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Analysis of Project Delay Using the Fault Tree Analysis (FTA) Method in Rising Building Projects

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ABSTRACT

A job on a construction project can affect delays throughout the project. Every construction project has a specific plan and schedule for when to start when to finish, how to schedule, and how to provide resources. There should be no delays in implementation because they will result in increased project costs. However, there was a delay in the performance of the lecture building construction project with the Faculty of Engineering UPN "Veteran" East Java. The methods given in the discussion to determine the factors that influence the occurrence of delays are the Fault Tree Analysis (FTA) method and the Obtain Cut Set Method (MOCUS). Work items that experienced delays were structural, architectural, and MEP work. There are three top events known through FTA analysis, namely delays caused by design changes and wrong drawings, which are factors causing delays from service users. The dominant factor causing delays in structural work is the difference in elevation with elegant buildings and a need for more attention to structural safety. This problem occurs in the top event factor of service users. The service users referred to in scientific research are the owners and/or planning consultants. From the results of a quantitative Fault Tree analysis, the reliability value of the structural work is 0.861. In this case, the structural work experienced a delay of >10% with a Reliability value below 90%, so the contract was declared critical.

Keywords: *Project Delays; Fault Tree Analysis; Obtain Cut Set Method*

INTRODUCTION

A project is an effort or activity organized to achieve important goals, objectives, and expectations using the budget and available resources, which must be completed within a certain period [1]. Project management is all planning, implementing, controlling, and coordinating a project from the beginning (idea) to the end of the project to ensure timely, cost-effective, and quality project implementation [2]. Project management is the application of knowledge, skills, tools, and techniques in an activity to fulfill or obtain the results needed in the project [3]. Project management is a process that requires skills, tools, and techniques in planning, implementing, and controlling company-owned resources (man, material, machine, money, method) to achieve the goals set. Making a construction project always refers to the estimates during the scheduling plan. Scheduling is allocating the available time to achieve optimal results by considering the existing limitations to carry out various jobs to complete a project. Scheduling aims to minimize processing time and budgeted costs. The successful completion of a project adheres to three interconnected aspects, namely on time, on price, to the exact scope or specifications set [4]. Project management is managing a project from start

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to finish For the smooth running of a project. A project is good if the completion of the project is efficient in terms of time and cost and achieves work efficiency, both human and equipment. Everything in a project that does not add value but instead adds costs is called waste [5]. Scheduling prepared to consider various existing limitations to have a positive impact, namely low operating costs and construction time, which can increase the probability of achieving the scheduling target [6]. Fault Tree Analysis (FTA) is an analytical technique to identify system failures. The artifact of system failure in scientific research is the delay in the building construction project. FTA can be analyzed qualitatively using Boolean Algebra or quantitatively using theoretical reliability [7]. Project implementation that is outside the plan can result in project delays. In the performance of construction projects, project delays often occur, which can cause various forms of losses for service providers and service users [8]. Construction project delays, namely the delay in project completion deadline from the time specified in the contract or from the time agreed by the parties involved in the completion of a project. [9]. Project delays arise when the contractor cannot complete the project according to the time specified in the contract [10]. Construction delays can be translated as a variety of development solutions in meeting the target time for completion of the work, exceeding the date agreed upon by all parties [11].

Developing the infrastructure sector in Indonesia has contributed to the growth of many other activities. In this study, the construction project of a lecture building with the Faculty of Engineering (GKB FT) is an example of developing the infrastructure sector and supporting student academic facilities in the province of East Java. The GKB FT UPN, "Veteran" East Java development project, was built with '4' floors. The GKB FT UPN "Veteran" East Java construction project has '2' zones in its construction, namely zone 1 and zone 2. The building has an area of 17x25.95 m2 with a height of 14.65 billion. Structural work is experiencing delays, which can be seen from the schedule for implementing the GKB FT UPN "Veteran" East Java development project, so delays in structural work affect other work. Where should the GKB FT UPN "Veteran" East Java development project be completed within 210 days from 'October 7, 2022' to 'May 4, 2023.' However, it had experienced a delay of up to 50 days on June 22, 2023.

