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Factors Affecting Improved Project Performance Using Lean Six Sigma Methods and Time Cost Trade Off for the Ammunition Warehouse Project of Indonesia

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ABSTRACT

Warehouse development in Indonesia has increased in 2013, data from the Ministry of Trade, in 2013 the number of warehouses in Indonesia is estimated to reach 9,300 units, up 18% from 2012, but the cost of building warehouses in Indonesia is relatively higher compared to some other countries. A warehouse is a special, fixed facility designed to achieve the target service level with the lowest total cost. Warehouses are needed in the process of coordinating the distribution of goods, which arises as a result of an unbalanced supply and demand process. The lack of balance between the demand and supply processes encourages the emergence of inventory (inventory), inventory requires space as a temporary storage area known as a warehouse [1]. The main function of a warehouse is as a storage area for raw materials, intermediate goods, and a place for storing final goods. In the implementation of a construction project, the quality of work execution and the timing of the work are indicators of the success of a construction project. One of the aspects of quality and time is analyzed using the Lean Six Sigma method and Time Cost Trade Off. The purpose of this study is to analyze the factors that influence the improvement of the project performance based on Lean Six Sigma and Time Cost Trade Off in the ammunition warehouse project. The tool used to obtain 10 influencing factors is using SPSS (Statistical Package for the Social Sciences). The results of the study of 10 influencing factors are: 1. Inadequate planning and scheduling, 2. Job-plan execution, 3. Delay in drawing preparation and approval, 4. Cost reduction, 5. Relationship between management, and labor. 6. Relationships within the design team, 7. Lack of skilled manpower, 8. Flexibility, 9. Errors during construction, 10. Inaccurate prediction of craftsmen production It is concluded that, the optimization of time performance and quality of work on this ammunition warehouse project.

Key Words: Warehouse Ammunition, Lean Six Sigma, Time Cost Trade Off, SPSS.

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1. INTRODUCTION

According to data from the Ministry of Trade, in 2013 the number of warehouses in Indonesia is estimated to reach 9,300 units, up 18% from 2012. Adequate warehouse management is an important thing to do to reduce costs, optimize space and time to order picking. [2].

Figure 1.1 Warehousing Infrastructure Development Direction

Warehouse costs in Indonesia are relatively higher compared to several other countries, amounting to 9.47% of Gross Domestic Product (State of Logistics Indonesia, 2013). In comparison, the cost of warehousing in the United States contributes 2.8% [3], India amounted to 3,8%, Brazil is estimated to be a maximum of 4.1% [4], Tiongkok amounted to 6,3%, dan Thailand amounted to 7,6% [5]. The data above, if presented in graphical form, is as follows:

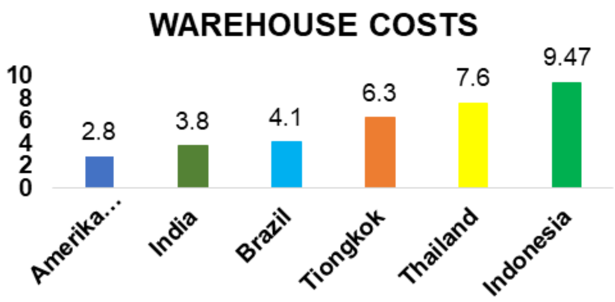

Figure 1.2 Percentage Graph of Warehouse Costs Against Gross Domestic Product

In the implementation of a construction project, the quality of the work is an indicator of the success of a construction project. One aspect of quality that is of concern is the work of Lean Six Sigma. Lean Six Sigma work is considered to be one of the endemic symptoms affecting cost. The costs of Lean Six Sigma on most construction projects are large, ranging from 5% to 20% of the contract value. Meanwhile, rework costs for warehouse construction and industrial building work ranged from 2.4% to 12.4%[6]. The method that will be used to speed up the project duration in this final project is the Time Cost Trade Off method or also known as the cost-to-time exchange method, which is an analysis method that aims to accelerate the time and costs of a project.

