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ORIGINAL RESEARCH PAPER

Study of relationship between cost overrun and material waste in building construction projects

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ABSTRACT

This paper aims to recognize the effect of material waste on cost increase in Palestinian construction projects. The study used questionnaire survey to achieve its objectives. The target population of the study are constructors and consultants involved in construction projects. The study also predicts the effect of cost overrun on material waste in some construction activities, namely: ceramic and brick works. The collected data were analyzed using statistical analyses. The study has established that among the various factors that affect cost overrun, experience in the line of work, conflicts among project participants, payments delay, and political situation are the key factors. While the analysis revealed that the main material waste factors are: poor site management, using untrained labors, rework due to workers' mistakes, selecting the lowest bidder contractor/subcontractor, and frequent change orders. Data from 55 building projects constructed in the West Bank between 2015 and 2020 were collected to test the relation between material waste and cost increase. Two mathematical models were developed: Model (l) links cost increase and waste in ceramic works. It indicates that if waste increases by 1%, the cost will increase by 1.07%. Model (2) links between cost increase and material waste in brick works. It tells that if waste increases by 1%, cost will increase by 1.25%. R square of value >0.7, for both models, indicates a strong linear relation between cost increase and material waste. This is the first study that predicts the effect of material waste on cost increase in Palestinian construction sector. The study encourages different parties related to construction projects to manage factors of cost overrun and material waste to enhance the sector of construction.

KEYWORDS

construction engineering, buildings, cost reduction

1. INTRODUCTION

The construction sector is one of the tools that develop countries' economy [1]. It contributes to about 10% of GDP in most of the countries in the world [2]. However, it is linked with high rate of risks [3]. It was indicated that risks in construction industry lead to failure of project in most cases [4].

Material waste was identified as a severe problem in construction projects [5]. For instance, [6–8] concluded that waste rate in construction projects is ranging from 10% to 40%. On the other hand, [9] found that cost increase is a key problem in construction industry all over the world. In his comprehensive study, [10] concluded the followings: 1) cost overrun was a common problem across five continents of the world, 2) 90% of construction projects were completed with cost overrun, 3) No significant solution has helped in reducing this problem during the past 70 years.

The study of [11] indicated a direct link between construction waste and cost increase on construction sites. Previous researches concluded that material waste increases the rate of cost overrun. For instance, [8] found that the material waste increases the project cost by 15% in the UK, 30% in Netherland, and 11% in Hong Kong. They pointed out that little attention is paid to the percentage of cost overrun resulting from material waste on construction sites.

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The literature review indicated that many researchers have studied the problem of cost increase and wastage in construction projects. However, very little focused on the link between them. In Palestine, no literature has focused on the relation between cost increase and waste on site, therefore this study is conducted. This is the first study that predicts the effect of material waste on cost increase in Palestinian construction sector and other neighboring countries. The study objectives are: finding out and ranking factors of cost overrun in construction projects, investigating material waste factors on sites and relating material waste and cost overrun using regression models. It is hoped that the study would help different construction parties to understand the relation between cost increase and material waste, and encourage them to manage factors of cost overrun and material waste to enhance the output of construction sectors in Palestine and other neighboring countries.

2. LITERATURE REVIEW

2.1. Cost overrun causes

Cost overrun, which is also called cost increase, is a main issue in construction industry that could not be controlled for decades [12]. Cost overrun is simply defined as the difference between the final and predicted cost of the project [13]. In Palestine, [14] conducted a study revealing that the rate of cost overrun in building projects is about 30%. The research of [15] concluded that the cost overrun is a key issue in the construction industry.

It was observed that the main cost overrun causes in construction projects in Ghana are: payments delay, changes in material price, poor performance, material procurement, lack of managerial skills [16]. The study of [17] revealed that the key factors of cost increase in Nigeria are: imported materials, late changes, material shortage, low profile of some players, inaccurate estimate, problems in contracts, late design changes, payments delay, weather, lack of managerial skills, time overrun, frauds, and site conditions.