This study uses the Fault Tree Analysis (FTA) method to determine the mechanism of the factors causing delays and the Obtain Cut Set Method (MOCUS) to determine the combination of factors causing delays.Conclude from the background above the problems studied in the preparation of scientific research, among others:

1. What work fields have experienced delays in implementing the GKB FT UPN "Veteran" East Java development project?
2. What factors affect the delay in implementing the GKB FT UPN "Veteran" East Java development project?
3. What is the reliability value of the factors causing delays in the GKB FT UPN "Veteran" East Java development project?

Meanwhile, the limitations of the problem in writing scientific research include:

1. The reliability value of the factors causing the delay in the GKB FT UPN "Veteran" East Java development project as a research object.
2. I am only looking for the factors causing the delay in the GKB FT UPN "Veteran" East Java development project.
3. I was using the FTA (Fault Tree Analysis) model.

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MATERIALS AND METHODS

This research case study concerns the analysis of delays in the GKB FT UPN "Veteran" East Java "Veteran" development project using the Fault Tree Analysis (FTA) method to further support the studies of East Java "Veteran" UPN students who are currently under construction in the city of Surabaya. The Fault Tree Analysis (FTA) method for technical analysis identifies the failure of a working system in a building project—data collection methods in the form of primary and secondary data. Primary data is the leading data used as a reference for processing data directly in the field. The interview is a face-to-face situation between the interviewer and the respondent, which is intended to gather the expected information and aims to obtain data about the respondent with minimum bias and maximum efficiency [12]. In scientific research, using the interview model is an excellent judgemental method. The scientific method is the opinion of experts/stakeholders based on knowledge and experience to respond to a problem that is appropriate to the topic in the student and expert discussion. Secondary data is supporting data for primary data. The secondary data from scientific research are S-curves, progress reports, weekly reports, and literature studies. During data collection, the writer conducts data analysis to determine the work sectors that are experiencing delays and the factors that affect work skills are experiencing delays.

They repeatedly carried out the design of The Fault Tree Analysis (FTA) for the GKB FT UPN "Veteran" East Java development project until it received validation from a construction expert. Then, after creating a Fault Tree Analysis (FTA) image to determine the combination of factors causing the delay. After obtaining the minimum cut set, the next step is to quantitatively analyze the fault tree to compare the plan's progress with the actual progress. Can be seen in picture 1 is the flow chart.

