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Risk-Based Evaluation of Large-Span Roof Building Structure using Roll Forming Construction Method to Increase Project Performance

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ABSTRACT

The large-span roof that is applied to many buildings nowadays are having some unique structural components, seen from its construction concept and design concept. Because of its uniqueness, several obstacles need to be considered. The application of roll forming machine in the making of the roof sheets can be used as a solution for several disputes that can happen while installing the large-span roof. The purpose of this research is to identify risk factors in large-span roof construction projects using the roll forming method. This research recruited 43 respondents in 24 different contractor companies. Based on the result of the questionnaire validation, this research analyzed 40 sub-variables need to be proceed into the qualitative risk analysis. Based on the outcome of the risk index assessment, there are 2 levels that need further scrutiny. It is the very high level of risk and the high level of risk. Regarding the risk level, some suggested strategy to improve the construction is to appoint an appropriate consultant, contractor, and construction management consultant, planning the detailed design and construction method, coordinate the roofing steel structure division, conduct some training for workers, and build a good collaboration between all stakeholders.

Keywords: Construction Method, Large-span Roof, Project Management, Roll Forming, Risk Management, Roof Structure

INTRODUCTION

Construction projects that adopt large-span roofs are starting to grow in big cities. Several obstacles need to be considered in building a large-span roof. Failures in choosing a construction method for building a large-span roof can make a major impact and even worse can inflict a financial loss. Construction methods that are not balanced with the weight of the roof load can be causing deformation and an inability to restrain the load. This research aims to identify risk factors in large-span roof construction projects using the roll forming method. The focus of this research is the production of the large-span roof, transport of the roof vertically and horizontally, and installing the roof.

The development of construction technologies provides a solution for large-span roof construction buildings, especially to deliver the needs of cross-sectional roofs without joints. One of the tools that can make this happen is roll forming machines. But several studies have stated that there are problems with the use of roll-forming machines to make large-span roofs. Further research on this topic is needed due to the lack of theories and concepts as a standardization for the large-span roof.

Based on the description above, this study analyzes risk factors that affect project performance and gives some strategic alternatives to minimize risk factors. The novelty of this research is the finding of risk variables for large-span roof building projects using the roll forming method that is suitable for conditions in Indonesia. The quotation of the variables is based on a literature review and the results of in-depth interviews with those who are experienced in working on large-span roof building projects.

LITERATURE REVIEW

Large-Span Building Structure

A large-span building system is a building structure that allows users to utilize free spaces. Free spaces in this structure system can be defined as a room that has columns with the widest possible span. The type of structure that is usually used is steel structure because of its high span capabilities (Zhou, Meng et.al. 2020). Moreover, a large-span steel structure is like steel bridge structures that can restrain various load effects and can support significant structural system transformations during a long construction process, which displays varying complex stress conditions (Zhou, Meng et.al. 2020).

Based on the definition and function of the large-span roof structure above, the large-span roof building has a unique structure in the construction and design process. Several obstacles need to be considered in building a large-span roof. Failures in choosing a construction method for building a large-span roof can make a major impact and even worse can inflict a financial loss. This kind of failure happened in 2006 at the new pavilion of Charles de Gaulle Airport in Paris due to the instability of the long-span roof and the shallowness of the structure (Carpinteri, A. et.al 2016)

Figure 1. Large-Span Roof Failure at the new pavilion of Charles de Gaulle Airport

Source: Daily Mail, 2010

Large-Span Roof Building Construction with Roll Forming Method

The project that requires continuous jointless roofs or roofs with complicated shapes and structures or both requires high-quality light steel. The light steel used in this project is cold-formed steel (Akmal, 2009). Not only on the roofing material, reducing the risks of transporting and supervising continuous roofing sheets, eliminating step joints and expansion joints, and allowing the production time to be in line with the installation schedule, demand some tools that support the installation of those roofing sheets.

Roll forming machines are a tool that can form metal sheets that are used to make long sheets with a constant cross-sectional and can be customized (Alsamhan, A. et.al 2003). Some of the advantages of the roll forming method include it can produce a roof without any joints. Moreover, it helps to transport the roof vertically and horizontally. This is advantageous for the management because it can help the project team coordinate easily and can be adapted to the site conditions. The two methods options, which are rolled ground method and the roll to roof method, provide flexibility to deliver design requirements and design application. Another advantage of using this machine is the removal of splices can reduce the need for purlins, reduce labor, and reduce the installation time. In addition, it can save on construction costs because it reduces the cost of cranage to lift the tarpaulin roof to the large-span roof and reduces ongoing maintenance problems.