2. DEFINITION OF LEAN SIX SIGMA, TIME COST TRADE OFF AND WAREHOUSE

2.1 LEAN SIX SIGMA

Lean Six sigma is a combination of lean and six sigma which can be defined as a business philosophy, systemic and systematic approach to identify and eliminate waste or activities that are not value added through radical continuous improvement to reach the six sigma level. , by flowing products and information using a pull system (Pull) from internal and external customers to pursue excellence and excellence by producing only 3.4 defective products for every one million opportunities or productions. The integration between lean and six sigma will improve business and industry performance through increased speed and accuracy. The lean approach aims at exposing Non-Value Added and Value Added as well as making Value Added flow smoothly along the value stream processes, while Six Sigma will reduce these Value Added variations. [7].

2.1.1 DEFINITION OF SIX SIGMA

The Six Sigma concept could provide Motorola with a simple and consistent way to track and compare customer performance and requirements (six sigma measures) and an ambitious target of practically perfect quality (six sigma goal). Accurate material calculations will reduce waste from the material transportation side, especially the distance in the material supplier and location [8]. The six sigma method is a process that applies statistical tools and defect reduction techniques until it is defined as no more than 3.4 defects out of one million opportunities to achieve total customer satisfaction. Six sigma provides added value to customers and stakeholders by focusing on improving the quality and productivity of the company [9].

2.1.2 STAGE OF SIX SIGMA

The most determining factors for improving process quality and generating profit consist of 5 stages called DMAIC (define, measure, analyze, improve, control). The following is an explanation of the DMAIC stages in Six Sigma [10].

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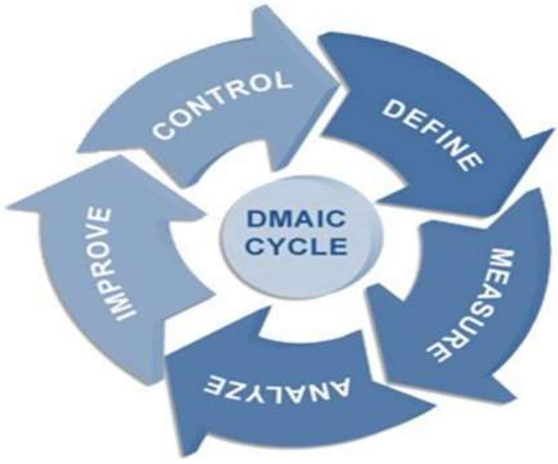

Figure 3. The Six Sigma Cycle [11]

2.2 Time Cost Trade Off

Time Cost Trade Off It often happens that a project must be completed faster than normal. In this case the project leader is faced with the problem of how to accelerate the completion of the project at minimum cost. Therefore, it is necessary to study the relationship between time and cost. Analysis of the exchange of time and costs is called the Time Cost Trade Off. The compression measures can be written as follows (Indriyani et al., 2015):

1. Development of a project network by writing the cost slope of each activity.
2. Compression in activities that are on a critical path and have a cost slope
3. Realignment of the project network.
4. Repeating the second step, the second step will stop if there is an increase in the critical path and if there is more than one critical path, the second step is carried out simultaneously on all critical trajectories and the calculation of the cost slopes is added up.
5. Stop the compliance step if there is one critical path where the activities are completely saturated (it is impossible to suppress it again) so that cost control is optimal

One of the methods to speed up or compress the project duration is Time Cost Trade Off or commonly called the time and cost exchange method. The calculation in the acceleration process is only carried out for activities that are on a critical trajectory in order to achieve the greatest possible reduction in project time with the smallest possible expenditure.

2.3 Warehouse

2.3.1 Definition Of Warehouse

According to [12], warehouse (warehouse) is a building used to store goods. The goods stored in the warehouse can be in the form of raw materials, semi-finished goods, spare parts, or work in progress that are prepared to be absorbed by the production process.

