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Risk Management of Time Overrun in Multiple Phases of Construction: Consultant Perspective

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ABSTRACT

This article reports a study on the construction of a food factory building in Indonesia by investigating the root causes of time overruns from the perspective of a consultant. Although many risks have been identified at various stages of the construction project, it is not clear which risk is the main cause of project delays. To better understand the optimization of risk management and risk mitigation, a multi-stage risk management is proposed, which is divided into four phases: pre-design, design, project bidding, and construction. Therefore, the use of bow tie analysis allows for more in-depth inspections to identify risks. From each bow tie diagram, a detailed risk mitigation table can be developed, and it is easier to plan the response to each risk. From this research, the top 5 reasons for the delay of the project were found. The first reason for the delay is X3a2, which has a value of 4.578, which is a change in design idea. The second value of X3c1 is 4.533, which is the technical data of new machines appearing. The third row is X2b4, the value is 4.467, waiting for owner's decision. The fourth place is the variable X1b3 Machine technical data appears after tender, with a value of 4.422, and the fifth place is the difference between local regulations and foreign regulations, with a value of 4.378.

Keywords**:** factory building, risk management, time overrun.

INTRODUCTION

Time overruns will affect work interruptions, low productivity, project delays, cost increases, third party claims and contract terminations. It refers to a long construction period due to problems that occurred during project implementation (Kikwasi, 2012). Unfortunately, project delays are a common risk and occur in almost all projects in Indonesia (Le Hoai et al., 2008) even though the supervisory function has been carried out properly. Susetyo, B. and Utami, T. (2017) stated that a project is considered successful if it meets the quality, cost and time targets.

Sudirman, W. B. and Hardjomuljadi, S. (2011) stated that project management can be defined as the application of knowledge, skills, tools, and techniques to complete projects in order to meet their requirements. Based on PMBOK Edition 6, the project management process consists of 5 process stages: initiation, planning, implementation, monitoring & control, and closure, but in this study we will focus on the initiation, planning, and implementation phases, as well as elaborating various risks. which can arise by identifying, measuring, mapping, developing alternative risk management, monitoring risks, and controlling risk management or prevention with a risk management system. Risk Management in the construction sector is very important to achieve project objectives (time, cost, quality and safety), the risk management system helps project managers in prioritizing resource allocation and also helps them in making more reliable decisions, thereby contributing to project success and achievement of objectives. This study elaborates the time overrun risk management. The object chosen is an 8-storey flour factory building located in an industrial area in Indonesia. This building is used as an object of research because of its high complexity, and risk management research can be carried out on a time overrun basis at all stages according to the research objectives, because all stages in this project have a time overrun.

RESEARCH PROBLEM AND OBJECTIVES

There are two main research problem: 1) How can the impact of risk factors cause the delay and how big the impact on the project? 2) How is risk handled? The research objectives are to analyse the impact of risk factors causing the delay and assess how big the impact is on the project. For research objectives to be achieved, it is necessary to make limitations that are adjusted to the research topic, given the wide scope of discussion in this project, namely regarding the delays that occur in each phase of the project from the point of view of the planning consultant. From the 5 phases of project management according to PMBOK 6th edition (initiating, planning, executing, monitoring & controlling, and closing), this research is limited to the initiating to executing phase which includes: pre-design phase, planning phase, tender phase, and construction phase.

LITERATURE REVIEW

Time Overrun

In research by Pai & Bharath (2013), time overrun is defined as slowing down work without stopping it altogether. Time overruns will result in work interruptions, low productivity, project delays, cost increases, third party claims, and termination of contracts. It refers to a long construction period due to problems that occurred during project implementation (Kikwasi, 2012). Lo, Fung & Tung (2006) and Assaf & Al-Hejji (2006) mention delay as the time that exceeds the contract date or exceeds the agreed date of the parties to complete the project. According to (Hasan, Suliman, and Malki, 2014), time overrun can be interpreted as a delay in project completion due to predictable and unpredictable reasons.

