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Identification of Factors Affecting Cost Overrun in The Construction of Industrial Buildings

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Abstract

Cost overrun in construction project is a common problem, especially material as one of the most in influencing component in project cost. This trend is more severe in industrial construction project where is located in areas with difficult accessibility. In order to minimize cost overrun, this paper aims to identify the factors that affect cost overrun in the construction of industrial buildings. Survey questionnaires were distributed to construction professionals, and data was analyzed through a statistical method. From the 74 factors which were identified, there were 9 factors which affected cost overrun in the construction of industrial buildings, such as material price fluctuations, material distribution costs to the site, material delay costs, specifications and material type change costs, shortage of materials, material damage, material lost, and excessive material quality. These factors will be analyzed in future research.

Keywords: *Cost overrun; Industrial construction project;*

1.0 INTRODUCTION

When conducting a construction project, cost remains the main factor for consideration because it requiresa large amount of investment with high risk of failure. Therefore, project costs needs to be managed properly, so that cost overrun can be minimized [1]. Furthermore, according to Al Bahar [2], one of the contractors most frequent efforts include representation of the amount of risk impact in a unit costs and include it to the bid cost components during the tender, commonly referred to as contingency costs. However, this unscientific approach is one of the cause of cost overrun[3].

In fact, cost overrun that often occurs in construction projects can be caused either by unforeseen or foreseen events, where a lack of uncertainty is not accommodated appropriately [4]. Therefore, according to Akinci and Fischer [5], a contractor will need to identify the sources of the main risks that cause high costs (cost overburden) and be pro-active to manage it. Furthermore, Wideman [6] stated that combined risk scenarios are needed simultaneously with the main impact followed by any of the consequences of the impact. In this case, risk management includes several interconnected actions such as planning, identification, analysis, response, monitoring, and control [7].

Various studies and observations that were made earlier show that different sources of major risk factors cause cost overrun. Whether these differences occur depends greatly on the characteristics of projects, the regional and country-specific nature [8]. As a result, there is a difference in the results of cost overrun estimates.

This paper amis to identify the dominant factors that affect cost overrun and its corrective action and preventive action to reduce material cost overrun in industrial construction projects

2.0 LITERATURE REVIEW

A project is a temporary activity made up of a series of activities, among others, which has special purposes with certain specifications, has a clear beginning and end, has funding limitations, and needs, i.e. money resources, manpower, and equipment [7]. Furthermore, Suharto [9] defines a

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project as an activity only done once, with a limited time frame and resources to achieve the end results that have been determined, such as product or production outcomes.

In general, a construction project can be divided into four main types, namely [10]: residential construction, building construction, heavy engineering construction, and industrial construction. According to Sulistianingrum et al. [11], a construction project resource is an ability and capacity to be potentially exploited for construction projects. Construction project resources consist of: resource costs, time resources of manpower, material resources, and equipment.

The differences between estimated cost and final cost are known as a cost overrun project [5]. Furthermore, Boukendour [12] defines cost overrun as the excess of actual cost towards the estimated cost.

Cost Overrun = Actual Cost - Estimated Cost (1)

One serious problem is when the budget is estimated with inadequate information. It should, since the early stages of planning, have already defined the scope and complexity of the project in a clearer manner. However, it should be noted that the changes that occur are not as good. If regulated effectively, it could be a chance to gain savings or give greater added value. The client must also contribute to establish an effective risk management process [13].

Most of the costs of a project consist of direct and indirect costs. The resources allocated to each project task force are done to determine the direct costs, indirect costs, or overhead costs. An additional cost is factored by contractors just in case a project is not completed on time. The duration of a project obtained from the placement of the task force is the sequence estimated on the basis of the allocation of resources for each task force and the conditions of employment. Therefore, the costs and durations are interrelated, as depicted in Figure 1. The second parameter is very important to the contractor in an attempt to minimize the costs, which at the same time must be adjusted to the contract requirements, which are resolved in a timely manner.

If it is assumed that the sequence does not change, then the direct costs generally have an opposite relationship with the duration of the project. Indirect costs increase with an increase in the project duration. The sum of the two cost can increase or decrease in accordance with the duration [14].