The research of [18] concluded that financial difficulties, problems in managerial techniques, and late design changes are the top cost overrun causes. It was concluded that the top cost increase factors are: escalation of materials costs, political conditions, delay, and currency exchange fluctuation [19]. In Turkey, it was found that the top cost overrun causes are: inadequate planning, inaccurate estimate, resources cost, lack of labors, high cost of land parcel [20]. In Palestine, the study of [21] found that 100% of projects Palestine have finished with cost and time increase. In the research of [22], it was observed that the top causes of cost increase are: high competition between contractors leading to low profit rate, bidding policy, difficulties in payments, money exchange rate, delay in decision making, high number of competitors, inflation, country's economic conditions, and mistakes in contract documents.

The study of [23] revealed that the critical cost increase factors in highway projects in Palestine include: money exchange rate, financial problems, poor management, poor competitors and material costs. In their study, [24] linked project size to cost increase in highway projects. Through a questionnaire survey in Cameroon, it was observed that inaccurate cost estimate, material supply, construction technology and weather are the main cost overrun causes in building projects [25]. In Jordanian construction projects, two main problems led to cost increase: weather and terrain [26].

In summary, the results of different research studies focused on cost increase problems presented in Table 1. It shows that some causes have correlation to other ones such as price of construction materials and inaccurate project cost estimation, and it shows that "payments issues" is the most frequent factor that leads to cost increase (concluded by 4 studies out of ten), followed by "estimating problems" (3 studies out of 10). The study of [27] stated that delayed payments impact the contractor ability to provide the project with materials and equipment needed, in addition it affects the output of labors due to delay of salaries. In their research, [28] concluded that cost estimating is a critical issue in construction projects because of its risky nature that should be taken into consideration.

2.2. Material waste on construction site

Construction waste is defined as material loss because of damage during construction process [29]. Construction waste is simply defined as material loss and excess [30]. The study of [31] indicated that waste in construction could

Table 1. Cost overrun factors (Previous researches) (Own source)

No.	Reference	Causes of cost overrun
1	[16]	payments problems, technical problems, poor procurement process, managerial issues related to contractors, changes in prices
2	[17]	difficulties in importing materials, materials availability, poor performance by contractors and subcontractors, mistakes in contract, payments delay, poor site management
3	[18]	financial problems, problems on site, changes in design
4	[19]	changes in material prices, political issues, unavailable equipment and materials
5	[15]	problems in cost estimating
6	[20]	lack of planning, problems in cost estimating, labor shortage, changes in material prices
7	[22]	financing problems, mistakes in contract, unstable material price
8	[24]	size of project and difficult terrain
9	[25]	Poor technology, unstable material price
10	[26]	weather, condition of terrain

be material waste, overproduction, material handling, and waiting time.

Waste in construction projects was divided into 9 divisions, namely: design and documentations, transportation, storage, operation, materials handling, procurement, site management, and environmental and other conditions [32]. The study of [33] concluded that the main factors of construction waste are: design problems, awareness, rework and variations. It was indicated that the main causes include: design changes, material storage, rework due to labors' mistakes, poor planning and material excess [34]. The study of [31] recognized the main factors of waste in Malaysian construction projects include: planning and management problems, poor labors' skills, mistakes in design and labors' mistakes. In Nigeria, the study of [35] investigated the critical waste factors, they are: supply materials that are not as per specifications, late changes in design, and uneconomical shapes. The research of [8] performed a survey research to assess material wastage in building construction projects. They concluded the followings: 1) Waste contributes to 30% of cost increase; 2) Mortar is the material with highest rate of waste; 3) Poor supervision, rework and material handling are the key waste factors. It was concluded that the main waste factors in Saudi Arabia are: over-ordering or under-ordering, poor materials' quality and errors in design [36]. The study of [6] concluded that the rate of waste in Jordanian construction projects is about 20%, and the critical waste factors are: frequent design changes, owner changes, rework, transportation, site conditions, storage of materials, lack of labor experience, mistakes in contract documents, frauds, and mistakes in quantity takeoff.

