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Factors that influence the implementation time of bridge projects

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ABSTRACT

Delays are common in project implementation, even in bridge construction projects. It is important to analyze the causes of these delays so that service providers and construction parties can take appropriate measures to overcome the problem. These measures can help reduce the costs associated with delays. The research aims factors that influence the performance of bridge project implementation times, and to find alternative solutions to resolve these factors. The research uses a quantitative method. Primary data is obtained through questionnaires distributed to respondents among bridge construction practitioners on three predetermined research objects: Desari, Cisumdawu, and Cijago toll road projects sections 2-3. The research data is processed using JASP software. After analyzing the implementation methods, budget availability, and engineering risk variables, it is found that engineering risk is the most dominant factor affecting the performance of bridge project implementation time, with a percentage of 61.68%.

ABSTRAK

Seringkali dalam pelaksanaan proyek terjadi keterlambatan yang tidak diinginkan dan tidak diketahui sebelumnya. Analisis penyebab keterlambatan ini penting agar penyedia jasa dan pihak-pihak terkait dalam jasa konstruksi dapat mengambil langkah dan solusi yang tepat untuk mengatasi masalah keterlambatan pelaksanaan pekerjaan yang seringkali terjadi berulang serta berakibat pada peningkatan biaya. Tujuan dari penelitian adalah untuk mendapatkan dan menganalisis faktor-faktor yang berpengaruh terhadap kinerja waktu pelaksanaan proyek jembatan, mendapatkan dan menganalisis faktor yang memiliki pengaruh paling dominan terhadap kinerja waktu pelaksanaan proyek jembatan serta mendapatkan dan menganalisis beberapa alternatif solusi yang dapat diberikan untuk penyelesaian faktor-faktor dominan di atas. Penelitian ini menggunakan metode quantitatif, dimana data primer didapatkan dari hasil membagikan kuesioner kepada responden di kalangan praktisi konstruksi jembatan pada tiga obyek penelitian yang sudah ditetapkan, yaitu proyek Tol Desari, Cisumdawu dan Cijago seksi 2-3. Selanjutnya data hasil penelitian tersebut diolah menggunakan software JASP. Dari tiga variabel yang diteliti meliputi metode pelaksaan, ketersediaan anggaran dan risiko teknik, setelah diolah menggunakan JASP dapat diketahui bahwa factor risiko teknik merupakan factor yang memiliki pengaruh paling dominan terhadap kinerja waktu pelaksanaan proyek jembatan, dengan prosentase 61,68%.

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1. Introduction

Transportation is critical for meeting the needs of moving people or items from one place to another. It plays a vital role in achieving various goals, including national development, economic efficiency, unity, and impacting almost all aspects of life [1]. Infrastructure development is a crucial aspect of accelerating the national development process of a country. This is because the progress and economic growth of a country cannot be separated from the availability of adequate infrastructure. The provision of toll road infrastructure plays an important role in accelerating the development process and driving economic growth [2].

The construction of toll roads can improve transportation efficiency and boost the economy of a region. However, such construction is not without risks [3]. The development of road infrastructure facilitates the distribution of goods and services and plays a role in improving the quality of life and human well-being. Infrastructure is one of the driving forces of economic growth in the context of regional development, where the government is the main responsible party. One of the main issues related to the development of road networks, especially in urban areas, is traffic congestion. To address this problem, alternative transportation routes such as elevated highways have been chosen and constructed as part of the land transportation network development to reduce congestion, particularly in urban areas [4].

A project is an activity that is carried out within a limited time and resources to achieve a predetermined outcome. In achieving this final outcome, project activities are constrained by budget, schedule, and quality, known as the triple constraint [5]. Every construction project should have a certain implementation plan and schedule, indicating when the project starts, when it should be completed, how the project will be carried out, and how resources will be provided. An inadequately planned or controlled project is likely to experience delays.

During project implementation, delays can occur which negatively affect all parties involved, including service providers and users, due to the significant impact on costs [6]. Project delays can have a negative impact on project schedules and costs, and may even lead to project failure [7]. It can also create a conflicting environment within an organization. Therefore, it's important to analyze the causes of delays so that service providers and related parties in construction services can take appropriate steps to overcome the problem of delays in work implementation. These delays often occur repeatedly and result in increased costs. Construction Management involves planning, implementing, and controlling project activities from start to finish by allocating resources effectively to achieve desired targets [5].

