Implementation of the Failure Mode and Effects Analysis (FMEA) Method to Determine Project Risk Priority

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Abstract. The purpose of this research is to determine the priorities of risks that might occur so that the implementation of project work can run smoothly and later can be used as a basis for making decisions in handling the project being worked on. One method that can be used to determine the priority of risks that arise in a project is the Failure Mode and Effects Analysis (FMEA). FMEA is one of the methods used to prevent project failures caused by project risks that arise. The results of this study are FMEA can be used to handle and determine the priority of risks that arise in the project and can be used by the person in charge of the project in making decisions in handling risks that arise in the project. By using FMEA project risks can be prevented and completed so that the project can be completed on time.

1. Introduction
The project is a combination of labor (human), material, equipment, facilities, and supporting services (capital / cost) in a temporary organization that is used to achieve the goals and objectives that have been determined [1]. Project risk is the cumulative effect of the chance of an uncertain event that affects project goals and objectives that can result in late completion of the project [2]. Risk refers to the uncertainty and severity of events and results of an activity in connection with something that human’s value [3]. Identification of risks in the project will be divided into several project risks [4]. To identify and take action on the project risks that arise can use several methods, one of the methods used is Failure Mode and Effects Analysis (FMEA) [5]. FMEA is a structured method that can be used to identify, prioritize failure modes and then prevent them as much as possible and be able to trace the sources of the causes of failure [6]. FMEA is an analytical technique that combines technology and experience in identifying the failure of the production process and planning to prevent it from happening again [5]. FMEA was originally created by Aerospace Industry in the 1960s. FMEA began to be used by Ford in the 1980s, AIAG (Automotive Industry Action Group) and the American Society for Quality Control (ASQC) set it as a standard in 1993. Currently FMEA is one of the core tools in ISO / TS 16949: 2022 (Technical Specifications for Automotive Industry) [7]. Previous studies that used FMEA were research conducted by Teng and Ho in 1996 [5], Santoso in 2007 [8] and Ahsen in 2008 [9] FMEA was used to identify failures in the production process that resulted in risks that appeared to be proven failures the production process does not repeat itself.

The purpose of this research is to apply the FMEA method to find out the risks that arise in the project and to determine which risk priorities must be addressed first so that the risks that arise in the project can be immediately addressed and the project can be completed on time.
2. Method
The research methodology in this study uses descriptive methods. Descriptive method is a method used to find facts with the right interpretation and try to describe a symptom, events that occur at the moment or an actual problem [10]. The research methodology in this study begins with a review of the FMEA literature study together with secondary data collection. The next step is to identify risks, followed by calculating the severity, occurrence and detection. After that, calculating the value of the Risk Priority Number (RPN) is continued to calculate the critical value and the last is managing risks that are used to assist the Responsible Person in identifying project risks at the beginning of the project implementation so that if these risks arise when project implementation can be dealt with quickly [11].

3. Results and Discussion
3.1 Secondary Data Collection
The data used in this research is the installation of paving in the Mandala project. In this project, the project implementation time is 200 days starting from December 27, 2018 until July 15, 2019. There are five steps in determining risk priorities using FMEA [11]. The step starts from identifying risks, then continues with calculating the severity, occurrence and detection. After that, calculate the value of the Risk Priority Number (RPN) and proceed to calculate the critical value and the last is risk management.

3.2 Project Risk Identification
Risk identification process aims to create a list of risks that have occurred in the previous project work and that will probably occur in the next projects. This risk identification process is carried out using an interview approach with the person in charge of the project. The identification of risks in this study can be seen in Table 1.

| No. | Name of Activities | Risk Code | Obstacle                  |
|-----|-------------------|-----------|---------------------------|
| 1   | Land Leveling and Compaction Land Work  with Tamping Rammer | R1 | Bad weather               |
|     |                   | R2 | Material prices have risen |
|     |                   | R3 | Material delivery delays  |
|     |                   | R4 | Damage to project tools   |
|     |                   | R5 | Labor is absent           |
|     |                   | R6 | Labor accident            |
|     |                   | R1 | Bad weather               |
|     |                   | R2 | Material prices have risen |
| 2   | Paving Alignment Work with Ash Stone and Paving Block Installation | R3 | Material delivery delays  |
|     |                   | R4 | Damage to project tools   |
|     |                   | R5 | Labor is absent           |
|     |                   | R6 | Labor accident            |
|     |                   | R1 | Bad weather               |
|     |                   | R2 | Material prices have risen |
|     |                   | R3 | Material delivery delays  |
|     |                   | R4 | Damage to project tools   |
|     |                   | R5 | Labor is absent           |
|     |                   | R6 | Labor accident            |
|     |                   | R1 | Bad weather               |
|     |                   | R2 | Material prices have risen |
| 3   | Casting filler work | R4 | Damage to project tools   |
|     |                   | R5 | Labor is absent           |
|     |                   | R6 | Labor accident            |
|     |                   | R1 | Bad weather               |
|     |                   | R2 | Material prices have risen |
| 4   | Paving Block Leveling Work With a Baby Roller | R3 | Material delivery delays  |
|     |                   | R4 | Damage to project tools   |
|     |                   | R5 | Labor is absent           |
|     |                   | R6 | Labor accident            |

