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## Spatial Economic Transport Interaction for Sustainable Development

October 24th, 2018
Department of Urban and Regional Planning
Institut Teknologi Sepuluh Nopember
Surabaya, INDONESIA

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# The analysis of supply chain risk logistics in implementation of West Sumatera - Riau toll road development

# The analysis of supply chain risk logistics in implementation of West Sumatera - Riau toll road development

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**Abstract.** The aim of this research is to develop a risk mitigation strategy in supply chain process of West Sumatra-Riau toll road pavement material. Data for this study was obtained through brainstorming techniques, questionnaires, field surveys and literature review. The data was analyzed using House of Risk (HOR) method. There were 18 items of risk event's and 21 items of risk agent's identified from the HOR phase 1, whereas risk agent handling priority data and risk mitigation actions are 19 items by using HOR phase 2. The results show that there are 2 (two) risk agents ranked 1 and 2 for the most critical, namely A1 (poor supplier performance) with ARP of 860 and A2 (Low of Contractor Capability) with ARP of 507, which can cause ± 80% of risk events where the remaining 20% is caused by other agents. There are 2 (two) mitigation actions were obtained from HOR phase 2, namely PA1 (appropriate supplier selection method) and PA4 (appropriate contractor selection method) which can prevent the emergence of ± 80% of these risk agents and ± 20% is overcome by 17 other mitigation actions.

**Keywords**: *risk mitigation, supply chain, toll road pavement material, House of Risk, West Sumatera-Riau Toll Road.*

## 1. Introduction

The physical improvement of road infrastructure in term of quantity and quality at some points is critical, to elude transportation problems such as traffic disruption. In West Sumatera, one of the infrastructure improvement plans which will be constructed soon is the West Sumatera - Riau Toll Road. This will be the first Toll Road in West Sumatera. As the first toll road construction in West Sumatera, a mitigation to the potential of disruption to the construction process due to incompetent personnel of contractor, consultant and owner, and/or the failure in supply chain of material for the pavement is needed. The competency of the personnel of contractor, consultant and owner has been evaluated in previous studies [1][ 2][3]. Therefore, a study to predict potential problem with material supply should be taken before the construction is started.

The aim of this study is to develop a risk mitigation analysis which can emerge in the supply chain of pavement material in the construction of the West Sumatra-Riau toll road that will soon be started. It is expected that a mitigation of the emergence of risks of the pavement material could be initiated. This strategy can be made by first inverting the risk event and risk agent data which can appear in the supply chain of pavement material, which is then be processed by utilizing the help of the House of Risk (HOR)

method. The HOR method will identify potential risk agents based on the value of ARP (Aggregate Risk Potential) and the priority of implementing mitigation actions based on ETD (Effectiveness to Difficulty) value.

It is expected that, the potential and critical risk agents toward the supply chain process of pavement material for the construction of the West Sumatra Toll Road - Riau Km 0 to 4.2 in the first phase; Padang - Sicincin could be identified and prevented.

## 2. Literature review

### 2.1. The analysis and risk management of construction project
Risk analysis is a process of identifying and assessing subjective and objective risks, while risk management is a formula consisting of responses and actions taken to reduce and manage the risks that have been analyzed [4].

### 2.2. Risk definition
Based on risk definitions by [5], [6] and [7], Risk can be defined as a condition where there are possibilities and opportunities for occurrence of deviations which are hazardous, damage, loss, accident, or any other unexpected consequences and are uncertain about the results to be achieved and also can cause unpleasant (harmful and harmful) consequences of an ongoing process or upcoming events.

### 2.3. The supply chain of construction project
According to [8], supply chain is a system which includes actors, suppliers, makers, transportation, distributors, vendors, and guarantors created to convert basic materials into a product and supply these products to users based on the requested value. In the context of construction, supply chain can be defined as a process of a set of activities which change natural materials to become the final products (e.g. roads, buildings, planning services), to be used by service users by ignoring the existing organizational boundaries.

### 2.4. House of Risk (HOR) method
The HOR method is a method which is often used in supply chain management. Previous researchers used the HOR method in their research, including [9] and [10].

The HOR (House of Risk) method is divided into 2 (two) phases, namely phase 1 and phase 2. Phase 1 is used to calculate the value of the ARP (Aggregate Risk Potential) of each risk agent and rank the risk agents to determine priority handling. Table 1 shows matrix model for HOR Phase 1.