1.1. Bridge History

Bridge construction is intended to serve as a means of connecting two areas separated by a river, ravine, valley, lake, strait, and road for road, railway, human, animal or water transportation [8]. Bridge construction is a complementary building construction of road transportation facilities that connects one place to another, which can be crossed by a moving object, for example, a crossing that is interrupted due to an obstacle or other cause, by jumping over the obstacle without burying or covering it, and if the bridge is interrupted then traffic will stop. The crossing can be a road, a railway or a pedestrian walkway, while the obstacle can be a road, a railway, a river, a waterway, a valley or a cliff. The bridge has three structures: foundation, lower building structure, and upper building structure. The part that connects the traffic obstacle is the upper building structure.

Throughout the history of human civilization, the development of bridges has continued to evolve. However, achieving the level of bridge engineering expertise we have today was not an easy task. It required a process of trial and error, known as "cut and try". Initially, an empirical method was used to estimate the strength of materials that could be used in bridge construction. Centuries ago, before humans categorized five types of bridges: beam, cantilever, arch, suspension, and truss, four early types of bridges were inspired by pre-Christian human life.

According to Supriyadi et al. (2007), the technology of bridges has been continuously developing over time, and the history of bridge development can be divided into several periods [9]:

1. Prehistoric period
2. Ancient Roman Period
3. During the Middle Ages, as seen in figure 1a.
4. The picture in Figure 1b showcases the period of iron and steel bridges.

(a) 

Figure 1 (a) Avignon Bridge, France

(b) 

Figure 1 (b) Coalbrookdale Bridge, England

5. The suspension bridge era is depicted in figure 2a
6. Figure 2b shows the Cable Stayed bridge era

(a) 

Figure 2 (a) Menai Straits Bridge, England

(b) 

Figure 2 (b) Sant Nazaire Bridge, France

1.2. Implementation Method

The methods used for implementing a construction project are crucial in achieving the desired project goals, namely cost, quality, and time. Technology plays a significant role in the construction industry, particularly in the methods used for carrying out construction work. The use of appropriate, practical, fast, and safe methods is essential to successfully completing a construction project. These methods help achieve the set targets of time, cost, and quality.

During construction work, unexpected obstacles may arise due to field conditions that do not match previous expectations. In such cases, it may be necessary to apply breakthrough construction methods to complete the project. It is essential to use appropriate construction methods that are compatible with the field conditions in order to successfully complete the construction project. The method of carrying out work for buildings is different from the method of work for irrigation buildings, power plant buildings, dock construction, and road and bridge construction. Therefore, selecting the right construction implementation method is crucial and depends on the type of project being carried out.

The implementation methods for all stages of bridge structural work are adapted to the design provided by the planning consultant. The planning methods for implementing structural work are based on the design, site conditions, and other relevant data provided in the project information. These data have a significant influence on determining and planning the implementation methods for the bridge construction project.

1.3. Budget

Costs refer to the expenses incurred during the implementation, operation, and maintenance of project installations. For example, building roads and maintaining them incurs costs. Benefits, on the other hand, are the profits or advantages obtained by society, which can be in the form of cash flow or other forms such as a newly constructed bridge that makes communication between two river banks faster and safer or improvements in a village. However, disbenefits or burdens are losses borne by the community due to a project. For instance, air pollution caused by the smoke emitted by industrial installations that result from a project is an example of a disbenefit or burden [10].

When carrying out construction activities, exceeding the predetermined work time can result in increased costs for both the contractor and the owner. The contractor may incur additional costs to complete the work and may also have to pay fines to the owner for not completing the work within the agreed time frame. On the other hand, the owner may lose time as the project cannot produce profits due to delays in completing the project. Furthermore, delays in infrastructure projects can result in significant economic losses for the owner [11].

Projects can be funded by either the government or the private sector. However, the government cannot solely be responsible for developing national infrastructure and needs the participation of the private sector. Table 1 below presents a comparison of cash flow objectives for the private sector and the public sector (government).

