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ASSESSING THE RISK PERCEPTION OF COST OVERRUN THROUGH IMPORTANCE RATING

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Abstract. Cost overrun in construction projects is a common issue affecting project performance. After a review of the literature, a list of 39 cost overrun attributes were gathered and presented in a survey. The survey was distributed online to construction professionals. 101 complete responses were received and analyzed by importance index, frequency index, cost index, frequency adjusted cost index, Spearman's rank correlation, student's t-test, risk assessment and factor analysis. The results of the survey revealed that the main causes of cost overrun in construction industry include inaccurate cost estimation, improper planning and scheduling, unrealistic contract duration and requirements, frequent changes to the scope of work, frequent design changes, inadequate labor/skill availability, inflation on costs of machinery, labor, material and transportation.

Keywords: risk assessment, cost overrun, importance index, frequency adjusted cost index.

JEL Classification: C83, L74, O22.

Introduction

Cost has its proven significance as the key factor for any project success. A completed project may not be considered as a successful endeavor unless it falls within the cost limitations applied to it. Despite its proven importance, it is very common to have a construction project that fails to achieve its specified cost goals. A lot of research has been performed to identify cost overrun attributes to improve the overall the construction industry performance (Azhar *et al.* 2008; Elchaig *et al.* 2005)

This study was conducted to identify and rank the major causes of cost overrun in construction sector and to compare responses obtained from professionals who work in various segments of the construction industry.

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1. Literature review

Cost variance is one of the most important indicators of project success (Frimponga *et al.* 2003). It is not just a measure of the company's profitability but also the productivity of that organization at any time during the construction. Despite its proven importance, it is rare to see a project completed within the estimated cost (Azhar *et al.* 2008). In this study, a literature review on construction cost overrun attributes was performed to identify the most common factors that cause the cost overrun and to address the required measures to overcome and reduce them. Flyvbjerg *et al.* (2003) conducted a global study on cost overrun. This study covered 258 infrastructure projects in 20 nations and concluded that 9 out 10 projects faced cost overrun. Through an extensive literature review on cost overrun factors related to construction projects, a list of 39 cost overrun factors was collected to summarize all the factors found in the related literature. The collected factors helped in ranking the factors based on their importance, frequency and impact on cost of construction industry. Table 1 presents the 39 cost overrun attributes with their corresponding references.

Table 1. Cost overrun attributes

Factors	References
Insufficient site management and inspection	(Harisaweni 2007; Azhar *et al.* 2008)
Schedule delay	(Harisaweni 2007; Omoregie 2006; Gunduz, Abuhassan 2017)
Improper planning and scheduling	(Arcila 2012; Harisaweni 2007; Azhar *et al.* 2008)
Improper monitoring and control	(Harisaweni 2007; Azhar *et al.* 2008; Frimponga *et al.* 2003)
Lack of experience in handling construction projects	(Enshassi *et al.* 2009; Sambasivan and Soon 2007; Chan, Kumaraswamy 1997)
Delay in inspection and approval of completed work	(Assaf *et al.* 1995; Sambasivan, Soon 2007; Long *et al.* 2004; Odeh, Battaineh 2002; Al-Kharashi, Skitmore 2008)
Errors during construction	(Assaf *et al.* 1995; Le-Hoai *et al.* 2008; Oludolapo 2011; Sambasivan, Soon 2007; Odeh, Battaineh 2002; Tumi *et al.* 2009; Al-Tabtabai 2002)
Accidents on site	(Lo *et al.* 2006; Assaf *et al.* 1995; Tumi *et al.* 2009; El-Razek *et al.* 2008)
Effect of weather	(Harisaweni 2007; Assaf *et al.* 1995; Sambasivan, Soon 2007; Frimponga *et al.* 2003; Long *et al.* 2004; Lo *et al.* 2006; Odeh, Battaineh 2002)
Unforeseen ground conditions	(Sambasivan, Soon 2007; Le-Hoai *et al.* 2008; Chan, Kumaraswamy 1997; Long *et al.* 2004; Lo *et al.* 2006; Odeh, Battaineh 2002)
Frequent Design changes	(Arcila 2012; Harisaweni 2007; Azhar *et al.* 2008; Omoregie 2006; Enshassi *et al.* 2009; Frimponga *et al.* 2003)
Design errors and mistakes	(Shibani, Arumugam 2015; Assaf *et al.* 1995; Tumi *et al.* 2009; El-Razek *et al.* 2008; Sweis *et al.* 2008; Le-Hoai *et al.* 2008)
Incomplete design at time of tender	(Azhar *et al.* 2008; Enshassi *et al.* 2009)