Several studies have stated that there are problems with the use of roll-forming machines to make large-span roofs. Dubrava, V (2013) found that problems happened several times while installing the large-span roof using a roll forming machine, in both vertical and horizontal traffic. When installation, the large-span roof is very vulnerable to wind speed and high rainfall. Thus far, there are still no theories and concepts that become the basis for calculating wind loads and design standardization for a large-span roof.

Jooa, B. D., Leea, H. J., Kimb, D. K., & Moona, Y. H. (2011) stated while during the machine forming the roof coil, roll forming execution using high-strength steel can cause defects when forming the roof coil, such as causing spring back, buckling, and scratches. Dubrava, V (2013) stated that the use of high-strength steel in forming the roof coil can result in some problems in controlling the deformation behavior, including longitudinal strain, longitudinal bending transverse bending, and shear forces. In addition, Carpintery, L. et.al. (2016) stated that the large span structure on the roof is prone to instability due to linear and nonlinear instability caused by the load and support of steel arches. All these things can cause the large-span roof to collapse.

Risk Factors in Large-Span Roof Building Project with Roll Forming Method

One of the most important aspects of construction management is project risk management. Project risk management is a series of planning, scheduling, monitoring, and controlling all project activities. Cited from the Project Management Guide, which defines risk management as the management of time or duration, achievements, and activities to achieve some goals. The goals must be determined by the project leader. In addition, the project leader must provide the right direction to manage existing resources properly. Agsarini, I., & Wiguna, I. A. (2015) stated that the elements in time management are as follows: (1) Planning; (2) Organizing; (3) actuating; (4) coordinating; (5) controlling and (6) evaluation. And then several studies have found factors that have the potential to affect construction execution time. For example, Andi et.al (2003) stated that the factors that affect the time of construction implementation are labor, finance, materials, equipment, managerial and other factors. Desai and Bhatt (2013) found 59 factors with 9 major categories that affect the time of construction, namely: project, material, owner, equipment, contractor, consultant, design, material, labor, and external factors.

Each construction project has different risks depending on the type of project and the environmental conditions of the project, thus requiring different project implementation methods. Risk can be defined as the probability of an outcome that is different from what is expected (Darma, A., 2017), therefore risk management must be applied to every construction work, to reduce the occurrence of accidents in construction work (Groover, M. P. (2007). However, other risks that have the potential to occur can be classified according to the source of the risk. Research from Rezakhani, P. (2012) distinguishes risk into two sources, namely non-technical risk, and technical risk.

The variety of the risk of a construction project has three (3) main items that become general risk priorities, namely cost, time, and quality (Sohrabinejad & Rahimi, 2015). The three risk priorities then form interrelated risk variables to form an analytical network consisting of (1) Design; (2) Construction Method; (3) Construction Management; (4) Manpower; (5) Tools; (6) Material; (7) External factors (British Standards Institution, 2006). The seven variables make up the sub-variables based on the reference as shown in Table 1.

Table 1. Risk Variables in Large Span Roof Projects with Roll Forming Method

Risk	*Variable*	*Reference*
	X1. Design	
X1.1	Changes in design and scope of work	Joo, Byeongdon, et.al (2011)
X1.2	Errors in analyzing design phase to control the roof construction	Joo, Byeongdon, et.al (2011)