Table 1 A comparison between the cash flow objectives of the private sector and the public sector will be discussed

No	Cash Flow	Private Sector	Public/General Sector
1	Budget		
	• Inflow	From private investors	From the government (taxes, loans, and aid funds) and/or sponsors
	• Outflow	To finance project development	To finance project development
2	Income		
	• Inflow	From sales of products/services for facilities built by the project	If any, from sales of products/services for facilities built by the project
3	Budget		
	• Outflow	To finance the products/services sold, including operations/production and maintenance	To finance the products and services that are sold, it is necessary to cover the costs of operations, production, and maintenance
4	Benefit	-	Benefits/facility of benefits received by the community from the project
5	Disbenefit	-	The project's outcomes have led to negative impacts that are being experienced by society

1.4. Engineering Risk

Risk is a result of uncertain circumstances. In construction projects, risks are also unpredictable due to the uncertainty involved in predicting potential issues [12]. The larger the scale of a construction project, the higher the risks involved. If these risks are not anticipated and addressed appropriately by the project implementer, it can hinder or even result in losses during project implementation [13]. Risks can have an impact on the productivity, performance, quality, and costs of projects.

In order to overcome risks, it is important to implement risk management. Risk management is the process of measuring or assessing risk, and developing strategies to manage it [14]. This process involves six stages, which are risk management planning, risk identification, analysis (which is divided into two types: quantitative analysis and qualitative analysis), planning risk management actions, and supervision and control [15]. It is especially important to identify, analyze, mitigate, and allocate risks that may occur, particularly those that fall within dominant categories, in order to minimize their negative impact. This information can then be used by stakeholders to make informed decisions and resolve any negative consequences that may arise during the construction of the Toll Road [16].

In order to deal with potential dangers that may arise in an organization, both for-profit and non-profit, it is important to implement risk management strategies. Risk management helps us to mitigate risks and also provides opportunities to gain benefits. If we can manage risks systematically, we can reap the benefits while minimizing the potential negative impact. Therefore, it is necessary to have sufficient scientific knowledge to manage risks effectively, both those that have already occurred and those that may arise in the future.

2. Research Methods

This study follows a quantitative descriptive methodology, which involves conducting a literature review, distributing questionnaires, and conducting interviews with respondents. The research process begins with identifying and studying relevant resources such as books, journals, and discussions with other experts. The study also aims to identify any research gaps, compile questionnaires, and validate them with experts. Data is then collected from respondents using the questionnaires, and the obtained data is validated by experts and analyzed using statistical tools such as JASP software. The analyzed data is then utilized for further calculations and study.

The independent variable (X) and dependent variable (Y) are the influence of implementation methods, budget availability, and engineering risks on the performance of bridge project implementation time. The independent variables are:

- Implementation Method Factor (X1)
- Budget Availability Factor (X2)
- Engineering Risk Factors (X3)

This study relied on both primary and secondary data. Primary data was collected through interviews and questionnaires distributed to respondents, while secondary data was gathered from literature reviews. The research questionnaire consisted of two stages. The first stage was Expert Validation, which assessed the significance of factors, while the second stage was a questionnaire given to respondents for more detailed and targeted problem analysis. The research samples included 30 bridge practitioners who worked on three toll road projects in DKI Jakarta and West Java. The distribution of respondents is shown in Table 2.

Table 2. Sample Distribution of Frequencies for Institution

Institution	Frequency	Percent	Valid Percent	Cumulative Percent
PT. VK	9	30.000	30.000	30.000
PT. GI	7	23.333	23.333	53.333
PT. MPB	7	23.333	23.333	76.667
PT. CW	3	10.000	10.000	86.667
PT. IKU	3	10.000	10.000	96.667
PT. CKJT	1	3.333	3.333	100.000
Missing	0	0.000		
Total	**30**	**100.000**		

In Table 3, respondent data is displayed based on their level of experience with all 30 respondents having over 10 years of work experience.

