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Construction Management Modeling in Partnership Governance of Laboratory Building Projects

Case Study: Biosafety Level (Bsl) 2 Building Construction

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Abstract: Construction management is a crucial aspect in the governance of building construction project partnerships. The complexity and challenges in building construction projects, such as multi-stakeholder involvement, uncertainty, and time and cost pressures, signal the importance of the construction management role. Good partnership governance can help address these challenges by improving transparency, accountability, and communication between parties. This study aims to find a partnership management model in determining the best vendors in the implementation of the Biosafety Level (BSL) 2 Building Construction project and describe the proposed partnership management model in determining the best vendors in the implementation of the BSL 2 Building Construction project. This is a research on dynamic system methods through the development of simulation models with the help of Powersim studio 10 software. The research was carried out at PT. Nella Putri Banjaran KSO PT. Bettindo Bintang Perkasa. Data were collected through field studies and literature studies. The results of the study show a significant trend of increasing delays in the supply of raw materials and project costs, it can be concluded that there are fundamental problems in project management. Persistent delays in the supply of raw materials indicate obstacles in project planning, implementation, or supervision. Solid partnerships between the various parties involved in the project, such as project owners, contractors, consultants, and subcontractors, can be key in addressing these issues. The partnership management model in determining the vendor for the implementation of the BSL 2 building construction project by reducing the average delay in the supply of project raw materials, improving project time management, reducing the average increase in project costs by improving project cost management. Through long-term agreements, joint planning, and effective monitoring mechanisms, supply delays can be minimized.

Keywords: Construction Management. Vendor Partnerships, Powersim, Dynamic Systems

INTRODUCTION

Construction projects are one of the important things that must be planned very well in advance where time, costs and resources that have been planned and calculated in advance to be able to get maximum results. However, in the construction of a construction project, it should be in accordance with the time that has been specified in the contract so that there are no delays and ultimately have an impact on costs that are not in accordance with the initial calculation.

In Karanganyar City itself, project delays often occur with various causative factors such as lack of human resources, and so on. In this study, the factors that cause project delays in Karanganyar City will be discussed.

Construction management is a crucial aspect in the governance of building construction project partnerships (Dhaniel, Pamadi, & Savitri, 2023). The success of a project depends heavily on how the project planning, execution, and control process is carried out. Joseph (2022) and Nurcahya (2020) affirmed, "Effective construction management is the key to completing projects on time and on budget." The complexity and challenges in building construction projects, such as multi-stakeholder involvement, uncertainty, and time and cost pressures, signal the importance of the construction management role. Darmawan & Prasetyo (2023) and Chatra et al. (2020) stated, "The key to successfully completing a construction project is effective coordination and communication between the parties involved."

Delays in construction projects are a common problem that can cause various negative impacts, such as financial losses, reputational damage, and disruption of public activities. To prevent delays in construction projects, careful planning efforts must cover all aspects of the project, from design to execution; selection of contractors who have good experience and reputation in completing projects on time and within budget; Communicate openly and clearly with all parties involved in the project, including project owners, contractors, subcontractors, and workers: implement effective project management methods and last but not least Monitor the project closely.

As a result of these preventive efforts, the Powersim application is used to analyze construction project delays. Some of the benefits that can be used are using Powersim. Powersim allows you to build models that meticulously mimic the behavior of complex construction projects. The model can consider a variety of factors that can affect the duration of the project, such as available resources, weather conditions, and potential risks. This makes it possible to gain a better understanding of how various factors are interrelated and affect the overall project. The formulation of the problems proposed in this study is 1) What is the partnership management model in determining the vendor for the implementation of the BSL 2 Building Construction project? and 2) What is the proposed partnership management model in determining the best vendor in the implementation of the BSL 2 Building Construction project?

According to Rusito (2019), The definition of delay is a part of the implementation time that cannot be utilized in accordance with the activity plan so that it can cause a delay in one or several activities so that it cannot be completed exactly according to the schedule that has been planned previously.

According to Rusdiyanto et al. (2019) The success in implementing the project so that it can be completed on time greatly affects the complete and appropriate project planning and scheduling. Delays in a project can be considered as a result of not fulfilling the schedule plan that has been made, because the actual conditions do not match the conditions when the schedule is made.

Karanganyar City is the capital of Karanganyar Regency which is developing, therefore in order to improve the economic wheels in Karanganyar Regency in order to achieve a better life for the community, the local government always strives to improve infrastructure facilities by carrying out development. The process of implementing projects in Karangayar Regency from year to year, it can be seen that almost most of the construction projects, both government-owned projects and privately owned projects, often experience delays. This can be seen in several projects such as building construction projects and building rehabilitation projects that are under construction.

Construction Projects

According to Primary (2021) A construction project is a process of activities in building a building, where in general in the field of civil engineering and architectural engineering is the main work. According to Nugroho (2019), project activities are temporary activities that take place within a limited period of time that has been determined, with the allocation of certain sources of funds that have been taken into account with the aim of being able to achieve the targets that have been agreed upon together.

Project Delays

Definition of project delay according to Kurniawan & Anggraeni (2020) It is a situation where the implementation time is not used in accordance with the activity plan so that one or several participating activities are delayed or not completed exactly according to the planned schedule. Walangitan, & Arsjad (2023) mentioned that the delay of a construction project means that it will take additional time to complete the project that has been planned and listed in the contract documents.

Causes of Project Delays

According to Hardina (2022) The internal factor of the cause of the delay of the construction project is from the implementing party of the construction project, in this case the contractor. Meanwhile, external factors are delays caused by parties outside the project implementer and play a direct role in the construction project, including delays caused by the owner, supervisors, and planners.

METHODOLOGY

Research Data

The variable data collected in this research are respondent data, project data and general factors data. In this study, primary data was used, namely data collected from respondents through documentation.

Data capture

Data collection was carried out through respondents in Karanganyar City. In addition, data is also obtained from public domain sources, namely from the internet, government documents, scientific publications, and previous research

Type of Research

This type of research is quantitative research using a dynamic simulation approach. Dynamic simulations are used to model systems that are complex and change over time, such as building construction projects. A dynamic simulation model will be built to analyze the occurrence of delays in building construction projects.

Data and Data Sources

The data used in this study are primary data and secondary data. Primary data were collected through interviews with project stakeholders, field observations, and documentation data collection. Secondary data is collected through literature studies such as scientific literature, project reports, and statistical data.

Data Analysis Techniques

The data analysis techniques used in this study are statistical analysis techniques and dynamic simulation techniques. Statistical analysis techniques are used to analyze primary and secondary data collected through questionnaires and observation lists. Dynamic simulation techniques are used to build dynamic simulation models that can be used to predict the duration of a building construction project and analyze the impact of various factors that can cause delays.