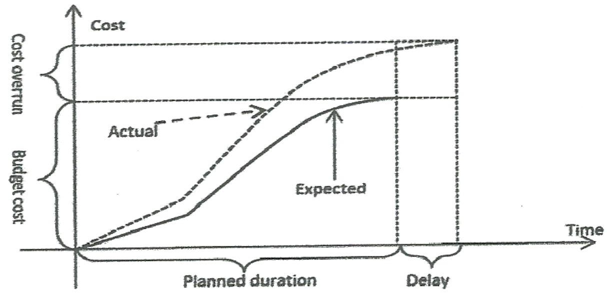

Fig. 1. Relationship of cost overrun by duration

The picture above shows the relationship between cost and duration. The greater the delay in the work, the greater the deviation cost incurred.

3.0 METHODOLOGI

The research methodology consisted of three stages, namely, in phase I, a literature study was conducted to obtain the variables which were risk factors that could have an impact on the cost overrun of a building industry project. In this case, it was restricted by the risk factors related to the cost of material risks associated with the relatively difficult accessibility conditions. These risk factor remedies were separated into source of risk and event risk. This data was then confirmed in the form of a detailed questionnaire to experts using the Delphi method.

In phase II, the experts' confirmation results were then used as a reference in making the questionnaire instrument, which was then distributed to stakeholders and/or project practitioners. The questionnaire was created into two parts. The first part of the questionnaire was devised with the ordinal scale to figure out the risk factors that influenced the deviations of material cost and frequency of occurrence of the source of the risk. The first part of the questionnaire format can be seen in Table 1 below.

Table 1. Detailed questionnaire project practitioners

No	**isk factor**	**Level of influence on material cost overrun**					**Frequency that occurs**					**Corrective and preventive actions, mitigation**
		1	2	3	4	5	1	2	3	4	5	
						ECONOMIC						
1	Inflation											
2	Exchange rate fluctuations											

Description:

Level of influence:
1 = no effect (material cost overrun = 0%)
2 = less (material cost overrun, 0 – 10%)
3 = moderate (material cost overrun, 10 – 20%)
4 = high (material cost overrun, 20 – 30%)
5 = very high (material cost overrun > 30%)

Frequency:
1 = never
2 = seldom
3 = sometimes
4 = often
5 = always

In phase III, the variables that had been collected then analyzed by using a factor analysis, thus acquiring the equation diversion costs. A factor analysis is a technique that describes the relationship between the diversity of some variables in a small number of factors, of which the variables that have high correlations are grouped in one group (factor), whereas the correlation between the variables in the group one with the other is relatively small. Between variables in one particular group, there is a very strong relationship, but compared with other variables in the other groups, it has a relatively weak relationship. An analysis of the factors used in this research was conducted to obtain the variable risk that is dominant and influential.

4.0 RISK DATA AND SURVEY OF RESPONDENTS

In phase I, a literature study was conducted to identify the factors that influence the cost overrun in a industrial construction project and acquired 74 factors. Then, there were clasified into 13 events and 61 risk sources. The variable sources and event risks are listed in Table 2.