According to [37], waste is generated during all construction phases. The study of [31] indicated that dealing with waste and new purchases to correct mistakes and replace wasted materials lead to high financial losses in construction projects. They also found that "planning shortage" is a key rework factor that generates waste. In their research, [38] concluded that lack of labor experience contributes to more mistakes and reworks which lead to material waste on sites. They also concluded that "design mistakes" causes rework and change orders that lead to waste.

To have a general view about the causes of material waste, the results of the investigated studies are summarized in Table 2. It shows that "rework" is the most frequent factor affecting material waste (4 out of 7 studies), followed by "design changes" (3 out of 7 studies). Rework is defined as the additional effort due to mistakes in implementation [39]. The study of [40] argued that rework leads to using extra materials. Design change, which occurs after bid awarding, leads to demolition and rework and results in material waste on site [41].

Indeed, much have been published on construction waste and cost overrun, but very few attempts have been made to address the link between them. Hence the need for this research, which aims to examine the link between waste and cost increase in Palestinian construction projects.

Table 2. Material waste causes (previous researches) (Own source)

No.	Reference	Causes of material waste
1	[33]	problems in design, rework, poor awareness
2	[34]	changes in design, storage issues, mistakes in implementation, weather, poor management
3	[31]	poor managerial skills, poor experience, mistakes in implementation
4	[35]	mistakes in drawings, unclear specifications, problems in design
5	[8]	rework, poor supervisors, poor storage techniques
6	[36]	errors in BOQ, errors in specifications and design, poor resource management
7	[6]	changes in design, rework, problems in contract, bad storage techniques, poor experience, errors in BOQ, poor management

3. RESEARCH METHOD

The aim of this study is to examine the link between waste and cost increase in Palestinian construction projects. Thus, the following stages were followed:

1. The first stage of this research was to conduct a survey targeting building contractors and consultants in Palestine. Three sections were included in the questionnaire. The first section was designed to gain information about the company and respondent, second section designed to collect data about material waste factors and the third section designed to collect data about cost overrun factors. Twenty (20) cost overrun causes and 20 material waste causes were considered in this study. These causes were identified from literature review and experts recommendations. Mean item score was used to analyze the data and to rank the identified causes. To identify the significant causes, factor analysis was used. Consequently, Eigen values were used to drop or retain the causes. Causes with Eigen values $\geq$ 1.0 are kept (significant factors), while causes with Eigen value < 1 are ignored (insignificant factors).
2. The second stage in this study: After determining the significant causes of material waste a questionnaire survey was performed to identify their impact on cost increase.
3. The third stage: In this stage, predictive models that relate cost overrun and material waste were developed. To construct these models, data from 55 building projects constructed over the years 2015–2020 were obtained from available records. The collected data included information about the cost overrun and material waste in ceramic works and brick works. Regression analysis was performed for this purpose. (explained in detail in section 4.4).

The target respondents include parties such as registered constructors and consultants in Palestine. One hundred questionnaires were sent randomly as follows: 60/40 (constructors/consultants). The response rate was 81% (90% of consultants and 75% of constructors). Six returned questionnaires were ignored because of mistakes and 75 questionnaires were considered for analysis. The title of the respondents were managers, engineers, designers, quantity surveyors. Their experience in the line of the work was 10 years and above. As the data were collected in two stages, it should be noted that the same participants completed the two surveys.

4. RESULTS AND DISCUSSION

4.1. Causes of cost overrun on construction sites

Table 3 shows the ranking of each factor that might affect cost overrun in building projects from respondents' perspective. Twenty (20) factors were identified. The respondents were asked to rank these factors according to their impact on cost overrun. The results show that the respondents pointed out "experience in the line of work" as the top affecting factor (ranked 1, 2, 1 contractor/consultant/overall).

Table 3 indicates that the key factors are the same, with different orders, from the perceptions of contractors and consultants. Such as (the rank is shown for the perspective of contractor/consultant/overall): experience in the line of work (ranked 1, 2, 1), conflict among project participants (ranked 3, 1, 2), payments delay (ranked 2, 3, 3), political situation (ranked 4, 4, 4), inadequate labor productivity (ranked 5, 5, 5).