Type of Delay

There are two types of delays, namely unforgivable delays and forgivable delays (Tumi, Omran and Pakir, 2009; Hamzah et al., 2011; Ibironke et al., 2013). Unforgivable delays are delays caused by the contractor or its suppliers, through no fault of the owner. For example: difficulties in project financing by contractors, poor site management and supervision by contractors, poor communication, and coordination by contractors with other parties, and inadequate planning and scheduling (Hamzah et al., 2011). Meanwhile, forgivable delays are divided into two, namely compensated delays and non-compensable delays. Delays also affect costs; therefore, time overrun risk management must be applied to each construction.

Risk management

In accordance with the construction management expert training module by Umum (2007), there are 4 stages in risk management. The first stage is project risk identification, the second stage is project risk analysis which is divided into qualitative and quantitative analysis, the third stage is risk management output in the form of risk management strategies, and the last stage is risk monitoring and auditing to recommend risk prevention and mitigation actions.

MATERIALS & METHODS

This research begins by creating a research gap to find research methods and objects. After that, the research title was obtained for further research purposes, the formulation of the problem and the limitations of the research. Then, the research instruments are arranged in the form of variables collected through pilot surveys, primary data collection such as minutes of meetings, pictures, sequence variations, location memos, planning schedules, implementation schedules, revisions to implementation schedules, project budgeting, and others. Data that can be used as a reference in analyzing the factors. Then secondary data collection was done in the form of literature study.

After that, the collected variables were analysed for cause and effect using a bow-tie diagram, and then conducted a questionnaire to find rankings with RII. The final step of the research is to formulate solutions and prevent risks in the most impactful phase.

Surveys and Questionnaires

The questionnaire was made based on the variables collected from the literature review conducted by the author and the variables were collected through a pilot survey. The author conducted interviews with 5 experts who worked on consultants to assess the suitability of the variables in previous studies so that they could be the basis for research in the case studies that the authors took. The selected experts all work in consultants and know in detail about the project in the selected case study.

Furthermore, the obtained variables will be combined with other additional variables obtained from the pilot survey to obtain predictive variables that will be the basis before carrying out the analysis using the Bow-Tie Analysis method to look for causes and effects (Cause and Consequences) on the 4 phases which the authors classify as main variable. A total of 45 questionnaires have been given to experts as well as other parties who participated in the design & construction of the Flour Mill project. The main variable in this study is the construction stage which consists of the pre-design stage (Xa), the design stage (Xb), the tender stage (Xc) and the construction stage (Xd). Primary and secondary data collection is also needed to classify sub-variables for each main variable.

A total of 45 major risks were identified in this study. 20 risks adopted from Gunduz et al. (2013), and other risks were identified from expert input through a pilot survey. Data collection in this study was carried out when the construction progress reached 90% and neared project completion. The construction time started from August 2019 and underwent several revisions to the time schedule due to time overruns.

The questionnaire survey was conducted online to 58 respondents using a google form. In the survey conducted, the number of questionnaires returned was 45 respondents, while the other 13 results could not be used as research data because they were incomplete, so they did not meet the requirements.

The distribution of the survey was carried out evenly to all parties responsible for this project, with varying work experiences. A total of 11% of respondents had 0-5 years of experience, 31% of 6-10 years of experience, 31% of 11-17 years of experience and 27% of 20 years of experience.

The variables used in this study can be seen in Table 1.

Table 1. Research Variable

Var	Phase	No.	Var	Main Factor	Var	Sub Factor
Xa	**Pre-Design**	**1**	X1a	Building Permit	X1a1	Building permit data is different from site conditions
		2			X1a2	Lack of open spaces on site
		3			X1a3	Changes in development regulations
		4	X2a	Owner	X2a1	Issuance of Purchase Order and Late progress payments
		5			X2a2	In-depth feasibility study
		6	X3a	Supporting Data	X3a1	Incomplete As Built Drawing
		7			X3a2	Design idea changes
		8	X4a	Coordination	X4a1	Consultant presentation
		9			X4a2	The process of tendering and the implementation of new site