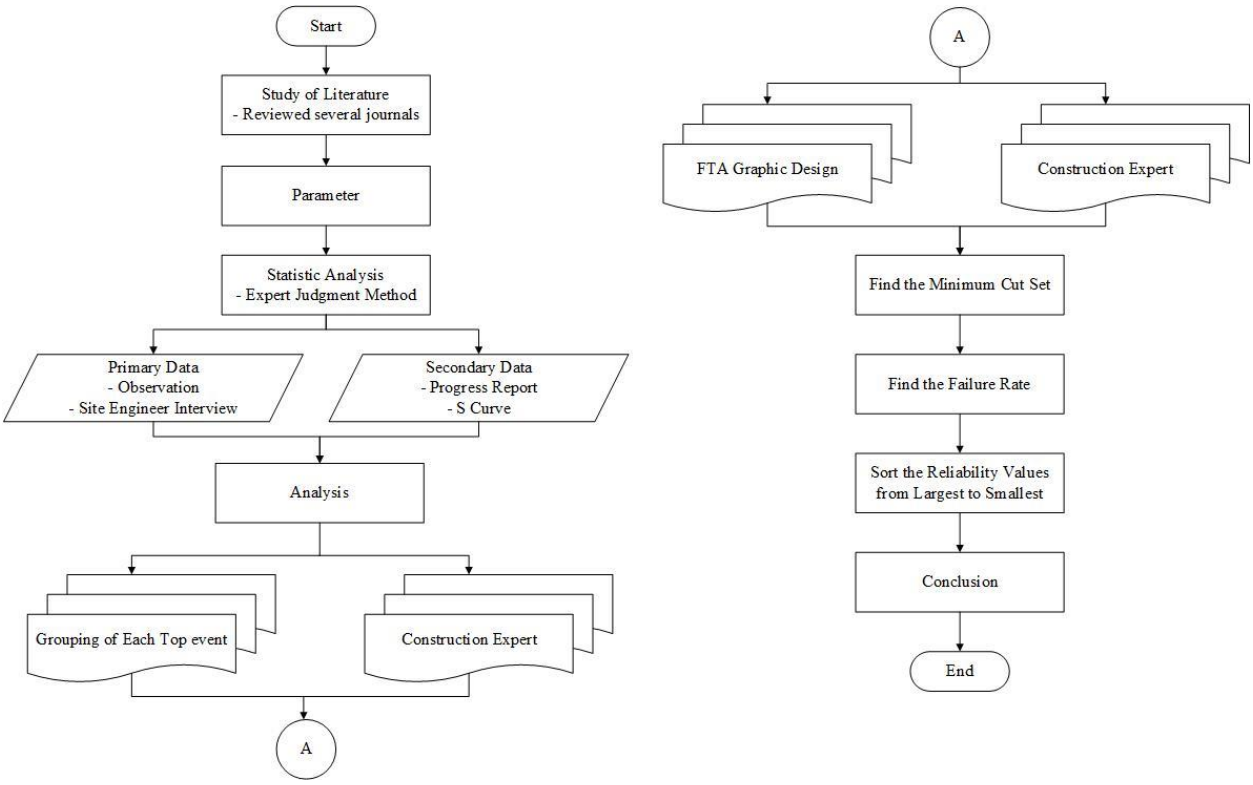

Figure1. Research Flow Chart

RESULTS AND DISCUSSION

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In this chapter, we will discuss the research analysis results to obtain late work items and the 'basic' factors that cause delays in these items.

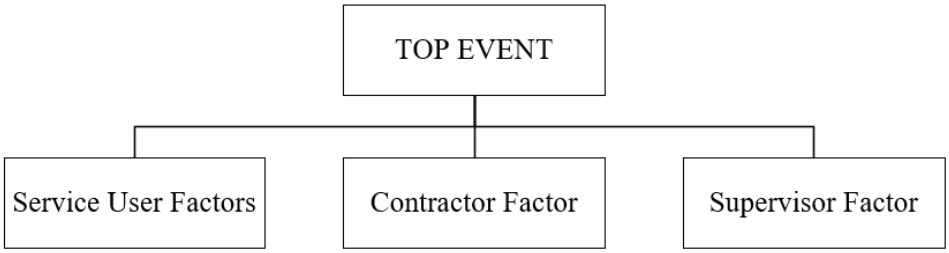
Identify overdue work items.

Based on the results of data analysis conducted by the author and the contractor.

Identification of factors causing delays

The purpose of identifying intermediate and 'basic events' is to describe a structured fault tree between one cause and another so that the possible causes of delays are identified systematically [13]. Among the 'basic' events in the GKB FT UPN "Veteran" East Java development project, data analysis and literature studies regarding the factors that influence the delay of a project to determine events. Grouping of intermediate events from each work item that is late to the first level becomes:

To systematically identify 'intermediate' events and 'base' events, it aims to describe a fault tree structure between one cause and another so that the possible causes of delays. Among the 'basic' events in the GKB FT UPN "Veteran" East Java development project, from data analysis and literature studies regarding the factors that influence project delays to obtain event identification. Intermediate event grouping of each work item that is late to the first level becomes:



FTA construction description

After determining the intermediate event at the first level, the next step is determining the intermediate event for the next level and the 'basic' event. This determination aims to obtain a relationship between the top event and various factors that cause delays. The next step is to describe the FTA construction. In describing the Fault Tree standard symbols to facilitate analysis. The steps for making FTA construction are as follows:

a. Determine the identification of peak events.
b. They are determining the first-degree intermediate event to the peak event.
c. Using logic gates, determine the relationship between the first-level intermediate and top events.
d. Determine the intermediate level / second level
e. Using logic gates, determine the relationship between the second and first-level intermediate events.
f. They are continuing the same steps to the 'basic' event.

Figures 2 and 3 are construction drawings of the FTA 'Structure Work.' Besides that, the description of FTA construction is also on the items 'Architectural Work' and 'MEP Work.'

