Risk impact on cost and time from the factors of contractor's managerial and operational

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Risk impact on cost and time from the factors of contractor's managerial and operational

S Husin[1,*], **Abdullah**[2], **M Riza**[2], **M Afifuddin**[2]
[1]Engineering Doctoral Study Program, Univ. Of Syiah Kuala, 23111 Banda Aceh, Indonesia
[2]Faculty of Engineering, Univ. Of Syiah Kuala, 23111 Banda Aceh, Indonesia

E-mail: saifulhusin@unsyiah.ac.id

Abstract. Aceh Province over the last 20 years has experienced different events that can be divided into 3 (three) phases. 1st Phase is the phase of the conflict (2000-2004), 2nd Phase is the post-earthquake and tsunami rehabilitation and reconstruction phase of Aceh (2005-2009), and 3rd Phase is the post-rehabilitation and reconstruction phase (2010-present). Events that occurred during the last 20 years are certainly likely to provide risks to community activities in the province of Aceh. One of the activities affected by the event is the construction project work. The implementation of construction works affected by events in Aceh Province over the last 20 years is highly vulnerable to risks that impact on achieving project objectives such as cost and time. This study analyzes the impact of the contractor and operational managerial risk factors on the cost and timing of construction. Data were obtained from questionnaires distributed to 15 large qualification companies in Aceh Province. Testing data is done by using the validity test and reliability test. Data that has been valid and reliable then analyzed by using Severity Index (*SI*). The variables of a managerial risk factor with *SI* to the highest cost in 1st Phase are F5 (incompetent Engineer), 2nd Phase is F3 (lack of contractor experience), and 3rd Phase is F5 (incompetent Engineer). From the operational risk factor, the highest cost *SI* in each phase is the G3 variable (electrical disorder). The managerial risk factors with the highest time *SI* in 1st Phase are F6 (lack of top management support), 2nd Phase is F5 (incompetent engineer), and in 3rd Phase is F3 (lack of contractor experience). From the operational risk factor, the highest time *SI* at each phase is G3 (electrical disorder).

1. Introduction

The construction project is a series of complex, non-routine activities, limited by time, budget, resources and carried out according to specifications, with the ultimate goal of cost, time and quality determined [1,2]. To achieve the ultimate goal of the implementation of the work can be influenced by various risk factors, both internal and external. Internal factors are factors that come from problems in the construction project, whereas external factors are factors that originate from problems outside construction projects which, if they occur, may pose a risk to the project [3,4]. The risk is something that arises from the emergence of these factors which can be either a negative or positive impact [5,6]. Positive impacts will certainly be directly accepted by the construction worker because they will

* Corresponding author: saifulhusin@unsyiah.ac.id

contribute to the achievement of the project's objectives, but if the risks that arise cause negative impacts will certainly be avoided because it will disturb targeted results until the failure of the objectives of the project.

In the case of the objective to increase the positive impact and reduce the negative impact of the occurrence of risks to the implementation of construction required construction management [1,2]. Construction management is required to implement the management process effectively and efficiently to achieve the project objectives optimally [1,6,7,8]. From the aspect of risk factors, construction management comes from internal risk factors. The construction management managed by the company's resources is one of the internal factors that greatly affect the success of a company, especially the construction company [9,10,11]. Internal risk factors that directly affect project management include the contractor's managerial and project operations. To analyze the risks from the aspects of construction and operational management will be the different result of analysis because of the happening and felt by the contractor in each implementation area is different.

Construction work in each different work area will experience different risks. This is caused by events or events occurring in each region will have an effect on the occurrence of the risk. Aceh province over the last 20 years has experienced different events that can be divided into 3 (three) phases. 1st Phase is the phase of the conflict (2000-2004), 2nd Phase is the post-earthquake and tsunami rehabilitation and reconstruction phase of Aceh (2005-2009), and 3rd Phase is the post-rehabilitation and reconstruction phase (2010-present). Events that occurred during the last 20 years are certainly likely to provide risks to community activities in the province of Aceh. One of the activities affected by the event is the construction project work. The implementation of construction works affected by events in Aceh Province over the last 20 years is highly vulnerable to risks that impact on achieving project objectives such as cost and time.