Table 1 Continued...						
Xb	**Design**	**10**	X1b	Consultant	X1b1	Differences in idealism with foreign consultants
		11			X1b2	Design Errors
		12			X1b3	The machine plan has not been fixed
		13			X1b4	Delay in production of drawings & tender documents
		14	X2b	Owner	X2b1	Late progress payment from owner
		15			X2b2	Late of design approval from owner
		16			X2b3	Changes from owner
		17			X2b4	Waiting for owner's decision
		18	X3b	Coordination	X3b1	Coordination meetings between consultants
		19			X3b2	Poor communication and coordination with other parties
		20	X4b	Software	X4b1	Drawing Information is in PDF format
		21			X4b2	Use of different software
		22	X5b	Regulatory Standards	X5b1	Differences between local and foreign regulations
		23	X6b	Scope of work	X6b1	Unclear scope of work
Xc	**Tender**	**24**	X1c	Schedule	X1c1	Determination of the long tender schedule
		25			X1c2	Many stages of clarification
		26	X2c	Tender Documents	X2c1	Post-meeting design revision
		27			X2c2	Design Changes
		28	X3c	Supporting data	X3c1	Machine technical data appears after tender
		29			X3c2	Tenders are carried out separately per scope of work
Xd	**Construction**	**30**	**X1d**	**External**	**X1d1**	**Weather factors**
		31			X1d2	Soil conditions
		32			X1d3	Late delivery of imported materials / machinery
		33			X1d4	Regional regulations
		34	X2d	Owner	X2d1	Owner request
		35			X2d2	Decision Making
		36			X2d3	Variation Order Price
		37	X3d	Implementation	X3d1	Additional work due to damage of existing buildings
		38			X3d2	Unfinished work.
		39			X3d3	Unclear scope of work
		40	X4d	Project Resources	X4d1	Number of workers
		41			X4d2	Material delivery
		42			X4d3	Heavy equipment damage
		43	X5d	Design	X5d1	Machine design changes
		44			X5d2	Design changes during construction
		45			X5d3	Differences in structure, architecture, and ME drawings

Statistical Analysis

The results of the validity test were carried out with SPSS software. With the validity test, it is believed that each question in this questionnaire provides valid results with the provisions of r Count > r Table. SPSS test results obtained r Count> 0.294 which means all factors are valid. The results of the reliability test on all the variables tested in this study stated that Cronbach's alpha was higher than the baseline value, namely 0.944> 0.60. These results prove that all of the variable statements tested on the questionnaire are reliable.

Hypothesis testing using multinomial regression coefficient test, which is used to determine whether the independent variables (Xa, Xb, Xc and Xd) in this study have a significant effect on the dependent variable (Y). There are 4 hypotheses in this study. (H1: Xa affects Y, H2: Xb affects Y, H3: Xc affects Y and H4: Xd affects Y). The results of the multinomial regression test resulted in sig < (0.05). The p-value for H1 is 0.000, the p-value for H2 is 0.001, the p-value for H3 is 0.018 and H4 is 0.001 where the four statements are <α (0.05) so that all statements H1, H2, H3 and H4 are accepted.

Bow-Tie Diagram

Baddredine (2014) explains, The Bow-tie Analysis Method was developed by the Shell company to describe the overall accident scenario. This model has proven its efficiency in several real applications such as; risk management, risk analysis, risk assessment and implementation of preventive barriers. So this model can be used for various branches of risk management, including in the construction sector. Bow-tie method is a quantitative analysis used in this study. This method is an early stage in the analysis of variable data. The initial stage of making Bow-tie

Analysis is to determine the source of the problem. The next stage is to determine the initial event taken from the variables contained in Table 1, then look for the cause why the incident occurred, find ways to solve the problem, and analyze the consequences of the incident. In this study, a bow-tie model was created to see the sequence of events causing delays, starting from finding all the sources of problems in this project, looking for preventive steps from the source of the problem, and looking for steps to reduce them, impact of the risks that have occurred. Figure 1 is a bow-tie diagram. After pre-modelling the bow-tie diagram, each variable was reanalyzed, looked for prevention and treatment steps and made into a model diagram using BowTieXP software.