Table 2. Variable sources and event risks

Var.	Source	Var.	Event
X1	Inflation	X3	Material price fluctuation
X2	Exchange rate fluctuations		
X6	Economic recession		
X23	Any taxation changes / new tax rates		
X5	Increase in the cost of loading and unloading	X4	Transportation cost is on increase
X7	Energy price changes		
X8	Bad weather condition changes		
X28	Poor road conditions leading to the site		
X29	Multiple handling		
X30	Change of transportation modes		
X31	Lack of local transportation services		
X8	Bad weather condition changes	X59	Material distribution costs on project's site
X9	Soil conditions at the site hinder the distribution of material		
X10	Impact of floods on material		
X22	Delays in the providing of services for utilities		
X42	Size of the site is inaccurate		
X50	Lack of material remnants of trash collection place (waste)		
X58	Stock piles are not strategically positioned		
X11	Payment delay progress	X32	Material delay (delivery/procurement)
X12	Duration of the procurement of materials is too short in the contract		
X14	Contract is not flexible (rigid)		
X15	Material specifications are hard to find in the market		
X16	Material criteria are less obvious / less information		
X21	Traffic barriers toward job sites		
X22	Delays in the provision of services for utilities		
X24	Permit and licensing documents		
X25	Issue of land claims from the local community (land compensation) that block material		
X33	Special manufacturer delays from abroad (imports)	X32	Material distribution costs on project's site
X34	Difficulties in material accessibility		
X38	Supplier has a poor reputation		
X39	Dependency on a certain suppliers		
X51	Mobilization difficulty for tools & materials		
X52	Lack of experience in a delivery system		
X53	Changes in the availability of materials		
X54	Material scarcity in the market		
X55	Conditions change the source material		
X57	Poor buyer strategies in determining suppliers		
X67	Poor material management and planning		
X65	Specification of raw material does not meet the prescribed specifications		
X66	Long waiting time for approval of a sample test material		
X19	Changes of scope	X13	Cost of change in material specification type
X20	Changes of design and engineering		
X16	Material criteria less obvious / less information	X56	The cost of material turnover because the quality does not match
X73	Lack of supervision of the material quality		
X17	Changes due to design errors	X40	Excessive amount of material
X46	Inaccurate quantity take-off		
X47	Inaccurate calculation of project material costs		
X48	Number of material errors in purchasing & delivery		
X67	Poor material management and planning		
X18	Poor/incomplete design	X41	Material shortages
X45	Excessive waste material in the field		
X46	Inaccurate quantity take-off		
X47	Inaccurate calculation of project material costs		
X48	Number of material errors in purchasing & delivery		
X63	Material spilled		
X27	Conditions of the community around the project location are less conducive	X26	Cost of material security
X35	Inadequate warehouse	X43	Material damages
X36	Poor warehouse management procedures		
X37	Material damage due to poor storage conditions		
X49	Lack of material storage		
X60	Poor reputation of the transportation		
X61	Material used up too fast in the project and not used for a long time		
X67	Poor material management and planning		
X74	Lack of logistical field supervision		
X73	Lack of supervision of the field by site	X64	Reworks
X17	Changes due to design errors		
X62	Errors in the work methods		
X68	Manipulation of the volume of material by the supplier	X44	Lost of materials
X69	Material volume manipulation by logistics		
X70	Theft of materials		
X73	Lack of field supervision		

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Var.	Source	Var.	Event
X67	Poor material management and planning	X72	Excessive quality of material

As explained, this research was conducted in two stages, namely the questionnaires were disseminated to expert respondents and practitioner respondents.

FIRST STAGE SURVEY OF RESPONDENTS

The number of respondents obtained consisted of 9 construction experts and expert institutions, as outlined in Table 3.

Table 3. Background of institutional experts

No	Expert institution	Total number	Total percentage (%)
1	Private company	7	78
2	Foreign company	1	11
3	State owned enterprise	1	11

The experience of the experts in the construction industry can be viewed in Table 4.

Table 4. Background Experience Expert

No	Expert experience (years)	Total number	Total percentage (%)
1	15 – 25	6	67
2	26 – 35	3	33

The experts' level of education can be observed in Table 5.

Table 5. Educational background of experts

No	Experts' level of education	Total number	Total percentage (%)
1	Bachelor's Degree	6	67
2	Master's Degree	3	33

Second Stage Survey of Practitioner Respondents

Thirty practicing respondents were obtained, against a background of institution respondents, as listed in Table 6.

Table 6. Background of institution respondents

No	Practitioner institution	Total number	Total percentage (%)
1	Private company	16	53.3
2	Foreign capital company	7	23.4
3	BUMN (state-owned enterprise)	3	10
4	Collaboration company of foreign capital/ domestic capital company	4	13.3

The experts' work experience in the construction industry world can be seen in Table 7.

