Factors Contributing to Rework and their Impact on Construction Projects Performance

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Abstract

Rework is considered as a significant factor that influences the construction project performance in Palestine. Yet, little is known about its causes and possible impact, and therefore it remains an innate problem. The objective of this research is to identify the factors that contribute to rework and to investigate their possible impact on construction project performance. A set of 57 rework factors that categorized under seven groups were identified through an extensive literature review of previous studies and then were refined based on a pilot study. To elicit the views of professionals in the construction industry of the Gaza Strip about rework factors impact on construction project performance, 200 questionnaires were distributed and175 were returned. Data were analysed using descriptive analysis such as the Relative Importance Index (RII), mean, and Kruskall-Wallas test by employing SPSS version 17. The results of this research revealed that contractors' related rework causes and human resources capability related rework causes are the major categories, which impact on the construction project performance. In addition, the findings showed that attempts to fraud, competitive pressure, ineffective management, schedule pressure and the absence of job security are the main rework factors, which have a considerable influence on construction project performance. The result of Kruskal-Wallis test indicated that there is an agreement among respondents with respect to the impact of rework causes on construction project performance. The findings may help construction parties' in Gaza Strip to understand rework causes, which affect construction project performance. This will help in the derivation of appropriate strategies to reduce rework and hence, enable project performance improvements to be made. The recommendation of this study may also apply to other developing countries. The study contributes to the overall body of knowledge relevant to rework in the construction industry of developing countries. It draws attention to potential factors which contribute to rework on construction projects.

Keywords: *Rework, Causes, Quality, Construction, Performance*

1.0 Introduction

Time and schedule overruns, quality deviations, and customer dissatisfaction are perennial problems in the construction industry of Gaza Strip [1]. Rework is regarded as a serious problem in the construction industry of Gaza Strip that has been identified as one of the key causes of schedule delays, cost overruns and customer dissatisfaction [2]. There are various definitions of rework in the construction management literature, which mainly include quality deviations, quality failures, defects, and non-conformance [3]. According to Oyewobi et al. [4] rework is the process when an element of building works fails to meet customer's needs and specification, or when completed work does not conform to contract documentation. McDonald [5] identified rework as "work measures that have to be completed more than once". Love and Edwards [6] defined the rework process as "'the unnecessary effort of re-doing a process or activity that was incorrectly implemented at the first time'. On the other hand, Rogge et al. [7] provided a more specific definition of field rework as " activities in the field that

have to be done more than once in the field or activities which remove work previously installed as part of the project". Rework is considered essential when any activity of the building fails to meet customer's requirement or when completed work does not conform to contract documentation [4].

Previous research efforts have attempted to determine the factors that affecting the performance of Palestinian construction industry [1, 2, 8]. Yet, little or no attention has been directed towards reworks causes and their impact on construction performance with respect to time and cost. Therefore, this paper is intended to address this important issue. Mainly, the objective of this paper is to identify rework causes and investigate their impact on construction project performance. This paper starts with an introduction about rework causes followed by reviewing previous related literature. Then methodology of the paper is discussed followed by results and discussing and conclusion of the paper.

2.0 Literature review

Rework has direct and indirect impacts on project performance. The literature identified the direct impact with respect to the productivity and the project performance in terms of cost and time [9]. Palaneeswaran [10] stated that rework affects morale level, dilution of supervision, conflict, absenteeism, fatigue, and communication. The direct impacts of rework on project management transactions include additional time to rework, additional costs for covering rework occurrences, additional materials for rework and subsequent wastage handling, additional labor for rework and related extensions of supervision manpower. On the other hand, some researchers investigated the indirect impact of rework. For example in their conceptual rework model**,** Love and Edward's [6] listed a number of indirect consequences impacts of rework such as: end-user dissatisfaction, inter-organizational conflicts, fatigue, stress, de-motivation, work inactivity, absenteeism, loss of future work, poor moral, reduced profit, and damage to professional image. Love and Edward's [11] reported that rework can seriously affect an individual, an organization and a project's performance indirectly.

At individual level, stress, fatigue, absenteeism, de-motivation, and poor morale were found to be the primary indirect effects of rework. In fact, when an individual is subjected to prolonged work hours because of errors, changes, or omissions, fatigue, stress are likely to emerge, increasing the likelihood of even further rework occurring [12]. At organization level, Love [3] identified reduced profit, diminished professional image, inter-organizational conflict, loss of future work and poor morale as indirect effects of rework. At project level, works in activity such as waiting time, idle time, travelling time, and end-user dissatisfaction were identified as indirect consequences of rework. Burati et al. [13] stated that rework in the form of changes can have an effect on the aesthetics and functional aspects of the building, the scope, as well as the nature of work, and its operational aspects. In the construction industry, the likelihood for errors, omissions and poor management practices may cause neglect that can lead to quality failures, which must then be reworked [5].

Palaneeswaran [10] stated that in addition to the direct impacts (i.e. with respect to time, cost, and resources) on specific activities, rework occurrences will often have some indirect impacts subsequently. Love [9] listed number of indirect consequences impacts of rework such as: end-user dissatisfaction, inter-organizational conflicts, fatigue, stress, de-motivation, work inactivity, absenteeism, loss of future work, poor moral, reduced profit, and damage to professional image. Love [3] concluded that rework can seriously affect an individual, an organization and a project's performance indirectly. At individual level, stress, fatigue, absenteeism, de-motivation, and poor morale were found to be the primary indirect effects of rework. In fact, when an individual is subjected to prolonged work hours because of errors, changes or omissions, fatigue and stress are likely to emerge, increasing the likelihood of even further rework occurring [12]. At organization level, Love and Edwards [6] identified reduced profit, diminished professional image, inter-organizational conflict, loss of future work and poor morale as indirect effects of rework. At project level, works in activity such as waiting time, idle time, travelling time and end-user dissatisfaction were identified as indirect consequences of rework.