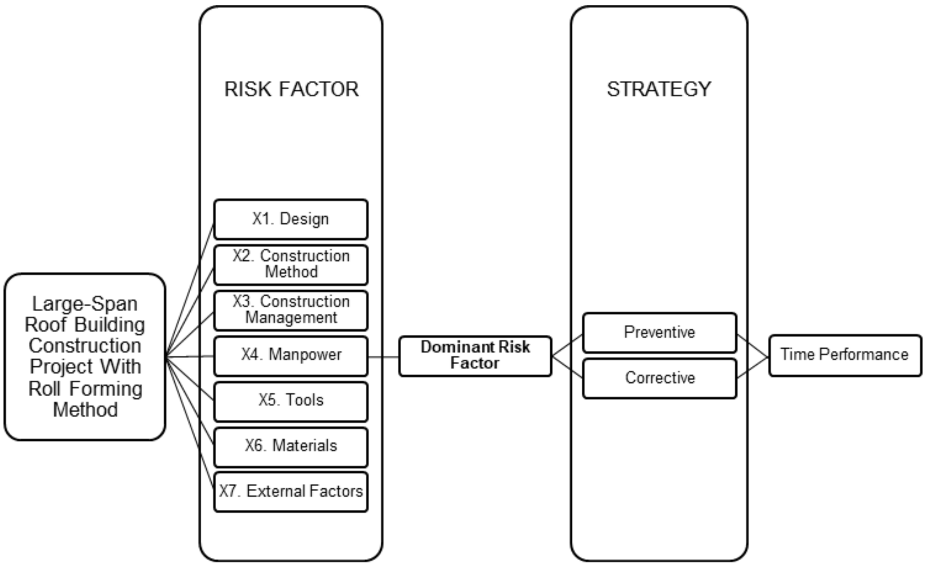
X1.3	Need a design phase analysis to control the roof construction	Milad R. et.al (2020)
X1.4	Customized (owner request) require human resources with high expertise in design and construction	Qin Yang. et.al. 2018
X1.5	The gap between planning and implementation	Joo, Byeongdon, et.al (2011)
	X2 Construction Method	
X2.1	Failure in verifying the Structure phase	Mistakidis, et.al (2020)
X2.2	Method that planned before is not based on the real conditions	Joo, Byeongdon, et.al (2011)
X2.4	Failure to choose roof segmentation	Milad R. et.al (2020)
X2.5	Failure in planning and scheduling	Joo, Byeongdon, et.al (2011)
X2.6	Failure to consider project characteristics	Joo, Byeongdon, et.al (2011)
X2.7	Manpower indiscipline in determining segments	Joo, Byeongdon, et.al (2011)
X2.8	The safety plan does not match the planned method	Mistakidis, et.al (2020)
	X3. Construction Management	
X3.1	Installation does not match with specifications or drawing plan	Mistakidis, et.al (2020)
X3.2	Work sequence does not plan based on the risks	Mistakidis, et.al (2020)
X3.4	Failure in planning the definition of project activities completely	Mistakidis, et.al (2020)
X3.5	Integrated communication is weak	Qin Yang. et.al. (2018)
X3.6	Lack of commitment to Standard Operating Procedure (SOP)	Qin Yang. et.al. (2018)
X3.7	Weak in planning, especially in determining the method of roof construction	Qin Yang. et.al. (2018)

X3.8	Weak in organizing the implementation of roof construction work	Qin Yang. et.al. (2018)
X3.9	Weak in HR Management (supervisor-technician)	Qin Yang. et.al. (2018)
	X4. Manpower	
X4.1	Labor productivity is lower than demand	Joo, Byeongdon, et.al 2011; Carpinter, et.al (2016)
X4.2	Labor specialization not according to plan	Joo, Byeongdon, et.al 2011
X4.3	The number of workers does not match the plan	Mistakidis, E. et.al. 2014
X4.4	Procurement of labor is not following the site's needs	Desai dan Bhatt, 2013
X4.6	The manpower is not ready for the implementation of the new method	Qin Yang. et.al. (2018)
X4.8	Labor qualifications are not according to plan	Carpinter, et.al (2016)
X4.9	Worker's duties and authorities are not according to the plan	Desai dan Bhatt, 2013
X4.10	Work time schedule surpasses the planning	Mistakidis, E. et.al. 2014
X4.11	The labor wages to be paid to surpass the planning	Desai dan Bhatt, 2013
	X5. Tools	
X5.1	The productivity of the tools that are planned does not match the needs	Joo, Byeongdon, et.al 2011
X5.2	Amount of the equipment planned does not match the needs	Mistakidis, E. et.al. 2014
X5.3	Unscheduled use of equipment	Desai dan Bhatt, 2013
X5.4	The equipment used is not in accordance with the planned implementation method	Qin Yang. et.al. (2018)
	X6. Material	
X6.1	The materials specifications that are used do not match	Joo, Byeongdon, et.al 2011

X6.2	Materials deform easily	Mistakidis, E. et.al. 2014
X6.3	Defects when forming the roof coil, such as causing spring back, buckling, and scratches.	Desai dan Bhatt, 2013
X6.4	Inflexible shape affects space utility	Qin Yang. et.al. (2018)
	X7. External Factors	
X7.1	Weather conditions are not according to plan	Joo, Byeongdon, et.al 2011
X7.2	No Work Instruction	Mistakidis, E. et.al. 2014
X7.3	Difficult to find theory or concept to calculate wind load	Desai dan Bhatt, 2013

To decide on strategies to minimize the risk factors, a preventive study is conducted on risk factors that have not yet occurred, and a corrective study on the impact of these risks. The description of these activities is illustrated in the conceptual framework of this research.