Table 7. Background of respondents' experience

No	Practitioner' experience (years)	Total number	Total percentage (%)
1	5 – 10	16	53.3
2	11 – 15	7	23.4
3	16 – 20	4	13.3
4	21 – 25	3	10

The experts' level of education can be viewed in Table 8.

Table 8. Respondents' educational background

No	Educational level of respondents	Total number	Total percentage (%)
1	Diploma	2	6.6
2	Bachelor's Degree	20	66.7
3	Master	8	26.7

The practitioner respondents' positions are outlined in Table 9.

Table 9. Background positions of respondents

No	Positions of the respondents	Total number	Total percentage (%)
1	Project Manager	5	16.7
2	Project/Cost Control	23	76.7
3	Contract Manager	1	3.3
4	Project Engineer	1	3.3

5.0 RESULT

Results and Discussion of the Survey Experts

In Phase II, the expert questionnaire stage was conducted with the aim to verify source of risks by reducing or adding a variable source of risk and event risk. As explained previously, there were 74 risk factor variables. These risk factors were then classified into 61 risk sources and 13 event risks, where the risk of a particular resource was the cause of a particular risk.

Based on the detailed questionnaire results obtained from 9 experts, and then from 61 risk sources that asked the respondents to relate items with event risk, then 25 "acceptable" risk sources were obtained by the respondents as a source of risk was the cause of the risk. In addition, the expert respondents were also asked to add details to the questionnaire if there were other sources of risk that could cause risks. Due to that, there were 11 additional sources of risk causes. So there was a total of 36 risk sources included in the respondents'/practitioners' questionnaire.

In tabulating the questionnaire data for experts' risk sources (Table 10), 25 sources of risks were considered "acceptable" and 11 additional sources of risk causes, as follow:

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Table 10. 25 sources of "acceptable" & 11 sources of "additional" risks by the respondents as a source of risk

No	Var	Source	Description
1	X1	Inflation	Acceptable
2	X2	Exchange rate fluctuations	Acceptable
3	X6	Economic recession	Acceptable
4	X7	Energy price changes	Acceptable
5	X28	Poor condition of the road leading to the site	Acceptable
6	X29	Multiple handling	Acceptable
7	X31	Lack of local transportation services	Acceptable
8	X9	Soil conditions at the site hinder the distribution of material	Acceptable
9	X22	Delays in providing of services from utilities	Acceptable
10	X39	Dependency on certain supplier	Acceptable
11	X51	Difficulty of mobilization tools & material	Acceptable
12	X54	Material scarcity in the market	Acceptable
13	X67	Poor material management and planning	Acceptable
14	X19	Changes of scope	Acceptable
15	X20	Changes of design and engineering	Acceptable
16	X18	Poor/Incomplete design	Acceptable
17	X46	Inaccurate quantity take-off	Acceptable
18	X48	Number of material errors in purchasing & delivery	Acceptable
19	X35	Inadequate warehouse	Acceptable
20	X36	Insufficient procedures for warehouse management	Acceptable
21	X37	Material damage due to poor storage conditions	Acceptable
22	X17	Changes due to design errors	Acceptable
23	X62	Errors in the work methods	Acceptable
24	X69	Material volume manipulation by logistics	Acceptable
25	X70	Theft of materials	Acceptable
26	X75	Illegal charges around the site	Additional
27	X76	Lack of planning for working road	Additional
28	X77	The mode of transportation changes according to the season	Additional
29	X78	Scarcity of material specification and type	Additional
30	X79	Inefficient material usage	Additional
31	X80	Material damage during delivery	Additional
32	X81	Poor work quality & ability	Additional
33	X82	Lack of material checking out procedure	Additional
34	X83	Errors in purchasing	Additional
35	X84	Inaccurate in reading the specification	Additional
36	X85	Poor material quality knowledge	Additional

Furthermore, of the 13 risk events asked to the respondents, a significant influence was associated by experts for cost overrun factors. Then the obtained results revealed that 10 risk events could be "acceptable" by the expert respondents.. The tabulated data from the questionnaire for the risk events is outlined in Table 11.