Research related to construction project risk in Aceh Province has been conducted related to the assessment of a number of risk factors to the objectives of the construction project in the form of cost, time, and quality. The results are related to project resources [12], external factors [13], managerial and operational factors [14], contracting and design factors [15], and financial factors and methods of construction [16]. To continue the research, this study analyzes the impact of the contractor and operational managerial risk factors on construction cost and time. Data were obtained from questionnaires distributed to 15 large qualification companies in Aceh Province. Testing data is done by using the validity test and reliability test. Data that has been valid and reliable then analyzed by using Severity Index (*SI*). The variables of a managerial risk factor with *SI* to the highest cost in 1st Phase are F5 (incompetent Engineer) (0,510 / Medium), 2nd Phase is F3 (lack of contractor experience), and 3rd Phase is F5 (incompetent Engineer). Of the operational risk factors, *SI* highest cost in each phase is variable G3 (Electrical Disorders). Managerial risk factors with the highest time *SI* in 1st Phase are F6 (Lack of Top Management Support), 2nd Phase is F5 (incompetent Engineer), and in 3rd Phase is F3 (Lack of Contractor Experience). Of the highest operational risk factor, *SI* time in each phase is G3 (Electrical Disorders).

2. Research Methods

The research method discusses the methods of data collection, testing of questionnaire instruments, and risk analysis methods to achieve research results.

2.1 Data collection

The data in this study were obtained from questionnaires distributed to large qualification construction companies in Aceh Province. The questionnaire contained a number of questions aimed at obtaining information on the characteristics of respondents and companies, the possibility of risk events, and the impact of risks on the cost and timing of construction implementation of the contractor and operational managerial risk factors felt by construction executors in Aceh Province. Internal risk factors of contractor managerial consists of 9 variables and operational consists of 11 variables, as shown in Table 1.

Table 1. List of managerial and operational risk variables

Risk Factors	Code	Variable
Managerial Contractor	F1	Lack of project manager experience
	F2	Lack of communication and coordination between parties involved in the project
	F3	Lack of contractor experience
	F4	Losing data / documents
	F5	Incompetent engineer
	F6	Lack of top management support
	F7	Project planning and control is not good
	F8	Unclear authority, duties, and responsibilities (unclear delegation)
	F9	Unregistered project documents
Operational	G1	Lack of supervision of subcontractors and suppliers
	G2	Lack of supervision of the work execution schedule
	G3	Electrical disorder
	G4	Difficulty to establish temporary facilities
	G5	Number of jobs that are not according to plan
	G6	Changes in construction work due to difficulty implemented
	G7	Changes in the performance of suppliers/contractors
	G8	Repairs due to repetitive work
	G9	Bad location conditions and difficult to reach
	G10	Lack of telecommunication network provision
	G11	Late getting permission to do work

The data collection was conducted by collecting the results of the distribution of questionnaires on 15 companies from a population of 20 large qualification companies that had been involved in the implementation of construction projects in Aceh Province over the last 20 years. Data from the company is obtained from the list of major qualification companies that exist in the Construction Services Development Agency 2016. The position of respondents filler the questionnaire is a minimal company employee with intermediate positions such as director, manager, and senior engineer.

2.2 Testing of instruments

To measure the accuracy and determination of respondents in providing answers in the research instrument is done testing the perception of respondents. The respondent's perception test is done to know the validity (accuracy) and reliability (determination) of research instrument before the data in use. The instruments used hereinafter in this study are those that have met the valid and reliable criteria, based on the results of validity and reliability tests that have been done.

2.2.1 Instrument validity test

Validity is the level of validity of the measuring instrument used. The instrument is said to be valid indicating the measuring instrument used to obtain the data is valid or can be used to measure what should be measured [17]. The validity of the questionnaire is measured by calculating the correlation between the data on each statement with the total score using the product moment correlation formula (Equation 1). To specify a valid item or not use the following criteria:

1. If $t_{count} > t_{sig}$, then the question item is valid.
2. If $t_{count} > t_{sig}$, then the question item is invalid.