Figure 2. Research Conceptual Network



RESEARCH METHOD

This study uses a post-positivism approach where information is obtained based on the subjective experience of the informant. The analysis is built based on the results of interviews and surveys related to the risk factors of large-span building construction with Roll Forming method projects and strategies to minimize these risk factors. The method used to collect data is quantitative method and qualitative method. Quantitative methods are implemented with the main objective of mapping risk factors. To obtain data, a survey was conducted using a non-probability sampling technique. For non-probability sampling method that is used in this research is purposive sampling. Qualitative methods are

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implemented by in-depth interviews with experienced experts in the construction field. 5 respondents in this research were selected based on experience.

The risk level in this research uses the probability-impact matrix developed by Dumbrava, V. (2013) which refers to a 5x5 matrix with its impacts ranging from the very low grade to the very high grade on the horizontal axis and the probability (with the same grade range) on the vertical axis. Probability-impact matrix developed by Dumbrava, V. (2013) allows coverage of risk levels in large-span roof building projects using the roll forming method.

Figure 3. Probability-Index Matrix

Very High	vl, vh	l, vh	m, vh	h, vh	vh, vh
High	vl, h	l, h	m, h	h, h	vh, h
Moderate	vl, m	l, m	m, m	h, m	vh, m
Low	vl, l	l, l	m, l	h, l	vh, l
Very Low	vl, vl	l, vl	m, vl	h, vw	vh, vl
	Very Low	Low	Moderate	High	Very High

Source: Dumbrava, V. (2013)

The five zones are stated as follows:

1. Dark red: The risks factors in this zone are critical and must be avoided or removed; this is a top priority, and attention must be paid.
2. Light Red: The risks factors in this zone are very important and should be avoided, reduced, and diverted; this is a priority, and attention should be given.
3. Yellow: The risk factors in this zone are quite important and must be controlled.
4. Light Green: The risks factors in this zone are considered low-level effects that can be monitored and controlled, especially if they are in the dark green zone
5. Dark Green: The risks factors in this zone have a very low level of impact that can be monitored, controlled, or ignored.

RESULTS

Profile

This research recruited 43 respondents who all worked in contractor companies. All the 43 respondents worked in 24 different contractor companies. The education level of the respondents also varied, with most respondents is from bachelor's degree (53,3%), followed by master's degree (23,3%), while diploma degree and vocational high school respectively 11,6%.

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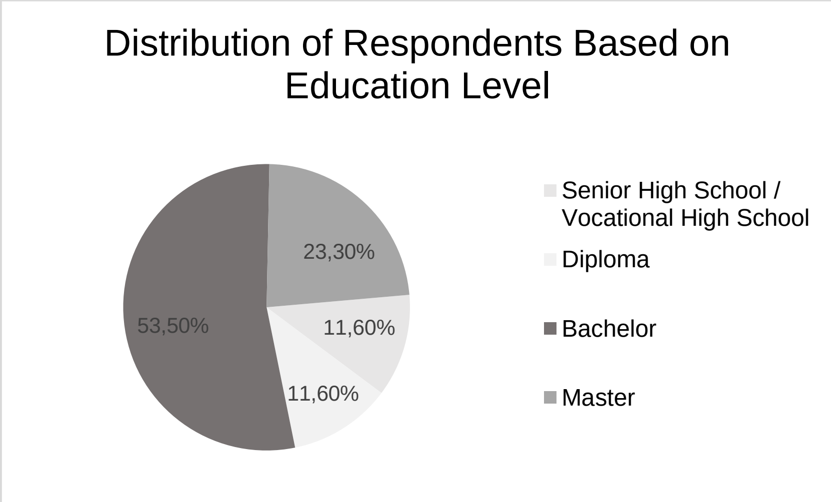
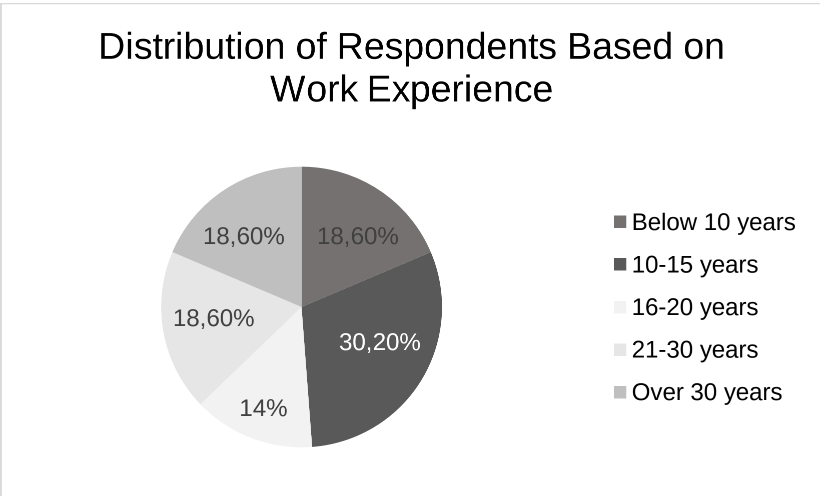
Figure 4. Chart of Respondents Based on Education Level