The factor analysis concluded only four (4) key significant causes of cost overrun, namely: experience in the line of work, conflicts among project participants, payments delay, and political situation. They had cumulative variance of 69.85% and Eigen values $\geq$ 1.0. The Eigen value ranges from 1.241 (last factor of the top 4) to 3.536 (first factor of the top 4).

The findings of this study are supported by the findings of previous studies. For example, [16] found that "monthly payment difficulties" is a key factor. The studies of [23], [17] and [18] concluded that "financing and payments of complete works" is a critical factor. The project cost management and cash flow analysis are largely affected by the interim payments. The unstable economic situation due to the political situations in Palestine make owners, especially public organizations, to have a finical deficit, and this makes owners incapable to meet their financial obligations to pay for contractors. The contractors will face a lack of financial liquidity, which means the construction works would be behind the schedule, which leads to cost increase.

The study of [19] indicated that "political situation" is a main cost overrun cause. The segmentation and obstacles such as checkpoints have restricted the access and movement of construction material, labor, and equipment between governorates, which lead to a slowdown in the progress of construction projects. The economic outcomes are highly affected by the market access due to slow and arbitrary closure as controlling the traffic within the West Bank. The people are not able to carry out activities and connect with their projects, which leads to cost increase.

The research of [20] found that "lack of skilled workforce" is among the critical cost overrun factors. The lower wages and unstable conditions in the Palestinian economy

Table 3. Cost overrun factors (Own source)

Factors	Contractor		Consultant		Overall	
	Mean	Rank	Mean	Rank	Mean	Rank
Experience in the line of work	4.17	1	4.09	2	4.14	1
Conflict among project participants	4.04	3	4.15	1	4.07	2
Payments delay	4.06	2	3.94	3	3.97	3
Political situation	3.91	4	3.90	4	3.90	4
Inadequate labor productivity	3.69	5	3.63	5	3.66	5
Insufficient time for estimate	3.58	6	3.58	6	3.58	6
Incomplete drawings	3.54	7	3.36	9	3.46	7
Materials price fluctuation	3.44	9	3.42	8	3.43	8
Knowledge of clients and consultants	3.28	10	3.53	7	3.40	9
Personal experience in the contract work	3.45	8	3.33	10	3.39	10
Lack of coordination between designers	3.15	11	3.24	12	3.19	11
Financial status of owner	3.08	12	3.29	11	3.18	12
Supplier manipulation	2.99	13	3.11	13	3.04	13
Location	2.86	14	2.97	14	2.91	14
Government requirements	2.68	17	2.92	15	2.79	15
Material procurement	2.73	16	2.79	17	2.76	16
weather	2.76	15	2.62	18	2.70	17
Estimating method used	2.49	20	2.84	16	2.65	18
Level of competitors	2.65	18	2.51	19	2.59	19
Public exposure of the project	2.61	19	2.46	20	2.54	20

force qualified labor to work abroad. The lack of deployed skilled labor in the projects leads to many problems such as bad quality, rework, waste and delay. This affects the cost of projects. The study of [21] found that "bad relation between construction parties" is a key cost increase factor. Bad relation between construction parties might lead to less communication and coordination on site, which affects the progress of construction activities and leads to cost increase.

4.2. Causes of construction material waste

The study had identified 20 waste factors that were ranked by the respondents as presented in Table 4. As shown in the table: poor site management, using untrained labors, rework due to workers' mistakes, selecting the lowest bidder contractor/subcontractor, and frequent change orders are the key waste factors. Consultants ranked the same top five factors same as overall ranking, while contractors are indifferent with the top fifth cause, which is "mistakes during construction" instead of "frequent change orders". "Poor site management" leads to poor resources management that interrupts the smooth progress of the works and leads to late changes, which in turn results in material waste. "Untrained labors" affects work quality, which leads to rework that generates waste. Checking bidders' qualifications will ensure better project performance. This is because most of "the lowest bidders" are low qualified. This leads to many problems on site such as: improper resources planning, poor productivity, and poor quality. Such problems on site lead to conflicts, reworks and change orders, which in turn result in construction wastes.