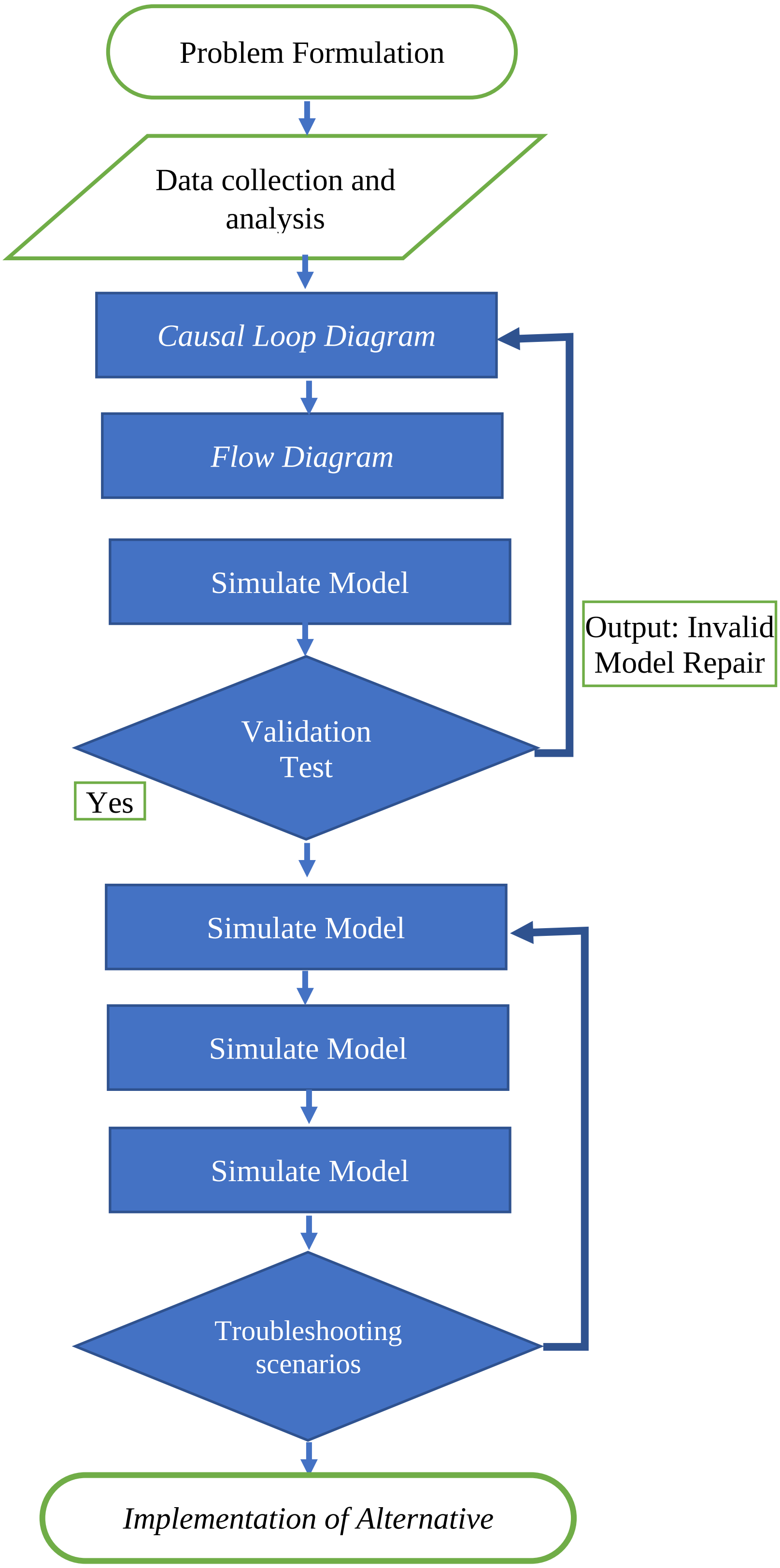


Figure 1. Research Flow Chart

RESULTS AND DISCUSSION

Data Analysis

Causal Loop

Causal loops are the basic relationships between dynamic variables that can be proportional, derivative (derivative), or integral. In this *causal loop*, it is intended to model the system of delay in the supply of raw materials for the construction of the BSL 2 building construction project. The delay in the supply of raw materials for this project is influenced by the management of vendor partners in collaboration with PT Bettindo Bintang Perkasa. In addition, other interrelated components can also affect such as delays in the supply of raw materials on the 1st floor, 2nd floor, WWTP, generators and laboratory supports.

Causal Components

A component is a part of a system that has a relationship between one component and another. The components of the delay system are as follows:

a. Delay in raw material supply
   It is the total delay in the supply of raw materials for the project which is affected by the entire sub-work.
b. Increased project costs
   The additional costs charged are due to delays in the supply of raw materials.
c. Delay in the supply of raw materials on the 1st floor
   Delay in the supply of raw materials for the 1st floor sub-work project by the vendor.
d. Delay in the supply of raw materials on the 2nd floor
   Delay in the supply of raw materials for the 2nd floor sub-work project by vendors.
e. Delay in the supply of raw materials for WWTP Generator
   Delay in the supply of raw materials for the sub-work of the Generator WWTP project by vendors.
f. Delay in the supply of raw materials for Laboratory Support
   Delay in the supply of raw materials for the sub-work of laboratory support projects by vendors.
g. Vendor Capacity
   The ability of vendors to work on projects in days.

Logical Conclusion

Logical conclusion is the logical conclusion (with regard to the rule of thinking, the way of thinking that is always based on something reasonable) in drawing conclusions to determine the relationship between the two components in the causal that is formed.

The *logical conclusions* contained in the modeling of the raw material supply delay system are as follows:

a. Vendor capacity with delays in the supply of raw materials on the 1st floor
   These two components are negatively related, meaning that the higher the vendor's capacity, the smaller the delay in the supply of raw materials on the 1st floor.
b. Vendor capacity with delays in the supply of raw materials on the 2nd floor
   These two components are negatively related, meaning that the higher the vendor's capacity, the smaller the delay in the supply of raw materials on the 1st floor.
c. Vendor capacity with delays in the supply of raw materials for WWTP Generators
   These two components are negatively related, meaning that the higher the vendor's capacity, the smaller the delay in the supply of raw materials for WWTP Generators.
d. Vendor capacity with delays in the supply of raw materials for Laboratory Support
   These two components are negatively related, meaning that the higher the vendor's capacity, the smaller the delay in the supply of raw materials to support the laboratory.

e. Delay in supply of raw materials with increased project costs
These two components are positively related, meaning that the higher the delay in the supply of raw materials, the higher the additional project costs will be.