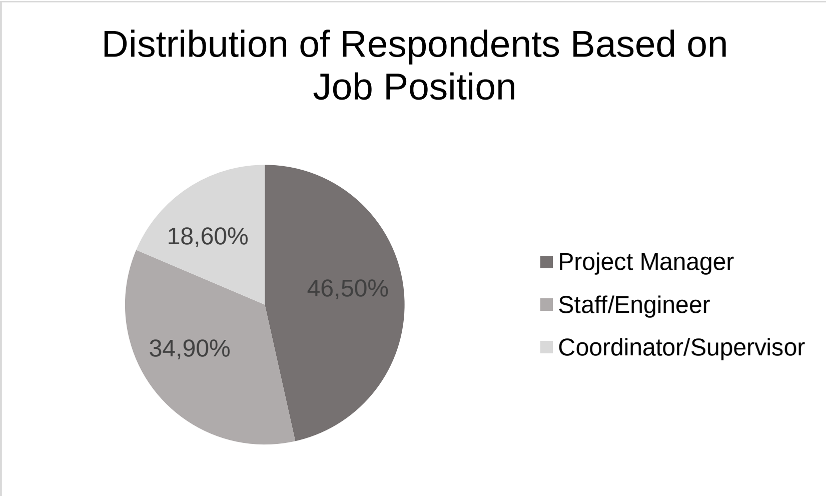
Not only in education level, but all the 43 respondents also have different work experiences. The dominant respondent's work experience (30.2%) is 10-15 years, then 16-20 years' work experience is 14%, 21-30 years' work experience, experience above 30 years and experience below 10 years each have a percentage of 18.6%.

Figure 5. Chart of Respondents Based on Work Experience



The variation of respondents also occurs in job positions. As shown in Figure 5.4. there are 3 (three) categories of positions held by respondents. The most category of job positions is Manager/PM, which is 46.5% of the total respondents. Then followed by staff/engineers (34.9%) and the rest were coordinators/supervisors (18.6%).

Figure 6. Chart of Respondents Based on Job Position



Risk Qualitative Analysis

Based on the results of the validity of the questionnaire, this study analyzed 40 sub-variables that could proceed to the next stage, namely the stage of qualitative risk analysis. Probability and Impact Matrix in PMBOK (2016) as a guide in analyzing risk levels. As stated earlier that the assessment of the frequency and impact of risk is carried out by selecting 5 (five) conditions which are Likert scales, together with this score has been assigned for each condition (PMBOK, 2016). Table 2 is the scale value for risk frequency and its score, while table 3 is the scale value for risk impact and its score.

Table 2. Frequency Scale Value

Scale	1	2	3	4	5
Frequency Criteria	Very unlikely to happen, only in certain conditions	Less likely to occur under certain conditions	Quite possible in every condition	May happen in every condition	Very possible
Score	0,1	0,3	0,5	0,7	0,9

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Table 3. Impact Scale Value

Scale	1	2	3	4	5
Impact Criteria	Not significant	Less significant	Moderately significant	Significant	Very significant
Score	0,05	0,1	0,2	0,4	0,8

Moreover, the 40 variables become inputs in this ranking analysis. The method of analyzing the risk rating is to calculate the average value of the impact and the frequency of the risk that has previously been scored based on the Probability and Impact Matrix. The average value of the frequency and impact of risk will be multiplied (Risk = Frequency x Impact) to get the Risk value. Next, the risk values will be sorted and given the highest risk rating to the lowest rating (High, Medium, and Low). The recapitulation of the frequency and impact assessment from respondents can be seen in Table 4.