Table 3. Respondents' Work Experience Frequency

Pengalaman	Frequency	Percent	Valid Percent	Cumulative Percent
5-10 tahun	5	16.667	16.667	16.667
>20 tahun	14	46.667	46.667	63.333
10-15 tahun	4	13.333	13.333	76.667
15-20 tahun	7	23.333	23.333	100.000
Missing	0	0.000		
Total	**30**	**100.000**		

3. Data and Analysis

In order to gather precise, accurate, and dependable data, we categorize information about respondents based on their backgrounds. This includes the agency where they work, their level of education, work experience, and worker position. Statistical analysis is carried out using JASP software.

3.1. Data Validity Test

The validity test evaluates the accuracy of the instrument by analyzing data from the variables under study [16]. The validity test is a measurement used to assess how accurately an instrument can reveal data from the variables that have been studied. To test the validity of each item, item analysis is used, which involves correlating the score of each item with the total score (corrected item total correlation). We can determine the validity test using the following equation:

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

Note:

rxy : correlation coefficient

n : Number of trial respondents

x : score each item

y : score of all trial items

The validity test is used to make decisions by comparing rcount and r-table based on certain criteria:

a. If the row rcount > r-table, then the statement can be considered as valid.
b. If the rcount < r-table, then the statement can be deemed invalid.

Using the r product moment table, the r-table value is determined for alpha (α) = 0.05 and df (n-2) = 30-2 = 28 respondents, which is 0.361.

Table 3. Validity Test Results

Variable	P value	Person's r
X1	8.518×10^{-9}	0.837
X2	0.012	0.454
X3	5.765×10^{-7}	0.722

The statistical analysis shows that the P values for X1, X2 and X3 are less than 0.05. This indicates that both independent and dependent factors have an influence on each other. This conclusion is valid because the correlation coefficient (Pearson's r) of the independent variable has a higher value than the correlation coefficient (r) of the dependent variable.

3.2. Data Reliability Test

A data reliability test is used to determine whether the data collection tool is precise, accurate, stable and consistent. An instrument is considered reliable if it produces the same data multiple times when used to measure the same object. A variable instrument is considered reliable if its Cronbach's Alpha coefficient value is greater than 0.60, which is the standard value for accepting the reliability of a research instrument. Generally, a research instrument with reliability in the range of > 0.60 to 0.80 is considered good, while a range of > 0.80 to 1.00 is considered very well. The table displays the alpha value calculated for each instrument and variable. All data is taken from the results of data processing via JASP.

Table 4. Reliability Test Results

Variable	Cronbach's α
X1	0.613
X2	0.898
X3	0.932

3.3. Linear Regression Analysis

Regression analysis measures the influence of independent variables on the dependent variable. Multiple linear regression involves more than one independent variable.

Table 5. Linear Regression

										Durbin-Watson		
Model	**R**	**R^2**	**Adjusted R^2**	**RMSE**	**R^2 Change**	**F Change**	**df1**	**df2**	**p**	**Autocorrelation**	**Statistic**	**p**
H_0	0.000	0.000	0.000	1.596	0.000		0	29		0.109	1.719	0.435
H_1	0.926	0.858	0.841	0.636	0.858	52.255	3	26	3.810×10^{-11}	-0.070	2.126	0.697

Referring to the table above, it can be deduced that the correlation coefficient (R) is 0.926 and the determination coefficient (R^2) is 0.858. From a statistical perspective, R^2 represents the level of accuracy at 85.80%, which implies that the remaining 14.20% is the impact of other variables that were not considered in this study.

Table 6. F-Test

Model		Sum of Squares	df	Mean Square	F	p
H_1	Regression	63.358	3	21.119	52.255	3.810×10^{-11}
	Residual	10.508	26	0.404		
	Total	**73.867**	**29**			

The variables X1, X2, and X3 have a positive and significant impact on variable Y. This is based on the significance value (p) which is 3.810×10-11, which is less than the acceptable threshold of 0.05. Additionally, the F-table value is 2.98, while the fcount value is 52.255. Since the fcount value is greater than the F-table value, which means 52.255 > 2.98, we can reject the null hypothesis (H0) and accept the alternative hypothesis (H1). This indicates that there is indeed an influence between the independent variable (X) and the dependent variable (Y).