Table 11: Tabulated experts questionnaire data for risk events

No	Var	Risk event	Description
1	X3	Material price fluctuation	Acceptable
2	X4	Transportation cost is on increase	Acceptable
3	X59	Material distribution costs on project's site	Acceptable
4	X32	Material delay (delivery/procurement)	Acceptable
5	X13	Cost of changes in specifications and material type	Acceptable
6	X41	Material shortages	Acceptable
7	X43	Material damages	Acceptable
8	X64	Reworks	Acceptable
9	X44	Lost of materials	Acceptable
10	X74	Excessive quality of material	Acceptable

Results and Discussion of the Survey Practitioner Responder

In Phase III, result from the practitioner questionnaire stage, then analyzed using factor analysis. An analysis of the factors used in this research was conducted to obtain the variable risk that is dominant and influential, for that factor analysis using extract and rotation step. The result of rotated component matrix is outlined in Table 12

Tabel 12. Rotated Component Matrix

	Rescaled									
	Component									
	1	2	3	4	5	6	7	8	9	10
X1	.29	.29	**.77**	.13	.09	-.09	.18	.20	.02	.11
X2	.04	.18	**.94**	.09	.02	-.09	.04	.03	.06	-.06
X6	.13	.34	**.67**	-.02	-.03	-.15	.18	.08	.35	.35
X7	.30	.24	**.73**	.01	.26	.20	.19	-.17	.01	-.12
X28	**.50**	.23	.44	-.10	.14	.17	.43	-.19	.26	.36
X29	.05	.18	.47	.01	.34	.14	**.74**	.01	-.03	-.01
X31	-.04	.43	.52	-.06	.02	.39	.45	.10	.18	-.26
X75	.06	.01	.37	**.64**	.14	.29	.08	.38	-.34	-.04
X9	.47	-.03	-.08	-.06	-.08	**.68**	.11	-.10	-.24	.32
X22	-.03	.00	-.07	.21	-.04	**.90**	.06	-.05	.07	-.14
X76	.07	.50	.13	.16	.20	**.71**	.08	.25	.02	.06
X39	-.06	.29	.11	.32	**.81**	.14	.15	.13	.07	-.13
X51	.42	.39	.37	.02	.17	.23	**.48**	.04	.36	.06
X54	.29	.35	.39	-.16	.30	-.01	.13	-.08	**.64**	-.06
X67	.30	.16	.08	-.07	**.89**	-.08	.06	.01	.09	.08
X77	.14	**.61**	.26	.02	.09	.09	.49	.01	.36	.01
X19	-.02	**.56**	.14	.24	.50	-.01	.25	.46	.11	-.06
X20	.39	**.55**	.35	.06	.38	.01	.32	.24	-.07	.16
X78	.25	**.63**	.35	-.04	.03	.32	.32	.14	.21	.12

continued ...

	Rescaled Component									
	1	2	3	4	5	6	7	8	9	10
X18	-.08	.80	.35	.05	.14	-.01	-.01	-.11	.09	-.23
X46	.54	.57	.29	.15	.09	.04	.01	-.23	.28	.08
X48	.72	.27	.20	.13	.22	-.04	.22	-.15	.39	.02
X79	-.08	.60	.42	.30	.44	.13	.27	.081	-.02	.06
X35	.14	.21	-.03	.82	-.01	.01	-.20	-.01	.03	-.01
X36	.20	.10	-.07	.80	.10	.01	.08	.13	-.27	-.27
X37	.94	-.05	.12	.12	-.08	.03	-.12	.05	-.15	-.01
X80	.93	.17	.12	.11	-.02	-.01	.06	.02	-.10	.01
X17	.28	.67	.17	.24	.25	-.24	.26	.25	.10	.06
X62	-.01	.59	.22	.56	.15	.18	-.14	.22	.01	.15
X81	.12	.75	.08	.32	.12	.14	.02	.07	-.03	.01
X69	.13	.10	.09	.86	.01	.15	.19	.15	.26	.11
X70	.14	.18	.04	.60	.19	.12	.02	.61	-.05	.11
X82	.37	.07	.03	.38	.03	-.04	-.04	.75	-.05	-.12
X67	.62	.18	.11	.23	.15	.41	.14	.36	.29	.06
X83	.81	.07	.01	.04	.16	.22	.01	.28	.33	.19
X84	.90	-.09	.10	.08	.15	-.03	.08	.13	.07	-.06
X85	.60	.24	.02	.33	.06	.06	.09	.24	.05	-.41

Based on factor analysis, the risk sources and events are outlined in table 13 and 14.