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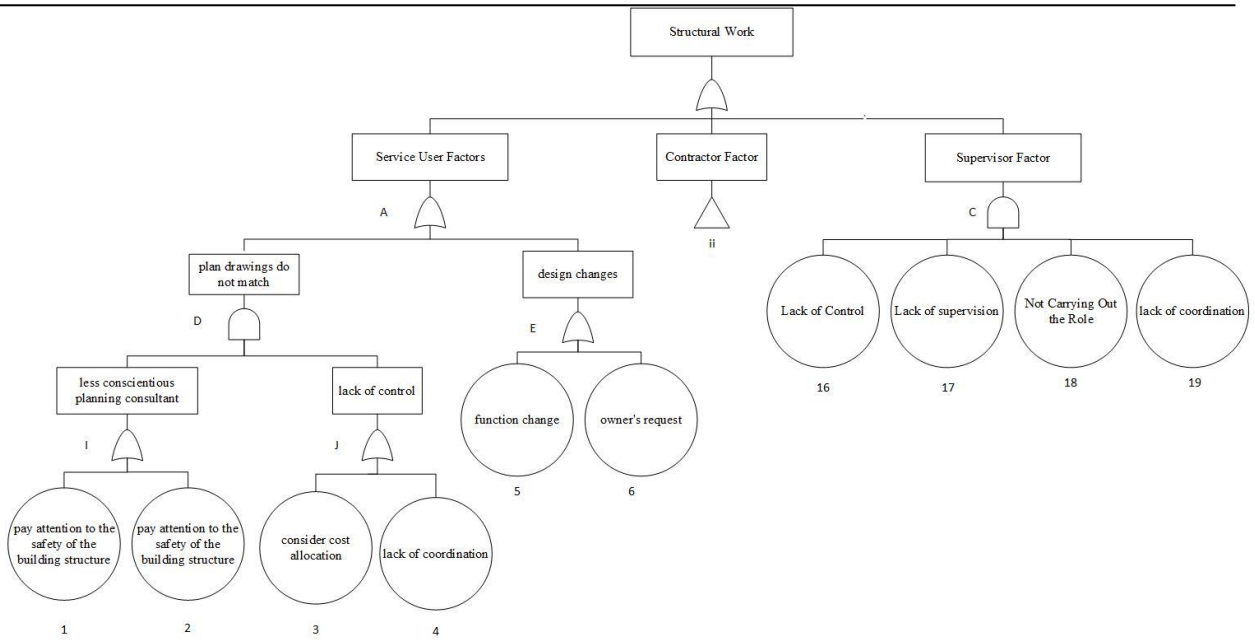

