



## RESEARCH ARTICLE

# QUALITY EVALUATIONS FOR THE FIELD WORKS RELATED TO SITE INVESTIGATIONS OF RESIDENTIAL PROJECTS IN JORDAN

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### ABSTRACT

The quality evaluations for the field works concerning previously conducted site exploration studies in Jordan were deeply investigated through this research; where the major aim was to provide recommendations regarding the improvement of the quality for these works, and consequently to improve the performance of the residential project that to be carried out at the study site. The methodology of this research included implementing several activities. The first of these was reviewing for the international standards in implementing the field works related to site investigations, in addition to collecting several previous reports concerning site investigations for residential buildings in Jordan. The second activity was the design and distribution of the questionnaire that included opinions in performing the field works for these investigations in accordance with the international standards. The third activity was related to analyzing the collected data using SPSS Software for the purpose of quality evaluations. And the last activity was the submittal for conclusions and recommendations. Based on the analysis of results regarding the conducted survey, this research concluded that many factors may affect the quality of the field works related to site investigations in Jordan. In general, the most of these were the lack of commitment with the requirements of the Jordanian Code of Site Investigation, in addition to the lack of commitment to carryout field tests based on the latest specifications. Accordingly, it was recommended that site investigation offices should accurately perform the Jordanian site investigation code for the purpose of raising the level of performance and quality of their products. It is also recommended that site investigations offices should review and update the engineering specifications of the field and laboratory tests in order to upgrade their performance towards the international standards.

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## INTRODUCTION

In general, site investigation refers to a technical study that should be carried out for a construction site before preparing any preliminary design for the structure that intended to be constructed at this site, by which the necessary engineering data will be obtained (Jordanian Site Investigation Code, 1991; Clayton and Bowles, 1997; Smith, 2013). According to British Standards Institution (1999), a site investigation program should comprise four stages:

- Desk study and site reconnaissance.
- Preliminary site investigation.
- Detailed site investigation.
- Monitoring.

Recently, a lot of constructed projects in Jordan are continuously suffering from deferent kinds of defects

represented by settlements in their foundations and various types of wall and ground cracks. These defects are commonly existed and used to be visually inspected by people who live in residential buildings. Despite of there are several causes of cracks and settlements; in this research, the hypotheses was that most of the above engineering problems that could be occurred for constructions are related to inaccurate site investigations that were previously performed for these projects (Enshassi *et al.*, 2009). Therefore, it was realized that a quality evaluation for those investigations is needed, and a comparison between the procedures of carrying out them and that as stated in the international standards was of the essential tasks that considered in this research in order to control and eliminate the severity of the previously mentioned engineering problems in Jordan. Although a site investigation includes several kinds of works (Clayton *et al.*, 1993; Joseph, 1995); however, in this research, it was focused on the quality evaluations for the field works related to those investigations that leads to provide recommendations to improve them, and consequently to improve the quality of the building that to be

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constructed at the investigated site (i.e., the quality evaluation for the office and laboratory works was postponed for further research).

### Questionnaire survey

The field survey for this research was focused on distributing a questionnaire sheet to a set of site investigation offices in Jordan in order to understand and evaluate the following:

- The key factors that influencing the field works related to site investigations in Jordan.
- The effect of those factors on the overall quality of site investigation.
- A control for the above factors, and how to eliminate them in order to improve the resulted products.

### Research sample size

The research sample size was restricted to forty offices. In general, the interviews that were performed in this research were concentrated with engineers and project managers. The questionnaire survey considered several demographic variables such as field employment, locations of office work projects, the classification of the office, and years of experience, etc, and the following is a brief presentation for those variables.

**a- Field Employment:** According to the respondents' responses presented in Table 1, about 65% of respondents are working in site investigation field, 32.5% are working in site investigation and testing materials, and the remaining 2.5% are in other (different) construction fields.

**Table 1. Distribution of the Sample by Field Employment**

Field Employment	Number	Percent
Site investigations	26	65
Site investigation and testing materials	13	32.5
Others	1	2.5
Total	40	100

**b. Locations of Office Work Projects:** Table 2 shows that about 87.5% of the offices (for the members of respondents) are working at Amman's projects, 7.5% are working at Zarqa's projects, 2.5%, are working at Irbid's projects, and other offices are working at both Amman and Zarqa's projects (about 2.5%).

**Table 2. Distribution of the Sample by the Locations of Office Work Projects**

Location of the Office Work Projects	Number	Percent
Zarqa	3	7.5
Amman	35	87.5
Amman and Zarqa	1	2.5
Irbid	1	2.5
Total	40	100

**c. Classification the Office:** Table 3 shows that about 57.5% of the offices of the total members of respondents are classified as first-class, 35% are consultant offices, 5% are classified as second-class, and 2.5% are undecided.

**d. Quality Accreditation (ISO No. 17025):** Table 4 shows that about 25% of the surveyed offices had been obtained the quality accreditation (ISO No. 17025); whereas, about 70% hadn't obtain it; and about 5% were undecided.