**Table 1.** HOR Phase1 Matrix Model (Source: [9])

| Supply Chain Side | Risk (Ei) | Risk Agent (Aj) | | | | | | | Risk Impact (Si) |
|---|---|---|---|---|---|---|---|---|---|
| | | **A1** | **A2** | **A3** | **A4** | **A5** | **A6** | **A7** | |
| Supply | E1 | R11 | R12 | R13 | · | · | · | · | S1 |
| | E2 | R21 | R22 | · | · | · | · | · | S2 |
| Control | E3 | R31 | · | · | · | · | · | · | S3 |
| | E4 | R41 | · | · | · | · | · | · | S4 |
| Process | E5 | · | · | · | · | · | · | · | S5 |
| | E6 | · | · | · | · | · | · | · | S6 |
| Demand | E7 | · | · | · | · | · | · | · | S7 |
| | E8 | · | · | · | · | · | · | · | S8 |
| **Risk Agent Emergence** | | O1 | O2 | O3 | O4 | O5 | O6 | O7 | |
| **Aggregate Risk Potential** | | ARP1 | ARP2 | ARP3 | ARP4 | ARP5 | ARP6 | ARP7 | |
| **Risk Agent Priority Rank** | | | | | | | | | |

Similar to [10], in this research, identification of risk events and risks agent were conducted on the four side of supply chain: supply, control, process and demand.

HOR phase 2 method is used to calculate the ETD value (Effectiveness to Difficulty) of each action that has been inverted to mitigate potential risk agents and rank the mitigation actions. Table 2 shows Matrix Model for HOR Phase 2.

**Table 2.** HOR Phase 2 Matrix Model (Source: [9])

| Risk Agent to be handled | Prevention Action (PAk) | | | | | Aggregate Risk Potentials (ARP) |
|---|---|---|---|---|---|---|
| | PA1 | PA2 | PA3 | PA4 | PA5 | |
| A1 | E11 | | | | | ARP1 |
| A2 | | | | | | ARP2 |
| A3 | | | | | | ARP3 |
| A4 | | | | | | ARP4 |
| Total Effectiveness of action | TE1 | TE2 | TE3 | TE4 | TE5 | |
| Degree of difficulty performing action | D1 | D2 | D3 | D4 | D5 | |
| Effectiveness to difficulty ratio | ETD1 | ETD2 | ETD3 | ETD4 | ETD5 | |
| Rank of priority | R1 | R2 | R3 | R4 | R5 | |

## 3. Research methodology

### 3.1. Research design
The object of this study was the planning of West Sumatera - Riau toll road construction project. House of Risk (HOR) method was used in this study. The variable used in this study was identified based on literature review and existing supporting data.

### 3.2. Data sources type
#### 3.2.1. Primary data
Data for this study was collected through interviews (interviews), brainstorming techniques, field investigations, and questionnaires. The data is the opinion of the experienced and competent (expert) parties toward possible major risk events and risk agents that could influence the construction of the West Sumatera – Riau toll road.

Respondents were selected from the different sides which was assumed to have understanding and/ or experience in toll road construction or rigid pavement road project elsewhere such as: (the owner in this case a key person in Ministry of PUPR); Academicians; Contractors; Suppliers. Each party was represented by 3 people.

The questionnaire used in this research consists of 3 (three) main parts. The first part contained of the identity consisting of name, position, agency, address, length of work. Part two, was the procedure for filling out the questionnaire, and Part three, was the contents of the questionnaire; the level of probability of the occurrence of a risk agent, the level of correlation between risk and risk agent and the severity of each risk.

#### 3.2.2. Secondary data
Secondary data such as: data of risk event and risk agents and Detailed Engineering Design (DED) were obtained from the literatures and project owner documentations.

### 3.3. The data analysis of questionnaire
First step in data analysis is to determine the level of severity risk events and risk agent's occurrence. After that, the severity risk events and level of risk agents' occurrence data are evaluated in terms of their agreement to each other and those which are non-sync data will be eliminated. A correlation scoring was then conducted to obtain the correlation level between both data.