Figure 2 FTA of Structural Works

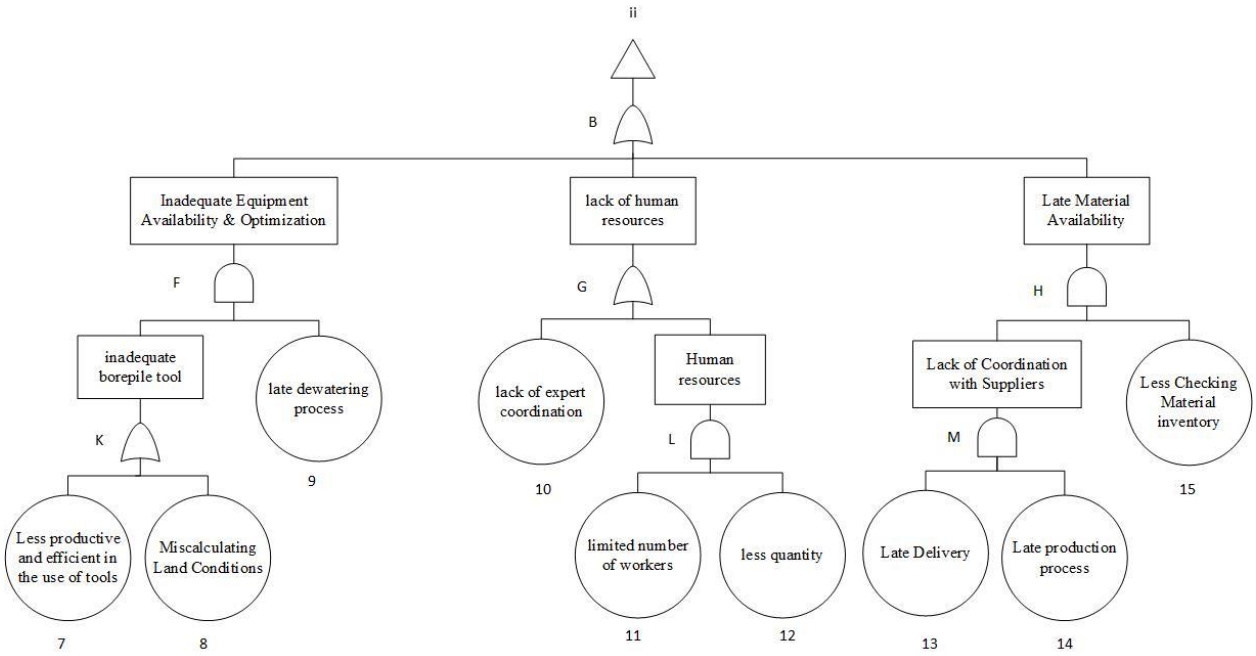

Figure 3 FTA of Structural Works

Basic Event Combination

After completing the Fault Tree Analysis (FTA) diagram, the next step is determining the cut set. Cut sets are combinations that form a fault tree, which, if all occur, will cause the highest event to occur [14]. This minimal cut set is the most minor combination of events that brings unwanted events. In comparison, 'Mocus' is a method to get a 'cut set' and a minimum 'cut set.' To derive various 'base' events using the description of the analyzed FTA, the 'and gate' or 'or gate' relationship. The following is the MOCUS analysis of each top event:

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a. MOCUS Analysis on Structure work.
Table 1 shows the minimum pieces specified for structural work.

Table 1. Minimum Cut Set of Structure Work

Minimal Cut Set			
1, 2	4	6	9, 10, 11
1, 3	5	7, 8	12, 13, 14, 15

The results of the FTA, which caused delays in the structural work of the GKB UPN "Veteran" East Java development project, resulted in 15 'basic' events, while the Mocus analysis resulted in 8 'basic' events.

Determine the identification of peak events. After getting the minimum cut set, the next step is quantitatively analyzing the fault tree. Total testing is the complete project implementation period written in the contract, which is 210 calendar days—beginning implementation on October 7, 2022, and ending on May 4, 2023.

In the structural work, the plan's duration is 140 days, and the realization duration is 161 days, resulting in a delay of 21 days. Then, look for the value of the failure rate as follows:

Failure Rate:

$\lambda(t) = \frac{f}{T}$

Where

$\lambda(t)$ = failure rate per unit time

f = Number of failures during testing time

T = Total testing time, then:

$\lambda(t) = \frac{21}{140} = 0{,}15$

From the results above, the reliability value of structural work is as follows

$R = e^{-\lambda(t)}$

$R = e^{-0{,}15} = 0{,}861$

In this case, the structural work has been delayed > 10% with a Reliability value below 90%, so the contract is declared critical. A show cause meeting/SCM is needed, as described in the 'regulation of the Indonesian government goods/service procurement policy agency number 12 2021', which discusses guidelines for implementing government procurement of goods/services through providers [15].

CONCLUSION

Analysis of the factors causing delays in the GKB FT UPN "Veteran" East Java development project based on field observations and data analysis that has been carried out in the previous chapter, the following conclusions can be drawn:

1. The items of work on the East Java GKB FT UPN "Veteran" development project which experienced delays are as follows:
   a. Structural work
   Architectural work
   MEPs work
2. From the results of the fault tree analysis (FTA), the following results are obtained :
   a. In the top event, the structural work of the GKB FT UPN "Veteran" East Java development project, the basic event that most often occurs is the difference in elevation from the existing building and attention to structural safety. In the intermediate event, the planning consultant is not thorough. Apart from that, the basic event that often arises is a lack of coordination. and weighed against the cost of the intermediate event of lack of control. This occurs in the top event factor of service users. The service users referred to in this study are the owner and/or planning consultant.

   b. In the top event 'architectural work', the basic event that often occurs is that the planning consultant is not careful with the intermediate event, the drawings do not match.

   c. In the top event 'MEP work', the most common basic event is lack of detail in MEP work, increasing the amount of material, and delays in material delivery.

   From the results of the research above, it can be concluded that the factors causing a project delay are due to changes in design and drawings that are not appropriate where the delay factor occurs from the owner and/or planning consultant.
3. From the results of a quantitative Fault Tree analysis, the reliability value of the structural work is 0.861. In this case, the structural work experienced a delay of >10% with a Reliability value below 90%, so the contract was declared critical.

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