Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.7, No.10, 2017

Quality Evaluations for the Office Works and Laboratory Tests Related to Site Investigation Studies in Jordan

Dr. Orabi Al Rawi[1*] Eng. Suliman Abu Amara [2]
1.Civil Eng. Dep., Isra University, PO Box 33 & 22 Isra University Office 11622, Jordan
2.Civil Engineer at Al-Karmi Engineers Co., Jordan

Abstract
This research aims at conducting evaluations for the quality of the office works and laboratory tests concerning site investigation studies for construction projects in Jordan.The applied methodology for this research comprises four phases. The first phase was focused on identifying factors, methods, and literature review of the international standards in implementing site investigations. The second phase was concentrated on designing a questionnaire regarding opinions in performing site investigations in Jordan (in accordance with the international standards), and then distributing it to several engineers and experts who work at site investigation offices. The next phase was the analysis of the collected data that resulted from the distributed questionnaire using SPSS Software. Whereas, the last phase of the methodology was focused on developing for guidelines and preparing for conclusions.Based on the analysis of the received data related to the distributed questionnaire, the results indicated that various factors may affect the quality of the office works and laboratory tests related to the intended investigations. In general, it was concluded that the most important factor of these was the lack of commitment with the requirements of the Jordanian Code of Site Investigation, in addition to the lack of commitment to carryout laboratory tests based on the latest standards (specifications). Also, site investigation reports were almost free of containing detailed descriptions of geological profiles that derived from boreholes. Furthermore, these reports contain very limited information regarding the existence of water table or other sources of ground water.
Keywords: Site Investigations, SPSS Software, Questionnaire, Laboratory Tests, Quality Evaluations.

1. Introduction

It is well known that a site investigation refers to an exploration process of ground conditions for a proposed project site that enables engineers to make sound decisions concerning a safe structural design, and a construction of stable foundations (Director G. and Partners, 2005). However, according to British Standards Institution (1999), the site investigation is performed to achieve the following purposes:

- Selecting the type and depth of foundation for a proposed structure.
- Determining the site bearing capacity.
- Estimating the total & differential settlements.
- Estimating the ground water level (if any).
- Predicting the lateral earth pressure against retaining wall, (if any).
- Selecting suitable construction techniques.
- Predicting for any potential foundation problems

In general, many constructed projects in Jordan are suffering from different problems regarding the structure durability that is encountered in terms of wall cracks or foundation excessive settlements. Due to the fact that a high percentage of conducted projects in Jordan are of residential projects; therefore, the above problems are commonly existed and used to be visual by those who live in these structures. Generally, the above problems may occur as a result of several causes such as weakness in the foundation ground, or that related to construction materials used in executing the structure. However, in this research, it is believed that a high percentage of engineering problems are related to several defects in previous site investigations that were performed for these projects. From this point of view, it was found that a quality evaluation for the existing site investigations is required, and therefore a comparison for these investigations with those as stated in the international standards is of the essential tasks that was considered in this research in order to decrease or eliminate the severity of the above mentioned engineering problems in Jordan.

However, in this research, it was focused on the quality evaluations of the office works and laboratory tests related to site investigation studies that leads to provide recommendations to improve these investigations, and consequently to improve the quality of structure that to be constructed at the investigated site (i.e., the quality evaluation for the field works was post ponded for further research).

2. Questionnaire Survey

The field study for this research was concentrated on distributing a designed questionnaire sheet that was consisted of a number of items. In general, this sheet was distributed to a set of site investigation offices in Jordan in order to understand and evaluate the following:

- The key factors that affecting the office works and laboratory tests related to site investigation studies in Jordan.
- How the above specified factors could affect the overall quality of the investigation.
- How to control the above factors, and try to eliminate them in order to enhance the resulted products.

3. Research Sample Size

The selection process for the research sample size was limited to forty offices. In general, the interviews that were conducted in this research were focused with engineers and project managers. In addition, the questionnaire survey considered several demographic variables, such as the classification of the office, years of experience, etc.

4. Research Hypothesis

The hypotheses that were studied in this research was as follows:

- Null Hypothesis (H0): the quality of office works and laboratory tests related to site investigation studies in Jordan (in general) is good and has no influences on the engineering problems that face projects in Jordan.
- Alternative Hypothesis (H1): There are defects in implementing the office works and laboratory tests related to site investigations in Jordan, compared with those fixed in the international standards, and the case required to focus on the main factors that affect the quality of implementing these investigations.