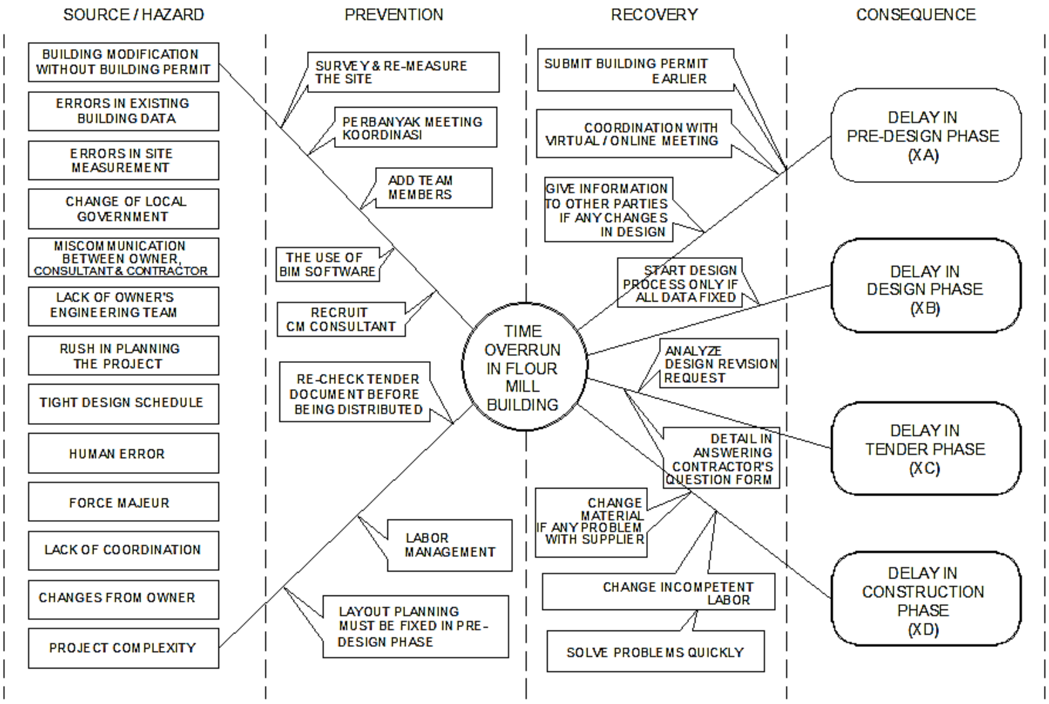

Figure 1. Bow-Tie Diagram

RESULT

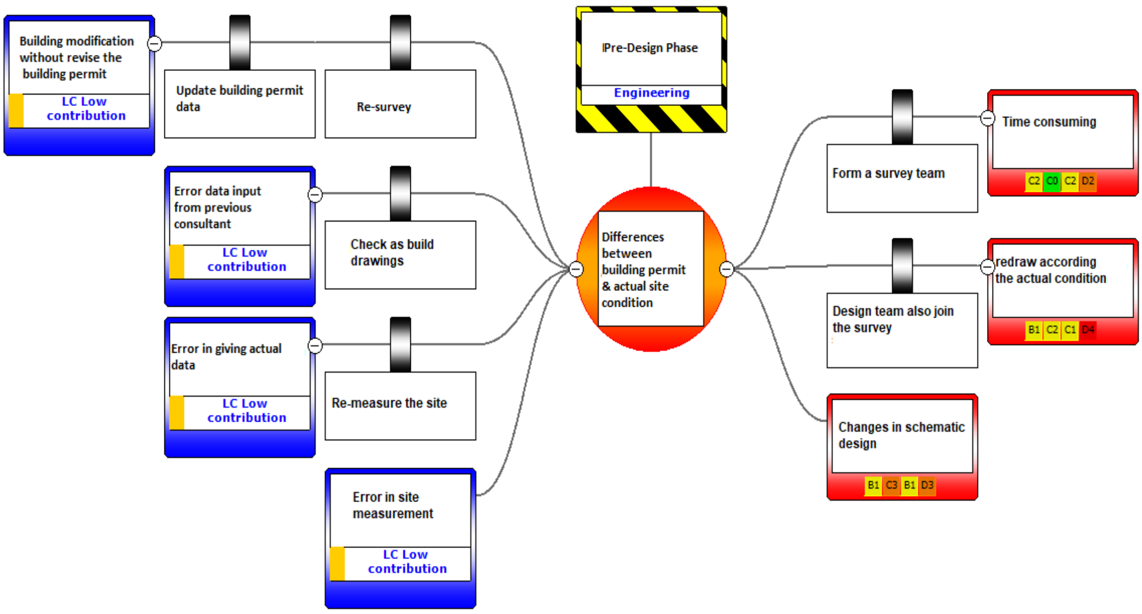

Figure 2. Bow-Tie Diagram

In this process, 45 bow-tie diagram models were obtained. Figure 2 is an example, in the pre-design phase there are 7 bowtie diagram models to see the initial causes and effects of each pre-designed variable. This X1a1 variable is the difference between the data of the existing building and the condition of the site. The reasons for the discrepancy were because the building had been modified without changing the IMB, errors in the IMB data entry from the previous consultant, errors in providing data from the owner, and measurement errors in the field.

While the consequences that arise from this variable are time consuming to conduct a re-survey to the site, redraw according to current conditions and changes to the design schematic drawings. The overall impact can be seen on the consequences/right side of the diagram. From each diagram that has been made, a risk mitigation table can be formulated by including prevention and risk management measures as can be seen in Table 2 below:

Table 2. Research Variable

Var	Sub Factor		Dampak Risiko		Langkah Pencegahan		Langkah Mengurangi
X1a1	Differences between building permit & actual site condition	o	Changes in schematic drawings and zoning of space requirements	o	Re-survey the site before conducting preliminary design	o	Revision of building permit drawings according to field conditions
		o	Changes in site calculation				
X1a2	Lack of open spaces on site	o	Constraints in managing building permits	o	Purchase of additional spaces beside the site	o	The management of the building permit is postponed until the planning of the new land begins
		o	Lack of space for directors of keet, materials, consulting offices				
X1a3	Changes in regulation	o	Design changes	o	Sesrch and update for latest regulation	o	Detailed design postponed until new regulation
		o	Building permit changes				

DISCUSSION

Relative Importance Index (RII)

It was found the top 5 causes of delays in this project. The first rank that caused the delay was X3a2 with a value of 4,578, namely changes in design ideas, the second rank was the variable X3c1 with a value of 4,533, namely Machine technical data appears after tender. The third rank is X2b4 with a value of 4,467, which is waiting for owner's decision. The fourth rank is variable X1b3 with an RII value of 4,422 and the fifth rank with an RII value of 4,378. RII can be seen in Table 3.