The Construction Industry Institute (CII) capital program benchmarking and metrics program collected data for approximately 360 projects where direct rework costs were measured as a portion of

actual construction costs [14, 15]. CII (14, 15] developed a formula to calculate a metric known as Total Field Rework Factor (TFRF), which is expressed as Total Direct Cost of Field Rework over the Total Construction Phase Cost as a leading indicator used for this group data analysis. Building Research Establishment (BRE) figured out that 50% of the origins of errors in buildings are in the design stage and 40% in the construction phase [16]. BRE [17] indicated that by utilizing a quality control system significant cost benefits could be achieved. BRE demonstrated that 15% of total construction cost could be saved by eliminating rework. According to Hammarlund et al. [18, 19], an observer used to record failures of quality within construction of a community service building which took two years to complete. A total number of 1,460 quality failures were registered on site, of which 80% were corrected satisfactorily and 8% not corrected at all.

Cnuddle [20] specified the costs of failures in construction by measuring the non-conformance amount that happened on site. It was found that between 10% and 20% of project cost is cost of non-conformance. Moreover, total deviation costs were created during design stage was found to be 46% and deviation costs during construction was figured out as 22%. Burati et al. [13] gathered quality aversions data from nine industrial projects. They attempted to identify degree and causes of quality problems in construction stage and design phase. According to their study, quality deviations can cost as high as 12.4% of total project cost. Results of their study indicated that almost 80% of costs of deviations were related to design and 17% were construction related. Abdul-Rahman [21] expanded a matrix of quality costs for measuring the non-conformance cost of projects. His research outcomes revealed that total non-conformance cost was 5% of tender value.

According to the case study which was conducted by Love et al. [22], in project A (residential apartment blocks) rework directly contributed 3.15% cost of the contract value and this cost for project B (industrial warehouse) was 2.40%. The results of study on ten high-rise buildings by Alwi et al. [23] demonstrated that rework costs ranged from 2.01% to 3.21% of the total project costs. This study compared rework costs of different projects with the amount of their training costs which is indicated that rework costs and training costs usually have a negative relationship. It seems that the more money spent on training, the less the rework cost is with the exception of one project. Contractors who have been conducted training programs regularly can reduce rework costs between 11% and 22%. Barber et al. [24] reported that the quality failure costs including costs of delay were 16% of construction cost for project one, and 23% for project two. Love and Li [25] found that the direct cost of rework was about 3.15 % and 2.40 % of the value of the entire contract.

Josephson et al. [26] calculated cost of defects from seven building projects which was ranged between 2.3% to 9.3% of contract value. They [26] reported that, factors influencing rework costs in order of precedence are: design, production management, workmanship, material, client, and machines. Fayek et al. [27] reported that the costs of rework causes as engineering and reviews (61.65%), human resource capability (20.49%), material and equipment supply (14.81), construction planning and scheduling (2.61%), and leadership and communication (0.45%). Rhodes and Smallwood [28] found that cost of rework reached 13% of project value. Marosszeky [29] reported that the mean of rework costs were found as 5.5% of contract value including 2.75% as direct costs, 1.75% indirect costs for main contractors and 1% indirect costs for subcontractors. Palaneeswaran [10] found that direct costs of rework were 3.5% of original contract value and related indirect costs was 1.7%.

Wasfy [30] indicated that rework increased cost of different work categories of residential-commercial tower between 2% to 30%. Rework caused delays in different work categories resulting in an increase of their original durations from 10% to 77%. Additionally, rework caused clients and contractors dissatisfaction. Oyewobi et al. [4] revealed that finishes have a higher contribution to rework costs than any other elements of building projects. Meshksarr [31] revealed that, reworks influenced the cost of project by 1.85% and 2.1%.. It should be taken into account that as a result of differences in definitions, scope, data collection methods used, and whether rework is calculated as a proportion of project or contract value, these numbers are not fully comparable [32,34]. Based on a description of Kumaraswamy and Chan [33] and CII [14], rework is a substantial contributor to time wastage and schedule overruns. It will ultimately impact on quality, costs (e.g. indirect costs such as overheads) and resources as well (Love and Edwards, 2004). Samson and Lema [34] remarked that the number of disputes and rework tasks through project affects the quality performance. Meshksarr [31]

indicated that, time delay of rework in case study and survey was 4.1% and 5.18% of construction duration respectively. Gündüz et al. [35] concluded that planning and scheduling, fluctuation of prices, rework due to errors, late delivery of material, owners demand, poor site management, complexity of project are all the major causes of delay. Alavifar and Motamedi [36] indicated that most severe causes of delay were rework due to errors during construction.

3.0. Methodology

To achieve the objectives of this paper, a two-stage investigation study was conducted. The first stage aimed at identifying the most significant causes of rework in the construction industry of Gaza Strip. This was obtained via a systematic literature review where 72 rework causes were selected. Those causes were then modified and grouped according to a pilot study with ten experts. Consequently, 57 rework causes that categorized under seven groups where structured into a questionnaire survey, which distributed to participants through the second research stage. The following section presents the questionnaire survey population and sampling method, the pilot study, and the questionnaire design process.

3.1 Research Population

The population of this research included contracting companies, consultants, and public-client. Contracting companies are registered in the Palestinian Contractors Union (PCU) in Gaza Strip that has valid registration in the PCU up to the year 2015 according to the national classification committee. According to the PCU in Gaza Strip, the number of construction contractors companies registered was 310 companies. The classification of contracting companies is based on company's capital, and number of projects performed, which consists of five grades. In this research, the target group to be investigated was contracting companies classified under the first, second and third grades. The fourth and fifth grades were excluded due to low practical and administration experience [37].

Total contracting companies that were under the grades first, second and third are 172 companies, which were the population target group of this research. Public-client group consists of government, ministries, municipalities, international agencies, non-governmental organizations (NGOs) and public project owners. According to the PCU [37] the numbers of public-clients who work in construction industry in the last five years are about 50 agencies. The number of consultant companies that have a valid membership of consulting offices in Gaza Strip is 61 according to Engineers Syndicate [38]. The research was carried out in Gaza Strip in Palestine, which consists of five governorates: The northern governorate, Gaza governorate, the middle governorate, Khan Younis governorate, and Rafah governorate.