5. Statistical Hypothesis Testing

Statistical hypothesis testing is generally employed (using SPSS Software) to determine if a result is statistically significant or not. The p-value (included in this test) is defined as the probability of obtaining a result "equal to" or "more extreme" than what was actually observed, assuming that the null hypothesis is true. However, before the test is performed, a threshold value is chosen, called the significance level of the test (traditionally 5%) and denoted as "α-alpha". Therefore, if the p-value is less than or equal to the chosen level (α-alpha), therefore the test suggests that the observed data are inconsistent with the null hypothesis, so the null hypothesis must be rejected; whereas, if the obtained results had indicated values different from what was discussed above, therefore alternative hypothesis must be rejected.

6. Results and Discussion

The results of this research were obtained based on analyzing the received data from questionnaire (using SPSS Software). However, these results are presented in the form of opinions to several major items as shown in the following sections and tables.

6.1 Opinions towards "Objectives for the Office Work Related to Site Investigation Studies"

The opinions of respondents towards the above title are indicated in Table 1. This table shows that Chi-Square test is statistically significant for most statements (in which p-values are less than 0.05) except that for statement No. 7, and this indicates that there are significant differences of the respondents for their opinions towards those statements. Therefore, the results for this category could be generalized to the study population except that for statement No. 7.

Table 1. Opinions towards "Objectives for the Office Works Related to Site Investigation Studies"

No.	Statement	Mean	Std. Deviation	Relative Importance	Ranking	Chi-Square	p-value	Trend
1	The type and depth of foundations for the structure were fixed during the investigation.	4.8	0.4	96.0	1	14.4	0.000	Agree
2	The bearing capacity for the soil and/or rock was not determined during investigation.	1.4	0.8	27.0	8	61.2	0.001	Disagree
3	The types and values of settlements were calculated during investigation.	4.7	0.5	93.8	2	29.1	0.000	Agree
4	The active soil pressure against retaining walls (if any) was not considered during investigation.	1.8	1	36.4	7	31.4	0.000	Disagree
5	The geological formations for the study site were reviewed during the initial stages of investigation.	4.6	0.8	92.0	3	47	0.000	Agree
6	Studying the availability of public safety for the investigated site through collected maps, and documents.	4.4	0.7	87.7	4	26.1	0.000	Agree
7	A time plan for implementing the required site investigation (based on the project and site nature) was not considered during the study.	2.8	1.3	55.0	5	6.8	0.150	Neutral
8	The site investigation engineer believes that the level of income to site investigation offices in Jordan is fair.	2	1.1	39.0	6	23	0.000	Disagree

6.2 Opinions towards "Laboratory Works for Site Investigation Studies"

The results of this item are shown in Table 2. This table shows that Chi-Square test is statistically significant for all statements (in which p-value are less than 0.05). This indicates that there are significant differences of the respondents for their opinions towards those statements. Therefore, the results for this category could be generalized to population study.

Table 2. Opinions towards “Laboratory Works for Site Investigation Studies”

No.	Statement	Mean	Std. Deviation	Relative Importance	Ranking	Chi-Square	p-value	Trend
1	All equipment and apparatus are provided for all types of necessary laboratory tests concerning the required study.	4.4	0.8	88	1	30.2	0	Agree
2	The international engineering standards are applied when conducting laboratory tests.	4.3	0.8	86	2	29.4	0	Agree
3	The global engineering standards for the laboratory tests are continuously reviewed and updated.	3.9	1.1	77	5	27.3	0	Agree
4	The soil samples are stored in proper places inside the laboratory, and for a limited period of time.	4.2	0.7	83	3	40.2	0	Agree
5	The undisturbed samples are collected, saved using sealed bags, and properly transported to the laboratory to be used for specific tests later.	4.2	0.8	83.5	4	45.8	0	Agree
6	The disturbed samples are collected to be used for general tests such as classification and other physical properties tests.	3.8	1.1	75	6	29.5	0	Agree

6.3 Opinions towards "Reports for Site Investigation Studies"

The opinions of respondents towards the above item are illustrated in Table 3. This table shows that Chi-Square test is statistically significant for all statements (in which p-value are less than 0.05) except that for statement No. 7. It means that there are significant differences of the respondents for their opinions towards those statements. Therefore, the results for this category could be generalized to population study except that for statement No. 7.