Warehouse is a storage place for goods, both raw materials to be used in the manufacturing process, as well as finished goods that are ready to be shipped. Meanwhile, warehousing activities are not only storing goods, but also the process of handling goods, starting from receiving goods, recording, storing, selecting, sorting, labeling up to the process of sending goods [13].

2.3.2 Function Of Warehouse

The main function of a warehouse is as a storage area for raw materials, intermediate goods, and a place for storing final goods. According to [14], function of warehouse is *Receiving, Inspection and Quality Control, Repackaging, Putaway, Storage, Order Picking, Postponement, Sortation, Packing and Shipping, Cross-Docking, Replenishing.*

2.3.3 Warehouse Activity

Activities that dominate in the warehouse are more on the activities of looking for, taking, preparing, and delivering the requested items (order picking), so the warehouse layout needs to be made to capture the smooth running of all these activities. In general, the functions and flow of warehouse activities according to [15] is as follows :

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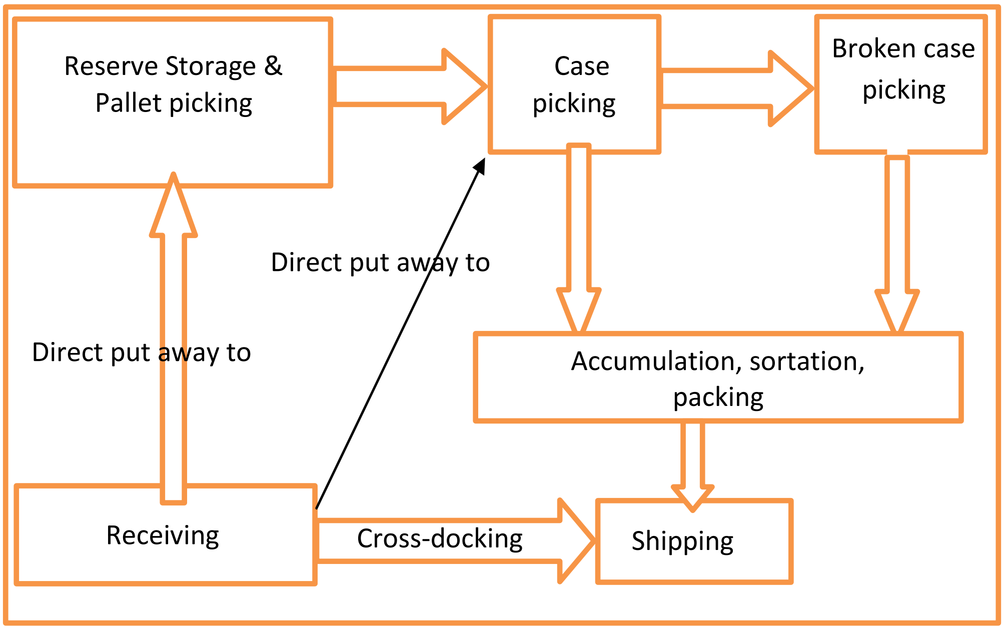

Figure 1.4 Warehouse Activity Flow Function

2.3.4 Warehouse Destination

The purpose of the storage area and the function of warehousing in general is to maximize the use of existing resources in addition to maximizing service to customers with limited sources.