Continue of Table 1

Factors	References
Deficient design and delays in design process	(Assaf *et al.* 1995; Fugar, Agyakwah-Baah 2010)
Delay in approval of drawings	(Omoregie 2006; Sambasivan, Soon 2007; Assaf *et al.* 1995; Odeh, Battaineh 2002; Al-Kharashi, Skitmore 2008; El-Razek *et al.* 2008; Aibinu, Odeyinka 2006).
Delay in progress payment by owner for work completed	(Arcila 2012; Azhar *et al.* 2008; Frimponga *et al.* 2003; Assaf *et al.* 1995; Odeh, Battaineh 2002; Al-Kharashi, Skitmore 2008; El-Razek *et al.* 2008; Sweis *et al.* 2008)
Financial difficulties of owner	(Moura *et al.* 2007; Azhar *et al.* 2008; Le-Hoai *et al.* 2008; Frimponga *et al.* 2003; Long *et al.* 2004; Sweis *et al.* 2008)
Cash flow difficulties faced by contractor	(Azhar *et al.* 2008; Moura *et al.* 2007; Frimponga *et al.* 2003; Assaf *et al.* 1995; Sambasivan, Soon 2007; Long *et al.* 2004; Tumi *et al.* 2009; Sweis *et al.* 2008)
Poor financial control on site	(Azhar *et al.* 2008; Oludolapo 2011)
Delay payment to supplier / subcontractor	(Omoregie 2006; Sweis *et al.* 2008; Moura *et al.* 2007)
Weak communication between project parties	(Azhar *et al.* 2008; Arcila 2012; Enshassi *et al.* 2009; Assaf *et al.* 1995; Sambasivan, Soon 2007; Chan, Kumaraswamy 1997; Long *et al.* 2004)
Weak coordination between project parties	(Assaf *et al.* 1995; Lo *et al.* 2006; Sweis *et al.* 2008; El-Razek *et al.* 2008)
Weak collaboration between management and labor	(Long *et al.* 2004; El-Razek *et al.* 2008)
Disputes on site	(Assaf *et al.* 1995; Odeh, Battaineh 2002; Al-Kharashi, Skitmore 2008; Sambasivan, Soon 2007)
Low labor productivity	(Harisaweni 2007; Moura *et al.* 2007; Chan, Kumaraswamy 1997; Assaf *et al.* 1995; Odeh, Battaineh 2002; Al-Tabtabai 2002)
Lack and shortage of skilled labors	(Harisaweni 2007; Azhar *et al.* 2008; Frimponga *et al.* 2003; Shibani, Arumugam 2015; Moura *et al.* 2007; Assaf *et al.* 1995; Lo *et al.* 2006)
Inflation in the cost of labors	(Azhar *et al.* 2008)
Fluctuation in raw material prices	(Azhar *et al.* 2008; Omoregie 2006; Enshassi *et al.* 2009; Frimponga *et al.* 2003; Shibani, Arumugam 2015)
Late delivery of materials and equipment	(Arcila 2012; Harisaweni 2007; Azhar *et al.* 2008; Omoregie 2006; Frimponga *et al.* 2003; Shibani, Arumugam 2015; Moura *et al.* 2007; Assaf *et al.* 1995; Tumi *et al.* 2009)
Insufficient number of equipment	(Harisaweni 2007; Assaf *et al.* 1995; Al-Kharashi, Skitmore 2008; El-Razek *et al.* 2008; Sweis *et al.* 2008; Aibinu, Odeyinka 2006)
Changes in material specs and types	(Harisaweni 2007; Assaf *et al.* 1995; Al-Kharashi, Skitmore 2008; El-Razek *et al.* 2008; Sweis *et al.* 2008)
Poor project management	(Arcila 2012; Azhar *et al.* 2008; Shibani, Arumugam 2015; Tumi *et al.* 2009; Le-Hoai *et al.* 2008; Sinesilassie *et al.* 2017; Yousefi *et al.* 2016)