3.3 Determine the Severity Value, Occurrence Value and Detection Value
Determine the severity, Occurrence and detection values based on the identification of risks that have been carried out in the previous stage. The severity, occurrence, and detection values were obtained from interviews with the project managers and can be seen in Table 2.
Table 2. Value of Severity, Event, and Detection

| Risk Code | Risks                                                | Severity Value | Occurrence Value | Detection Value |
|-----------|------------------------------------------------------|----------------|-----------------|-----------------|
|           | Land Leveling and Compaction Land Work with Tamping Rammer |                |                  |                 |
| R1        | Bad weather                                          | 5              | 7               | 5               |
| R2        | Material prices have risen                           | 2              | 5               | 4               |
| R3        | Material delivery delays                             | 3              | 4               | 5               |
| R4        | Damage to project tools                              | 6              | 4               | 6               |
| R5        | Labor is absent                                      | 3              | 2               | 7               |
| R6        | Labor accident                                       | 3              | 2               | 7               |
|           | Paving Alignment Work with Ash Stone and Paving Block Installation |                |                  |                 |
| R1        | Bad weather                                          | 5              | 7               | 5               |
| R2        | Material prices have risen                           | 3              | 6               | 4               |
| R3        | Material delivery delays                             | 4              | 4               | 3               |
| R4        | Damage to project tools                              | 6              | 4               | 5               |
| R5        | Labor is absent                                      | 4              | 2               | 6               |
| R6        | Labor accident                                       | 3              | 2               | 7               |
|           | Casting Filler Work                                  |                |                  |                 |
| R1        | Bad weather                                          | 5              | 7               | 5               |
| R2        | Material prices have risen                           | 3              | 6               | 4               |
| R3        | Material delivery delays                             | 4              | 4               | 4               |
| R4        | Damage to project tools                              | 3              | 3               | 5               |
| R5        | Labor is absent                                      | 3              | 4               | 3               |
| R6        | Labor accident                                       | 3              | 3               | 6               |
|           | Paving Block Leveling Work with a Baby Roller         |                |                  |                 |
| R1        | Bad weather                                          | 4              | 7               | 5               |
| R2        | Material prices have risen                           | 1              | 5               | 4               |
| R3        | Material delivery delays                             | 1              | 3               | 4               |
| R4        | Damage to project tools                              | 4              | 3               | 4               |
| R5        | Labor is absent                                      | 3              | 5               | 3               |
| R6        | Labor accident                                       | 1              | 3               | 3               |

3.4 Determine the Value of The Risk Priority Number (RPN)

The next step is to calculate the Risk Priority Number (RPN) is an overall danger score calculated by multiplying Severity, Occurrence, and Detection. Higher RPNs are design priorities. [11].

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RPN = \text{Severity Value} \times \text{Occurrence Value} \times \text{Detection Value} \]

The results of the calculation of the RPN value can be seen in Table 3.
### Table 3. Result of RPN Value Calculation