3.2 Sample Size

The sample was selected randomly from professional's engineers of contracting companies, consultant offices and public-clients (respondents). The following statistical equation was used to determine the sample size [30].

$$SS = \frac{Z^2 \times P \times (1-P)}{C^2} \quad \ldots\ldots\ldots [1]$$

Where:
SS: The sample size
Z: Z value *(e.g. 1.96 for 95% confidence interval)*
P: Percentage picking a choice, expressed as decimal, (0.50 used for sample size needed)
C: Maximum error of estimation (0.08)

$$SS = \frac{1.96^2 \times 0.5 \times (1-0.5)}{(0.08)^2} = 150$$

Correction for finite population

$$SS_{new} = \frac{SS}{1 + \frac{SS - 1}{pop}} \quad \text{[2]}$$

Where: pop is the population;

For contracting companies (First, Second and third class): 172 companies.

So that:

$$SS_{new} = \frac{150}{1 + \frac{150 - 1}{172}} = 80.4 \approx 81$$

The total number distributed was 100 questionnaires.
The total number returned was 89 questionnaires.

For consulting offices: 61 offices.

So that:

$$SS_{new} = \frac{150}{1 + \frac{150 - 1}{61}} = 43.5 \approx 44$$

The total number distributed was 50 questionnaires.
The total number returned was 46 questionnaires.

For owner agencies: 50 agencies.

So that:

$$SS_{new} = \frac{150}{1 + \frac{150 - 1}{50}} = 37.9 \approx 38$$

The total number distributed was 50 questionnaires.
The total number returned was 40 questionnaires.

Figure 1 illustrate the response rate of respondents.

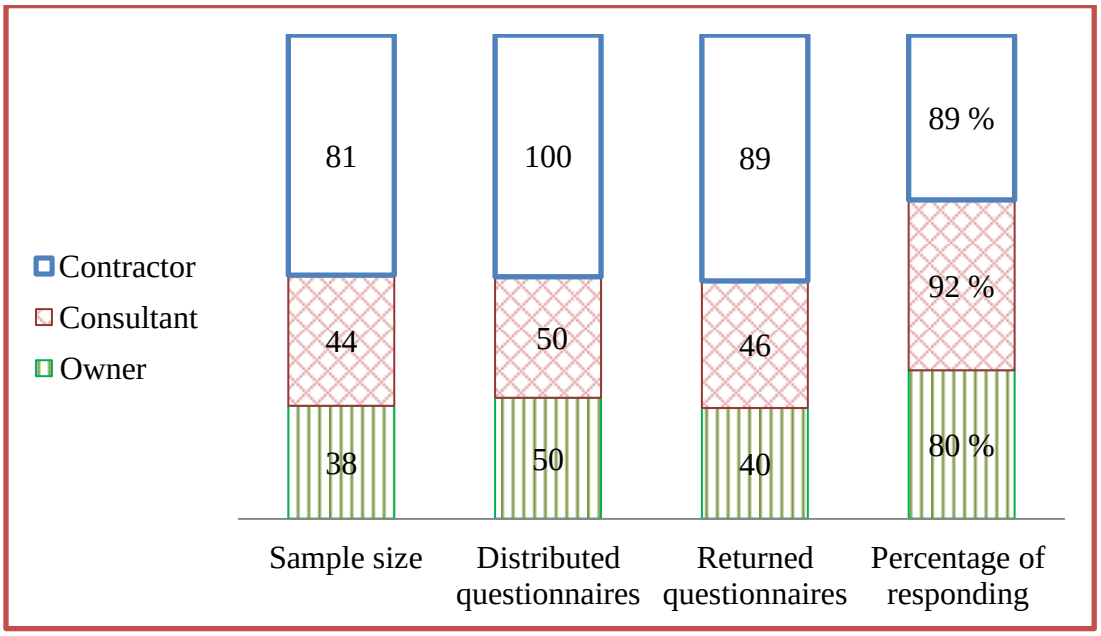

Figure 1: Respondents response rate

3.3 Data Collection Method

A structured questionnaire survey was selected to be the main data collection method in this research. Questionnaires have been widely used for descriptive and analytical surveys in order to find out the facts, opinions and views [40]. The questionnaire was initially designed based on the extensive literature review of previous studies. The questionnaire framework was modified and refined based on the pilot study. A total of 72 rework causes were assembled from a thorough literature review, those causes were modified, aggregated and restructured according to the context of this study that is Gaza Strip. In addition, further modification was applied based on the pilot study, where new questions were added as a result of interviews with experienced construction managers.

3.4 Pilot Study

In order to test the appropriateness, reliability, and validity of the questionnaire scales, a pilot study was undertaken, where the researchers firstly conducted face-to-face interviews with ten projects managers from contract parties. Each interview took approximately one hour, where the researchers met each interviewee in their project and discussed the research aim and the purpose of the pilot study. By the end of each interview the researchers handed out a hard copy of the questionnaire to the participants. The participants were invited to provide their feedback and comments in the designed questionnaires; they were also allowed to add any suggestions for refining the survey instruments. The methodology of selecting the pilot study participants took into account the participants area of expertise and years of experience, mainly the participants were selected had more than 10 years' experience in construction work.

Consequently, 57 rework causes were selected that categorized under seven broad headings, namely: (i) causes related to human-resource capability, (ii) causes related to construction process, (iii) causes related to materials and equipment supply, (iv) external environment-related causes, (v) client-related causes, (vi) design-related causes and (vii) contractor-related causes. The selected rework causes and categories were suggested by previous researchers and according to the pilot study as illustrated in Table 1.

