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CASE STUDY



Rework investigation in residential building projects: Cost, factors and effects

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ABSTRACT

This article aims at investigating rework cost, factors and effects in residential building projects in the West Bank – Palestine. Questionnaire survey is used to collect and rank the main factors and effects of rework from consultants' and constructors' point of view. Respondents show that more than 80% of the projects completed with rework cost of value greater than 5% of the total project cost. Overall, respondents' view concludes that the top rework factors include: mistakes in design, unskilled labors, unqualified subcontractors, non-conformance with required specifications, and bid awarding policy. Respondents indicate that the main effects of rework are cost overrun, project time extension, material waste excess and profit reduction. Spearman correlation test concludes a good correlation between contractors and consultants in ranking of rework factors and effects. Data collected from 47 residential projects reveal a high rework impact on cost overrun in construction projects. The results of this study would be helpful for researchers and professionals to guide their efforts to minimize rework in construction projects and to improve projects outcomes in term of cost, time and quality.

KEYWORDS

rework, factors, effect, construction, regression, cost

1. INTRODUCTION

Construction sector is one of the most important sectors as it contributes to increasing GDP and absorbing local labors [1]. However, there are many common problems in construction projects that should be handled to improve and enhance the outcomes of this sector. One of these problems is rework [2]. Rework is simply defined as extra efforts to redo the same work after completion [3]. Rework is concluded by many studies as a main source of poor performance in construction projects. Many previous articles pointed out that rework is a main contributor to cost increase, delay, conflicts, disputes and parties' dissatisfaction [2–5], and [6]. For instance, [7] found that rework accounts for 5% of cost increase in construction projects. [8] revealed that rework could delay the construction projects by duration = 70% of planned time.

Rework has an adverse effect on project outcomes. Yet, little is done to understand and analyze the root factors and effects of this common and severe problem on construction sites. In Palestine and other neighboring countries, no or very little attention is paid to this area of knowledge. Thus, this paper is performed. It aims at 1) investigating the rework cost in residential projects, 2) recognizing the rework-related factors, 3) identifying the rework-related effects, and 4) investigating the relation between rework and cost overrun in some construction activities. The study findings would push professional efforts to understand the problem of rework and help them to minimize it and to enhance project outcomes in construction industry.

2. PREVIOUS STUDIES

Rework is simply defined as redoing an activity that is incorrectly implemented [1]. [9] concluded that little attention is paid to rework management in construction projects.

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They claimed that good rework management can improve the performance in construction projects and increase the profits. [10] reported that rework is a major challenge that leads to project failure in construction industry. [11] concluded that rework leads to schedule delay, material waste excess and cost overrun. In the same vein, [8] found that rework increases project cost and schedule by values reaching to 30% and 70%, respectively. [12] revealed that rework cost is about 5% in new building projects. [13] indicated that rework is a main source of cost overrun in construction projects. They pointed out that rework cost in residential projects is about 5% of the total project cost. They also concluded that the main contributors to rework cost include contractors (20.10%), design (18.91%) and client (14.73%).

Previous studies found a number of factors leading to rework in construction projects. [8] concluded that the main factors of rework are: unqualified supervisors, unskilled labors and unqualified contractors and subcontractors. He recommended to improve the bidding policy and to select the qualified subcontractors and contractors to execute the project, because unqualified subcontractors suffer from shortage in cash forcing them to hire unskilled labors (low salary) who cannot implement the work correctly, which leads to rework. Through a questionnaire survey, [12] found that among the factors affecting rework, the top factors are: poor communication between parties, late changes, design errors, and additions or omissions. They claimed that communication between parties should be improved during early phases to reduce the size of changes and mistakes during construction. [14] investigated the critical rework causes in construction projects using questionnaire survey. The top causes are: poor material specifications, improper project planning and management and inappropriate construction technology.

[2] performed a questionnaire survey to study the main factors of rework in building projects. He found that rework cost is about 15% of original cost. He found that the top contributors include: poor communication between different parties, manipulation in material specifications and variation orders. [15] conducted a field survey in Gaza to understand the main rework causes in construction projects. They found that the top causes are: fraud, poor project security and tight project schedule. Through a questionnaire survey, [1] conducted a study to rank the main factors leading to rework in construction industry. The factors that top the list include: scope change, poor labor skills, variation orders and specifications requirements. [16] concluded that the main effects of rework in construction projects are: loss of future business for the firms, reduction in labor motivation and profit reduction.