Table 3. Opinions towards "Reports for Site Investigation Studies"

No.	Statement	Mean	Std. Deviation	Relative Importance	Ranking	Chi-Square	p-value	Trend
1	The report contains an aim that seeks to be achieved.	4.6	0.5	92.5	1	23.5	0.00	Agree
2	The report is not matched with the requirements of the Jordanian Code.	1.6	0.8	31.5	10	31.4	0.00	Disagree
3	The report is clearly describing the project site, adjacent buildings, roads, utilities, etc.	4.4	0.6	87.7	4	17.2	0.00	Agree
4	The report reviews the history of the existed neighbor constructions.	2.7	1	54	7	26.8	0.00	Neutral
5	The report doesn't compare the data obtained from the drilling with those as presented on the geological maps.	2.2	0.9	44.5	8	46.8	0.00	Disagree
6	The report reviews any geological features existed at the study site.	4.4	0.6	88	3	14.6	0.00	Agree
7	The report presents limited descriptions to the geological profiles of boreholes, in addition to presenting few information regarding any source of ground water (if any).	4.6	0.5	91.5	2	0.9	0.34	Agree
8	The report contains a brief description to the carried out tests without many details, with a focus to them in a form of tables of results.	4.3	0.8	85.5	6	20.6	0.00	Agree
9	The report doesn't contain summarized results related to the design of foundations according to the nature of the underplaying soil and applied loads.	1.8	0.9	35.5	9	37.8	0.00	Disagree
10	The report contains recommendations in a form of brief points to assist the owner, designer, and contractor.	4.3	0.7	86.7	5	32.7	0.00	Agree

6.4 Opinions towards "Various Paragraphs and the Impact of Each on the Quality of Site Investigations"

The results of this item are shown in Table 4. This table shows that Chi-Square test is statistically significant for all statements (in which p-value are less than 0.05) except that for statements No.1 and No. 6. It means that there are significant differences of the respondents for their opinions towards those statements. Therefore, the results for this category could be generalized to population study except that for statements No. 1 and No. 6.

Table 4. Opinions towards "Various Paragraphs and the Impact of each on the Quality Site Investigations"

No.	Statement	Mean	Std. Deviation	Relative importance	Ranking	Chi-Square	p-value	Trend
1	Lack of commitment to conduct the requirements of the Jordanian code.	2.7	1.4	54	4	7.3	0.123	Neutral
2	Lack of cooperation by the Association of Engineers with site investigation offices.	2.6	1.3	52.3	5	14.2	0.007	Disagree
3	There are problems concerning the owner's payments to the office.	3.4	1.4	67	1	12.3	0.016	Neutral
4	Lack of preparation for the specifications of bidding for investigations that suit the conditions of the required site.	3.2	1.3	64.5	2	10.5	0.033	Neutral
5	Writing for reports based on the experience without actually conducting the required study.	2.6	1.4	52	6	13.8	0.008	Disagree
6	Weakness in making the right decision to select the required laboratory tests according to the existing site and structure conditions	2.8	1.4	56	3	4.8	0.314	Neutral
7	Focusing efforts on the profitability rather than the application of the required specifications.	2.6	1.5	51.3	7	11.6	0.020	Disagree
8	Recruitment of engineers with specialties that do not fit with the nature of the office.	2.5	1.2	50.5	8	33.3	0.000	Disagree
9	Lack of commitment to calibrate laboratory equipment and devices used in site investigation offices.	2.4	1.3	47.2	9	13	0.009	Neutral
10	There is a need to conduct perfect site investigations in Jordan	4.8	0.4	96	14.4	0.00	Agree	4.8

6.5 Summary of Results

The analysis was mainly concentrated on chi-square goodness of fit test that showed statistically significant differences between the observed and expected attitudes towards most statements (in which p-values are less than 0.05) except that for the following statements:

- A time plan for implementing the required site investigation in accordance with the project and site nature was not considered during the study.
- The report presents limited descriptions to the geological profiles of boreholes that showing soil layers and levels, in addition to presenting few information regarding the groundwater table or other sources of water (if any).
- Lack of commitment to implement the Jordanian engineering code requirements.
- Weakness in making the right decision to select the required laboratory tests according to the site conditions, structure loads, the geological formations for the project area.