Causal Loop Research

After testing the distribution and *logical conclusion* of the system components, the initial *loop causal* is obtained as follows:

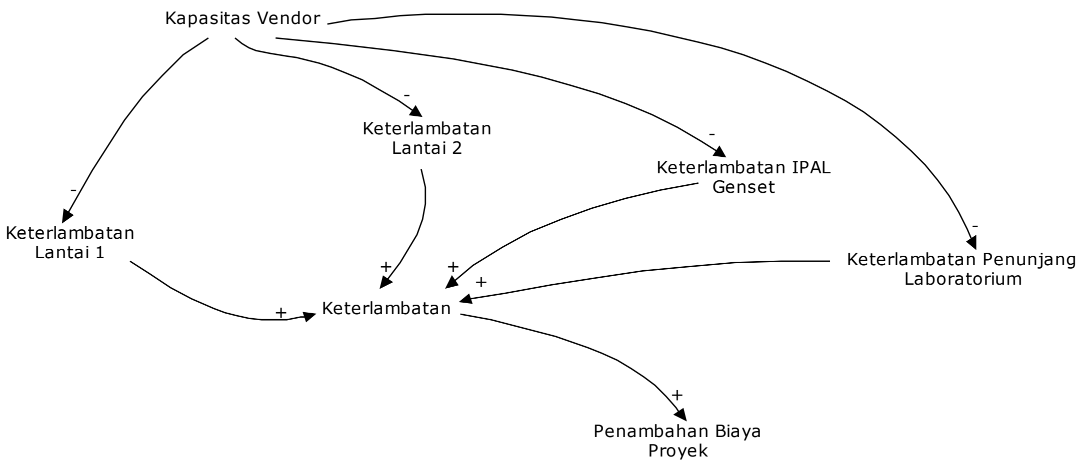


Figure 2. Causal Loop Raw Material Supply Delay System Project

The figure above shows a causal loop diagram that illustrates the interaction between various factors that affect the delay in the supply of project raw materials. This diagram uses arrows to show causal relationships between various factors.
The factors depicted in the diagram:

a. Vendor Capacity: Vendor capacity refers to the vendor's ability to meet the project's demands in terms of time and quality.
b. Delay in the supply of raw materials on the 1st floor: The delay in the supply of raw materials on the 1st floor refers to the delay in the work on the first floor of the project.
c. Delay in the supply of raw materials on the 2nd floor: The delay in the supply of raw materials on the 2nd floor refers to the delay of work on the second floor of the project.
d. Delay in the supply of WWTP raw materials: Delay in the supply of WWTP raw materials refers to the delay in work on the project's Wastewater Treatment Plant (WWTP).
e. Delay in the supply of raw materials for generators: Delays in the supply of raw materials for generators refer to delays in work on the project's power generators.
f. Delay in the supply of supporting raw materials: Delay in the supply of supporting raw materials refers to the delay in work on the project's supporting infrastructure, such as roads, water, and electricity.
g. Delay in the supply of laboratory raw materials: Delay in the supply of laboratory raw materials refers to the delay of work on the project laboratory.
h. Project Cost Increase: Project cost increase refers to an increase in project cost due to delays.

Causal relationship between these factors:

a. Vendor Capacity: Low vendor capacity can cause delays in the supply of raw materials on the 1st and 2nd floors.
b. Delay in the supply of raw materials on the 1st floor: Delays in the supply of raw materials on the

1st floor can cause a delay in the supply of raw materials on the 2nd floor.

c. Delay in the supply of raw materials on the 2nd floor: Delays in the supply of raw materials on the 2nd floor can cause delays in the supply of raw materials for WWTP and generators.
d. Delay in the supply of WWTP raw materials: Delays in the supply of WWTP raw materials can cause delays in the supply of supporting raw materials.
e. Delay in the supply of generator raw materials: Delays in the supply of generator raw materials can cause delays in the supply of laboratory raw materials.
f. Delay in the supply of supporting raw materials: Delays in the supply of supporting raw materials can cause delays in the supply of raw materials on the 1st floor, 2nd floor, WWTP, generators, and laboratories.
g. Delay in the supply of laboratory raw materials: Delays in the supply of laboratory raw materials can lead to additional project costs.

This causal loop diagram shows that the delay in the supply of raw materials for the project can be caused by various interrelated factors. To overcome the delay in the supply of raw materials for the project, it is necessary to make efforts to overcome all factors that contribute to the delay in the supply of raw materials. Some suggestions to overcome the delay in the supply of raw materials for the project:

a. Increase vendor capacity: Vendors should be selected considering their ability to meet the project's demands in terms of time and quality.
b. Accelerate work on floors 1 and 2: Work on floors 1 and 2 should be accelerated by optimizing workflows and adding resources.
c. Accelerate WWTP and generator work: WWTP and generator work must be accelerated by optimizing workflows and adding resources.
d. Accelerate support work: Support work should be accelerated by optimizing workflows and adding resources.
e. Accelerate lab work: Lab work should be accelerated by optimizing workflows and adding resources.
f. Manage risks well: Risks that can cause delays in the supply of project raw materials must be identified and managed properly.

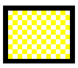
A causal loop diagram is simply a tool for understanding the complexity of a system. This diagram does not provide a definitive solution to overcome the delay in the supply of project raw materials. The right solution to overcome the delay in the supply of raw materials for the project will depend on the specific situation of the project.

Main Model

<u>Level Components</u>

The level components of the project raw material supply delay system can be seen in Table 1.

Table 1. Level Components

Symbol	Information
	Delay in the supply of raw materials for the project

<u>Auxiliary Components</u>

The auxiliary components of the project raw material supply delay system can be seen in Table 2.

Table 2. Component Auxiliary

Symbol	Information
	Vendor A 1st floor
	Vendor B 1st floor
	Vendor Capacity 1st floor
	1st Floor Requirements
	Delay in raw material supply Floor 1
	Vendor A 2nd floor
	Vendor B 2nd floor
	Vendor Capacity 2nd floor
	2nd Floor Needs
	Delay in raw material supply 2nd Floor
	Vendor A WWTP Generator
	Vendor B WWTP Generator
	Capacity of Generator WWTP Vendors
	The Need for WWTP Generator
	Delay in the supply of raw materials for WWTP Generator
	Vendor A Lab Support

	Vendor B Supporting Labs
	Lab Support Vendor Capacity
	Lab Support Needs
	Total raw material supply delay
	Additional Project Costs

Constant Components

The constant component of the project raw material supply delay system can be seen in Table 3.