To obtain t_{count} value used the formula as follows:

$$r = \frac{n(\sum xy) - (\sum x) - (\sum y)}{\sqrt{\{n\sum x^2 - (\sum x)^2\}\{n\sum y^2 - (\sum y)^2\}}} \quad (1)$$

$$t_{count} = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \quad (2)$$

With r_{xy} = correlation coefficient, Σx = total item score, Σy = total total score and n = number of respondents.

To obtain a t_{sig} value is to determine the desired significance level. In this case, a significant level is taken at 5%. Significant means convincing or meaningful. In this study significant meaning that the proven hypothesis in the sample can be applied to the population. If it is not significant, then the conclusions of the sample cannot apply to the population (no generalization) or apply only to the sample only. A significant level of 5% or 0.05 means taking the wrong risk in making a decision to reject the wrong hypothesis as much as 5% and correct in making a decision at least 95% (trust level). To obtain the t_{sig} value required product moment values as shown in Table 2. From the product, moment values can be concluded that the t_{sig} value taken in this study is $t_{sig} > 0{,}514$ because the number of respondents in the study there are 15 respondents (n = 15) with a significant level of 5%. Therefore, the Instrument item is considered valid by comparing it with t_{sig}, therefore if $t_{count} \geq 0.514$ then the instrument is deemed valid.

Table 2. Product moment values

n	Significant Level		*n*	Significant Level		*n*	Significant Level	
	5%	1%		5%	1%		5%	1%
3	0,997	0,999	27	0,381	0,487	55	0,266	0,345
4	0,950	0,990	28	0,374	0,478	60	0,254	0,330
5	0,878	0,959	29	0,367	0,470	65	0,244	0,317
6	0,811	0,917	30	0,361	0,463	70	0,235	0,306
7	0,754	0,874	31	0,355	0,456	75	0,227	0,296
8	0,707	0,834	32	0,349	0,449	80	0,220	0,286
9	0,666	0,798	33	0,344	0,442	85	0,213	0,278
10	0,632	0,765	34	0,339	0,436	90	0,207	0,270
11	0,602	0,735	35	0,334	0,430	95	0,202	0,263
12	0,576	0,708	36	0,329	0,424	10	0,195	0,256
13	0,553	0,684	37	0,325	0,418	12	0,176	0,230
14	0,532	0,661	38	0,320	0,413	15	0,159	0,210
15	0,514	0,641	39	0,316	0,408	17	0,148	0,194
16	0,497	0,623	40	0,312	0,403	20	0,138	0,181
17	0,482	0,606	41	0,308	0,398	30	0,113	0,148
18	0,468	0,590	42	0,304	0,393	40	0,098	0,128
19	0,456	0,575	43	0,301	0,389	50	0,088	0,115
20	0,444	0,561	44	0,297	0,384	60	0,080	0,105
21	0,433	0,549	45	0,294	0,380	700	0,074	0,097
22	0,423	0,537	46	0,291	0,376	800	0,070	0,091
23	0,413	0,526	47	0,288	0,372	900	0,065	0,086

Table 2. Product moment values

n	Significant Level		*n*	Significant Level		*n*	Significant Level	
	5%	1%		5%	1%		5%	1%
24	0,404	0,515	48	0,284	0,368	1000	0,062	0,081
25	0,396	0,505	49	0,281	0,364			
26	0,388	0,496	50	0,279	0,361			

Source: Sugiyono (2010)