| Risk Code | Risks                                           | Severity Value | Occurrence Value | Detection Value | RPN Value |
|-----------|------------------------------------------------|----------------|------------------|-----------------|-----------|
| R1        | Bad weather                                   | 5              | 7                | 5               | 175       |
| R2        | Material prices have risen                     | 2              | 5                | 4               | 40        |
| R3        | Material delivery delays                       | 3              | 4                | 5               | 60        |
| R4        | Damage to project tools                        | 6              | 4                | 6               | 144       |
| R5        | Labor is absent                                | 3              | 2                | 7               | 42        |
| R6        | Labor accident                                 | 3              | 2                | 7               | 42        |
|           | Paving Alignment Work with Ash Stone and Paving Block Installation
| R1        | Bad weather                                   | 5              | 7                | 5               | 175       |
| R2        | Material prices have risen                     | 3              | 6                | 4               | 72        |
| R3        | Material delivery delays                       | 4              | 4                | 3               | 48        |
| R4        | Damage to project tools                        | 6              | 4                | 5               | 120       |
| R5        | Labor is absent                                | 4              | 2                | 6               | 48        |
| R6        | Labor accident                                 | 3              | 2                | 7               | 42        |
|           | Casting Filler Work                            |
| R1        | Bad weather                                   | 5              | 7                | 5               | 175       |
| R2        | Material prices have risen                     | 3              | 6                | 4               | 72        |
| R3        | Material delivery delays                       | 4              | 4                | 4               | 64        |
| R4        | Damage to project tools                        | 3              | 3                | 5               | 45        |
| R5        | Labor is absent                                | 3              | 4                | 3               | 36        |
| R6        | Labor accident                                 | 3              | 3                | 6               | 54        |
|           | Paving Block Leveling Work With A Baby Roller  |
| R1        | Bad weather                                   | 4              | 7                | 5               | 140       |
| R2        | Material prices have risen                     | 1              | 5                | 4               | 20        |
| R3        | Material delivery delays                       | 1              | 3                | 4               | 12        |
| R4        | Damage to project tools                        | 4              | 3                | 4               | 48        |
| R5        | Labor is absent                                | 3              | 5                | 3               | 45        |
| R6        | Labor accident                                 | 1              | 3                | 3               | 9         |

### 3.5 Determine Critical Value

After getting the RPN value for each risk, the next step is to calculate the Critical Value. This critical value is used to determine what risks are included in the high-risk category. Risks included in the high category is a risk that has an RPN value greater or equal to the critical value (RPN critical value). Critical values are calculated using the formula: Total RPN / Total risk [12]. Calculation of critical values in this study can be seen in Table 4.
Table 4. Critical Value and Risk Categories

| Risk Code | Risks                                      | RPN Value | Critical Value | Risk Category |
|-----------|--------------------------------------------|-----------|----------------|---------------|
| R1        | Bad weather                                | 175       | 83.83 ≈ 84     | High          |
| R2        | Material prices have risen                  | 40        | Low            |               |
| R3        | Material delivery delays                    | 60        | Low            |               |
| R4        | Damage to project tools                     | 144       | High           |               |
| R5        | Labor is absent                             | 42        | Low            |               |
| R6        | Labor accident                              | 42        | Low            |               |
|           | Land Leveling and Compaction Land Work with Tamping Rammer |           |                |               |
| R1        | Bad weather                                | 175       | 84.17 ≈ 85     | High          |
| R2        | Material prices have risen                  | 72        | Low            |               |
| R3        | Material delivery delays                    | 48        | Low            |               |
| R4        | Damage to project tools                     | 120       | High           |               |
| R5        | Labor is absent                             | 48        | Low            |               |
| R6        | Labor accident                              | 42        | Low            |               |
|           | Paving Alignment Work with Ash Stone and Paving Block Installation |           |                |               |
| R1        | Bad weather                                | 175       | High           |               |
| R2        | Material prices have risen                  | 72        | Low            |               |
| R3        | Material delivery delays                    | 48        | Low            |               |
| R4        | Damage to project tools                     | 120       | High           |               |
| R5        | Labor is absent                             | 48        | Low            |               |
| R6        | Labor accident                              | 42        | Low            |               |
|           | Casting Filler Work                         |           |                |               |
| R1        | Bad weather                                | 175       | 74.33 ≈ 75     | High          |
| R2        | Material prices have risen                  | 72        | Low            |               |
| R3        | Material delivery delays                    | 64        | Low            |               |
| R4        | Damage to project tools                     | 45        | Low            |               |
| R5        | Labor is absent                             | 36        | Low            |               |
| R6        | Labor accident                              | 54        | Low            |               |
|           | Paving Block Leveling Work with a Baby Roller |           |                |               |
| R1        | Bad weather                                | 140       | High           |               |
| R2        | Material prices have risen                  | 20        | Low            |               |
| R3        | Material delivery delays                    | 12        | Low            |               |
| R4        | Damage to project tools                     | 48        | High           |               |
| R5        | Labor is absent                             | 45        | Low            |               |
| R6        | Labor accident                              | 9         | Low            |               |

From Table 4, it can be seen that there are 2 risk categories, namely High and Low, which is going to be used by the person in charge of the project to find out which risks must be addressed first.

3.6 Risk Handling

Table 4 can be used as a reference for the person in charge of the project in handling risks that arise in the project. The risk management in the project in this study can be seen in Table 5.