Table 4. Recapitulation of the Frequency and Impacts from Respondents

Risk	*Frequency Recapitulation*					*Total*	*Impact Recapitulation*					*Total*
	1	2	3	4	5		1	2	3	4	5	
X1.1	2	2	8	25	6	43	0	3	6	24	10	43
X1.2	2	3	5	27	6	43	0	3	4	29	7	43
X1.3	2	1	6	33	1	43	1	1	5	31	5	43
X1.4	0	1	5	30	7	43	0	3	2	32	6	43
X1.5	0	2	4	35	2	43	0	3	3	29	8	43
X2.1	1	9	13	20	0	43	1	1	2	31	8	43
X2.2	0	6	5	29	3	43	0	3	5	28	7	43
X2.4	0	12	20	9	2	43	0	2	8	28	5	43
X2.5	1	4	5	29	4	43	0	0	6	33	4	43
X2.6	0	8	14	16	5	43	0	4	3	34	2	43
X2.7	0	5	8	21	9	43	0	2	9	27	5	43
X2.8	1	3	8	26	5	43	0	9	18	10	6	43
X3.1	0	9	18	15	1	43	0	7	18	13	5	43

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X3.2	1	5	13	22	2	43	0	0	10	27	6	43
X3.4	0	3	9	28	3	43	0	3	10	22	8	43
X3.5	0	3	4	31	5	43	0	3	5	32	3	43
X3.6	0	3	4	29	7	43	0	20	9	12	2	43
X3.7	0	2	7	30	4	43	0	0	2	36	5	43
X3.8	1	2	9	30	1	43	0	1	2	33	7	43
X3.9	1	2	4	35	1	43	0	0	11	32	0	43
X4.1	0	3	4	31	5	43	0	0	11	27	5	43
X4.2	1	3	8	26	5	43	0	0	1	37	5	43
X4.3	0	3	9	28	3	43	0	7	18	12	6	43
X4.4	0	10	16	17	0	43	1	1	5	31	5	43
X4.6	1	5	13	22	2	43	0	3	2	32	6	43
X4.8	1	3	9	25	5	43	0	2	10	26	5	43
X.10	0	3	9	28	3	43	0	3	5	32	3	43
X4.11	0	10	16	17	0	43	0	3	6	28	6	43
X5.1	2	2	8	24	7	43	0	0	12	27	4	43
X5.2	0	3	4	29	7	43	0	1	5	30	7	43
X5.3	1	9	13	20	0	43	0	0	8	30	5	43
X5.4	0	10	16	17	0	43	0	0	4	35	4	43
X5.5	1	8	14	20	0	43	0	1	5	34	3	43
X6.1	2	14	17	10	0	43	0	0	11	29	3	43
X6.2	2	7	4	27	3	43	0	0	8	28	7	43
X6.3	2	11	14	10	6	43	0	3	10	26	4	43
X6.4	1	20	11	9	2	43	0	1	14	26	2	43
X7.1	0	5	6	25	7	43	0	2	8	26	7	43
X7.2	2	21	11	6	3	43	0	1	19	20	3	43

X7.3	3	4	4	28	4	43	0	7	28	8	0	43

The next stage is the risk index assessment. The risk index assessment is carried out by multiplying the frequency and impact so the level of each risk can be seen. The index assessment and the level of each risk can be seen in table 5.

Table 5. Risks Level from each Risks Variable

Sub. Var.	*Potential Risk*	*Frequency*	*Impact*	*Risk Value*	*Risk Level*
X1.1	Changes in design and scope of work	0,6	0,4	0,29	High
X1.2	Errors in analyzing design phase to control the roof construction	0,6	0,4	0,28	High
X1.3	Need a design phase analysis to control the roof construction	0,6	0,4	0,26	Moderate
X1.4	Customized (owner request) require human resources with high expertise in design and construction	0,7	0,4	0,3	Very High
X1.5	The gap between planning and implementation	0,7	0,4	0,3	Very High
X2.1	Failure in verifying the Structure phase	0,5	0,5	0,24	Low
X2.2	A method that planned before is not based on the real conditions	0,6	0,4	0,27	High
X2.4	Failure to choose roof segmentation	0,5	0,4	0,2	Low
X2.5	Failure in planning and scheduling	0,6	0,4	0,26	High
X2.6	Failure to consider project characteristics	0,6	0,4	0,22	Low