Table 3. Component Constant

Symbol	Information
	Additional charges per day

So that the *main model* obtained before the quantification is carried out is as follows.

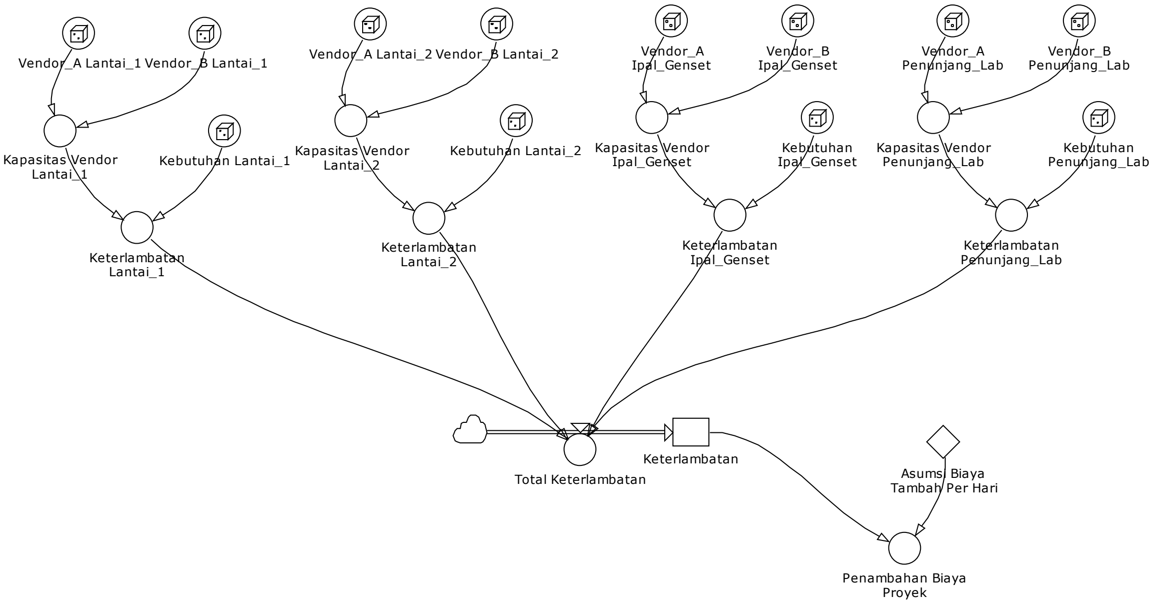


Figure 3. Main System Model

The figure above shows a causal loop diagram that illustrates the interaction between various factors that affect the delay in the supply of project raw materials. This diagram uses arrows to show causal relationships between various factors.

The factors depicted in the diagram:

a. Vendor A Floor 1: Vendor A Floor 1 refers to vendors who provide services on the 1st floor of a project.
b. Vendor A Floor 2: Vendor A Floor 2 refers to a vendor that provides services on the 2nd floor of a project.
c. Vendor B: Vendor B refers to a vendor that provides services throughout the project.
d. 1st Floor Requirements: 1st Floor Requirements refer to the number of services needed on the 1st floor of the project.
e. 2nd Floor Requirements: 2nd Floor Requirements refer to the number of services needed on the 2nd floor of the project.
f. Vendor A Capacity Floor 1: Vendor A Capacity Floor 1 refers to the number of services that Vendor A can provide on the 1st floor of the project.
g. Vendor A Capacity Floor 2: Vendor A Capacity Floor 2 refers to the number of services that Vendor A can provide on the 2nd floor of the project.
h. Vendor B Capacity: Vendor B capacity refers to the number of services that Vendor B can provide throughout the project.
i. Delay in the supply of raw materials on the 1st floor: The delay in the supply of raw materials on the 1st floor refers to the delay in the work on the first floor of the project.
j. Delay in the supply of raw materials on the 2nd floor: The delay in the supply of raw materials on the 2nd floor refers to the delay of work on the second floor of the project.
k. Delay in the supply of WWTP raw materials: Delays in the supply of WWTP raw materials refer to the delay in work on the project's Wastewater Treatment Plant (WWTP).
l. Delay in the supply of generator raw materials: Delays in the supply of generator raw materials refer to delays in work on the project's power generator.
m. Delay in the supply of supporting raw materials: Delay in the supply of supporting raw materials refers to the delay in work on the project's supporting infrastructure, such as roads, water, and electricity.
n. Delay in the supply of laboratory raw materials: Delay in the supply of laboratory raw materials refers to the delay of work on the project laboratory.
o. Total raw material supply delay: Total raw material supply delay refers to the total delay of work throughout the project.
p. Cost Increase: Cost increase refers to the increase in project costs due to delays.
q. Cost Increments Per Day: Cost increments per day refer to the average increase in project costs per day due to delays.

Causal relationship between these factors:

a. Vendor A Capacity 1st Floor: Low Vendor A Capacity 1st Floor can cause delays in the supply of raw materials on the 1st floor.
b. Vendor A Capacity 2nd Floor: Low Vendor A Capacity 2nd Floor can cause delays in the supply of raw materials on the 2nd floor.
c. Vendor B Capacity: Low Vendor B capacity can cause delays in the supply of raw materials on the 1st floor, 2nd floor, IPAL, generators, supports, and laboratories.
d. 1st Floor Requirements: High 1st Floor Requirements can cause delays in the supply of raw materials on 1st floor if the capacity of Vendor A on 1st Floor or Vendor B is insufficient.

e. 2nd Floor Requirements: High 2nd Floor Requirements can cause delays in the supply of raw materials on the 2nd floor if the capacity of Vendor A on the 2nd Floor or Vendor B is insufficient.
f. Delay in the supply of raw materials on the 1st floor: Delays in the supply of raw materials on the 1st floor can cause a delay in the supply of raw materials on the 2nd floor.
g. Delay in the supply of raw materials on the 2nd floor: Delays in the supply of raw materials on the 2nd floor can cause delays in the supply of raw materials for IPAL and generators.
h. Delay in the supply of raw materials for IPAL: Delays in the supply of raw materials for WWTP can cause delays in the supply of supporting raw materials.
i. Delay in the supply of generator raw materials: Delays in the supply of generator raw materials can cause delays in the supply of laboratory raw materials.
j. Delay in the supply of supporting raw materials: Delays in the supply of supporting raw materials can cause delays in the supply of raw materials on the 1st floor, 2nd floor, Ipal, generators, and laboratories.
k. Delay in the supply of laboratory raw materials: Delays in the supply of laboratory raw materials can lead to additional project costs.