End of Table 1

Factors	References
Frequent changes to the scope of work	(Harisaweni 2007; Azhar *et al.* 2008; Enshassi *et al.* 2009; Frimponga *et al.* 2003; Moura *et al.* 2007; Lo *et al.* 2006; Assaf *et al.* 1995)
Delays in decisions making	(Enshassi *et al.* 2009; Frimponga *et al.* 2003; Assaf *et al.* 1995; Sambasivan, Soon 2007; Chan, Kumaraswamy 1997; Long *et al.* 2004; Odeh, Battaineh 2002)
Poor contract management	(Sambasivan, Soon 2007; Long *et al.* 2004; Odeh, Battaineh 2002; Le-Hoai *et al.* 2008)
Errors in contract documents	(Sambasivan, Soon 2007; Lo *et al.* 2006; Assaf *et al.* 1995; Odeh, Battaineh 2002; Al-Kharashi, Skitmore 2008; Tumi *et al.* 2009)
Unrealistic contract duration and requirements imposed	(Sambasivan, Soon 2007; Chan, Kumaraswamy 1997; Long *et al.* 2004; Lo *et al.* 2006; Assaf *et al.* 1995; Odeh, Battaineh 2002; Al-Kharashi, Skitmore 2008)
Owner interference	(Sambasivan, Soon 2007; Long *et al.* 2004; Assaf *et al.* 1995; Sweis *et al.* 2008; Yates 1993)
Inaccurate time and cost estimates of project	(Harisaweni 2007; Omoregie 2006; Frimponga *et al.* 2003; Le-Hoai *et al.* 2008; Long *et al.* 2004; Yates 1993)

2. Methodology

This study was based on reviewing past literature to come up with a summarized list of cost overrun attributes affecting construction projects. A survey has been distributed on construction industry experts to rank the 39 attributes based on importance, frequency and impact on cost. The survey contains two sections: 1) Respondents information: To categorize the respondents into different groups for the purpose of comparisons. Cost overrun attributes evaluation: Composed of the 39 cost overrun attributes affecting construction projects. These 39 factors can be seen in Table 1. The respondents were requested to evaluate the "importance" (The impact of this factor on cost overrun in construction project), "frequency" (How often the attribute is implemented or considered) and "Impact on Cost Overrun" (What is the direct impact of this factor on the cost overrun) on a 5 point Likert Scale (1 = Very Low, 2 = Low, 3 = Moderate, 4 = high, 5 = Very High). For an example, for the first cause of cost overrun factors" insufficient site management and inspection", the respondent was asked to evaluate the: The factors have been ranked as perceived by various groups of industry professionals. The survey was sent to numerous contacts that play key roles in the construction industry worldwide. A total of 101 completed surveys were received. A comparison between respondents' rankings was applied based on their location, organization type, job designation, industry type, total construction experience, and size of their companies. Results were discussed and analyzed based on various statistical analyses methods such as: importance index, frequency index, cost impact index, frequency adjusted cost index, Spearman's rank correlation, T-test and risk assessment matrices. Those results have been used to generate recommendations to industry firms and professionals.

3. Data characteristics

The survey has been developed using an online website. The website was used in distributing the survey and collecting the responses. 101 complete responses were selected to be the base of the analysis. For the organization type, contractors were the largest contributors to the survey with 41.2% of responses, while consultants were the second forming almost 18% of the total participants as shown in Figure 1. 37.5% of the respondents were project or construction managers, 23.8% of them were project engineers, 17.5% of them were resident engineers, 16.3% were site engineers and 5% were owners. 46.1 % of the respondents indicated their major industry type as superstructure whereas 37.1 % indicated as infrastructure. The percentages for industrial and oil gas sectors were 12.4% and 4.5% respectively. Respondents were also classified based on total years of work experiences in construction. Of the 101 participants, 33.7% of them are professionals with more than 16 years of experience in construction industry. The respondents who work in superstructure projects formed the majority of participants with a rate of 46.1%, followed by infrastructure construction projects with a rate of 37.1%. Respondents were also classified based on their company sizes which are either large companies with more than 250 employees, medium companies with 50 to 250 employees or small companies which have less than 50 employees. Majority of respondents fall into the category of large company size with a percentage of 59%, followed by a medium size company which is 29% of the respondents.