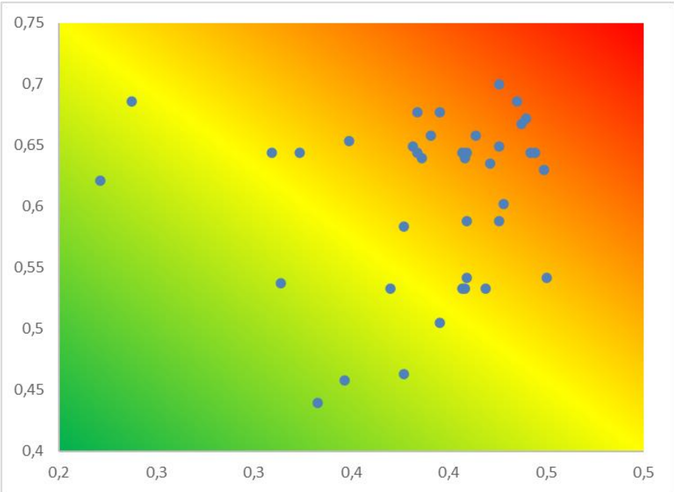
X2.7	Manpower indiscipline in determining segments	0,7	0,4	0,26	Moderate
X2.8	The safety plan does not match the planned method	0,6	0,3	0,2	Low
X3.1	Installation does not match with specifications or drawing plan	0,5	0,3	0,17	Very Low
X3.2	Work sequence does not plan based on the risks	0,6	0,4	0,24	Low
X3.4	Failure in planning the definition of project activities completely	0,6	0,4	0,26	Moderate
X3.5	Integrated communication are weak	0,7	0,4	0,26	Moderate
X3.6	Lack of commitment to Standard Operating Procedure (SOP)	0,7	0,2	0,16	Very Low
X3.7	Weak in planning, especially in determining the method of roof construction	0,7	0,4	0,29	Very High
X3.8	Weak in organizing the implementation of roof construction work	0,6	0,4	0,28	High
X3.9	Weak in HR Management (supervisor-technician)	0,7	0,3	0,23	Low
X4.1	Labor productivity is lower than the demand	0,7	0,4	0,27	High
X4.2	Labor specialization not according to plan	0,6	0,4	0,28	High

X4.3	The number of workers does not match the plan	0,6	0,3	0,21	Low
X4.4	Procurement of labor is not in accordance with the site's needs	0,5	0,4	0,22	Low
X4.6	The manpower is not ready for the implementation of the new method	0,6	0,4	0,25	High
X4.8	Labor qualifications are not according to the plan	0,6	0,4	0,25	High
X4.10	The work schedule surpasses the planning	0,6	0,4	0,25	High
X4.11	The labor wages to be paid surpass the planning	0,5	0,4	0,22	Moderate
X5.1	The productivity of the tools that are planned does not match the needs	0,6	0,4	0,25	High
X5.2	Amount of the equipment planned does not match the needs	0,7	0,4	0,3	Very High
X5.3	Unscheduled use of equipment	0,5	0,4	0,22	Moderate
X5.4	The equipment used is not in under the planned implementation method	0,5	0,4	0,22	Moderate
X6.1	Materials specifications that are used do not match	0,5	0,4	0,17	Low
X6.2	Materials deform easily	0,6	0,4	0,26	High
X6.3	defects when forming the roof coil, such as causing spring back, buckling, and scratches.	0,5	0,4	0,2	Low
X6.4	Inflexible shape affects space utility	0,5	0,3	0,16	Low

X7.1	Weather conditions are not according to the plan	0,7	0,4	0,27	High
X7.2	No Work Instruction	0,4	0,3	0,15	Very Low
X7.3	Difficult to find theory or concept to calculate wind load	0,6	0,2	0,14	Very Low

Figure 7 is a visualization of the risk level, which shows the number of variables with moderate and high-risk levels more than those with lower risk levels.