Rework is concluded as a main source of major obstacles in construction projects such as poor productivity, quality defects, time-extension, claims and disputes, and over budget [2, 16] and [17]. Through a case study, [1] and [10] indicated that rework has a great impact on change orders and material waste in construction projects. To improve the performance of construction projects, they recommended to

reduce rework through conducting training for labors, more communication and cooperation between parties in planning phase, and using proper planning and management techniques. [18] conducted a questionnaire survey to recognize the most frequent factors of rework. Thirty-eight (38) factors were considered in their study and responses were received from 62 participants. They found that the most frequent rework factors are: schedule shortening, delays in payments, bid award strategy, design mistakes, and lack of skilled labors.

The literature review shows that there are a good number of studies that dealt with the problem of rework in construction projects in many developed and developing countries, but there is no study on the reality of this problem in Palestinian construction projects. Therefore, this study is carried out. It is hoped that its results will identify the cost, causes, and effects of rework in construction projects in Palestine. The results of this study will also be of great importance to neighboring countries, in which the situation of the construction industry is similar to the situation in Palestine. The results will be important for academic researchers and builders to learn about the problems of rework in projects, and will form a gateway for future studies and put forward strategies to mitigate this problem and its consequences in the construction sector.

3. RESEARCH METHODS

The objective of this study is to find out the cost, factors and effects of rework in residential buildings. A questionnaire survey is used to investigate that. The questionnaire is divided into 3 divisions. Division A asks for information related to the respondent and the firm (experience, type of works, position, etc.). One of the main questions asked in this division is: What is the average of rework cost in the projects you have experienced? Division B includes the identified rework factors. Twenty-six (26) factors were collected from previous studies and opinions of professional experts. Factors were put in a table form and the participants were asked to rank them according to their severity. A 5-point Likert scale ranging from 1 to 5 was used. The ordinal scale was: 1 = very low severe, 2 = low severe, 3 = moderate severe, 4 = high severe and 5 = very severe. Division 3 includes rework effects. Six (6) effects are considered from previous published researches and experts input. As in division B, the effects were arranged in a table form and participants were required to rank them using the 5-point Likert scale.

3.1. Pilot study

Before sending the designed questionnaire to the participants, 3 local project managers with experience of more than 30 years in the residential building projects were asked to test its validity for measuring the study objectives. Minor changes were introduced by them. The questionnaire was reviewed according to their remarks.



3.2. Target population

Population of the study were contractors of class 1 and 2, and consultants with valid membership in Engineers Association of Palestine. Target respondents were selected randomly from an available list of 190 contractors and 90 consultants in Engineers Association of Palestine. Target respondents assumed to have normal distribution. Sample size was computed according to Eq. (1) [19].

$$SS = [z^2 \times P \times (1 - P)] / C^2 \tag{1}$$

Where;

SS = size sample

Z = Z-value

P = picking choice %, (0.5 used)

C = confidence interval (0.5 used)

$$SS = (1.96^2 * 0.5 * (1-0.5)) / 0.5^2 = 384$$

Finite population correction

$$SS_{new} = SS / (1 + ((SS - 1) / n)) \tag{2}$$

Where, n = 190 contractors, 90 consultants.

Using Eq. (2), the calculated sample size was 51 contractors and 29 consultants based on a 95% confidence level. The questionnaire was sent, by email, fax, or face to face, to 60 contractors and 50 consultants who were asked to fill the questionnaire and to rank the related factors and effects from their point of view. Responses were received from 87% of targeted contractors (52 filled questionnaires) and 80% of targeted consultants (40 filled questionnaires). Overall response rate was 84%. Most of the responses came from persons with high experience in construction projects (Fig. 1). Regarding the respondent position in their organizations, it included managers (16%), site engineers (26%), office engineers (22%), project engineers (32%) and others (4%).

3.3. Data analysis

The collected data was analyzed using SPSS. Average score, standard deviation, correlation were some of stats calculated. Average score was computed as weighted average. Table 1 shows the illustration for the average score results.