Table 1: List of selected rework causes

	Rework causes	Main sources
	Causes related to human resource capability	
1.	Excessive overtime	[23, 25, 27, 32]
2.	An insufficient manpower skill level	[10, 23, 27, 41]
3.	Inadequate coordination &integration	[12, 13, 22, 23, 26, 27, 30, 51]
4.	Insufficient training and skill development	[6, 11, 12, 27, 29, 51, 52]
5.	Disturbances in personnel planning	[4, 10, 12, 27, 30, 51]
6.	Lack of employee motivation and rewords	[6, 12, 13, 41]
7.	The absence of job security	Added (pilot study)
8.	Unclear line of authority and responsibility	Added (pilot study)
9.	Personnel attitude (personnel issues)	Added (pilot study)
10.	Conflict of interest	Added (pilot study)
11.	Lack of safety and welfare commitment	[13, 23, 41, 51]
12.	Poor communication system	[3, 4, 6, 10, 11, 12, 13]
13.	Ineffective management and decision-making	[13, 27, 41, 52]
14.	Failure to implement Quality management practices	[23, 27, 52]
	Causes related to construction process	
15.	Lack of Audit and control	[10, 30]
16.	Schedule pressures	[6, 23,27, 41]
17.	Late designer input	[6, 27]
18.	Constructability problems	[27, 51]
19.	Inadequate pre-project planning	[6, 13, 41, 52]
20.	Non-compliance with specification	[23, 26, 32, 49]
21.	Unclear work specification	[27, 32, 49]
22.	Inadequate supervision	[10, 12, 23, 27, 41]
23.	Poor project document	[6, 27, 42]
24.	Rigidity to improvement	Added (pilot study)
25.	Absence of clear uniform standard to accept work	Added (pilot study)

Table 1: List of selected rework causes

	Rework causes	Main sources
	Causes related to materials and equipment supply	
26.	Untimely deliveries	[6, 12, 23, 26, 27]
27.	Non-compliance with specification	[12, 23, 27, 30]
28.	Materials not in right place when needed	[12, 23, 25, 27, 30]
29.	Pre-Fabrication not to project requirement	[13, 23, 27, 30]
30.	Emergency conditions (siege and closures)	Added (pilot study)
31.	Adulterated materials	Added (pilot study)
32.	Invalidity of needed tests	Added (pilot study)
	Client-related causes	
33.	Lack of knowledge of construction process	[10, 12, 13, 41])
34.	Inadequate briefing	[10, 12, 41]
35.	Lack of funding allocated for consultation	Added (pilot study)
36.	Changes because of change in officials	Added (pilot study)
	Design-related causes	
37.	lack of professionalism	[10, 12, 41, 52]
38.	Inadequate procurement methods	[13, 26, 27, 42]
39.	Poor project document	[6, 27]
40.	Design errors and omission	[12, 13, 6, 27]
41.	Competitive/ low design fees	[10, 12, 41, 52]
42.	Incomplete information for design	[6, 10, 26,30]
43.	Incomplete design	Added (pilot study)
	Contractor-related causes	
44.	Poor quality system	[10, 23, 49]
45.	Misreading of drawings and specifications	[10, 12, 41]
46.	Competitive pressure / low contract value	[13, 49]
47.	Attempts to fraud	Added (pilot study)
48.	Unqualified technically	Added (pilot study)
49.	Financial weakness (Phantom cash flow)	Added (pilot study)

Table 1: List of selected rework causes

	Rework causes	Main sources
	External environment related causes	
50.	Government (Regulations, taxes. Interest rates)	[3, 9, 12, 51]
51.	Economy (Inflation, exchange rates, market)	[13, 41, 51, 52]
52.	Social (Changing social environment, resistances)	[11, 41, 51]
53.	Technological (techniques, facilities, machines)	[22, 23, 30, 32, 41, 51, 52]
54.	Inadequate local education (Collectors - craftsman - technical)	[3, 6, 13, 41, 51]
55.	Physical conditions (Infrastructure, transportation, etc)	[10, 41, 51]
56.	Acts of God/Force Major (Weather, disaster)	[10, 30]
57.	Political situation (Siege- conflicts)	Added (pilot study)

3.5 Validity and reliability of the questionnaire

Instrument validity
Field [43] defined the validity of an instrument as; "Validity refers to the degree to which an instrument measures what it is supposed to be measuring". Validity has a number of different aspects and assessment approaches. There are two ways to evaluate instrument validity: (1) content validity and (2) statistical validity, which include criterion-related validity and construct validity.

Content validity
The content validity of the questionnaire was tested by a panel consisting of ten experts with minimum experience of 10 years in construction and excellent knowledge of project management. Each expert was requested to evaluate content validity for each item based on rating the index of content validity. Based on comments of the experts some factors were added, modified, or deleted.

Statistical validity
To insure the validity of the questionnaire, two statistical tests were applied. The first test is criterion-related validity test (Spearman test) which measures the correlation coefficient between each paragraph in one group and the whole groups. The second test is structure validity test (Spearman test) that used to test the validity of the questionnaire structure by testing the validity of each group and the validity of the whole questionnaire. It measures the correlation coefficient between one group and all the groups of the questionnaire that have the same level of similar scale [43].

Spearman rank correlation coefficient is used to determine whether there is evidence of a linear relationship between two ordinal variables, or, if both variables are interval and the normality requirement may not be satisfied [44]. The sample spearman correlation coefficient is denoted r_s and is given by:

$$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. [3]$$

Where:
r_s= Spearman's rank correlation coefficient
d = the difference in ranking between the usage and effectiveness of factors
n = the number of factors
To evaluate the hypothesis testing to verify the association between two variables, the following equation is used:

$$t = r_s \sqrt{\frac{n-2}{1-r_s^2}} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots [4]$$

Internal consistency of the questionnaire was measured by a scouting sample, which consisted of 30 questionnaires through measuring the correlation coefficients between each paragraph in one field and the whole field. The p-values (Sig.) are less than 0.05, so the correlation coefficients of this field were significant at α = 0.05, so it can be said that the paragraphs of each field were consistent and valid to measure what it was set for (Field, 2003). It was found that the p-values (Sig.) for each field and for the entire questionnaire were less than 0.05, so the correlation coefficients of all the fields were significant at α = 0.05, so it can be said that the fields were valid to measure what it was set for to achieve the main aim of the study.

Reliability analysis
Reliability aimed to examine the quality of measurement. One of the most commonly used indicators of reliability analysis was Cronbach's alpha coefficient [43]. Cronbach's Alpha typically varies between 0 and 1. The closer the Alpha is to 1, the greater the internal consistency of items in the instrument being assumed. The normal range of Cronbach's coefficient alpha value between 0.0 and + 1.0 [45], and the higher values reflects a higher degree of internal consistency.