Table 3. RII

X3a2	**4.578**	**1**	**Design idea changes**
X3c1	4.533	**2**	Machine technical data appears after tender
X2b4	4.467	**3**	Waiting for owner's decision
X1b3	4.422	**4**	The machine plan has not been fixed
X5b1	4.378	**5**	Differences between local and foreign regulations
X2b2	4.333	**6**	Late of design approval from owner
X2b3	4.311	**7**	Changes from owner
X2d1	4.289	**8**	Owner’s request
X5d1	4.178	**9**	Changes in machine plan
X2c1	4.133	**10**	Post-meeting design revision
X4d1	4.133	**11**	Number of workers
X4b2	4.111	**12**	Use of different software
X1d3	4.111	**13**	Late delivery of imported materials / machinery
X5d2	4.089	**14**	Design changes during construction
X1b2	4.067	**15**	Design errors
X5d3	4.044	**16**	Unfixed design
X1d1	4.022	**17**	Weather condition

Table 3: Continued…			
X2d2	4.022	**18**	Decision making
X3b2	4.000	**19**	Bad communication and coordination
X4b1	3.978	**20**	Drawing information is in PDF format
X1d2	3.956	**21**	Soil condition
X2b1	3.911	**22**	Late progress payment by owner
X2a1	3.867	**23**	Issuance of Purchase Order
X3d2	3.844	**24**	Unfinished work
X3d3	3.844	**25**	Unclear scope of work
X4d3	3.844	**26**	Damage of heavy equipment
X1b4	3.778	**27**	Delay in production of drawings & tender documents
X6b1	3.756	**28**	Unclear scope of work
X1a3	3.622	**29**	Changes in regulation
X2d3	3.622	**30**	Variation order price
X4d2	3.622	**31**	Material delivery time
X2a2	3.600	**32**	Feasibility study
X4a1	3.600	**33**	Consultant presentation
X2c2	3.556	**34**	Design and drawing changes
X1c1	3.511	**35**	Determination of the long tender schedule
X4a2	3.422	**36**	The process of tendering and the implementation of new site
X1c2	3.378	**37**	Many stages of clarification
X1d4	3.200	**38**	Regional regulations
X1b1	3.178	**39**	Differences in idealism with foreign consultants
X3c2	3.156	**40**	Tenders are carried out separately per scope of work
X1a1	3.133	**41**	Building permit data is different from site conditions
X3a1	3.133	**42**	Incomplete As-built drawings
X3b1	3.133	**43**	Coordination meetings between consultants
X3d1	3.111	**44**	Additional work due to damage of existing buildings
X1a2	3.022	**45**	Lack of open spaces