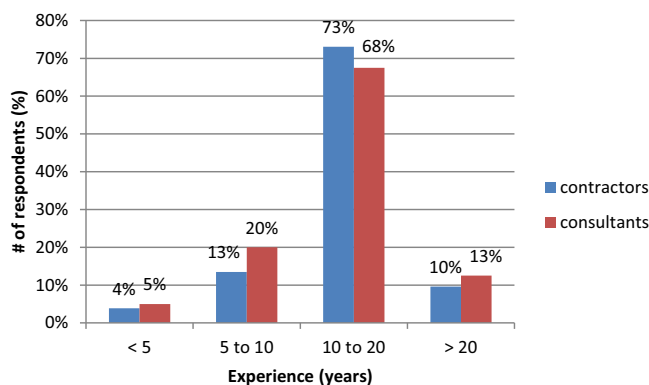


Fig. 1. Respondents' experience (Own source)

Table 1. Illustration of average score results (Own source)

Average score	Severity level
1	very low
1-2	low
2-3	moderate
3-4	high
4-5	very high

3.4. Spearman rank correlation (r_s)

The value of Spearman rank correlation (r_s) was computed to reveal the agreement between the respondents regarding the severing of rework-related factors. If the value of r_s is close to 1, it indicates a good agreement between responses about the severity of the factors and the results are reliable. Otherwise, the data shows scattered responses.

3.5. Case study

Data from 47 building projects were collected. The data include information about the rework cost in steel reinforcement works and the total cost overrun in the projects. Linear regression model was built to show the relation between rework cost and cost overrun which helps to conclude the effects of rework on cost overrun in construction projects. More details about the projects, data and regression model are explained in section 4.5.

4. RESULTS AND DISCUSSION

4.1. Rework cost

The respondents were asked about the rework cost in residential project that they have experienced during the last 5 years. The answers show that more than 70% of contractors indicated that rework cost in residential projects is between 5 and 10% of the total project cost (Fig. 3). While more than 75% of the consultants show that the rework cost is between 5 and 10% of the total project cost (Fig. 2). These figures indicate that the problem of rework in residential project is

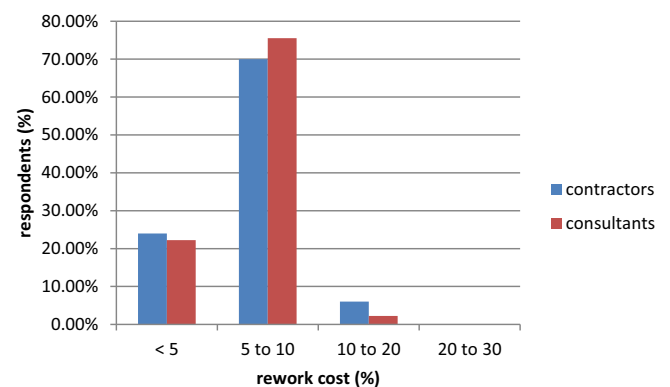
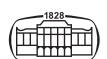


Fig. 2. Rework cost as a percentage of total project cost (Own source)



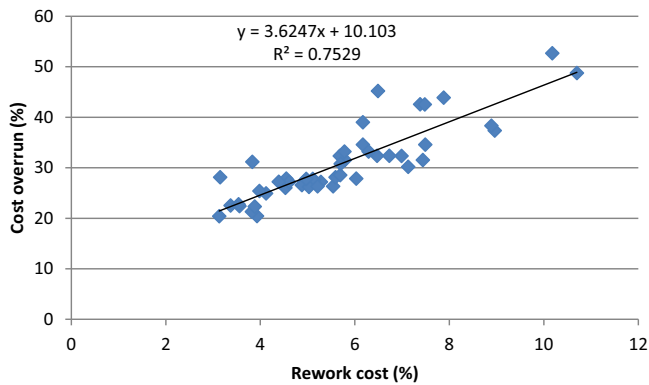


Fig. 3. Rework cost and cost overrun in steel reinforcement works (Own source)

severe, alarming and should be handled. Therefore, it is very important to understand the rework contributors, so they could be managed and rework could be minimized.

4.2. Rework-related factors

Table 2 indicates the ranking of rework-related factors in residential projects from the point of view of consultants and contractors. Twenty six (26) factors were identified from interview with local experts and review of similar published articles. Contractors ranked the following factors as the top five: mistakes in design, unskilled labors, non-conformance with required specifications, unqualified subcontractors, and bid awarding policy. Whereas the consultants revealed that the top contributors are: unskilled labors, mistakes in design, unqualified subcontractors, bid awarding policy, and non-conformance with required specifications. The least severe factors from contractors' point of view are: use of unsuitable construction methods, poor motivation system for labors and weather. Whereas the least important factors from consultants' point of view are: poor motivation system for labors, poor site management and weather. Overall rank finds that the top factors include: mistakes in design, unskilled labors, unqualified subcontractors, non-conformance with required specifications, and bid awarding policy.