The Cronbach's coefficient alpha was calculated for each field and for the entire questionnaire. For the fields, values of Cronbach's Alpha were in the range from 0.671 and 0.917. This range was considered high; the result ensured the reliability of each rework category of the questionnaire. Cronbach's Alpha equals 0.84 for the entire questionnaire which indicated an excellent reliability of the entire questionnaire. Thereby, it can be said that the questionnaire was valid, reliable, and ready for distribution for the population sample.

3.6 Data measurement and data analysis methods

In this research, ordinal scales were used. Ordinal scale is a ranking or a rating data that normally uses integers in ascending or descending order. Those integrates do not indicate that the intervals between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels [40]. Likert scale was used in this questionnaire, which is a device to discover the strength of feeling or attitude towards a given statement or series of statements and the implication. The higher the category chosen, the greater the strength of agreement, but care has to be taken not to read too much in these ranked scales. Likert scales are usually a three, five or seven-point range where the respondents are usually asked to indicate the rank order of agreement or disagreement by circling the appropriate number [46]. For this research, five-point Likert scale was adopted (No impact=1, Limited impact=2, Average impact=3, Much impact=4 and Extreme impact=5). SPSS 17 was used for the analysis.

The Relative Importance Index (RII) was used to determine the ranks of all questionnaire factors. The relative importance index was computed as [1, 8]:

$$RII = \frac{\sum W}{A \times N} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots [4]$$

Where:
W is the weighting given to each factor by the respondents (ranging from 1 to 5)
A: the highest weight (i.e. 5 in this case)
N: the total number of respondents

The RII value had a range from 0 to 1 (0 not inclusive), the higher the value of RII, the more impact of the attribute. However, RII doesn't reflect the relationship between the various attributes.

In addition, Kruskal-Wallis test was used to examine if there was a statistical significant difference between several means among the respondents toward the rework among professionals in the construction projects.

4.0 Results and discussion

The main purpose of this study was is to investigate the impact of rework causes on the project performance. A list of 57 rework causes were investigated in this paper, which were grouped under seven categories according to literature review and the pilot study, those were: human-resource capability, construction process, materials and equipment supply, external environment, client-related causes, design-related causes and contractor-related causes. The most important causes will be discussed in the following sections.

4.1 Human resource capability related reworks causes impact on project performance

Table 2 illustrates the results of ranking the impact of human resource capability rework causes group on project performance.

Table 2: RII and ranks of human resource capability related rework impact on project performance

Rework Causes	Degree of impact on project performance quoted by 175 Respondents					Score	Mean	SD	RII %	Rank	Over all rank
	1	2	3	4	5						
Ineffective management and decision-making	5	12	27	46	85	719	4.11	1.16	82.2	1	3
The absence of job security	5	22	24	48	76	693	3.96	1.33	79.2	2	5
An insufficient skill level	5	0	55	56	59	689	3.94	0.9	78.8	3	7
Disturbances in personnel planning	0	15	33	81	46	683	3.9	0.78	78.0	4	10
Lack of employee motivation and rewords	0	14	57	40	64	679	3.88	1.00	77.6	5	12
Conflict of interest	4	6	60	55	50	666	3.81	0.93	76.2	6	16
Excessive overtime	5	20	38	70	42	649	3.71	1.09	74.2	7	21
Personnel attitude (personnel issues)	0	24	49	66	36	639	3.65	0.91	73.0	8	25
Unclear line of authority	9	16	36	88	26	631	3.61	1.03	72.2	9	32
Inadequate coordination and integration	4	22	62	46	41	623	3.56	1.10	71.2	10	37
Poor communication system	12	17	43	70	33	620	3.54	1.23	70.8	11	39
Insufficient training and skill development	4	14	80	44	33	613	3.5	0.92	70.0	12	40
Lack of safety and welfare commitment	9	28	45	63	30	602	3.44	1.22	68.8	13	46

This group includes 13 rework causes related to human-resource capability. As illustrated in Table 2, "*Ineffective management and decision-making*" was ranked as the first rework cause, which has a high impact on project performance with RII of 82.2% and third among all causes explored. Such poor management practices may contribute to time wastage, unnecessary costs, increased errors, rework incidents, and misunderstandings, which have significant effect on project performance. This is in agreement with the findings of [2, 6, 14, 27, 29, 47]. Hammarlund and Josephson [47] suggested that a large part of the failure costs found in construction projects is attributable to the poor skills of site management. Fayek et al. [27] ranked this cause in the first of rework causes under leadership and communication group. This study strongly agreed with Enshassi et al. [2] who ranked level of project leadership and management skills as second factor that affect project performance in Gaza Strip with RII 0.902.

"The absence of job security" was ranked as the second cause influencing project performance in this group with RII of 79.2%. This cause is ranked as the fifth in its impact among the 57 causes surveyed. Most workers in construction field in Gaza Strip work on temporary basis, this may lead to low workmanship quality. Negligence of workers satisfaction and security increase defects, errors and rework. This can seriously affect project performance. The findings of this study align will with previous researchers results [30, 23, 36] who illustrated that insecurity job feeling between labors negatively affect project performance and is one of main delay causes in construction project in Iran. *"An insufficient skill level"* of manpower was ranked in the third position in this group with RII of 78.8%, and seventh among all causes. Unskilled and poorly trained labors are commonly characterized with low and faulty outputs coupled with unjustifiably high inputs. Their outputs are usually rejected, either in whole or in part, by the inspection architect/engineer, resulting in extensive and expensive rework, rectifications, or repairs. This outcome agreed with the findings of [4, 10, 23, 27, 31, 41]. This result is in line with Meshksarr [31] who indicated that insufficient skill levels and inadequate supervision extremely affect project cost and time.

Test of agreement among respondents

The Kruskall-Wallas test was conducted to test if there is an agreement among respondents concerning human resource rework causes impact on project performance. The results showed that the probability of significance is 0.91 which is more than 0.05; this means that there is an agreement among the three participants' group in ranking the impact of rework causes related to human resources on project performance.

4.2 Construction process related rework causes impact on project performance

This group comprised 12 rework causes related to construction process. The results are shown in Table 3. As shown in Table 3 *"Schedule pressure"* was ranked the first with RII of 81% and fourth among all causes explored. Schedule pressure increases errors, and rework incidents, have significant impact on project performance. This result is in agreement with the findings of [3, 6, 27, 41].