This causal loop diagram shows that the delay in the supply of raw materials for the project can be caused by various interrelated factors. To overcome the delay in the supply of raw materials for the project, it is necessary to make efforts to overcome all factors that contribute to the delay in the supply of raw materials. There are several suggestions to overcome delays in the supply of project raw materials, in choosing the right vendor with adequate capacity as a crucial step to minimize the delay in the supply of project raw materials. Here are some factors to consider when choosing a vendor:

a. Technical Capabilities and Experience:
    1) Ensure the vendor has expertise and experience relevant to the scope of the project's work.
    2) Check the vendor's portfolio to see examples of similar projects they've completed.
    3) Ask about the qualifications and certifications of the vendor staff.
b. Production Capacity:
    1) Make sure the vendor has enough production capacity to meet the needs of the project.
    2) Ask about the number of personnel and equipment available to work on the project.
    3) Consider the vendor's ability to handle a surge in demand or a change in the scope of work.
c. Financial Performance:
    1) Check the financial stability of the vendor to ensure they are able to complete the project without financial constraints.
    2) Ask about the vendor's credit history and financial reputation.
    3) Consider the vendor's ability to provide financial guarantees if needed.
d. Project Management:
    1) Ensure vendors have an effective project management system in place to ensure smooth project execution.
    2) Ask about the project management methodology that the vendor uses.
    3) Consider the vendor's experience in working with the project team and the client.
e. Communication and Collaboration:
    1) Make sure the vendor has good and open communication with the project team.
    2) Ask about the communication platform that the vendor uses to collaborate with clients.

3) Consider the vendor's ability to adapt to changes and resolve disputes effectively.

f. In addition to the above factors, it is also important to consider:

1) Vendor location: Vendors located close to the project can save time and logistics costs.
2) Reputation and testimonials: Find out the vendor's reputation from previous clients and read their testimonials.
3) Terms and conditions of the contract: Be sure to understand all the terms and conditions of the contract before signing an agreement with the vendor.

Data Quantification

Manual Formulation Concept

The concept of manual formulation is as follows:

a. Vendor A 1st Floor = INTEGER(RANDOM(106; 130))

b. Vendor B 1st Floor = INTEGER(RANDOM(106; 130))

c. 1st Floor Vendor Capacity = IF('Vendor_A Lantai_1'>'Vendor_B Lantai_1';' Vendor_B Lantai_1';' Vendor_A Lantai_1')

d. 2nd Floor Needs = INTEGER(RANDOM(112; 124))

e. Vendor A 2nd Floor = INTEGER(RANDOM(62; 78))

f. Vendor B 2nd Floor = INTEGER(RANDOM(62; 78))

g. 2nd Floor Vendor Capacity = IF('Vendor_A Lantai_2'>'Vendor_B Lantai_2';' Vendor_B Lantai_2';' Vendor_A Lantai_2')

h. 2nd Floor Needs = INTEGER(RANDOM(66; 74))

i. Vendor A WWTP Generator = INTEGER(RANDOM(24; 32))

j. Vendor B WWTP Generator = INTEGER(RANDOM(24; 32))

k. Generator WWTP Vendor Capacity = IF('Ipal_Genset Vendor Capacity'> 'Ipal_Genset Needs';' Vendor Capacity Ipal_Genset-'Ipal_Genset Needs'; 0)

l. The Need for WWTP Generator = INTEGER(RANDOM(26; 30))

m. Vendor A Lab Support = INTEGER(RANDOM(93; 117))

n. Vendor B Supporting Labs = INTEGER(RANDOM(93; 117))

o. Lab Support Vendor Capacity = IF('Vendor_A Penunjang_Lab'>'Vendor_B Penunjang_Lab';' Vendor_B Penunjang_Lab';' Vendor_A Penunjang_Lab')

p. Lab Support Needs = INTEGER(RANDOM(99; 111))

q. Delay in raw material supply = Total delay in raw material supply

r. Total delays in raw material supply = 'Delay in supply of raw materials Ipal_Genset' + 'Delay in supply of raw materials Lantai_1' + 'Delay in supply of raw materials Lantai_2' + 'Delay in supply of raw materials Penunjang_Lab'

s. Increased project costs = 'Assumption of additional costs per day'*Delay in supply of raw materials

t. Assumption of mooring costs = 50000000

Equation Window Software Powersim

The equation *window* display of the main model that has been quantified can be seen in Figure 4.