From the risk categories obtained in Table 4, the person in charge of the project can see which risks have a major impact on the project and which risks have a small impact on the sustainability of the project and the person in charge of the project can see risk priorities from R1 to R6 which risks will be resolved first if they occur risk at the same time so that the project can be completed on time.

In addition, the person in charge of the project can also make the handling of risks that arise, while the risk management in this study can be seen in Table 5.
Table 5. Risk Handling Scenario

| Risk Code | Risks                                                                 | RPN Value | Risk Category | Risk Handling Action                                      |
|-----------|----------------------------------------------------------------------|-----------|---------------|----------------------------------------------------------|
| R1        | Bad weather                                                          | 175       | High          | Increase worked hours (overtime)                         |
| R2        | Material prices have risen                                           | 40        | Low           | Agreement with suppliers regarding the prices of materials |
| R3        | Material delivery delays                                             | 60        | Low           | Communicating with suppliers of materials                |
| R4        | Damage to project tools                                              | 144       | High          | Immediately replace damaged equipment and increase supervision of work equipment |
| R5        | Labor is absent                                                      | 42        | Low           | Replacing with other workers                             |
| R6        | Labor accident                                                       | 42        | Low           | Directing the workforce to prioritize safety             |
|           | Land Leveling and Compaction Land Work With Tamping Rammer           |           |               |                                                          |
| R1        | Bad weather                                                          | 175       | High          | Increase worked hours (overtime)                         |
| R2        | Material prices have risen                                           | 40        | Low           | Agreement with suppliers regarding the prices of materials |
| R3        | Material delivery delays                                             | 60        | Low           | Communicating with suppliers of materials                |
| R4        | Damage to project tools                                              | 144       | High          | Immediately replace damaged equipment and increase supervision of work equipment |
| R5        | Labor is absent                                                      | 42        | Low           | Replacing with other workers                             |
| R6        | Labor accident                                                       | 42        | Low           | Directing the workforce to prioritize safety             |
|           | Paving Alignment Work with Ash Stone and Paving Block Installation    |           |               |                                                          |
| R1        | Bad weather                                                          | 175       | High          | Increase worked hours (overtime)                         |
| R2        | Material prices have risen                                           | 40        | Low           | Agreement with suppliers regarding the prices of materials |
| R3        | Material delivery delays                                             | 60        | Low           | Communicating with suppliers of materials                |
| R4        | Damage to project tools                                              | 144       | High          | Immediately replace damaged equipment and increase supervision of work equipment |
| R5        | Labor is absent                                                      | 42        | Low           | Replacing with other workers                             |
| R6        | Labor accident                                                       | 42        | Low           | Directing the workforce to prioritize safety             |
|           | Casting Filler Work                                                  |           |               |                                                          |
| R1        | Bad weather                                                          | 175       | High          | Increase worked hours (overtime)                         |
| R2        | Material prices have risen                                           | 40        | Low           | Agreement with suppliers regarding the prices of materials |
| R3        | Material delivery delays                                             | 60        | Low           | Communicating with suppliers of materials                |
| R4        | Damage to project tools                                              | 144       | High          | Immediately replace damaged equipment and increase supervision of work equipment |
| R5        | Labor is absent                                                      | 42        | Low           | Replacing with other workers                             |
| R6        | Labor accident                                                       | 42        | Low           | Directing the workforce to prioritize safety             |
|           | Paving Block Leveling Work With a Baby Roller                        |           |               |                                                          |
| R1        | Bad weather                                                          | 175       | High          | Increase worked hours (overtime)                         |
| R2        | Material prices have risen                                           | 40        | Low           | Agreement with suppliers regarding the prices of materials |
| R3        | Material delivery delays                                             | 60        | Low           | Communicating with suppliers of materials                |
| R4        | Damage to project tools                                              | 144       | High          | Immediately replace damaged equipment and increase supervision of work equipment |
| R5        | Labor is absent                                                      | 42        | Low           | Replacing with other workers                             |
| R6        | Labor accident                                                       | 42        | Low           | Directing the workforce to prioritize safety             |

In this study, it can be concluded that the use of FMEA in project implementation can not only be used to identify project failures caused by emerging risks developed by Teng and Ho in 1996 [5] but can also be used to choose which risk priorities must be resolved first if there are several risks that arise simultaneously and can also be used to deal with risks that arise so that project failure can be minimized and the project can be completed on time.

4. Conclusion
The conclusion of this research is that FMEA can be used to help the project person in charge, to determine the risks, risk categories and treatment measures so that if risks arise in the project, they can be overcome immediately and the project can be completed on time.

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