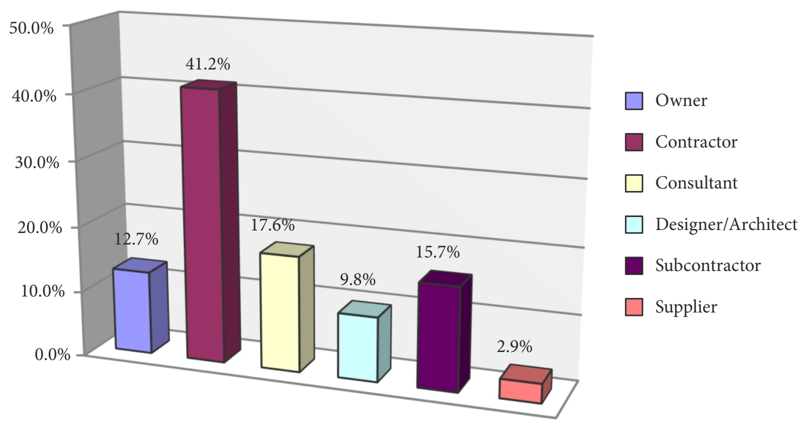

Figure 1. Percentage of respondents based on organization type

4. Data analysis

One of the objectives of this research is to identify the influencing cost overrun attributes based on point of views of the construction industry professionals. Survey participants used a 5 - point Likert Scale to rate each individual cost overrun factor's importance, frequency and impact on cost. The ratings of the scale are 1 (very low), 2 (low), 3 (moderate), 4 (high), and 5 (very high). The importance was rated to measure the impact of the factor on the cost of the construction project, while the frequency was used to determine how often the attribute occurs in construction projects, and the impact on cost was used to assess the effect of that particular attribute.

Importance index, Spearman's rank correlation, t-test and risk assessment were used to analyze the results. The data analysis is explained in the coming sections.

4.1. Frequency Cost Adjusted Importance Index (FCAII)

The Frequency-Cost Adjusted Importance Index (FCAII) is an inventive ranking approach adopted in this research to rank cost overrun attributes in construction industry. This technique considers the importance, the frequency and the cost impact in its formula. In order to find the FCAII, the Relative Importance Index (RII), the Frequency Index (FI) and the Cost Impact Index (CII) are required to be measured and calculated referring to data collected from the survey. The equations for RII, FI and CII are shown in Eq. (1), Eq. (2) and Eq. (3):

$$RII(\%) = \frac{\sum Wi * Xi}{A(N)} \times 100; \quad (1)$$

$$FI(\%) = \frac{\sum Wi * Xi}{A(N)} \times 100; \quad (2)$$

$$CII(\%) = \frac{\sum Wi * Xi}{A(N)} \times 100, \quad (3)$$

where: W – weighting given to each factor by respondents and it ranges from 1 to 5; X – frequency of ith response given for each cause; A – highest weight (i.e. 5 in this case); N – total number of participants (i.e. 101 in this research)

Based on the RII, FI and CII equations, the frequency cost adjusted importance index will be calculated as follows:

$$FCAII = (RII \times FI \times CII). \quad (4)$$

FCAII reflect the effects of importance, frequency and cost impact all together and hence it provides better ranking results.

Table 2 below shows RII, FI, CII and FCAII values in addition to the FCAII rankings of all the participants.

Table 2. RII, FI, CII and FCAII (values and rankings) of cost overrun attributes by all respondents.

Category	Factor	RI	FI	CII	FCAII	Rank
CPH	Schedule delay	0.820	0.693	0.824	0.47	1
CPH	Improper planning and scheduling	0.865	0.653	0.826	0.47	2
D	Frequent Design changes	0.871	0.606	0.844	0.45	3
PM	Frequent changes to the scope of work	0.844	0.608	0.836	0.43	4
PM	Inaccurate time and cost estimates of project	0.853	0.614	0.808	0.42	5
PM	Unrealistic contract duration and requirements imposed	0.869	0.586	0.830	0.42	6