The respondents ranked *"Inadequate supervision"* and *"Lack of audit and control"* in the second position with of RII equals to 73.2%; and they ranked them as 23rd among all explored causes. The quality of site supervision has a major impact on the overall performance and efficiency of construction projects. Inadequate supervision is believed to be one of the major causes of rework. Therefore, experienced and well-trained supervisors have an important role in minimizing the amount of rework due to construction defects. This outcome corroborates the finding of Palaneeswaran [10] who indicated that inadequate supervision is one of the major causes of rework. Alwi et al. [23] stated that the quality of site supervision has a major impact on the overall performance and efficiency of construction projects. Simpeh [12] ranked *"Inadequate supervision"* as the third rework causes that have an impact on project cost.

Test of agreement among respondents

The Kruskall-Wallas test was conducted to test if there is an agreement among respondents concerning construction process rework causes impact on project performance. The results showed that the

probability of significance is 0.358 which is more than 0.05; this means that there is an agreement among the three participants' group in ranking the impact of rework causes related to construction process on project performance.

Table 3: RII and ranks of construction process related rework impact on project performance

Rework causes	Degree of impact on project performance quoted by 175 Respondents					Score	Mean	SD	RII %	Rank	Over all rank
	1	2	3	4	5						
Schedule pressures	3	10	37	51	74	708	1.02	4.0	81.0	1	4
Inadequate supervision	0	10	71	63	31	640	0.69	3.7	73.2	2	23
Lack of Audit and control	8	8	57	64	38	641	1.02	3.7	73.2	2	23
Unclear work specification	6	26	38	61	44	636	1.24	3.6	72.6	4	29
Late designer input	3	13	79	31	49	635	1.04	3.6	72.6	5	30
Failure to implement Quality management practices	2	14	72	55	32	626	0.84	3.6	71.6	6	34
Non-compliance with specification	4	41	37	40	53	622	1.46	3.6	71.0	7	38
Inadequate pre-project planning	15	9	55	67	29	611	1.2	3.5	69.8	8	41
Rigidity to improvement	10	15	58	68	24	606	1.04	3.5	69.2	9	42
Poor project document	12	10	88	33	32	588	1.12	3.4	67.2	10	49
Absence of clear uniform standard to accept work	12	32	63	36	32	569	1.33	3.3	65.0	11	53
Constructability problems	13	35	61	57	9	539	1.02	3.1	61.6	12	56

4.3 Materials and equipment supply related rework causes impact on project performance

This group composed of seven rework causes related to materials, and equipment supply. The results (see Table 4) indicated that *"Emergency conditions (such as: siege and closures),"* has a high impact on project performance. It was ranked in the first position with RII of 78.2%, and the eighth cause among the 57 causes surveyed. Because of the political complex situation, getting materials in required specifications and on time is difficult in Gaza Strip. As a result of blockage situation, sometimes materials with less quality were used and that increase the percentage of rework. This result was supported by Enshassi et al. [1] who identified 45 factors that negatively affect construction labor productivity and performance in Gaza Strip. They ranked material shortage in the first position which affects construction productivity and performance.

"Adulterated material" was ranked as second rework cause related to materials, which affects project performance with RII 77.8 %, and it was ranked as an eleventh cause among all explored rework causes. This result agreed with Josephson et al. (2002) who indicated that faults in material cause 18% of rework cost.

Test of agreement among respondents

The Kruskall-Wallas test was conducted to test if there is an agreement among respondents concerning materials and equipment supply rework causes impact on project performance. The results showed that

the probability of significance is 0.329 which is more than 0.05; this means that there is agreement among the three participants' group in ranking the impact of rework causes related to materials and equipment supply on project performance.

Table 4: RII and ranks of materials and equipment supply related rework impact on project performance

Rework causes	Degree of impact on project performance quoted by 175 Respondents					Score	Mean	SD	RII %	Rank	Overall rank
	1	2	3	4	5						
Emergency conditions (siege and closures)	4	0	65	45	61	684	0.92	3.9	78.2	1	8
Adulterated Materials	3	11	53	44	64	680	1.06	3.9	77.8	2	11
Invalidity of needed tests	9	7	68	56	35	626	1.03	3.6	71.6	3	35
Pre-Fabrication not to project requirement	17	11	59	57	31	599	1.31	3.4	68.4	4	47
Non-compliance with specification	12	16	68	53	26	590	1.12	3.4	67.4	5	48
Materials not in right place when needed	8	35	44	65	23	585	1.16	3.3	66.8	6	50
Untimely deliveries	5	38	72	26	34	571	1.19	3.3	65.2	7	52

4.4 Owner related rework causes impact on project performance

This group consists of five rework causes related to owner/client. These causes were subjected to the views of respondents to determine their impact on the performance (time and cost) of construction projects.

Table 5: RII and ranks of owner related rework impact on project performance

Rework causes	Degree of impact on project performance quoted by 175 Respondents					Score	Mean	SD	RII %	Rank	Overall rank
	1	2	3	4	5						
Inadequate briefing	0	25	39	63	48	659	1.01	3.8	75.4	1	19
Lack of knowledge of construction process	0	18	68	48	41	637	0.9	3.6	72.8	2	27
Lack of funding allocated for site investigation	14	0	53	77	31	636	1.07	3.6	72.6	3	31
Changes because of change in officials	12	8	54	67	34	628	1.13	3.6	71.8	4	33
Lack of funding allocated for consultation	20	4	37	82	32	627	1.34	3.6	71.6	5	36

As illustrated in Table 5 *"Inadequate briefing,"* was ranked first regarding owner related rework causes with RII 75.4%, and the nineteenth cause among the 57 causes surveyed. *"Lack of knowledge of construction process"* was ranked as second causes related to the owner with RII 72.8 % and it was ranked as 27th rework cause among all explored causes. *"Lack of funding allocated for site*

investigation" was ranked as third causes related to owner which cause rework events that usually has a considerable impact on project performance with RII 72.6 %, and it was ranked as 31st cause among all explored causes. These results are in line with Simpeh [12] who clarified that there was a significant correlation between client-related sources of rework and the impact of rework on project performance. Palaneeswaran [10] indicated that lack of knowledge of design and of the construction process; a lack of funding allocated for site investigation; a lack of client involvement throughout the project; inadequate briefing; poor communication with design consultants; and inadequacies in contract documentation are the main rework causes, which related to the owner.