3. RESEARCH METHODOLOGY

This research process contains a research flow from the beginning to finding a hypothesis to answer the problem formulation by conducting scientific research, where in the process there are stages / sequences that are adjusted to the research framework that has been compiled in the form of a flow chart. The flow chart is prepared based on the formulation and research objectives to be achieved by referring to the project feasibility study [16]:

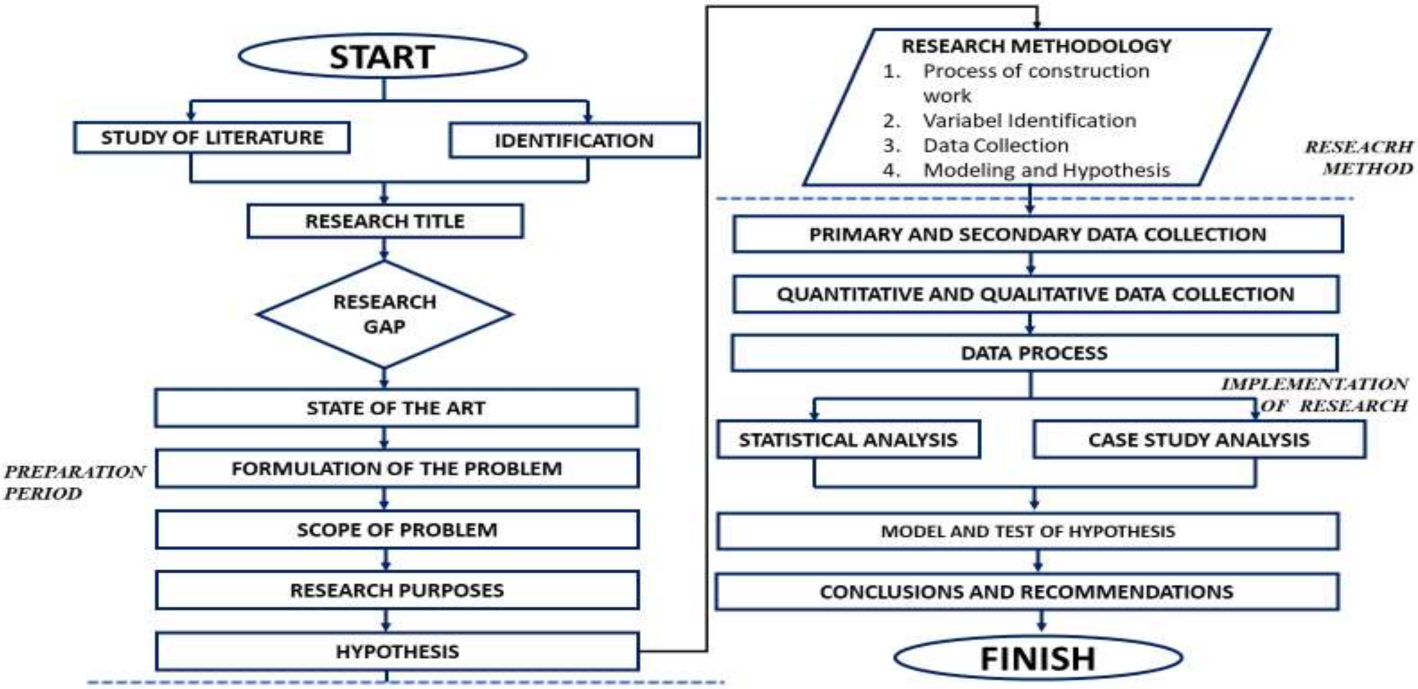

Figure 1.5 Research Flow

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The data that has been collected is continued by processing and analyzing the data to get the initial data results. From the findings of the preliminary data, the discussion analysis is then carried out to be able to draw conclusions about the cost efficiency process and an understanding that can improve the project cost performance. [17].

3.1 Variable Identification

In this case the researcher takes 2 (two) main variables to get cost efficiency and time accuracy as independent variables, and 3 (three) variables as dependent. The variables are: [18]

Independent Variable: X1 = *Lean Six Sigma*
X2 = *Time Cost Trade Off*
X3 = Ammunition Warehouse

Dependent Variable : Y1 = Cost
Y2 = Time

The identification of sub-variables related to the cost and time performance of the project consists of 5 variables, namely Lean Six Sigma, Time Cost Trade Off, Ammunition Warehouse, Time and Cost. Respondents used in this study amounted to 37 respondents.The following factors affect the improvement of the ammunition warehouse project performance:

Table 1.1 Influencing Factors

No.	Variable	Main Factor	Sub Factor		Reference
1	**LEAN SIX SIGMA (X1) (Cost)**	**Define**	X1	Cost reduction	Jeyaraman (2010), Emerald
			X2	Elimination or reduction of waste	Jeyaraman (2010), Emerald
			X3	Product quality	Jeyaraman (2010), Emerald
			X4	Productivity	Jeyaraman (2010), Emerald
			X5	Flexibility	Jeyaraman (2010), Emerald
		Analyze	X6	Effectiveness of project leader	Ozorhon and Cinar (2015), ASCE
			X7	Training and support for users	Ozorhon and Cinar (2015), ASCE
			X8	Organizational change management	Ozorhon and Cinar (2015), ASCE
			X9	Use of consultants	Ozorhon and Cinar (2015), ASCE
			X10	End-user involvement	Ozorhon and Cinar (2015), ASCE
2	**TIME COST TRADE OFF(X2) (Time)**	**Lateness**	X1	Finance	Idzurnida et al (2013)
			X2	Characteristics of the place	Idzurnida et al (2013)
			X3	Inspection system, control	Ryan emanual et al (2020)
			X4	Job Evaluation	Ryan emanual et al (2020)
			X5	Contract	Ryan emanual et al (2020)
		Design Improvements	X6	Consultant communication is poor	Ekambaram et al (2014)
			X7	Design knowledge	Ekambaram et al (2014)
			X8	Less number of workers	Desmond Hamid et al (2017)
			X9	Inefficient use of technology	Desmond Hamid et al (2017)
			X10	Management is not good	Desmond Hamid et al (2017)
3	**AMMUNITION WAREHOUSE (X3)**	***Team composition and capability***	X1	Job-plan execution	Chen et al. (2010), ELSEVIER
			X2	team leader personality	Chen et al. (2010), ELSEVIER
			X3	client input	Chen et al. (2010), ELSEVIER
			X4	workshop plan	Chen et al. (2010), ELSEVIER
			X5	relationships within the design team	Chen et al. (2010), ELSEVIER
		Control	X6	control of workshop	Leung et al. (2013), ASCE

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Table 1.1 Influencing Factors

No.	Variable	Main Factor	Sub Factor		Reference
3	**AMMUNITION WAREHOUSE (X3)**	***project***	X7	plan for implementation	Leung et al. (2013), ASCE
			X8	personalities of participants	Leung et al. (2013), ASCE
			X9	Client support and active participation	Leung et al. (2013), ASCE
			X10	cooperation from related departments	Leung et al. (2013), ASCE
4	**COST (Y1)**	**Cost**	Y1.1	The relationship between management and labor	Hamed Samarghandi et al.(2016)
			Y1.2	Delays Preparation and approval of drawings	Hamed Samarghandi et al.(2016)
			Y1.3	Inadequate planning and scheduling	Hamed Samarghandi et al.(2016)
			Y1.4	Poor site management and supervision	Hamed Samarghandi et al.(2016)
			Y1.5	Error during construction	Hamed Samarghandi et al.(2016)
5	**TIME (Y2)**	**Time**	Y2.1	Inaccurate predictions of craftsmen production levels	Seyed Mohammad Moosavi . At all (2016)
			Y2.2	Lack of skilled workforce	Seyed Mohammad Moosavi . At all (2016)
			Y2.3	Project location restrictions	Seyed Mohammad Moosavi . At all (2016)
			Y2.4	Poor labor productivity	Seyed Mohammad Moosavi . At all (2016)
			Y2.5	Design changes	Abd El-Razek, Bassioni and Mobarak (2008)