End of Table 2

Category	Factor	RI	FI	CII	FCAII	Rank
PM	Poor project management	0.871	0.588	0.802	0.41	7
PM	Delays in decisions making	0.818	0.602	0.739	0.36	8
L	Lack and shortage of skilled labors	0.810	0.636	0.699	0.36	9
F	Delay in progress payment by owner for work completed	0.826	0.612	0.711	0.36	10
CPH	Improper monitoring and control	0.768	0.602	0.768	0.36	11
D	Incomplete design at time of tender	0.798	0.550	0.790	0.35	12
F	Cash flow difficulties faced by contractor	0.794	0.584	0.717	0.33	13
PM	Errors in contract documents	0.808	0.531	0.770	0.33	14
L	Low labor productivity	0.794	0.582	0.707	0.33	15
PM	Poor contract management	0.762	0.588	0.727	0.33	16
M&E	Fluctuation in raw material prices	0.816	0.552	0.719	0.32	17
F	Delay payment to supplier /subcontractor	0.762	0.606	0.701	0.32	18
CPH	Insufficient site management and inspection	0.747	0.598	0.725	0.32	19
M&E	Late delivery of materials and equipment	0.784	0.596	0.681	0.32	20
D	Design errors and mistakes	0.798	0.513	0.768	0.31	21
CPH	Lack of experience in handling construction projects	0.731	0.584	0.729	0.31	22
M&E	Changes in material specs and types	0.749	0.572	0.721	0.31	23
F	Poor financial control on site	0.752	0.558	0.725	0.30	24
F	Financial difficulties of owner	0.816	0.493	0.747	0.30	25
C	Weak communication between project parties	0.756	0.576	0.683	0.30	26
C	Weak coordination between project parties	0.770	0.578	0.663	0.30	27
D	Deficient design and delays in design process	0.762	0.529	0.719	0.29	28
D	Delay in approval of drawings	0.727	0.586	0.667	0.28	29
CPH	Delay in inspection and approval of completed work	0.669	0.632	0.663	0.28	30
CPH	Errors during construction	0.707	0.572	0.693	0.28	31
PM	Owner interference	0.721	0.566	0.646	0.26	32
L	Inflation in the cost of labors	0.739	0.507	0.701	0.26	33
M&E	Insufficient number of equipment	0.671	0.550	0.636	0.23	34
C	Weak collaboration between management and labor	0.677	0.549	0.596	0.22	35
CPH	Accidents on site	0.741	0.418	0.663	0.21	36
C	Disputes on site	0.628	0.513	0.584	0.19	37
CPH	Unforeseen ground conditions	0.578	0.400	0.547	0.13	38
CPH	Effect of weather	0.497	0.430	0.446	0.10	39

Where code CPH stands for construction phase factors, D is Design factors, F is Finance factors, C is Communication factors, L is Labor factors, M&E is Material and Equipment factors, and PM is Project Management factors

From Table 2, it can be seen that the top 5 ranked cost overrun factors based on FCAII values are: 1) Schedule delay; 2) Improper planning and scheduling; 3) Frequent Design changes; 4) Frequent changes to the scope of work; 5) Inaccurate time and cost estimates of project.

4.2. Ranking comparison amongst respondents

The Spearman's rank correlation coefficient (ρ) was used to show the degree of agreement between the rankings of any two parties. The formula is as follows:

$$\rho = 1 - \frac{6\sum d^2}{N^3 - N},$$

where, ρ – Spearman rank correlation coefficient between two parties; d – difference between ranks assigned to variables for each cause;. n – the number of attributes which is 39.

The Spearman's correlation assesses relationship between different parties regarding different factors strength. In this research, it has been used in comparing responses based on location, organization type, job designation etc. According to the definition of its formula, the correlation coefficient varies between +1 and −1, where +1 implies a perfect positive relationship (agreement), while −1 results from a perfect negative relationship (disagreement). Assumption of no multi-collinearity between attributes was made.

Nine comparisons were conducted: Contractor vs. consultant, Contractor vs. Subcontractor, Contractor vs. Owner, Owner vs. consultant, Project / Construction manager vs. Project Engineer, Superstructure vs. Infrastructure, Superstructure vs. all others, Large (>250 employees) vs. Medium (50 < employees < 250), Over 16 years vs. ALL Less than 16

Spearman's rank correlation factors for the above-mentioned comparisons are presented in Table 3. It can be seen from the Table 3 that the agreement level between various groups of respondents range from 0.60–0.79.

Table 3. Ranking comparison amongst respondents

Groups Compared	Spearman's rank correlation factors
Contractors vs. Consultants	0.77
Contractors vs. Subcontractors	0.79
Contractor vs. Owner	0.60
Owner vs. consultant	0.68
Project managers vs. Project Engineers	0.61
Superstructure vs. Infrastructure	0.62
Superstructure vs. all others	0.79
Over 16 years experience vs. Less than 16 years experience	0.74
Large (>250 employees) vs. Medium (50 < employees < 250)	0.71

4.3. T-test

T-test is a tool which is used to statistically identify if there is any significant difference between two independent categories groups. In this research, T-test is used to identify which cost overrun attributes has significant level of disagreement among the independent set of groups. Probability (p) value less than 0.1 shows a significant disagreement. Table 4 show the results of the T-test which represent significant disagreement among various groups based on location, job designation, organization type, industry type, total construction experience, and size of the company.