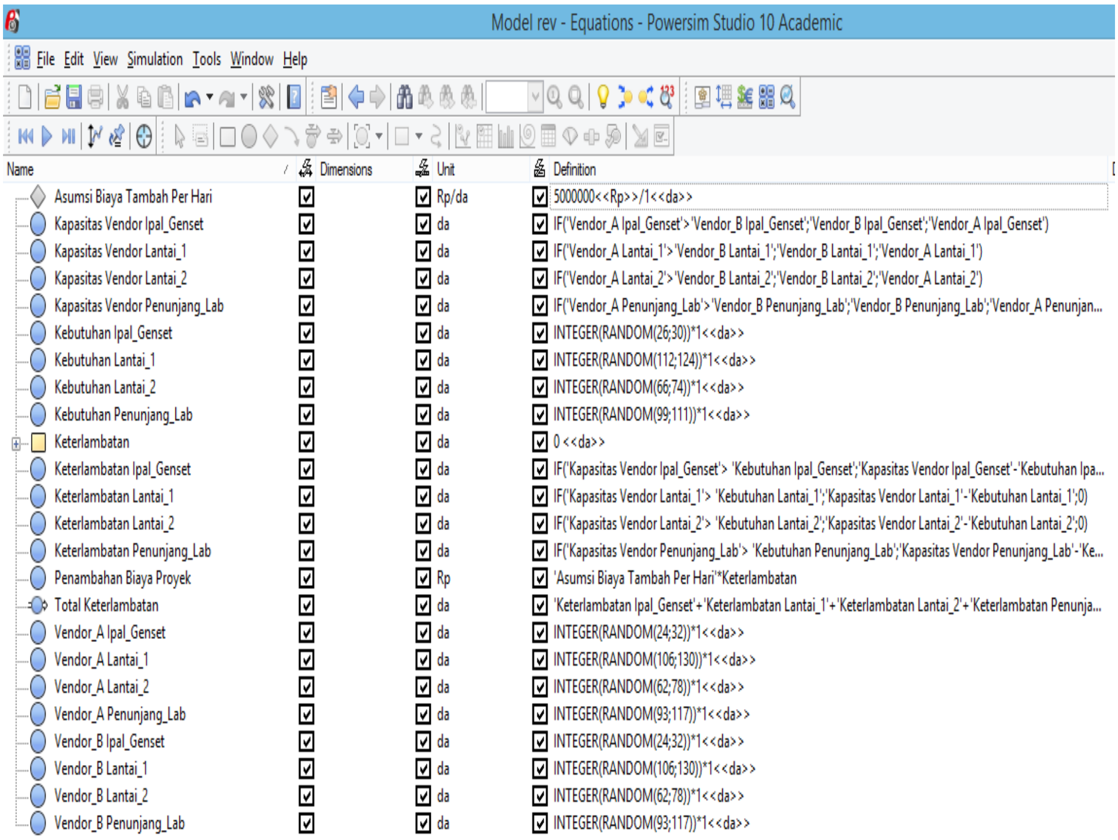


Figure 4. Equation Window Software Powersim

The image above shows *a stock-and-flow* diagram created using Powersim Studio. *A stock-and-flow* diagram is a system dynamics modeling tool used to illustrate the relationship between inventory and flow in a system.

a. Stock:

1) Denton: The name of the simulation model.
2) Asumi Land Cost Per Ha: Assumption of land cost per hectare.
3) Pal Gemet Vendor Capacity: Vendor capacity for generators.
4) Lanta Vendor Architect: The vendor's capacity for the floor.
5) Larta Vendor Capacity: The vendor's capacity for the roof.
6) Capacity of Supporting Vendors Ja: The capacity of vendors to support laboratories.

b. Flow:

1) Generator pal requirement: Generator requirement.
2) Latte Needs: Flooring needs.
3) Larta2 Needs: Roof needs.
4) Lab Support Needs: Laboratory support needs.
5) Delay *in the supply* of raw materials for generator pol: Delay *in the supply of* raw materials for generator procurement.

6) Lanta Outage: Delay *in the supply* of raw materials for floor work.
7) Delay *in the supply* of raw materials 2nd floor: Delay *in the supply* of raw materials for roofing.
8) Lab Support Resilience: Delay *in the supply* of raw materials to support the laboratory.
9) Additional Project Costs: Additional project costs due to delays *in the supply* of raw materials.

c. Relationship Between Components:

1) The delay *in the supply* of raw materials for generator procurement is affected by:
   a) Generator vendor capacity.
   b) Generator needs.
   c) Delay *in the supply* of raw materials for floor work.
2) The delay *in the supply* of raw materials for flooring is affected by:
   a) Floor vendor capacity.
   b) Flooring needs.
   c) Delay *in the supply* of raw materials for roofing.
3) The delay *in the supply* of raw materials for roofing work is affected by:
   a) Capacity of roofing vendors.
   b) Roofing needs.
   c) Delay *in the supply* of raw materials to support the laboratory.
4) The delay in *the supply* of raw materials for laboratory support is affected by:
   a) Capacity of laboratory support vendors.
   b) Laboratory support needs.
   c) Additional project costs.
5) The additional project costs are affected by:
   a) Delay *in the supply of* raw materials for generator procurement.
   b) Delay *in the supply* of raw materials for floor work.
   c) Delay *in the supply* of raw materials for roofing.
   d) Delay *in the supply* of raw materials to support the laboratory.

d. Additional Explanations:

1) This model uses random numbers to generate the value of the needs of generators, floors, roofs, and laboratory supports, indicating the uncertainty of demand.
2) The model uses equations to calculate the delay in *the supply of* raw materials, showing the relationships between complex variables.
3) The model uses simulations to run and analyze the results, demonstrating its usefulness for understanding system behavior over time.

This stock-and-flow diagram is a useful tool to analyze the causes of project raw material supply delays and find potential solutions. By understanding the relationships between components in the diagram, efforts can be made to increase vendor capacity, reduce needs, and minimize delays in the supply of raw materials in various aspects of the project.

Presentation of Simulation Results

1. Partnership Management in Determining Vendors for the Implementation of BSL 2 Building Construction Projects

The initial presentation of this system can be seen in Table 4.

Table 4. Initial Presentation of Project *Raw Material* Supply Delay System

Periode	Keterlambatan (da)	enambahan Biaya Proyek (Rp
0	0,00	0,00
1	3,00	15.000.000,00
2	6,00	30.000.000,00
3	11,00	55.000.000,00
4	11,00	55.000.000,00
5	11,00	55.000.000,00
6	11,00	55.000.000,00
7	11,00	55.000.000,00
8	22,00	110.000.000,00
9	24,00	120.000.000,00
10	26,00	130.000.000,00
11	28,00	140.000.000,00
12	33,00	165.000.000,00
13	34,00	170.000.000,00
14	35,00	175.000.000,00
15	39,00	195.000.000,00
16	40,00	200.000.000,00
17	41,00	205.000.000,00
18	41,00	205.000.000,00
19	53,00	265.000.000,00
20	69,00	345.000.000,00

Table 4 provides an overview of the relationship between the project period and the delay in *the supply* of raw materials and the increase in costs that occur. Each period represents a stage or phase in the project, and the longer the period, the greater the delay in *the supply* of raw materials and the increase in costs that occur. After the initial period, the delay *in the supply of* project raw materials tends to increase steadily. This indicates that there are fundamental problems in project management that have not been resolved. Although the delay in *the supply of* raw materials has increased steadily, the increase in costs has not always followed the same pattern. There are periods where the increase in costs is more significant than other periods. This indicates the existence of other factors that affect costs besides the time factor. After a certain period, the increase in costs tends to slow down even though the delay in *the supply* of raw materials continues to increase. This could indicate that the additional costs incurred have reached the maximum tolerable point.

This table shows data on delays in the supply of raw materials for construction projects. The specific factors contributing to the delay in the supply of raw materials are listed in the first column, labeled "Period". The second and subsequent columns show the delay in the supply of raw materials in a day caused by each factor for different periods. Detailed Description:

a. First Column (Period): This column lists the time period during which the raw material supply delay data is presented. It appears to be a sequence of numbers, perhaps representing weeks or months.

b. Second Column (Raw material *supply* delay (da)): This column translates as "Raw material *supply* delay (days)" and shows the total raw material *supply* delay caused by all the factors listed below for the corresponding period.

c. Next Column: These columns show the delay in the supply of raw materials in a day caused by specific factors for the corresponding period. The labels for these factors are:
   1) 0 (initial start)
   2) Delay in raw material supply Floor 1 (Delay in raw material supply Floor 1)
   3) Delay in raw material supply on the 2nd floor (Delay in raw material supply on the 2nd floor)
   4) Delay in the supply of raw materials for WWTP (Delay in the supply of raw materials for Wastewater Treatment Plant)
   5) Delay in the supply of generator raw materials (Delay in supply of generator raw materials)
   6) Delay in the supply of supporting raw materials (Delay in the supply of raw materials for Supporting Facilities)
   7) Delay in the supply of laboratory raw materials (Delay in the supply of laboratory raw materials)

d. Non-commercial use ontvi: This note likely refers to a data source or table maker.