Figure 7. Visualization of the Risk Level



Based on this risk level, two levels need further scrutiny, namely the very high level of risk and the high level of risk. The very high-risk level consists of 4 variables, there are:

1. X1.4 - Customized (owner request) require human resources with high expertise in design and construction
2. X1.5 - The gap between planning and implementation
3. X3.7 - Weak in planning, especially in determining the method of roof construction
4. X5.2 - Amount of the equipment planned does not match the needs

The high-risk level consists of 12 variables, there are:

1. X1.1 Changes in design and scope of work
2. X1.2 Errors in analyzing the design phase to control the roof construction
3. X2.2 Method that was planned before is not based on the real conditions
4. X2.5 Failure in planning and scheduling
5. X3.8 Weak in organizing the implementation of roof construction work
6. X4.1 Labor productivity is lower than demand
7. X4.2 Labor specialization not according to plan
8. X4.8 Labor qualifications are not according to the plan
9. X4.10 Work schedule surpasses the planning
10. X5.1 Productivity of the tools that are planned does not match the needs

11. X6.2 Materials deform easily
12. X7.1 Weather conditions are not according to plan

Strategy for Improving the Large-Span Roof Building Construction using Roll Forming Method

To answer the strategy of improving large-span roof building construction using the roll forming method below is described the improvement strategy, that is:

1. Project owner must appoint construction management consultant that can assist owner in make a Term of Reference and estimate the time needed to work on the project. Project owner must choose consultants and contractors who have experienced in large-span roof projects.
2. Implementation of Large-Span Roof Building Project using Roll Forming Method:
    a. Plan the design and construction method
    b. Prepare some equipment that is used according to design and construction methods. If the equipment is not available, immediately seek a vendor that meets the design and construction method
    c. From project manager perspective:
        i. Manage roofing steel structure division by coordinating and assigning responsibility to the site manager for each segment of the roll forming roof component.
        ii. Make horizontal and vertical lifting methods, either manually or mechanically.
        iii. The method of lifting the roof manually is carried out in a narrow area with on-ground roll forming
        iv. Method of lifting the large-span roof with elevated roll forming if the project site is spacious
    d. Conduct some training for workers that involved in the project
        i. Training aimed gradually starting from supervisors, practitioner, foremen, and workers.
        ii. Training aims to equate perceptions of the implementation of construction, including the Standard Operating Procedures (SOP), details of Occupational Health and Safety (OHS) rules, and the details of construction method.
    e. Project manager conduct coordination meetings gradually, starting with site managers, engineering managers, supervisors, practitioners, quality control, OHS, foreman, and workers.
    f. OHS manager overcome with weather problems
3. Reduces misunderstanding in the project
    a. Building collaboration between stakeholders to exchange information efficiently and collaborate in making development/construction projects more efficient so that there are fewer errors.
    b. Conduct coordination meetings regularly between stakeholders (owners, planners, contractors) and all meeting decisions are binding and must be implemented. The purpose of the coordination meeting is to:
        i. Increase productivity among stakeholders.
        ii. Detect mitigation/reduce risk in the planning process, and uncertainty, and analyze potential impacts.
        iii. Solving problems and optimizing resources (cost, time, human resources)
        iv. Solve technical drawing problems
        v. Minimize the occurrence of variance order (VO).

DISCUSSION

To answer the strategy of improving large-span roof building construction using the roll forming method below is described the recommendation for the construction, that is:

1. It is recommended that large-span roof building construction projects use the roll forming method to obtain buildings that have high and unique aesthetics while minimizing the risk of leakage.
2. Increase suppliers of lifting equipment (mobile cranes) above 50 tons.
3. To ensure the quality of the planning personnel, the project owner requires the possession of a certificate of expertise/professionalism with the main grade.
4. In addition to the requirements for having a certificate of expertise/professionalism with the main grade, they also have leadership in managing project activities, time, quality, and cost.

CONCLUSION

To answer the research question, it can be concluded as follows:

1. The project owner must appoint an appropriate consultant, contractor, and construction management consultant to make a Term of Reference and estimate the time needed.
2. Planning the design and construction method in detail, specifically in prepare some equipment and make horizontal and vertical lifting methods either manually or mechanically.
3. Manage roofing steel structure division through several segments by coordinating and assigning responsibility to the site manager.
4. Conduct some training for workers that involved in the project gradually including supervisors, practitioners, foremen, and workers to equate perceptions of the implementation of construction.
5. Building collaboration between stakeholders' exchange information efficiently and must conduct coordination meetings regularly between stakeholders.

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DECLARATION OF CONFLICTING INTERESTS

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