Risk Response

According to Flanagan and Norman (1993) there are 4 types of response to risk, namely risk retention, risk reduction, risk transfer, and risk avoidance. If the risks that arise as a result of an activity have been identified, according to it, then actions are taken to reduce the risks that arise. After conducting surveys and interviews with experts, the response to risk can be seen in Table 4.

Table 4. Risk Response

PHASE	Var	Sub	Risk	Category	Response
PRE DESIGN (Xa)	X1a	X1a1	0,28	High	Reduction
		X1a2	0,10	Medium	Retention
		X1a3	0,20	High	Retention
	X2a	X2a1	0,28	High	Transfer
		X2a2	0,28	High	Transfer
	X3a	X3a1	0,10	Medium	Reduction
		X3a2	0,28	High	Reduction
	X4a	X4a1	0,10	Medium	Retention
		X4a2	0,10	Medium	Retention
	X1b	X1b1	0,10	Medium	Retention
		X1b2	0,14	Medium	Reduction
		X1b3	0,56	Very High	Reduction
		X1b4	0,28	High	Reduction
DESIGN (Xb)	X2b	X2b1	0,56	Very High	Transfer
		X2b2	0,72	Very High	Transfer
		X2b3	0,28	High	Retention
		X2b4	0,36	High	Transfer
	X3b	X3b1	0,20	High	Retention
		X3b2	0,56	Very High	Avoidance
	X4b	X4b1	0,28	High	Transfer
		X4b2	0,24	Very High	Retention
	X5b	X5b1	0,24	Very High	Retention
	X6b	X6b1	0,28	High	Avoidance
TENDER (Xc)	X1c	X1c1	0,28	Very High	Transfer
		X1c2	0,28	Very High	Retention
	X2c	X2c1	0,24	High	Retention
		X2c2	0,28	High	Retention
	X3c	X3c1	0,28	High	Reduction
		X3c2	0,24	Very High	Transfer

Table 4: Continued...					
KONSTRUKSI (Xd)	X1d	X1d1	0,28	High	Reduction
		X1d2	0,24	Very High	Retention
		X1d3	0,28	High	Reduction
		X1d4	0,10	Medium	Reduction
	X2d	X2d1	0,28	High	Transfer
		X2d2	0,36	High	Transfer
		X2d3	0,28	High	Transfer
	X3d	X3d1	0,20	High	Retention
		X3d2	0,28	High	Reduction
		X3d3	0,28	High	Avoidance
	X4d	X4d1	0,14	Medium	Reduction
		X4d2	0,20	High	Reduction
		X4d3	0,28	High	Reduction
	X5d	X5d1	0,56	Very High	Retention
		X5d2	0,72	Very High	Reduction
		X5d3	0,28	High	Avoidance

CONCLUSION

This study found 45 factors causing delays in all phases which were divided into 7 factors from the pre-planning phase, 14 factors from the planning phase, 6 factors from the tender phase and 16 factors from the construction or implementation phase. Recommendations for risk management with 4 options: retained, reduced, transferred or avoided by looking at the magnitude of the risk of each factor.

In the RII, which is sorted by all phases, it is found that the top 5 causes of delays in this project are found. The first reason for the delay is X3a2, which has a value of 4.578, which is a change in design idea. The second value of X3c1 is 4.533, which is the the technical data of new machines appearing. The third row is X2b4, the value is 4.467, waiting for owner's decision. The fourth place is the variable X1b3 Machine technical data appears after tender, with a value of 4.422, and the fifth place is the difference between local regulations and foreign regulations, with a value of 4.378.

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