### 3.4. Risk evaluation
#### 3.4.1. HOR phase 1
HOR phase 1 consists of some processes. The first step of this phase was Risk Identification. In risk identification, the risks which can occur on each side of the supply chain, namely supply, control, process and demand were identified. The impact (severity) of the risk and the likelihood of the risks agent occurrence were assessed in a 5-point scale as shown in Table 3 and Table 4.

**Table 3.** Risk Event Severity Value

| Scale | Information | Impact |
|---|---|---|
| 1 | Very small impact | $0\% \leq - < 5\%$ |
| 2 | Small impact | $5\% \leq - < 15\%$ |
| 3 | Average impact | $15\% \leq - < 45\%$ |
| 4 | Big impact | $45\% \leq - < 80\%$ |
| 5 | Very big impact | $\geq 80\%$ |

**Table 4.** Occurrence Risk Agent Value

| Scale | Information | Emergence |
|---|---|---|
| 1 | Very rare | $0\% \leq - < 20\%$ |
| 2 | Rare | $20\% \leq - < 40\%$ |
| 3 | Sometimes | $40\% \leq - < 60\%$ |
| 4 | Often | $60\% \leq - < 80\%$ |
| 5 | Very often | $80\% \leq - \leq 100\%$ |

A correlation matrix between each risk agent with each risk occurrence were scored as 0 if there is no correlation and 1, 3, and 9 indicate a low, moderate, and high correlation respectively. The next step is to calculate the Aggregate Risk Potential of Agent (ARP) and rank risk agents based on ARP values and choose several risk agents with the highest ARP to be used in HOR Phase 2.

#### 3.4.2. HOR phase 2
In HOR Phase 2, the risk agents with high ARP values were selected using the Pareto Diagram. Further, identify possible actions to prevent the emergence of those and then, determine the correlation between each preventive action and each risk agent ($E_{bc}$) with a score 0 if there is no correlation and score 1, 3, and 9 for a low correlation, medium, and high correlation respectively.

For the next step, calculate the Total Effectiveness ($TE_k$) of each action using the eq. 1.

$$TE_k = \sum ARP_b * E_{bc} \tag{1}$$

Where:

$TE_k$ = Total Effectiveness

$ARP_b$ = Aggregate Risk Potential

$E_{bc}$ = The Correlation between Preventive Action with each Risk Agent.

The difficulty level in carrying out each mitigation action (Difficulty - Dk) was then be predicted using scale 1 or 2. The score = 1 if there are additional cost of mitigation actions and score = 2 if no additional cost needed.

Total Effectiveness Ratio (TEk) to the Difficulty Level (Difficulty - Dk) was calculated using eq. 2.

$$ETD_k = TE_k/D_k \tag{2}$$

Finally, determine the Priority Rating of each mitigation action based on the ETD value. Figure 3 shows all of the steps mentioned in the section 3.
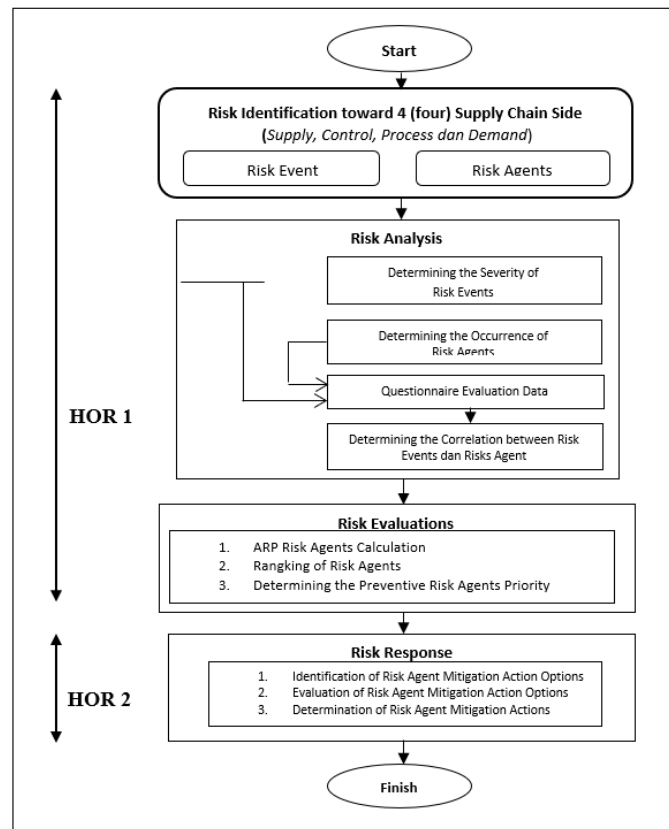
**Figure 1.** Research Methodology Flowchart