3.4. Shapiro Wilks Test

The Shapiro-Wilk method is a reliable and valid way to test for normality when dealing with small samples. It helps to determine if random variables follow a normal distribution or not. According to the analysis results obtained using JASP, the independent variable has a Shapiro-Wilk value greater than 0.05.

Table 7. Shapiro Wilks Test

Descriptive Statistics	X1	X2	X3	Y1
Valid	30	30	30	30
Missing	0	0	0	0
Mean	24.000	32.167	38.933	6.067
Std. Deviation	3.384	9.588	12.622	1.596
Skewness	-0.395	0.368	0.146	-0.062
Std. Error of Skewness	0.427	0.427	0.427	0.427
Kurtosis	-0.857	-0.889	-1.338	-0.579
Std. Error of Kurtosis	0.833	0.833	0.833	0.833
Shapiro-Wilk	0.939	0.947	0.936	0.939
P-value of Shapiro-Wilk	**0.085**	**0.142**	**0.069**	**0.085**
Minimum	18.000	18.000	20.000	3.000
Maximum	29.000	50.000	60.000	9.000

3.5. Normal Distribution Histogram

To test for normality in a dataset, one way is to analyze a histogram graph. The histogram graph displays the distribution pattern of the data in a bell shape that is centered and does not deviate to the right or left. A normal distribution is indicated by the histogram graph, where the data is spread symmetrically around the means

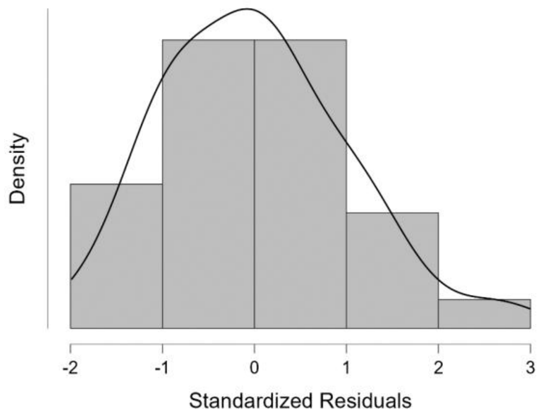

Figure 1 Standardized Residuals Histogram

To test for normality in a dataset, one way is to analyze a histogram graph. The histogram graph displays the distribution pattern of the data in a bell shape that is centred and does not deviate to the right or left. A normal distribution is indicated by the histogram graph, where the data is spread symmetrically around the mean grafik.

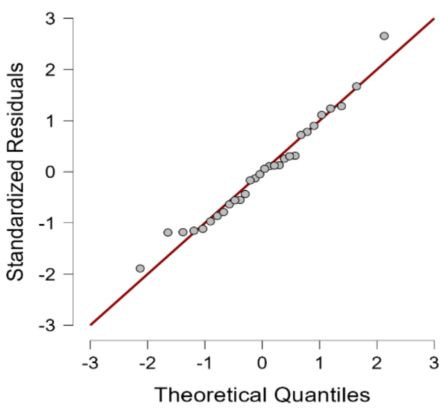

Figure 2. Q-Plot of Normal Distribution

In a normal q-plot graph, the sample points typically form a diagonal line that slants from the bottom left to the top right. This pattern indicates that the data follows a normal distribution, which means that the normality assumption holds.

4. Conclusion

After analyzing the data, it can be concluded that Technical Risk variable (X3) is the most dominant factor affecting the project completion time on the bridge. It accounts for approximately 61.683% of the variance in the project completion time performance. Technical risk factors affect the project completion time performance of the bridge simultaneously. To overcome this dominant factor, alternative solutions can be implemented:

1. Personnel replacement in the administration/licensing section will not be allowed to avoid delays.
2. It is advisable to create shop drawings at an early stage and share them informally with all stakeholders to ensure effective communication.
3. It is recommended to create shop drawings early on and share them informally with all stakeholders to ensure effective communication.
4. To calculate the volume accurately, you can work together by referring to the drawings, predetermined specifications, and supporting data.
5. Mobilize personnel, equipment, and materials to the site as needed for work progress.
6. Improve communication efficiency among owners, consultants, and contractors.

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