2.2.2 Instrument reliability test

Reliability test is a reliability or consistency of measuring instrument in measuring what to be measured, meaning whenever the measuring instrument is used will give the same result [17]. So that reliability is a stability or consistency of respondents in answering things related to the forms of questions or statements that are the dimensions of a variable and arranged in a form of a questionnaire. Commonly used reliability analysis is Cronbach Alpha (*C-Alpha*) analysis. The test using the coefficient C-Alpha must be greater or equal to 0.6 is a value that is considered to be able to test whether or not the questionnaire is used. The formulas used are as follows:

$$r = \frac{k}{(k-1)}\left[1 - \frac{\sigma_b{}^2}{\sigma_1{}^2}\right] \tag{3}$$

with r = instrument reliability, k = number of questions, σ_b^2 = number of grain variance and σ_1^2 = varians total. The formula for calculating grain variance and total variance is:

$$\sigma_b{}^2 = \frac{JKi}{n} - \frac{JKs}{n^2} \tag{4}$$

$$\sigma_1{}^2 = \frac{\sum xt^2}{n} - \frac{(\sum xt^2)}{n^2} \tag{5}$$

with $\sum xt$ = the total number of respondents' answers, $\sum xt^2$ = squared the total number of respondents' answers, *Jki* = sum of squares of whole grains and *Jks* = the sum of the squares of the subject.

2.2.3. Methods of data analysis

The data analysis used is to obtain the result of possible risk occurrence (frequency) and impact of risk (severity). Therefore, the Severity Index (*SI*) analysis is needed to analyze the possibility of risk occurrence and Severity Index to analyze the impact of risk.

Severity index shows the index of the impact of risk from the emergence of risk factors. For the calculation of severity index analysis use the formula in the following equation [12].

$$Severity\ Index\ (SI) = \frac{\sum_{I=1}^{5} a_i n_i}{5N} \tag{6}$$

with i = category index of respond, the a_i = weight associated with the value of the i-th response, n_i = frequency of impact of respondent i as a percentage of total respondent for each factor and N = total number of respondents. Measurement of severity is done using a Likert scale with criteria shown in Table 3.

Table 3. *SI* scoring criteria and scales

Qualification	Likert Scale	Assessment Scale
Very Low	1	$0,000 \leq SI \leq 0,125$
Low	2	$0,125 < SI \leq 0,375$
Medium	3	$0,375 < SI \leq 0,625$
Haight	4	$0,625 < SI \leq 0,875$
Very Hight	5	$0,875 < SI \leq 1,000$

Source: Majid and McCaffer (1997)

3. Results and Discussion

In this section will be presented the results of data processing and data analysis based on research methods. The discussion is directed to the problem of the impact of risks on construction costs and timing of contractor and operational managerial risk factors.

3.1 Characteristics of respondents and companies

Characteristics of data obtained from the distribution of questionnaires divided into two, namely the characteristics of the questionnaire data from the respondents and the characteristics of the questionnaire data from the company. Results of the company characteristic questionnaire. The company experience in the field of construction has more than 15 years of experience, the number of projects ever handled, almost entirely handled projects of more than 10 projects with the dominant project type of road and bridge projects, the average value of projects worked every year more than Rp. 10,000,000,000 - Rp. 50,000,000,000 with the actual project time being completed every year for 6-12 months.

Respondent data obtained from the results of respondents' answers on questions regarding respondents data. Respondent data are grouped on behalf of respondent, position, gender, the age of the respondent, last education, and years of service. Table 5 shows the results of data processing of respondent characteristics. The position of respondents is dominated by the director, male sex, with an average age above 30 years, recent education domination undergraduate (*SI*) and with average work experience more than 7 years. Based on the results obtained enough reliable respondents to fill out the research questionnaire.

Table 4. Characteristics of respondents

Characteristics of Respondent	Category of Measurement	Amount	(%)
Personel position	Director	5	33,3
	Manager	7	46,67
	Other	3	20,00
Last education	SMA	3	13,33
	Diploma	2	13,33
	Bachelor (S1)	9	60,00
	Post Graduate (S2/S3)	1	6,67
Working Experience in personnel	>2-4 years	1	6,67
	>4-7 years	1	6,67
	>7 years	13	86,67

3.2 Instrument test results

Research results were obtained after data collection and data processing. The data obtained in the form of responses of respondents from the questionnaires that have been disseminated. The questionnaire was addressed to 20 respondents which is a large qualified construction service company in Aceh province, but the respondents obtained as many as 15 companies. This happens because the company address listed on the LPJK is not appropriate and there is no reply from the respondents. This chapter describes the results of research in the form of characteristic data, validity test, reliability test, descriptive statistical analysis, Severity Index analysis (*SI*), and discussion.