**Table 3. Distribution of the Sample by the Classification of the Office**

Classification of the Office	Number	Percent
Consultant Office	14	35
Office of second-class	2	5
Office of first-class	23	57.5
Undecided	1	2.5
Total	40	100

**Table 4. Distribution of the Sample for Obtaining the Quality Accreditation (ISO No. 17025)**

The Case	Number	Percent
Yes	10	25
No	28	70
Undecided	2	5
Total	40	100

**e. Educational Level:** Table 5 shows that about 72.5% of the surveyed offices (i.e., persons who received the questionnaire sheet) had an educational level of bachelor degree; whereas, about 27.5% were of graduate studies.

**Table 5. Distribution of the Sample by Educational Level**

Educational Level	Number	Percent
Bachelor Degree	29	72.5
Graduate Studies	11	27.5
Total	40	100

**f. Experience:** Table 6 shows that about 90% of the surveyed offices (persons) had an experience of more than 10 years; whereas, about 10% of them had an experience of 10 years or less.

**Table 6. Distribution of the Sample by Years of Experience**

Experience	Number	Percent
≤ 5 years	2	5
6-10 years	2	5
11-20 years	17	42.5
≥ 21 years	19	47.5
Total	40	100

### Research hypothesis

The studied hypotheses for this research were as follows:

- Null Hypothesis ( $H_0$ ): the quality of field works related to site investigations in Jordan is good and has no effects on the engineering problems.
- Alternative Hypothesis ( $H_1$ ): There are defects in implementing the field works related to site investigations in Jordan, compared with those as stated in the international standards, and it needs to focus on the main factors that influencing the quality of performing these investigations.

### Statistical hypothesis testing

In general, the statistical hypothesis testing is used to decide if a result is statistically significant or not (British Standards Institution, 1987; Walpole R. *et al.*, 2007; Jaks M. *et al.*, 2009). The p-value that included in this test (defined as the probability of obtaining a result equal to or "more extreme" than what was actually observed) assumes that the null hypothesis is true. Before the test is performed, a threshold value is chosen, called the significance level of the test (about 5%) and denoted as ( $\alpha$ -alpha).

**Table 7. Opinions towards “Objectives of the Field Works Related to Site Investigation Studies”**

No.	Statements	Mean	Std. Deviation	Relative importance	Ranking	Chi-Square	p-value	Trend
1	The seismicity characteristics were found during investigation.	3.8	1.2	76.4	5	18.3	0.000	Agree
2	The level of groundwater (if any) was not studied during investigation.	2.1	1.3	41.5	7	24.3	0.000	Disagree
3	Studying for the problems that will be faced by the contractor during excavation.	4.5	0.5	90.5	2	0.1	0.752	Agree
4	Studying the safety for the neighbored buildings during the excavation period.	4.5	0.7	89	3	15.8	0.000	Agree
5	The active soil pressure against retaining walls (if any) was not considered during investigation.	1.8	1	36.4	9	31.4	0.000	Disagree
6	The geological formations for the study site were recognized during investigation.	4.6	0.8	92	1	47	0.000	Agree
7	Confirming for the availability of public safety at the investigated site.	4.4	0.7	87.7	4	26.1	0.000	Agree
8	A schedule for conducting the investigation is not considered during the implementation of the field work.	2.8	1.3	55	6	6.8	0.150	Neutral
9	The site investigation engineer believes that the level of income to site investigation offices in Jordan is fair.	2	1.1	39	8	23	0.000	Disagree

**Table 8. Opinions towards “Field Works related to Site Investigation Studies”**

No.	Statements	Mean	Std. Deviation	Relative importance	Ranking	Chi-Square	p-value	Trend
1	There is always an available number of rigs and apparatus that suit to the nature of the study site.	4.3	0.8	85	3	26	0.000	Agree
2	An engineered staff specialized with site investigations is not available in Jordan.	1.9	0.8	37.9	13	29	0.000	Disagree
3	The site investigation engineer carries out a site reconnaissance study before mobilizing the rig to the site.	4.3	0.6	86.5	2	20.2	0.000	Agree
4	The site investigation engineer always makes sure for the availability of the apparatus and materials that are required in conducting the site investigation study.	4.4	0.5	87.2	1	17.2	0.000	Agree
5	The international engineering standards (specifications) are not considered during performing field tests.	2.1	1	41.6	12	23.3	0.000	Disagree
6	The site investigation engineer supervises the sampling at the site by himself.	4	0.8	80	5	19.6	0.000	Agree
7	The site investigation engineer carries out a visual description for the collected samples in accordance with the standards.	3.9	0.9	77.9	9	12	0.007	Agree
8	Soil samples were not collected in proper sequence inside wooden boxes to be transferred to the laboratory.	2.2	1.1	44.5	11	16.8	0.002	Disagree
9	The collected samples are transported from the site to the laboratory without any disturbance.	4	0.8	79.5	6	26	0.000	Agree
10	The site investigation engineer always inspects the site after it was excavated, and compares his findings with that previously stated in the site investigation report.	4.3	0.8	86	4	34.2	0.000	Agree
11	An adequate transportation means are always provided to the site investigation engineer for the purpose of site inspections.	3.9	0.9	77.9	8	18.7	0.000	Agree
12	Skilled and unskilled workers believe that their salaries are fair.	3	1.1	59	10	12.8	0.013	Neutral
13	The site investigation engineer believes that the quality of a site investigation is highly affected by the rig and equipment depreciations, in addition to its maintenance cost.	4.2	0.8	83	7	26.6	0.000	Agree