Table 4. T-test results

Code	Attributes	T-Test (p)
Project Managers vs. Project Engineers		
CPH	Schedule delay	0.0338
CPH	Improper monitoring and control	0.0061
CPH	Delay in inspection and approval of completed work	0.0257
CPH	Accidents on site	0.0627
C	Weak coordination between project parties	0.0179
L	Low labor productivity	0.0879
L	Lack and shortage of skilled labors	0.0514
PM	Delays in decisions making	0.0651
Superstructure vs. Infrastructure		
CPH	Schedule delay	0.0454
CPH	Unforeseen ground conditions	0.0841
F	Delay payment to supplier/subcontractor	0.0122
L	Lack and shortage of skilled labors	0.0825
L	Inflation in the cost of labors	0.0672
M&E	Changes in material specs and types	0.0058
PM	Errors in contract documents	0.0180
More than 16 years experience vs. less than 16 years experience		
CPH	Insufficient site management and inspection	0.0735
CPH	Schedule delay	0.0001
CPH	Improper monitoring and control	0.0804
CPH	Accidents on site	0.0024
D	Delay in approval of drawings	0.0735
L	Inflation in the cost of labors	0.0172
M&E	Fluctuation in raw material prices	0.0067
PM	Errors in contract documents	0.0328
Large Companies vs. Medium Companies		
CPH	Insufficient site management and inspection	0.0707
CPH	Improper monitoring and control	0.0011

Continue of Table 4

Code	Attributes	T-Test (p)
CPH	Lack of experience in handling construction projects	0.0511
CPH	Accidents on site	0.0001
CPH	Effect of weather	0.0595
D	Frequent Design changes	0.0105
D	Incomplete design at time of tender	0.0111
D	Delay in approval of drawings	0.0804
F	Delay in progress payment by owner for work completed	0.0000
F	Financial difficulties of owner	0.0000
F	Cash flow difficulties faced by contractor	0.0026
F	Poor financial control on site	0.0007
F	Delay payment to supplier/subcontractor	0.0001
L	Inflation in the cost of labors	0.0000
M&E	Fluctuation in raw material prices	0.0001
M&E	Late delivery of materials and equipment	0.0095
M&E	Insufficient number of equipment	0.0062
M&E	Changes in material specs and types	0.0273
PM	Frequent changes to the scope of work	0.0046
PM	Delays in decisions making	0.0012
PM	Poor contract management	0.0015
PM	Errors in contract documents	0.0002
PM	Unrealistic contract duration and requirements imposed	0.0065
GC vs. Owner		
CPH	Insufficient site management and inspection	0.0082
CPH	Schedule delay	0.0212
CPH	Improper planning and scheduling	0.0250
CPH	Improper monitoring and control	0.0095
D	Incomplete design at time of tender	0.0718
D	Delay in approval of drawings	0.0285
F	Financial difficulties of owner	0.0086
F	Cash flow difficulties faced by contractor	0.0974
F	Poor financial control on site	0.0376
L	Lack and shortage of skilled labors	0.0932
M&E	Fluctuation in raw material prices	0.0021
PM	Poor project management	0.0128
PM	Inaccurate time and cost estimates of project	0.0418
GC vs. Consultant		
D	Frequent Design changes	0.0032

Continue of Table 4

Code	Attributes	T-Test (p)
C	Weak coordination between project parties	0.0186
M&E	Changes in material specs and types	0.0840
PM	Frequent changes to the scope of work	0.0594
PM	Delays in decisions making	0.0520
PM	Poor contract management	0.0443
PM	Unrealistic contract duration and requirements imposed	0.0005
PM	Owner interference	0.0253
PM	Inaccurate time and cost estimates of project	0.0263
	GC vs. Subcontractor	
CPH	Lack of experience in handling construction projects	0.0335
CPH	Errors during construction	0.0220
CPH	Accidents on site	0.0556
D	Frequent Design changes	0.0165
D	Delay in approval of drawings	0.0851
F	Delay in progress payment by owner for work completed	0.0000
F	Financial difficulties of owner	0.0404
F	Cash flow difficulties faced by contractor	0.0230
F	Poor financial control on site	0.0181
F	Delay payment to supplier/subcontractor	0.0000
C	Disputes on site	0.0782
L	Low labor productivity	0.0422
L	Lack and shortage of skilled labors	0.0444
M&E	Fluctuation in raw material prices	0.0716
M&E	Late delivery of materials and equipment	0.0000
M&E	Changes in material specs and types	0.0003
PM	Frequent changes to the scope of work	0.0100
PM	Delays in decisions making	0.0059
PM	Poor contract management	0.0014
PM	Unrealistic contract duration and requirements imposed	0.0088
	Owner vs. Consultant	
CPH	Schedule delay	0.0006
CPH	Improper planning and scheduling	0.0301
CPH	Improper monitoring and control	0.0586
D	Frequent Design changes	0.0168
D	Incomplete design at time of tender	0.0083
D	Delay in approval of drawings	0.0016
F	Delay in progress payment by owner for work completed	0.0509