Factor analysis found 5 key waste factors: poor site management, using untrained labors, rework due workers' mistakes, selecting the lowest bidder contractor/subcontractor, and frequent change orders. They had cumulative variance of 70.86% and Eigen values $\geq$ 1.0. The Eigen value ranges from 1.048 (last factor of the top 5) to 4.681 (first factor of the top 5).

These findings are supported by similar studies. For example, [33] found that changes and rework are the main factors that cause material waste on construction sites in UAE. The lack of quality control process by the contractor on work is a major contributing factor to rework. Furthermore, the experience of crews to understand the specification, drawings, and other documents is playing a vital role in avoiding rework. The rework can adversely affect material loss, performance and productivity, and cost overrun. The study of [34] concluded that mistakes and poor planning are critical material waste causes. Due to lack of experience of labors and supervisors, mistakes in implementation occur and lead to material waste on site. The study of [6] concluded that rework due to workers' mistakes is a top factor affecting material waste on construction sites in Jordan. "Poor management" is a top material waste cause. Lack of proper planning and management leads to disputes, conflicts, and lack of communication between parties. This might also lead to poor resources management on site, poor supervision and frequent changes and reworks. These effects

Table 4. Contractors and consultants' perception of causes affecting construction material waste (Own source)

Causes	Contractor		Consultant		Overall	
	Mean	Rank	Mean	Rank	Mean	Rank
Poor site management	4.21	1	4.23	3	4.22	1
Using untrained labors	4.05	3	4.35	1	4.18	2
Rework due to workers' mistakes	4.10	2	4.25	2	4.16	3
Selecting the lowest bidder contractor/ subcontractor	3.96	4	3.92	5	3.94	4
Frequent change orders	3.70	6	3.94	4	3.80	5
Mistakes during construction	3.75	5	3.71	6	3.73	6
Poor quality of materials	3.44	7	3.68	7	3.55	7
Design and construction detail errors	3.23	9	3.49	8	3.35	8
Poor site supervision	3.26	8	3.31	9	3.28	9
Lack of coordination among crews	3.14	10	2.92	11	3.04	10
Changes in material specifications	2.93	11	3.15	10	3.03	11
Purchasing materials not complying with specifications	2.67	14	2.67	12	2.67	12
Weather conditions	2.81	12	2.44	17	2.64	13
Insufficient instructions about storage and stacking	2.64	15	2.56	14	2.60	14
Wrong storage of materials	2.75	13	2.37	19	2.58	15
Wrong orders	2.45	18	2.60	13	2.52	16
Lack of attention paid to dimensions of products	2.50	16	2.53	15	2.51	17
Improper methods of unloading	2.47	17	2.40	18	2.44	18
Insufficient instructions about handling	2.29	20	2.48	16	2.38	19
Poor quality and unavailability of equipment	2.36	19	2.32	20	2.34	20

impact the size of material waste on site. This result is supported by the study of [31].

4.3. Cost overrun and material waste

The study investigated the effects of critical cost overrun factors on material waste as shown in Table 5. It shows that "experience in the line of work" had the highest impact on material waste. Seventy-seven percent of responses ranked this factor as significant factors affecting material waste. Learning effect implies that doing the same things again and again will improve the performance. "Lack of labor experience" means more mistakes in work, rework, changes and lack of productivity, which lead to material waste and cost increase. Sixty-nine percent of respondents rated "conflict among project participants" as a critical factor. This proves that conflicts between construction parties lead to poor resource management and inadequate planning in the whole project life like other key factors lead to waste and cost increase.

Sixty-six percent of respondents indicated that "payments delay" has a high impact on material waste. Payment delay by the owner has negative effects on work progress because it affects the ability of the contractor to meet the financial requirements of the project. In addition, the payment delay by contractors affects labors' motivation, labor productivity, and material availability. Therefore, payment delay affects material waste and cost increase in construction projects. With 59% response, "Political situation in Palestine" concluded to be a significant factor causing construction material waste. Unstable political situation in Palestine might affect the availability of materials, labors and other resources. It prevents people from completing the projects and limits the entrance of materials from abroad. These impacts interrupt the smooth progress of the projects and lead to material waste and cost increase.

