching (3.75), with standard deviation (1.03), which was evaluated as in the High level. Variable (9) (The contractors receive legal permits to dispose the excavated soils outside the project) with a mean of (3.35), a standard deviation (1.16) which was evaluated as in the medium level. Variable (4) (If lab results proved that the soil is not suitable to be reused, then special technologies cure it according to the disposal procedures) came in last with a mean of (2.66), and a standard deviation (1.14), which was evaluated as in the Medium level.

From Table 6, the results showed that the total mean of (General requirements in implementing deep excavations) was (2.96), with a standard deviation of (0.71), and the T-calculated of (10.76). Accordingly, these results indicated that there is a statistically significant difference between the mean of the scale and the default mean; also, the T-calculated is more than the T-tabulated that pointing to an existence of defects in the engineering management related to conducting the suitable requirements regarding deep excavations in Jordan

From Table 7, the results showed that the total mean of (Methods used in deep excavations "Waste management and disposal") was (2.98), with a standard deviation of (0.81), and the T-calculated of (9.784). Accordingly, the results indicated that there was a statistically significant difference between the mean of the scale and the default mean; also, the T-calculated is more than the T-tabulated that assures an existence of defects in the engineering management related to deal with the wastes resulted from deep excavation projects in Jordan

CONCLUSIONS

Referring to the analyses of results shown above, it is concluded that several deficiencies are existed in conducting engineering management for deep excavations and their wastes in Jordan as follows:

1. Lack of commitment from the projects' managers to conduct accurate site explorations for projects (in general) and especially for those requiring deep excavations.
2. Poor organization from the managers in the distribution of construction materials, tools, and equipment at the project site.
3. Lack of commitment of the contractors to carry out the required design of deep excavations that was prepared for this purpose.
4. Indetermination for the optimum location of the output of excavations (wastes) especially for those to be used as backfill materials.
5. Lack of commitment for the projects' managers to use techniques of soil treatment (soil improvement) in the case of non-compliance with the specification of the backfill.
6. Poor plans to estimate the quality of the soil produced from the excavations and how to handle them.
7. Lack of commitment of the contractors to provide documents showing their compliance with the regulations on management of the project wastes.

8. Poor plans concerning the health and safety systems of labors and engineers in the site.

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