Mistakes in design could be as a result of unqualified designers, tight schedule for design and review, lack of coordination between designers, improper planning, unclear scope, design copy from previous projects, etc. Design mistakes have adverse impact on project progress in terms of rework which interrupts the construction process and plans. The same finding is concluded by [12]. "Unskilled labor" leads to mistakes in works execution which leads to work damage and redoing it. Therefore, construction companies should hire skilled labors to guarantee a good work performance. This result agrees with [1] and [8]. "Unqualified subcontractors" and "bid awarding policy" are two major rework factors. Selection of subcontractors and contractors because of their lowest price is the common bid awarding strategy in Palestine. The lowest bidders are generally unqualified and do not have the needed resources and staff to

Table 2. Ranking of rework-related factors in residential projects (Own source)

Factor	Contractors' view		Consultants' view		Overall view	
	Avg. Score	Rank	Avg. Score	Rank	Avg. Score	Rank
Mistakes in design	4.27	1	4.13	2	4.21	1
Unskilled labors	4.21	2	4.17	1	4.19	2
Unqualified subcontractors	3.96	4	4.08	3	4.02	3
Non-conformance with required specifications	4.11	3	3.77	5	3.95	4
Bid awarding policy	3.85	5	3.88	4	3.87	5
Additions and omissions	3.78	6	3.54	8	3.67	6
Incomplete design drawings	3.62	8	3.70	6	3.65	7
Mistakes by labors	3.63	7	3.55	7	3.59	8
Unclear contract documents	3.61	9	3.46	11	3.54	9
Late changes by owner	3.57	10	3.49	10	3.53	10
Lack of supervision	3.48	11	3.53	9	3.50	11
Change of scope by owner	3.32	14	3.44	12	3.37	12
Financial conditions of owner	3.42	12	3.25	13	3.34	13
Manipulation by contractor	3.39	13	3.18	16	3.30	14
Poor site conditions	3.19	17	3.22	14	3.20	15
Reallocation of labors to other projects	3.22	16	3.12	19	3.18	16
Frequent design changes	3.26	15	3.04	22	3.16	17
Use of old equipment	3.10	19	3.21	15	3.15	18
Lack of communication between parties	3.15	18	3.13	18	3.14	19
Unskilled supervisors	3.06	21	3.17	17	3.11	20
Mistakes in shop drawings	3.05	22	3.10	20	3.07	21
Improper planning	3.08	20	3.06	21	3.07	22
Use of unsuitable construction methods	2.94	24	3.03	23	2.98	23
Poor site management	3.02	23	2.90	25	2.97	24
Poor motivation system for labors	2.86	25	2.99	24	2.92	25
Weather	2.81	26	2.79	26	2.80	26

implement the work as planned. Mistakes, manipulation in materials and specifications, inadequate supervision are some of the problems occurring because of unqualified subcontractors. These all lead to rework on construction sites. [18] concluded the “bidding strategy” as a main rework factor, while no previous study pointed to “unqualified subcontractor” as a main source of rework. “Non-conformance with required specifications” is a major problem in construction projects. This can be justified as some unqualified contractors and subcontractors use materials with poor quality to save cost and make profit. This factor is concluded by [1] as a critical factor leading to rework on construction sites.

4.3. Rework effects

Table 3 addresses the main effects of rework in residential buildings. Eight (8) rework effects are recognized from experts' opinions and review of similar studies. According to contractors and consultants, cost overrun is the top effect of rework (ranked in position 1), followed by project time extension (ranked in position 2). Contractors identified “profit reduction” in position 3, while consultants identified “material waste excess” in this position. Table 3 indicates that all effects have average scores greater than 4 which means that rework has a very high impact on these factors. Redoing the same activity for more than one time, leading to using the project resources more and more, which leads to cost overrun and project delay. Material waste could be a result of damaging the completed work and redoing it. This situation increases the cost of resources used to complete the work, which leads to loss in profit. Rework that occurred because of contractors might lead to conflict with other parties that adversely affects their reputation and limits their chances in winning future bids. Results agree with previous studies in identifying cost overrun and time extension as the

Table 3. Rework effects in residential projects (Own source)

Effect	Contractors' view		Consultants' view		Overall view	
	Avg. Score	Rank	Avg. Score	Rank	Avg. Score	Rank
Cost overrun	4.55	1	4.62	1	4.58	1
Time extension	4.50	2	4.56	2	4.53	2
Material waste excess	4.25	4	4.42	3	4.33	3
Profit reduction	4.40	3	4.20	7	4.31	4
Frequent change orders	4.18	5	4.31	4	4.24	5
Loss future business of firm	4.12	6	4.28	5	4.19	6
Bad reputation of the constructor	4.07	8	4.22	6	4.14	7
Reduction in labor motivation	4.11	7	4.13	8	4.12	8

Table 4. Description of the residential projects used in the case study (Own source)

Category	Residential
# of floors	4–7
Floor area (m ²)	250–320
Total area (m ²)	1200–2000

top effects of rework in construction industry [2, 16] and [17]. The new findings in this regard are: material waste excess, frequent change orders, and bad reputation of the constructor. They are not concluded as significant effects of rework in the investigated studies. Efforts should be guided to minimize rework and to reduce its effects on project performance.