3.2 DETERMINATION OF THE NUMBER OF RESPONDENTS

The minimum number of respondents to answer the questionnaire is needed as a limitation in collecting the required results. According to [19] Respondents' needs can be obtained using the following equation:

$$m = \frac{Z^2 \times P \times (1-P)}{\varepsilon^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$n = \frac{m}{1+\frac{(m-1)}{N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where : N = 40, ε = 0,05, P = 0,5

$$p - value = \frac{1-\varepsilon}{2} = \frac{1-0,05}{2} = 0,475$$

Based on the p-value, the Z value is obtained based on the Z table of normal distribution, Z = 1.96
Then the minimum respondent needs are as follows:

$$m = \frac{Z^2 \times P \times (1-P)}{\varepsilon^2}$$

$$m = \frac{Z^2 \times P \times (1-P)}{\epsilon^2} = \frac{0,96}{0,0025} = 384,16$$

$$n = \frac{m}{1+\left[\frac{(m-1)}{N}\right]} = \frac{384,16}{10,58} = 36,31345 \sim 37$$

3.3 DATA PROCESSING STAGE

In his own validity test [20] a measure that can show the validity or validity of the instrument. So in testing the validity it refers to an instrument in carrying out its function. Variables obtained from published journals, articles and e-books. [21]. The process of testing the validity and reliability is carried out using the tools in the SPSS program, which is a data processing flowchart:

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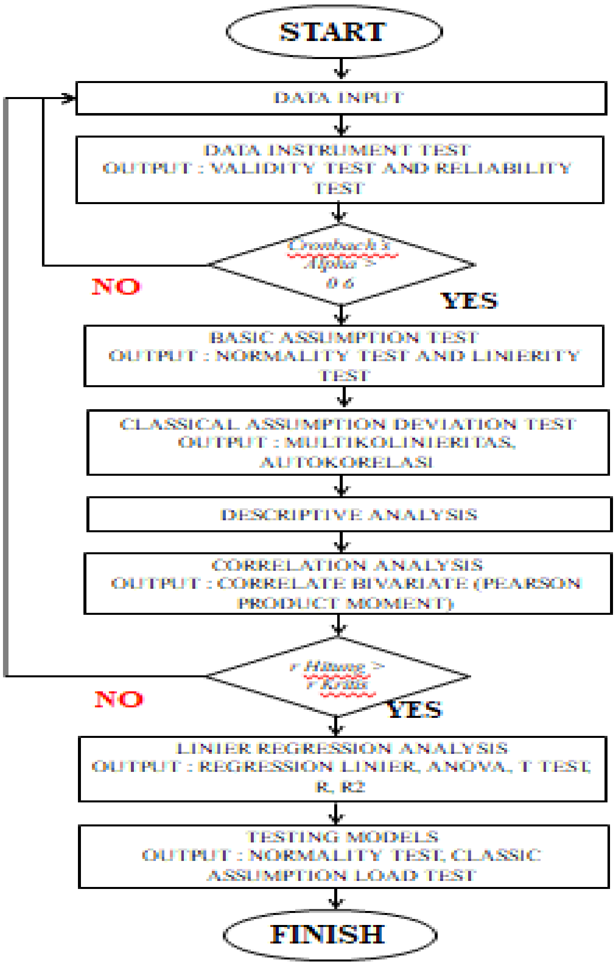

Figure 1.6 Flowchart of SPSS

3.4 VALIDITY AND RELIABILITY TEST

From each variable will be tested using SPSS tools, namely the value of the corrected item total correlation (calculated validity) if the value is more than 0.2027 then it can be stated as valid and the value of Cronbach's Alpha (Calculated Reliability). If the value is more than 0.600 then can be stated as realistic, here are the results of data grouping that are both realistic and valid. [22]

Table 1.2 Validity Test Results

Variable	Alpha Cronbach	Comprative Value	Remark
Lean Six Sigma	0.372	0.2027	valid
Time cost trade off	0.621	0.2027	Valid
Ammunition Warehouse	0.521	0.2027	valid
Cost	0.555	0.2027	valid
Time	0.539	0.2027	valid