Table 13. 24 sources of "acceptable" risks based on factor analysis

No	Var	Source	Description
1	X1	Inflation	Acceptable
2	X2	Exchange rate fluctuations	Acceptable
3	X6	Economic recession	Acceptable
4	X9	Soil conditions at the site hinder the distribution of material	Acceptable
5	X22	Delays in providing of services from utilities	Acceptable
6	X39	Dependency on certain supplier	Acceptable
7	X67	Poor material management and planning	Acceptable
8	X19	Changes of scope	Acceptable
9	X20	Changes of design and engineering	Acceptable
10	X18	Poor/Incomplete design	Acceptable
11	X46	Inaccurate quantity take-off	Acceptable
12	X37	Material damage due to poor storage conditions	Acceptable
13	X17	Changes due to design errors	Acceptable
14	X62	Errors in the work methods	Acceptable
15	X70	Theft of materials	Acceptable
16	X76	Lack of planning for working road	Acceptable
17	X78	Scarcity of material specification and type	Acceptable
18	X79	Inefficient material usage	Acceptable
19	X80	Material damage during delivery	Acceptable
20	X81	Poor work quality & ability	Acceptable
21	X82	Lack of material checking out procedure	Acceptable
22	X83	Errors in purchasing	Acceptable
23	X84	Inaccurate in reading the specification	Acceptable
24	X85	Poor material quality knowledge	Acceptable

Table 14. 9 events of "acceptable" risks based on factor analysis

1	X3	Material price fluctuation	Acceptable
2	X59	Material distribution costs on project's	Acceptable
3	X32	Material delay (delivery/procurement)	Acceptable
4	X13	Cost of changes in specifications and material type	Acceptable
5	X41	Material shortages	Acceptable
6	X43	Material damages	Acceptable
7	X64	Reworks	Acceptable
8	X44	Lost of materials	Acceptable
9	X74	Excessive quality of material	Acceptable

6.0 CONCLUSION

After doing the three phases of research, namely the first phase, from 74 factors wich were identified through literature review, there were clasified into 13 risk events and 61 risk sources. The second phase, to confirm to the experts to make the questionnaire by dividing the sources of risk and event risk, the importance of the 25 sources of risk and 10 risks of event.In the third phase, by using factor analysis, then the tenth of event risk decline into 9 events are an important factor affecting the cost overrun in the construction of industrial building as follow:

1. *Material price fluctuation*. Source of this factor are inflation, exchange rate fluctuations, and economic recession.
2. *Material distribution costs on project's site*. Sources of this factor are soil conditions at the site hinder the distribution of material, delays in the provision of services for utilities, lack of planning for working road.
3. *Material Delay*. Sources of this factor are dependency on certain supplier, and poor material management and planning.
4. *Cost of changes to specifications and material type*. Sources of this factor are change of scope, change of design and engineering and scarcity of material specification & type.
5. *Material shortage*. Sources of this factor are poor/incomplete design, inaccurate quantity take-off and inefficient material.
6. *Material damage*. Sources of this factor are material damage due to poor storage conditions, and material damage during delivery
7. *Reworks*. Sources of this factor are changes due to design error, errors in the work methods, and poor work quality & ability.
8. *Lost of materials*.Sources of this factor are theft of materials, and lack of material checking out procedure.
9. *Excessive quality of material*. Sources of this factor are poor material management and planning, errors in purchasing, inaccurate reading the specification, and poor material quality knowledge.

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Meanwhile, the ninth of events still be analyzed at the future research, where they will be analyzed to know their quantity and their impact to the cost overrun in the construction of industrial building.

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