The results revealed that the top cost overrun causes are the main contributors to construction material waste. Therefore, efforts should be performed to manage and control the critical factors of waste and cost increase.

4.4. Regression equations linked cost increase and waste

To establish the link between waste and cost increase, a case study was conducted, and regression equations were built using material waste as independent variable and cost overrun as dependent variable. The case study includes two construction activities, namely: ceramic works and brick works.

4.4.1. Predictive model of material waste impact on cost overrun in ceramic works. To build a linear regression model that finds the link between waste and cost increase in ceramic works, data from 55 building projects constructed over the years 2015–2020 in the West Bank – Palestine were gathered (Fig. 1). The data were gathered from the available records in construction firms. the cost is deflated to 2020 using index from the Palestinian Central Bureau of Statistics (PCBS).

Cost overrun is computed as the actual cost minus the estimated cost, and material waste is computed as the delivered materials minus the actual measured materials. The results revealed cost overrun value ranging from +6% to +49% with an average of +21.75%, and material waste ranging from +5% to +34% with an average of +15.45%.

Table 6 shows a high correlation between the model variables (R^2 = 0.77, $F_{(1,54)}$ = 234.51, P = 0.000). The developed model (model 1) indicates that if waste increases by one unit, the cost will increase by 1.07 unit. The prediction model is presented below:

$$Y = 1.07X + 4.38 \qquad \text{model (1)}$$

Where; Y is cost overrun in ceramic works (%), X is material waste in ceramic works (%).

4.4.2. Regression equation that links waste and cost increase in brick works. The data from 55 building construction projects were collected to build the relation between cost overrun and material waste in brick works (same projects used to construct the predictive model in ceramic works). The analysis revealed that 100% of projects completed with cost overrun with a value between +7%

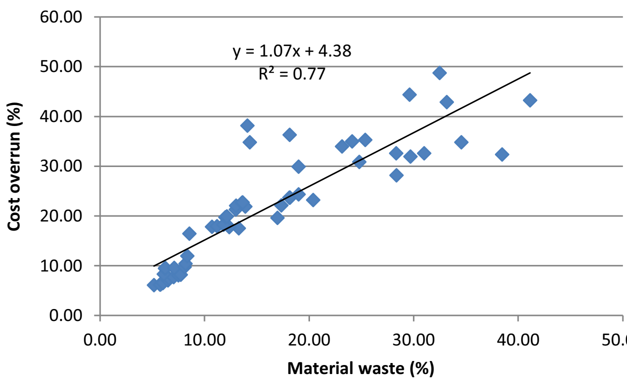

Fig. 1. Cost increase vs. waste in ceramic works (Own source)

Table 5. Impact of key cost overrun factors on waste (Own source)

Significant cost overrun causes (Eigen values ≥1.0)	Effect on material waste					
	No effect	Low effect	Moderate effect	High effect	Extreme effect	Relative index
Experience in the line of work	0	1.8	21.5	59.2	17.5	0.58
Conflict among project participants	0	3.8	27.3	55.2	13.7	0.56
Payments delay	0	5.6	28.4	52.3	13.7	0.55
Political situation	0	6.4	34.7	51.4	7.5	0.52

Table 6. Statistics results for model 1 (Own source)

Regression Statistics			Coefficients	*t* Stat	Value of *P*
Multiple *R*	0.87	Intercept	4.38	2.89	0.00
R Square	0.77	Material waste in ceramic works (%)	1.07	15.36	0.00
Adjusted *R* Square	0.75				
F	234.51				
Observations	55				

and +55% (average = 23.87%). The material waste value is found to be ranging from +5% to +38% with an average of +16.11%

Figure 2 shows the linear relation between cost increase and waste in brick works in 55 building construction projects. Regression analysis is used to describe the impact of waste on cost, the result is shown in model 2:

$$Y = 1.25X + 2.87 \qquad \text{model (2)}$$

Where; Y is cost overrun in bricks works (%), X is material waste in bricks works (%).