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Table 1.3 Reability Test Results

Variable	Alpha Cronbach	Comprative Value	Remark
Lean Six Sigma	0,722	0,600	reliabel
Time cost trade off	0,841	0,600	reliabel
Ammunition Warehouse	0,719	0,600	reliabel
Cost	0,707	0,600	reliabel
Time	0,722	0,600	reliabel

The results of the average analysis are then compiled into a recapitulation which is presented in the form of sub-factor rankings, 10 most influential sub factors, 10 most influential sub factors, the most influential main factor rank and the most influential variable ranking. The results of the recapitulation of statistical analysis using the average method, more details can be seen in the discussion below:

Table 1.4. The results of the recapitulation of statistical analysis

No	Sub Factor	VAR	Valid	Mean	Median	N
1	Inadequate planning and scheduling	Y1_03	65	4.98	5	Valid
2	Job-plan execution	X3_01	65	4.94	5	Valid
3	Delays Preparation and approval of drawings	Y1_02	65	4.94	5	Valid
4	Cost reduction	X1_01	65	4.88	5	Valid
5	The relationship between management and labor	Y1_01	65	4.86	5	Valid
6	relationships within the design team	X3_05	65	4.83	5	Valid
7	Lack of skilled workforce	Y2_02	65	4.68	5	Valid
8	Flexibility	X1_05	65	4.65	5	Valid
9	Error during construction	Y1_05	65	4.65	5	Valid
10	Inaccurate predictions of craftsmen production levels	Y2_01	65	4.65	5	Valid
11	Poor site management and supervision	Y1_04	65	4.62	5	Valid
12	Project location restrictions	Y2_03	65	4.62	4	Valid
13	client input	X3_03	65	4.55	4	Valid
14	Product quality	X1_03	65	4.54	4	Valid
15	Finance	X2_01	65	4.48	4	Valid
16	Design changes	Y2_05	65	4.45	4	Valid
17	Job Evaluation	X2_04	65	4.42	4	Valid
18	Poor labor productivity	Y2_04	65	4.42	4	Valid
19	Consultant communication is poor	X2_06	65	4.4	4	Valid

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20	Inefficient use of technology	X2_09	65	4.35	4	Valid
21	team leader personality	X3_02	65	4.35	4	Valid
22	Elimination or reduction of waste	X1_02	65	4.28	4	Valid
23	Effectiveness of project leader	X1_06	65	4.23	4	Valid
No	**Sub Factor**	**VAR**	**Valid**	**Mean**	**Median**	**N**
24	Productivity	X1_04	65	4.2	4	Valid
25	Characteristics of the place	X2_02	65	4.06	4	Valid
26	workshop plan	X3_04	65	4.03	4	Valid
27	Contract	X2_05	65	4.02	4	Valid
28	Inspection system, control	X2_03	65	4	4	Valid
29	Use of consultants	X1_09	65	3.97	4	Valid
30	Design knowledge	X2_07	65	3.92	4	Valid
31	Client support and active participation	X3_09	65	3.88	4	Valid
32	control of workshop	X3_06	65	3.82	4	Valid
33	Less number of workers	X2_08	65	3.75	4	Valid
34	Management is not good	X2_10	65	3.75	4	Valid
35	plan for implementation	X3_07	65	3.75	4	Valid
36	Training and support for users	X1_07	65	3.69	4	Valid
37	personalities of participants	X3_08	65	3.58	4	Valid

4. CONCLUSION

The factors that must be considered are the company's experience in doing similar work, which is the factor that has the highest index value, namely:

1. Inadequate planning and scheduling
2. Job-plan execution
3. Delays in preparation and approval of drawings
4. Cost reduction
5. The relationship between management and labor
6. relationships within the design team
7. Lack of skilled manpower
8. Flexibilities
9. Error during construction
10. Inaccurate artisan production level prediction

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