Overall, this table is a useful tool for visualizing the impact of various factors on delays in the *supply of* raw materials for construction projects. By analyzing the data in the table, project managers can identify the most significant causes of raw material supply delays and take steps to mitigate them.

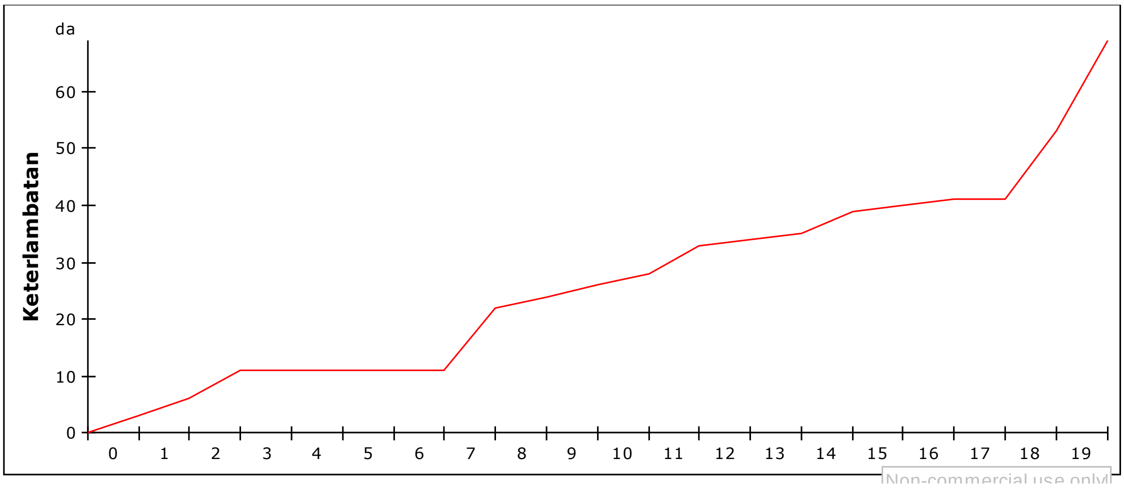


Figure 1. Delay Presentation Graphics *Supply* Raw Materials

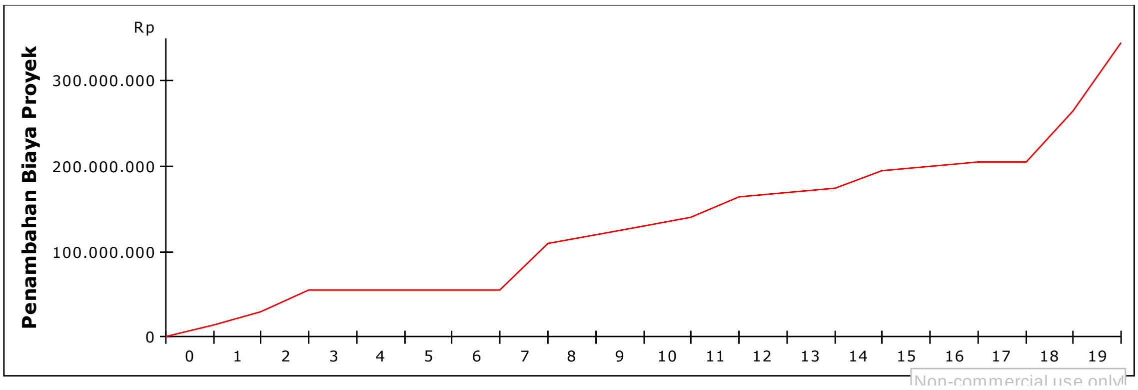


Figure 2. Project Cost Addition Presentation Chart

2. Dynamic System of Proposed Partnership Management Model in Determining Vendors for the Implementation of the BSL 2 Building Construction Project

The proposed system in this study emphasizes the efficiency of material use and the acceleration of project work which is projected to be 10%. The results of the simulation of the proposed system are seen in the following figure.

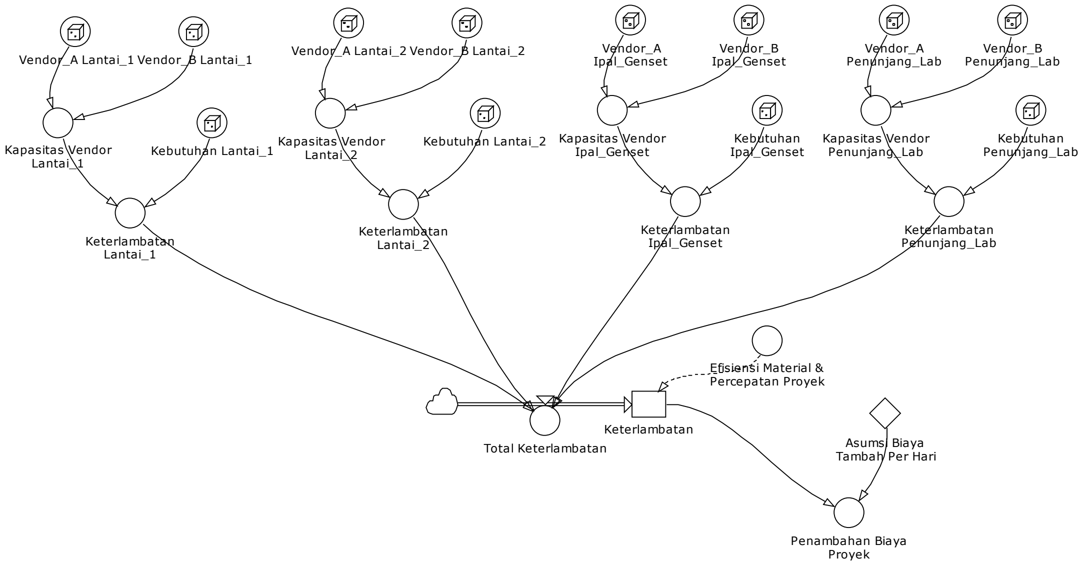


Figure 3. *Main Model* Proposal System

The presentation of this proposed system can be seen in table 5.