3.2.1 Test results validity

Validity test is used to determine whether or not a question item in the questionnaire. This test is performed on each questionnaire statement and the results are compared with rsig = 0,514.

Table 5. The result of validity test

Impact	Code Var.	Value Range t_{count} Per Phase			Information
		1st Phase	2nd Phase	3rd Phase	
Cost	F1-F9	0,530–0,828	0,517–0,768	0,578–0,753	Valid
	G1-G11	0,524–0,884	0,520–0,804	0,520–0,861	Valid
Time	F1-F9	0,518-0,839	0,530-0,797	0,515-0,737	Valid
	G1-G11	0,523-0,889	0,520-0,795	0,520-0,726	Valid

Based on Table 5 can be seen all items of the question under study have value t_{count} greater than rsig. Thus the validity test on the contractor and operational managerial risk factors with the time phase of the review indicates that the questionnaire data collection in this study is entirely valid so that it can be executed to the next analysis process.

3.2.2 Reliability test results

After doing the validity test the researchers conducted a reliability test that aims to determine the level of reliability of research instruments so that the measuring tool remains consistent when measured at different times. This calculation uses the Cronbach Alpha formula. The value of a variable is said to be reliable if the Cronbach Alpha value exceeds the value of 0.6. Reliability test is done jointly to all questions and the results are compared with the value of 0.6.

Table 6. The results of the reliability test of cost impact data

Impact	Risk Factor	Value Range t_{count} Per Phase			Information
		1st Phase	2nd Phase	3rd Phase	
Cost	Managerial Contractor	0,77	0,76	0,82	Reliabel
	Operational	0,82	0,86	0,85	Reliabel
Time	Manajerial Contractor	0,79	0,80	0,92	Reliabel
	Operstional	0,80	0,82	0,87	Reliabel

In Table 6 we can see that the reliability test for each variable indicates that the C-Alpha value for all variables of the contractor and operational managerial risk factors in the analyzed data is greater than 0.6. Thus the reliability test on the contractor and operational managerial risk factors with the time phase of the review indicates that the questionnaire data collection in this study is all reliable so that it can be executed to the next analysis process.

3.3 Result of analysis of Severity Index (SI)

From the result of risk impact analysis using *SI* which has been summarized in Table 7, from contractor managerial risk factors there is no variable with "high" severity scale. The variable with the highest scale for cost and time severity only impacts the risk on a "medium" scale.

The results of the *SI* analysis on the cost of contractor risk managerial factors in 1st Phase and 2nd Phase of all variables have a "medium" impact scale on construction costs. In 3rd Phase, from 9 (nine) contractor risk managerial variables there are only 2 (two) variables with a low cost "cost" scale of the variables F9 and F8, while the other variables have a "medium" impact scale on costs. The results of the *SI* analysis of the time on the contractor's managerial risk factors in 1st Phase and 3rd Phase of the 9 (nine) variables there is only 1 (one) variable with the scale of "low" impact on construction work time is variable F9. In 2nd phase all the variables of the contractor's managerial risk factors show the "medium" impact scale over time.