End of Table 4

Code	Attributes	T-Test (p)
F	Financial difficulties of owner	0.0161
C	Weak coordination between project parties	0.0192
L	Inflation in the cost of labors	0.0592
M&E	Fluctuation in raw material prices	0.0049
PM	Poor project management	0.0179
PM	Frequent changes to the scope of work	0.0048
PM	Delays in decisions making	0.0755
PM	Poor contract management	0.0866
PM	Unrealistic contract duration and requirements imposed	0.0025
PM	Owner interference	0.0266
PM	Inaccurate time and cost estimates of project	0.0003

5. Risk assessment

Risk assessment is used in order to improve the understanding of risks associated with each cost overrun factor, by illustrating the nature of impact of risks resulted from the attribute that is presented as a matrix. Risk assessment matrix is a visual tool used to present risk associated with cost overrun factors: importance, frequency and impact on cost. Data will be plotted on scatter plot chart using mean values of data from respondents. The mean values represent the whole data set for the study.

Figures 2, 3 and 4 below show visual representation of each attribute average value of mean importance vs. mean frequency, mean importance vs. mean impact on cost, mean frequency vs. mean impact. Only the construction phase factors are shown below as an example.

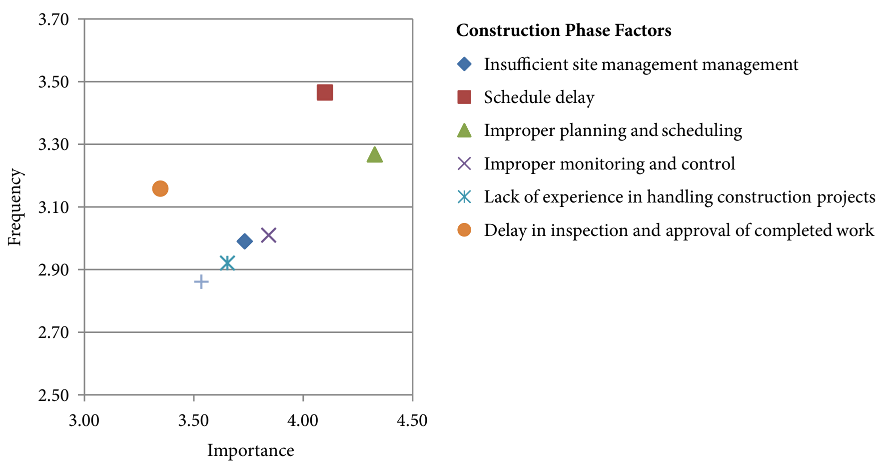

Figure 2. Risk matrix chart for cost overruns related to Construction Phase (Frequency vs. Importance)

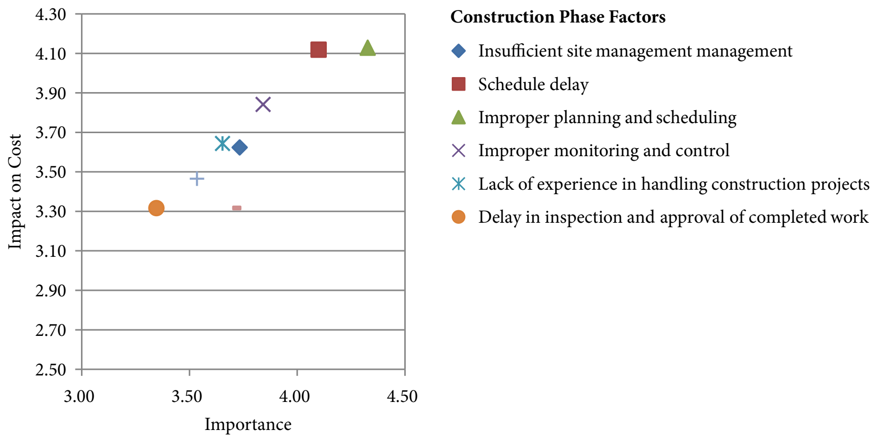

Figure 3. Risk matrix chart for cost overruns related to Construction Phase (Impact on Cost vs. Importance)