Test of agreement among respondents
The Kruskall-Wallas test was conducted to test if there is an agreement among respondents concerning owner related rework causes impact on project performance. The results showed that the probability of significance is 0.613 which is more than 0.05; this means that there is agreement among the three participants' group in ranking the impact of rework causes related to owner on project performance.

4.5 Design related rework causes impact on project performance

This group composed of seven rework causes related to design. According to Table 6, *"Design errors and omission"* was ranked first with RII of 77.4% as rework causes related to design which has a high impact on project performance. This cause was further ranked 13th among the 57 causes surveyed. Rework due to design errors and omission has a significant impact on project performance, rework in design increase project cost and time. In addition, when work was implemented according to wrong design, rework will be demanded, which increase the cost of the project. This result is in agreement with the findings of Love et al. [41] who indicated that on-site problem solving, because of design errors influence productivity, performance and production cost inversely, while rework act upon the production cost directly.

Table 6: RII and ranks of design related rework impact on project performance

Rework causes	Degree of impact on project performance quoted by 175 Respondents					Score	Mean	SD	RII %	Rank	Over all rank
	1	2	3	4	5						
Design errors and omission	2	2	57	72	42	675	0.69	3.9	77.2	1	13
Incomplete information for design	5	4	58	53	55	674	0.97	3.9	77	2	14
Incomplete design	5	4	60	58	48	665	0.93	3.8	76	3	17
lack of professionalism	4	7	67	40	57	664	1.03	3.8	75.8	4	18
Inadequate procurement methods	7	16	43	60	49	653	1.18	3.7	74.6	5	20
Competitive/ low design fees	9	20	48	46	52	637	1.36	3.6	72.8	6	28
Poor project document	9	19	63	52	32	604	1.14	3.5	69	7	43

"Incomplete information for design" was ranked second rework cause related to design that impact project performance with RII of 77% and 14th among all causes explored. *"Incomplete design"* was ranked as third design causes, and 17th among the 57 causes surveyed, with RII 76%. *"Lack of professionalism"* of designers causes rework with relative importance index of RII about 75.8%. It was ranked as fourth design causes, and 18th among the 57 causes surveyed. These results agreed with Josephson et al. [26] who suggested that there are some factors that may cause rework referring to design causes like incomplete designs, lack of professionalism and inadequate information for design, where these factors have a significant impact on project performance. These results are supported by Love et al. [41] who indicated that when limited duration and inadequate information are allocated to

design tasks, the result could be insufficiently advanced contract documents, which will lead to rework.

Test of agreement among respondents
The Kruskall-Wallas test was conducted to test if there is an agreement among respondents concerning design related rework causes impact on project performance. The results showed that the probability of significance is 0.041 which is more than 0.05; this means that there is agreement among the three participants' group in ranking the impact of rework causes related to design on project performance.

4.6 Contractors related rework causes impact on project performance

This group consists of six rework causes related to the contractor. As depicted in Table 7, the results indicated that *"Attempts to fraud"* was ranked first rework cause related to contractor that has a high impact on project performance with RII of 85%. This cause was further ranked first among the 57 causes surveyed. It was perceived by the respondents as the most significant rework cause that has an impact on project performance in construction industry in Gaza Strip. This result is conformed to a study by Olawale and Sun [48] who identified causes of cost, and time overruns in construction projects.

The surveyed respondents ranked "*Competitive pressure/ low contract value,"* as second rework cause related to the contractor causes group according to impact on project performance, and it was ranked as second among 57 explored causes, with RII 82.6%. These results agreed with Clough et al. [49] who argued that low contract value will encourage contractors to use fewer qualified materials and workers, and may enforce him to look for profit by an illegal way. That will increase project cost and time significantly.

Table 7: RII and ranks of contractors related rework impact on project performance

Rework causes	Degree of impact on project performance quoted by 175 Respondents					Score	Mean	SD	RII %	Rank	Overall rank
	1	2	3	4	5						
Attempts to fraud	8	2	28	37	100	744	1.13	4.3	85	1	1
Competitive pressure / low contract value	0	0	56	41	78	722	0.75	4.1	82.6	2	2
Unqualified technically	5	2	52	53	63	692	0.96	4.0	79	3	6
Poor quality system	3	7	53	52	60	684	0.95	3.9	78.2	4	9
Financial weakness (Phantom cash flow)	13	6	53	29	74	670	1.5	3.8	76.6	5	15
Misreading of drawings and specifications	5	15	67	37	51	639	1.15	3.7	73	6	26

With RII 79% the respondents ranked "*Unqualified technically"* as third rework causes related to the contractor impact on project performance, and they ranked it as the sixth among all explored causes. The inability of many contractors to plan work, communicate with workers and direct activity adequately is fundamentally linked to increasing amounts and costs of rework. this result supported by Palaneeswaran [10] who indicated that the quality of site supervision and technical ability of contractors has a major influence on the overall performance and efficiency of construction projects. Respondents agreed that *"Poor-quality quality system"* rework has a considerable impact on project cost and time with RII 78.2%. They ranked it as fourth rework causes related to the contractor group, and they ranked it as ninth among all explored causes. This outcome corroborates the finding of [7, 32].

Test of agreement among respondents
The Kruskall-Wallas test was conducted to test if there is an agreement among respondents concerning contractors related rework causes impact on project performance. The results showed that the probability of significance is 0.028 which is more than 0.05; this means that there is agreement among the three participants' group in ranking the impact of rework causes related to contractors on project performance.

4.7 External environment related reworks causes impact on project performance

This group consists of eight rework causes related to external environment. Respondents ranked *political situation (such as: Siege-conflicts)"* as first rework cause related to external environment that has a high impact on project performance with RII of 74.2% and 22nd among all causes explored (Table 8). This result largely conforms to Omran et al. [50] findings that indicated that external environment factors are factors beyond the control for the project performance. They determined three factors under external environment that influence the performance of construction projects in construction industry. Economic environment factors (RII= 83%) is in the first ranking, political environment (RII= %79) at the second rank and the third ranked was social environment (RII= %71). This result is supported by Mastenbroek [51] who indicated that construction rework may be caused by weather conditions, natural disasters or changes in external environment.