**Table 9. Opinions towards “Various Paragraphs and the impact of each on the quality of Site Investigations”**

No.	Statements	Mean	Std. Deviation	Relative importance	Ranking	Chi-Square	p-value	Trend
1	Lack of commitment to conduct the requirements related to the Jordanian engineering code.	2.7	1.4	54	6	7.3	0.123	Neutral
2	Lack of cooperation by the representatives of the association of engineers with site investigation offices.	2.6	1.3	52.3	7	14.2	0.007	Disagree
3	There are defects in making the right decision to select the required field tests according to the site conditions, structure loads, and the geological formations for the project area.	2.8	1.4	56	5	4.8	0.314	Neutral
4	There is a lack to check the presence of faults or any strange geological structures at the project area.	2.9	1.3	58.5	3	8.8	0.068	Neutral
5	Lack of commitment to calibrate Field equipment and devices used in site investigation offices.	2.4	1.3	47.2	12	20.5	0.000	Disagree
6	There are some problems concerning the payments from the owner to the office (in accordance with the agreement between them).	3.4	1.4	67	1	12.3	0.016	Neutral
7	Writing for site investigations reports based on the experience for the project area (without actually conducting the required study).	2.6	1.4	52	8	13.8	0.008	Disagree
8	Lack of sufficient expertise to site investigation engineers regarding the visual descriptions for the geological formations and layers for the study site.	2.4	1.2	47.5	11	22	0.000	Disagree
9	Focusing the offices efforts on the profitability rather than the application of the required specifications	2.6	1.5	51.3	9	11.6	0.020	Disagree
10	Recruitment of engineers and workers with specialties that do not fit with the nature and requirements of the site investigation offices.	2.5	1.2	50.5	10	33.3	0.000	Disagree
11	Uncertainty regarding the installation of the boundaries for the required study site.	2.8	1.3	55	4	25.5	0.000	Neutral
12	There are always difficulties to access the project site required to be studied.	2.9	1.3	58	2	13.5	0.009	Neutral

Therefore, if the p-value is less than or equal to the chosen  $\alpha$ -alpha, the test suggests that the observed data are inconsistent with the null hypothesis, so the null hypothesis should be rejected; whereas, if they obtained results showed values different from what was discussed above, therefore alternative hypothesis must be rejected (Ministry of Environment, 2005).

## RESULTS AND DISCUSSION

After analyzing the received data from questionnaire (using SPSS Software), the results of this research are presented in the form of opinions to several major items as shown below.

### a-Opinions towards “Objectives of the Field Works Related to Site Investigation Studies”

The opinions of respondents towards the above title are indicated in Table 7. 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. 3 and No. 8, 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.3 and No.8.

### b- Opinions towards “Field Works related to Site Investigation Studies”

The results of this item are shown in Table 8. 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.

### c- Opinions towards “Various Paragraphs and the Impact of Each on the Quality of Site Investigations”

The results of this item are shown in Table 9. This table shows that Chi-Square test is statistically significant for all statements except that for statements No.1, No.3 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, No. 3 and No. 6.

## SUMMARY OF RESULTS

In this research, it was indicated that the analysis of results 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 some referred statements. Accordingly, the analyses for this research proved that the alternative hypothesis ( $H_1$ ) is accepted (i.e., There are defects in implementing the field works related to site investigations in Jordan).

## CONCLUSION

The main conclusions derived from this research are indicated below:

1. The majority of site investigations for residential buildings in Jordan are carried out without clear and accurate schedule required to perform the investigation, and accordingly affects the quality and total period needed to execute the project.
2. Most investigations suffer from a lack of information concerning the engineering history for the existed neighbor buildings, in addition to the possibility of transmitting their loads to the new building.
3. Several site investigation offices used to provide recommendations based on their previous experience for the area in the vicinity of the intended site without performing the actual study for the purpose of quick profit.
4. Faults or other geological structures are rarely detailed through the investigation.
5. There is a lack of commitment to carry out the requirements of the Jordanian site investigation code and the international engineering standards.
6. There is a lack of preparations related to the technical specifications for bidding of the required site investigation.
7. The majority of site investigation reports do not indicate the problems that will be faced by the contractor during excavation.
8. There is a lack of sufficient expertise to site investigation engineers regarding the accurate visual descriptions for the geological formations and layers of the study site.

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