Accordingly, the analyses for this research proved that the alternative hypothesis (H1) is accepted (i.e., There are defects in implementing the office works and laboratory tests related to site investigations in Jordan).

7. Conclusions

The following are the main conclusions that derived from this research:

1. Most site investigations that were implemented in Jordan disregarded the planned time (schedule) needed to conduct the required investigation, therefore this parameter may affect the quality and total period of time required to execute the intended project.
2. The site investigation report often doesn't contain a detailed description of the geological profiles for the boreholes (showing soil layers and their levels).
3. The site investigation report usually contains very limited information regarding the existence of water table or other sources of ground water that could potentially be detrimental during carrying out the project excavation or at any time during the life period of the building.
4. Lack of data regarding a review to the engineering history for the existed neighbor constructions, and also regarding the possibility of transmitting their loads to the new buildings.

5. Providing recommendations based on previous experience for the area in the vicinity of the intended site without actually performing the required site investigation study (for the purpose of quick profit).
6. The majority of reports do not indicate the problems that will be faced by the contractor during excavation.
7. Lack of commitment to conduct the requirements regarding the Jordanian engineering code and also regarding the international engineering standards (specifications) related to field and laboratory tests.
8. Weakness in making the right decision to select the required laboratory tests according to local site conditions, structure nature, and the geological formations for the project area.
9. Lack of commitment to calibrate laboratory equipment and devices used in site investigation offices.

References

Andrew S., Sin J., and Fang Y. (2009). Engineer Self-Evaluation Checklist for Effective Site Visits. *Journal of Construction Engineering and Management*, Vol. 138, No. 10.

British Standards Institution (1999). *Code of practice for Site Investigations*, BSI 5930, Authority of the Standards Committee, London.

British Standards Institution (1987). *Quality Systems*. BSI, BS 5750, Authority of the Standards Committee, (Part 1: Ground investigation and foundations), London.

Bowles J. (1997). *Foundation Analysis and Design*, 4th Edition Chapter nine, McGraw-Hill Inc.

Clayton C. and Smith D. (2013). *Effective site investigation*, First Edition, ICE, London.

Clayton C., Simons N., and Matthews M. (1993). *Site Investigation*, First Edition, ICE, London.

Director G. and Partners (2005). *Problems of Site Investigation Works in a Linear Infrastructure Project*, IEM-MSIA Seminar on Site Investigation Practice", Malaysia.

Enshassi A., Mohamed S. and Abushaban S. (2009). Factors affecting the Performance of Construction Projects in the Gaza Strip. *Journal of Civil Engineering and Management*, Vol. 15, No. 3.

Harvey W. (2004). *Planning and Site Investigation in Tunneling. President*, Harvey Parker & Associates, USA.

Hijjawi S. (2003). *Soil Tests for the Purposes of Construction*, First Edition, Palestine.

Hyari K. and Kandil A. (2009). Validity of Feasibility Studies for Infrastructure Construction Projects. *Journal of Civil Engineering*, Vol. 3, No. 1.

Joseph S. (1995). *Geotechnical Site Investigation Methods*, Department of Civil and Environmental Engineering Tulane University, New Orleans.

Jaksa M., Hong k., and Woodward M. (2009). *Management, Training and Education in Geotechnical Engineering*, Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering, Australia.

Kholousy M. (1991). *Site Investigation and Soil Research and Foundations*, 5th Edition, Egypt.

Ministry of Public Works and Housing, the First Edition (1990). *Site Investigation Code*, Jordanian National Building Council First Edition, Amman.

Ministry of Environment (2005). *Checklist for Reviewing a Preliminary Site Investigation*, Ministry of Environment, British Columbia.

Parsons R. and Frost J. (2002). Evaluating Site Investigation Quality using GIS and Geo-statistics. *Journal of Geotechnical and Geo-environmental Engineering*, Vol. 128, No. 6.

Smith G. and Smith I. (1998). *Statements of Soil Mechanics*, 7th Edition, Blackwell Science.

Walpole R. and Myers L. (2007). *Probability and Statistics for Engineers and Scientists*, 8th Edition, Pearson Education International.