Test of agreement among respondents
The Kruskall-Wallas test was conducted to test if there is an agreement among respondents concerning external environment related rework causes impact on project performance. The results showed that the probability of significance is 0.041 which is more than 0.182; this means that there is agreement among the three participants' group in ranking the impact of rework causes related to external environment on project performance.

Table 8: RII and ranks of external environment related reworks impact on project performance

Rework causes	Degree of impact on project performance quoted by 175 Respondents					Score	Mean	SD	RII %	Rank	Overall rank
	1	2	3	4	5						
Political situation (Siege- conflicts)	21	8	36	45	65	650	1.76	3.7	74.2	1	22
Economy (Inflation, exchange rates, market)	11	11	69	56	28	604	1.07	3.5	69	2	44
Physical conditions (Infrastructure, transportation, etc)	23	15	50	34	53	604	1.81	3.5	69	3	45
Government (Regulations, taxes, Interest rates)	12	19	70	48	26	582	1.15	3.3	66.6	4	51
Inadequate local education (Collectors - craftsman - technical)	23	7	83	43	19	553	1.22	3.2	63.2	5	54
Acts of God/Force Major (Weather, disaster)	20	29	59	37	30	553	1.49	3.2	63.2	6	55
Technological (techniques, facilities, machines)	22	47	66	30	10	484	1.12	2.8	55.4	7	57
Social (Changing social environment, resistances)	40	34	52	36	13	473	1.52	2.7	54	8	58

4.8 Rework causes categories

Table 9 shows the rework categories impact on project performance.

Table 9: RII and ranks of rework categories and their impact on project performance

Rework causes category	Degree of impact		
	RII %	SD	Rank
Contractor related causes	79%	4.58	1st
Human resource capability related causes	75%	7.90	2nd
Design related causes	75%	5.47	3rd
External environment related causes	74%	6.59	4th
Client related causes	73%	3.93	5th
Materials and equipment supply related causes	71%	4.42	6th
Construction process related causes	71%	7.98	6th

According to results in Table 9 rework causes related to contractor was ranked as the first group which has a high impact on project performance with RII 79%. This result is in line with Love et al. [41] Love and Edwards [6]; Palaneeswaran [10] and Simpeh [12]. Rework causes related to human-resource capability was ranked as the second group with RII 75% for its impact on project performance. That reflects the importance of human-resource management in reducing rework on project performance. This result is in line with previous researchers [6, 10, 13, 25, 27, 29, 31, 51] who indicated the significant effect of the human resources rework causes on project performance. Fayek et al. [27] indicated that human-resource capability rework causes category contributed about 21% of rework cost, they ranked it as second category, and this result conforms significantly to this paper. Rework causes related to design was ranked as the second group with RII 75%, which has a high impact on project performance. Rework causes related to external environment was ranked as the third group with RII of 74% which influence project performance.

Rework causes related to the clients was ranked as the fifth group with RII 73% regarding its impact on project performance. This result is in line with Love et al. [41]; Palaneeswaran [10] and Simpeh [12]. Rework causes related to materials and equipment supply was ranked as the sixth group with RII 71% regarding its impact on construction performance. Fayek et al. [27] indicated that materials and equipment supply rework causes category to contribute about 15% of rework cost. Rework causes related to construction process was ranked as the last group with respect to its impact on project performance with RII 71%. This result is consistent with previous researchers [13, 25, 52, 54].

4.9 Summary of the most important ten rework causes and their impact on project performance

Table 10 shows the most ten important rework causes and their impact on project performance (cost and time) in construction project in Gaza Strip.

Table 10: RII and ranks of most important ten rework category and their impact on project performance

Rework causes	**Rework category**	**Degree of impact on project performance (cost & time) quoted by 175 Respondents**					**Score**	**RII%**	**Rank**
		1	**2**	**3**	**4**	**5**			
Attempts to fraud	Contractor	8	2	28	37	100	744	85	1st
Competitive pressure / low contract value	Contractor	0	0	56	41	78	722	82.6	2nd
Ineffective management and decision-making	HR capability	5	12	27	46	85	719	82.2	3rd
Schedule pressures	construction process	3	10	37	51	74	708	81	4th
The absence of job security	HR capability	5	22	24	48	76	693	79.2	5th
Unqualified technically	Contractor	5	2	52	53	63	692	79	6th
An insufficient skill level	HR capability	5	0	55	56	59	689	78.8	7th
Emergency conditions (siege and closures)	Materials & equipment	4	0	65	45	61	684	78.2	8th
Poor quality system	Contractor	3	7	53	52	60	684	78.2	8th
Disturbances in personnel planning	HR capability	0	15	33	81	46	683	78	9th
Adulterated Materials	Materials & equipment	3	11	53	44	64	680	77.8	10th

5.0 Conclusion

The objective of this study was to to identify the factors that contribute to rework and to investigate their possible impact on construction project performance. A set of 57 rework factors that categorized under seven groups were identified through an extensive literature review of previous studies and then were refined based on a pilot study. The results of this research revealed that contractor's related rework causes and human resources capability related rework causes are the major categories, which impact on the construction project performance. In addition, the findings showed that attempts to fraud, competitive pressure, ineffective management, schedule pressure and the absence of job security are the main rework factors, which have a considerable influence on construction project productivity. The result of Kruskal-Wallis test indicated that there is an agreement among respondents with respect to the impact of rework causes on construction project performance.

The results of this study indicated that the most important rework causes that have a significant impact on project performance are: attempt to fraud, competitive pressure, ineffective management, schedule pressure, and the absence of job security. The temporary nature of workers in the Gaza Strip leads to errors and rework. The findings may help construction parties' organizations in Gaza Strip to understand rework causes, which affect construction project performance. This will help in the derivation of appropriate strategies to reduce rework and hence, enable project performance improvements to be made. The recommendation of this study may also apply to other developing countries.

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