Table 7. Results of Severity Index analysis (*SI*)

Var. Code	1st Phase		2nd Phase		3rd Phase	
	SI **Cost**	***SI*** **Time**	***SI*** **Cost**	***SI*** **Time**	***SI*** **Cost**	***SI*** **Time**
F1	0,410/Medium	0,480/Medium	0,450/Medium	0,490/Medium	0,400/Medium	0,470/Medium
F2	0,430/Medium	0,510/Medium	0,400/Medium	0,480/Medium	0,400/Medium	0,450/Medium
F3	0,450/Medium	0,510/Medium	0,490/Medium	0,490/Medium	0,430/Medium	0,530/Medium
F4	0,390/Medium	0,400/Medium	0,410/Medium	0,400/Medium	0,390/Medium	0,440/Medium
F5	0,510/Medium	0,520/Medium	0,430/Medium	0,510/Medium	0,430/Medium	0,480/Medium
F6	0,480/Medium	0,550/Medium	0,450/Medium	0,450/Medium	0,390/Medium	0,470/Medium
F7	0,440/Medium	0,510/Medium	0,400/Medium	0,470/Medium	0,410/Medium	0,470/Medium
F8	0,430/Medium	0,440/Medium	0,400/Medium	0,440/Medium	0,360/Low	0,400/Medium
F9	0,390/Medium	0,370/Low	0,400/Medium	0,430/Medium	0,370/Low	0,370/Low
G1	0,450/Medium	0,450/Medium	0,470/Medium	0,490/Medium	0,450/Medium	0,440/Medium
G2	0,430/Medium	0,470/Medium	0,410/Medium	0,440/Medium	0,430/Medium	0,450/Medium
G3	0,590/Medium	0,560/Medium	0,570/Medium	0,590/Medium	0,520/Medium	0,550/Medium
G4	0,430/Medium	0,470/Medium	0,400/Medium	0,430/Medium	0,440/Medium	0,410/Medium
G5	0,350/Low	0,390/Medium	0,360/Low	0,390/Medium	0,350/Low	0,370/Low
G6	0,400/Medium	0,370/Low	0,430/Medium	0,440/Medium	0,400/Medium	0,430/Medium
G7	0,410/Medium	0,470/Medium	0,440/Medium	0,410/Medium	0,450/Medium	0,480/Medium
G8	0,440/Medium	0,370/Low	0,400/Medium	0,360/Low	0,400/Medium	0,410/Medium
G9	0,510/Medium	0,510/Medium	0,470/Medium	0,470/Medium	0,440/Medium	0,410/Medium
G10	0,370/Low	0,400/Medium	0,410/Medium	0,410/Medium	0,410/Medium	0,400/Medium
G11	0,480/Medium	0,450/Medium	0,370/Low	0,400/Medium	0,360/Low	0,370/Medium

The results of the *SI* analysis on the cost of operational risk factors in 1st Phase of 11 (eleven) variables are only 2 (two) variables with a "low" impact scale on costs, ie, variables G5 and G10. In 2nd Phase and 3rd Phase, there are 2 (two) variables with a "low" scale ie variables G5 and G11 while all other variables have a "medium" impact scale on construction costs. The results of the *SI* analysis of the time on the operational risk factor in 1st Phase there are only 2 (two) variables with the "low" impact scale on the construction work time ie the variables G6 and G8. In 2nd phase there is 1 (one) variable with a "low scale" that is G8. In 3rd phase there is only 1 (one) variable with a "low scale" is the variable G5.

From the calculation of *SI* cost and time that have been summarized in Table 7 for each variable, it shows that in 1st Phase, 2nd Phase, and 3rd Phase the risk value to cost and time tends to decrease from 1st Phase to 3rd Phase. This is because from phase to phase the conditions in Aceh Province are stable enough so that the influence of these risk factors on the cost and time of construction is reduced.

4. Conclusions

The results of this study show the assessment of the impact of risks on costs and time derived from contractor and operational managerial risk factors. Project risk is one of them influenced by the assessment of the impact of risk. From the risk impact assessment using Severity Index (*SI*) analysis can be known how big the impact caused by the variable of a risk factor to the project target. In this study, the targets of the projects studied are cost and construction time.

Based on the assessment of the impact of risks on construction costs and timing, from contractor and operational managerial risk factors there is no variable with a "high" impact scale on cost and time. The highest severity value is in the "medium" impact scale range of costs and time. Nevertheless, the variables on these risk factors still have a different effect on the cost and timing of the construction in the three phases of the review.

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