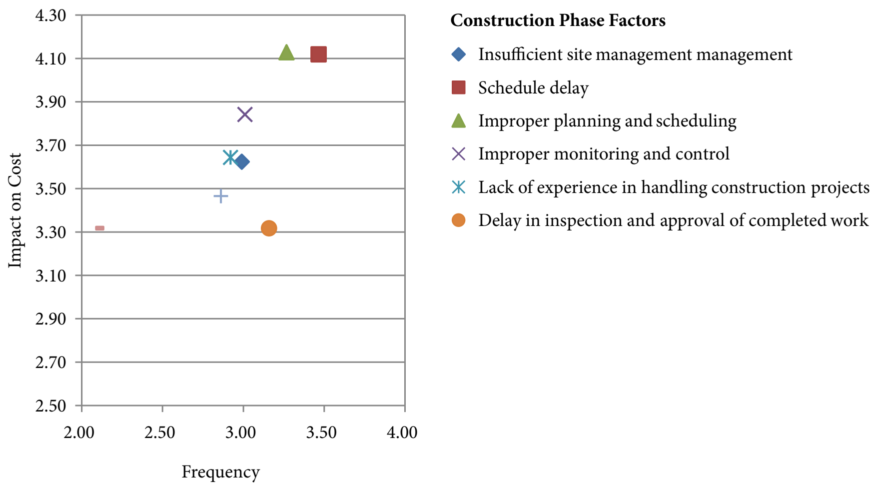

Figure 4. Risk matrix chart for cost overruns related to Construction Phase (Impact on Cost vs. Frequency)

6. Discussion of results

The objective of this paper is to identify the most influential cost overrun attributes affecting the construction industry. After a review of past literature, a list of 39 cost overrun attributes was gathered and presented in a survey. The survey was distributed to various experts in the field of construction industry. 101 respondents evaluated the 39 cost overrun attributes based on importance (The cost overrun factor importance for a construction project), frequency (How often the attribute is implemented or considered) and the impact on cost (The extent of direct impact on project's cost overrun). The gathered data of 101 complete responses were then analyzed by importance index, Spearman's rank correlation, T-test, risk assessment.

From Table 2, it can be concluded that the most significant cost overrun factor is the schedule delay (47%). This overlaps with what have been reported by the past literature. The second most significant factor was the improper planning and scheduling (47%). This shows that investing in hiring skilled planners and estimators will save the project from exceeding the budgeted cost.

Frequent design changes (45%) and frequent changes to the scope of work (43%) were observed as the third and fourth most significant factors. These factors have a major impact on any project, because even changing the design of a single beam in a whole building might affect the scope, the cost and the duration of the whole project. Moreover, design or scope change will require re-estimation of the cost and the schedule required to complete the project. All these would add additional costs to the project and therefore cause an overrun in the project.

Inaccurate time and cost estimates of project (42%) was the fifth significant factor. This reflects the importance of hiring skilled and experienced planners and estimators in order to accurately estimate the required time and budget to complete the project.

Conclusions

Various researches were conducted to understand the factors affecting the construction projects cost overrun. This study focused on identifying the influential cost overrun attributes affecting construction industry. The contribution of the paper to the development of the state-of-the art in the topic is the extensive literature review to capture most significant factors that lead to cost overrun and analyzing them with various powerful statistical tools. 39 cost overrun attributes were collected based on literature review. In order to rank these attributes, an online survey was distributed among various professionals with various backgrounds, expertise, and locations. 101 respondents evaluated the 39 cost overrun attributes based on importance (The cost overrun factor importance for a construction project), frequency (How often the attribute is implemented or considered) and the impact on cost (The extent of direct impact on project's cost overrun).

Analysis of the survey results were performed by various statistical ranking tools such as relative importance index, frequency importance index, cost impact index, frequency-cost adjusted importance index, Spearman's rank correlation, T-Test, and risk assessment. According to the FCAII, the top three most significant cost overrun factors are schedule delay, improper planning and scheduling and frequent design changes. The conclusions of this research would help the construction professionals on mitigating the negative impact of the critical cost overrun factors. The results of the surveys can be generalized to all countries of the world easily by understanding the factors affecting the construction projects' cost overrun. The collected data and analysis makes it easy for the end users to rank top critical factors affecting cost overrun. These factors could be monitored with more attention to reduce cost overrun.

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