Table 5. Initial Presentation of the Proposal System

Periode	Keterlambatan (da)	enambahan Biaya Proyek (Rp
0	0,00	0,00
1	1,00	5.000.000,00
2	11,00	55.000.000,00
3	11,00	55.000.000,00
4	11,00	55.000.000,00
5	19,00	95.000.000,00
6	22,00	110.000.000,00
7	22,00	110.000.000,00
8	22,00	110.000.000,00
9	33,00	165.000.000,00
10	33,00	165.000.000,00
11	33,00	165.000.000,00
12	34,00	170.000.000,00
13	34,00	170.000.000,00
14	37,00	185.000.000,00
15	37,00	185.000.000,00
16	39,00	195.000.000,00
17	44,00	220.000.000,00
18	46,00	230.000.000,00
19	46,00	230.000.000,00
20	46,00	230.000.000,00

The average delay in *the supply* of project raw materials in Table 5 is lower than that of Table 4. This indicates an improvement in project time management. The average increase in project costs in Table 5 is also lower compared to Table 4. This shows that there is an improvement in project cost management. Nonetheless, there is still potential to improve the project's performance further, especially when it comes to maintaining the stability of cost increases. It can be stated that the data in Table 5 shows improvements in project management compared to Table 4. The strategies and actions implemented in the Table 5 project can be a good example to apply to future projects.

Based on the table above, it can be seen that the average delay in *raw material supply* in Table 5 (6.60 days) is 8.40 days lower than Table 4. (15.00 days). Similarly, the average cost increase in Table 5 (146000.00 Rp) is 154000.00 Rp lower than Table 4. (300000.00 Rp). These findings suggest that Table 5 has the potential to be an improvement model for project management. The average delays in *raw material supply* and lower cost increases in Table 5 indicate that the approach applied in the table may be more effective in project completion.

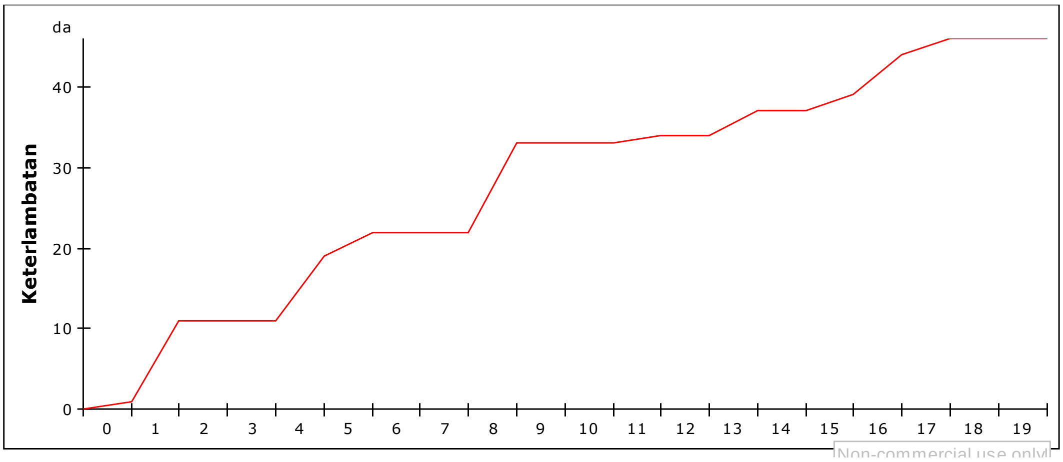


Figure 8. Graphic Presentation of Raw Material Supply Delay System Proposed System

Based on the results of the above simulation by making material use efficiency and accelerating project work, there was a decrease in the *delay in the supply* of project raw materials from 69 days to 46 days.

CONCLUSION

Based on the trend of increasing delays in *the supply of* raw materials and project costs significantly, it can be concluded that there are fundamental problems in project management. Persistent delays *in the supply* of raw materials indicate obstacles in project planning, implementation, or supervision. The significant increase in costs shows that the problem not only has an impact on time, but also on the financial aspect. In this context, the role of partnerships is very crucial. Solid partnerships between the various parties involved in the project, such as project owners, contractors, consultants, and subcontractors, can be key in addressing these issues. A good partnership allows for open and effective communication between all parties involved. It is very important to identify problems early and find solutions together. Strong partnerships encourage good coordination between all parties. With good coordination, each party can work together efficiently to achieve the project objectives. In partnerships, project risks can be shared together. This can reduce the burden on each party and increase the stability of the project. Delays in *the supply* of raw materials are a serious problem in building construction projects. The overall trend from periods 1 to 20 indicates challenges in project management, especially in terms of time control. While there are periods where delays can be controlled, the general trend shows that projects tend to experience greater and greater delays. In some periods, the percentage increase in delays from period 1 to period 2 reached more than 60%, especially in the early and middle periods. This indicates that the project experienced significantly greater delays compared to the baseline.

The partnership management model in determining the vendor for the implementation of the BSL 2 building construction project by reducing the average delay in *the supply of* project raw materials, improving project time management, reducing the average increase in project costs by improving project cost management. Improvements are made so that there is potential to improve project performance further, especially in terms of maintaining the stability of cost increases.

Building strong partnerships with suppliers can ensure a stable and timely supply of raw materials. Through long-term agreements, joint planning, and effective monitoring mechanisms, supply delays can be minimized. By managing the supply chain efficiently, the risk of supply disruptions can be identified and mitigated early. It involves inventory monitoring, risk analysis, and contingency plan development. Good partnerships allow for more detailed and collaborative project planning. By involving all relevant parties from the outset, the risk of delays can be identified and anticipated; Project scheduling that is more flexible and responsive to change. This is very important to overcome unexpected obstacles.

Based on the conclusion above, suggestions can be made. The BSL-2 building construction project is a complex project and requires special attention from the construction manager. In addition to the common challenges in construction projects, these projects also have unique challenges related to biological safety, strict regulations, and high technical specifications. The role of the construction manager in this project is crucial. Construction managers are not only responsible for the overall planning, execution, and control of the project, but they must also ensure that all aspects of occupational safety and health are met. In addition, construction managers must also be able to manage the risks associated with these projects, such as the risk of biological contamination and the risk of project delays.

Construction managers must create a detailed project plan, covering all project stages, realistic schedules, and optimal resource allocation. Additionally, construction managers must also identify potential risks that could hinder the project and create an effective mitigation plan. With good planning, construction managers can minimize the risk of delays and cost overruns.

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