4.4. Spearman rank correlation (r_s)

The value of Spearman rank correlation (r_s) is computed to reveal the agreement between the respondents regarding the severing of rework-related factors. Results with values of 0.83 for rework factors and 0.88 for rework effects indicate good agreement between respondents.

4.5. Case study

Since cost overrun is concluded as the top effect of rework in residential projects, this case study is conducted. It aims to show the impact of rework on cost overrun. Data from 47 residential projects implemented in the West Bank over the past 5 years were collected (Table 4). The data were collected from available records in the targeted construction firms. The data included information about the rework cost and cost overrun in steel reinforcement works (Fig. 3). Linear regression was used to identify the relation between rework cost and cost overrun. Linear regression was decided to be used in this case study because it is one of the most suitable methods used to describe the relation between two variables [20]. All collected cost data were arranged and deflated to 2023. Then, the data were analyzed using regression analysis. Data analysis revealed that the average of rework cost = 5.7% and the average of cost overrun = 30%.

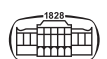
Model 1 describes the effect of rework on cost overrun in residential projects. The model shows that if rework cost increases by 1 unit, the cost overrun increases by about 4 units. With R^2 value = 0.75, the model indicates a good correlation between the variables.

$$Y = 3.62X + 10.1 \quad \text{Model (1)}$$

Where; Y cost overrun in reinforcement works (%), X cost of rework in reinforcement works (%).

5. CONCLUSION

This article aims at investigating rework cost, factors and effects in residential building projects in the West Bank – Palestine. Questionnaire survey was used to rank the main



factors and effects of rework from consultants' and constructors' point of view. More than 70% of the respondents indicated that the rework cost in residential projects is between 5% and 10%. Regarding the ranking of rework factors, consultants indicated that the main rework-related factors are: unskilled labors, mistakes in design, unqualified subcontractors, bid awarding policy, and non-conformance with required specifications. Contractors ranked the following factors as the top five rework factors: mistakes in design, unskilled labors, non-conformance with required specifications, unqualified subcontractors, and bid awarding policy. Overall rank concluded that the top rework factors include: mistakes in design, unskilled labors, unqualified subcontractors, non-conformance with required specifications, and bid awarding policy. Both contractors and consultants indicated that the main effects of rework are cost overrun and project time extension. Reduction in profit and material waste excess also concluded among the top effects or rework in construction project. Spearman correlation test concluded a good correlation between contractors and consultants in the ranking of rework factors and effects.

Data collected from 47 residential projects reveal a high correlation between rework cost and cost overrun in reinforcement works. The regression model developed to describe the relation between them indicate that 1 unit increase in rework cost leads to 4 unit increase in cost overrun.

The importance of this study lies in the fact that it is the first detailed study of rework problem in construction projects in Palestine, as it gives us a comprehensive and clear idea of the reality of this problem in the Palestinian construction industry. Thus, this study fills the gap in this field. The results of this study confirm the results concluded by previous studies, with reference to some new findings that were not addressed in previous studies, namely: the conclusion of the "unqualified sub-contractors" as a main reason for the rework, and also the conclusion that "material waste excess", "frequent change orders", and "bad reputation of the constructor" are significant effects of rework in construction industry. This is an important addition to the literature on rework problem in construction projects.

Construction participant should pay their efforts to handle the main rework-related factors to minimize its cost and effects on project performance. They are recommended to: (1) hire qualified designers and give them enough time to prepare and review project designs, (2) hire skilled labors and organize training workshops to improve their skills, (3) motivate labor financially and morally to increase their productivity and efficiency. This will help in reducing mistakes and rework, (4) change bidding policy; qualification of contractors and subcontractors should be taken into consideration during bidding phase. Qualified contractors and subcontractors guarantee proper planning and management, availability of qualified staff and labors, minimizing rework-related factors, and enhancing the performance in construction projects.

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