With $R^2 = 0.71$, $F_{(1,54)} = 154.31$, P is less than 0.05 (as shown in Table 7), results indicate a good correlation between dependent variable (cost overrun in brick works) and independent variable (material waste in brick work). Model 2 tells that if waste increases by one unit, cost will increase by 1.25 unit.

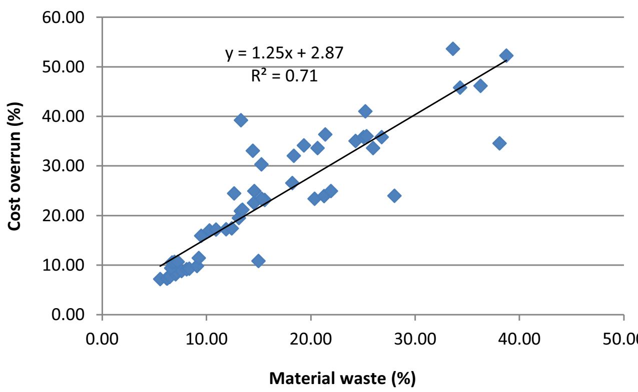

Fig. 2. Cost overrun vs waste in brick works (Own source)

Table 7. Statistic results for Model 2 (Own source)

Regression Statistics			Coefficients	*t* Stat	*P*-value
Multiple *R*	0.82	Intercept	2.87	2.25	0.00
R Square	0.71	Material waste in bricks works (%)	1.25	28.72	0.00
Adjusted *R* Square	0.70				
F	154.31				
Observations	55				

5. CONCLUSION

This study concluded that the top cost overrun factors are: experience in the line of work, conflicts among project participants, payments delay and political situation. These results are in line with similar previous studies such that: (1) delay in payments affect work progress, labor motivation, and materials availability which lead to cost overrun; (2) lack in labor experience affects construction productivity and leads to cost overrun; (3) lack of coordination and communication between parties affects work flow and leads to cost increase.

The study also revealed that the key material waste factors are: poor site management, using untrained labors, rework due workers' mistakes, selecting the lowest bidder contractor/subcontractor, and frequent change orders were the most significant. These causes mainly lead to errors and omissions and doing the same work more than once. Availability of well trained and highly skilled labors guarantees conformance with specifications that will reduce mistakes and rework during construction, while checking capabilities of the bidders will ensure better project performance. Good planning will minimize late changes and reduce material waste and the cost overrun. The findings of this study agree with the previous studies that indicated a high correlation between causes, such as: rework, lack of experience, and change orders, and material waste on site.

The results revealed that the top cost overrun causes are the main contributors to construction material waste. Therefore, efforts should be performed to manage and control the critical factors of waste and cost increase. Field data collected from 55 building projects constructed in the West Bank between 2015 and 2020 were used to build mathematical models to establish the relation between cost increase and waste on site. Two mathematical models were developed: model (l) indicates that if waste increases by 1% in ceramic works, the cost will increase by 1.07%; model (2) tells that if waste increases by 1% in brick works, cost will increase by 1.25%. *R* square of value > 0.7 indicates a good linear relation between cost increase and material waste. These figures prove that material waste is a main contributor to cost overrun in construction projects. Therefore, to minimize cost overrun in construction projects, efforts should be paid to minimize waste on sites.

Based on the study outcomes, the following recommendations are suggested:

a) Managerial techniques have to be enhanced. It could be through training programs and workshops.
b) Payments should be made on time since delay of payments could affect contractor ability to finance the projects and affect labors' motivation, which lead to poor

performance such as the work not completed to specifications, reworks, etc., thus, material waste occurs.

c) Bids awarding policy should be changed. Bids should be awarded to the qualified contractors/subcontractors.
d) Political and environmental risks should be taken into consideration by top management during planning phase.
e) Factors of waste and cost increase should be managed by all related parties.

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