## 4.  Results and discussions

*4.1. Risk identification toward 4 (four) supply chain side*

Based on literature review, 18 of risk events and 21 of risk agents were identified in the supply chain process of the pavement process for the Toll road planning in West Sumatra – Riau as shown in Table 5 and Table 6.

**Table 5.**  Identified Risk Events

| No. | Risk Events | Severity |
|---|---|---|
| E1 | Material quality is not in accordance with the order specifications and need to be resubmitted. | 4.07 |
| E2 | Delayed material due to the production constraints at the factory. | 3.80 |
| E3 | Damaged Material during the supply. | 3.87 |
| E4 | Delivery delay of material due to the material limitations stock from supplier. | 3.80 |
| E5 | Material delivery was canceled because the supplier does not have the transportation facility. | 3.73 |
| E6 | The waiting duration for the material to meet the required quantity number due to the limitation of the available transportation equipment. | 3.80 |
| E7 | The supplier does not commit to the agreement in the contract. | 4.27 |
| E8 | The volume of material coming does not meet the specification quantity. | 4.13 |
| E9 | Sudden changes to the project activity schedule. | 3.80 |
| E10 | Changes in logistics demand due to the miscalculation of the works schedules of the contractors. | 3.67 |

| No. | Risk Events | Severity |
|---|---|---|
| E11 | Lack of managerial skill which led to a delay in finishing a task which cause the material supply being delayed. | 3.60 |
| E12 | Material is resent as the previous delivery was failed due to inaccurate instructions received. | 3.67 |
| E13 | The contractor was negligence in doing the payment to the sub-contractor. | 3.33 |
| E14 | Delayed material due to accidents when shipping. | 3.33 |
| E15 | The Difficulties in getting material. | 3.80 |
| E16 | Additional material ordering due to the changes in technical specifications. | 3.40 |
| E17 | Delays in material shipping due to the traffic congestion. | 3.87 |
| E18 | No constant price for material. | 3.40 |

**Table 6.** Identified Risk Agents

| No. | Risk Agents | Occurrence |
|---|---|---|
| A1 | Supplier bad performance. | 3.13 |
| A2 | Low contractor capacity. | 3.13 |
| A3 | Suppliers is not consistent. | 3.00 |
| A4 | The slow response of suppliers. | 3.13 |
| A5 | Shipping is not on time. | 3.00 |
| A6 | The appropriate and accurate information from suppliers. | 3.33 |
| A7 | The amount of project material needs. | 3.40 |
| A8 | The scarcity of material. | 3.07 |
| A9 | Sudden request. | 3.20 |
| A10 | The appropriate and accurate information from consultants. | 3.40 |
| A11 | Count on one supplier. | 2.93 |
| A12 | Project team competency. | 3.33 |
| A13 | The appropriate and accurate information from owner. | 3.27 |
| A14 | Logistics prices reference is not accurate. | 2.53 |
| A15 | A long technical evaluation and needs an adjustment of the budget. | 2.93 |
| A16 | Impact toward local communities. | 3.20 |
| A17 | Safety Factor process. | 3.53 |
| A18 | Natural disaster factor. | 2.93 |
| A19 | Damage to supply transportation. | 2.80 |
| A20 | Delay related to the changes in specification | 2.67 |
| A21 | Rupiah exchange rate instability against dollar | 2.40 |

*4.2. Reliability test*

Reliability test was conducted to test the data consistency. Risk events reliability ($r_{count}$) was 0.737 with number of data (N) is 18. Compared with $r_{table}$ of 0.468, the $r_{count}$ was higher than $r_{table}$, so that the data is said to be consistent. Similarly, risk agents reliability test shows that $r_{count}$ is 0.697 which was higher than $r_{table}$ of 0.433 so that the agent risk data is also consistent.

*4.3. Data processing with HOR phase 1 method*

Before doing the tabulation through HOR matrix phase 1, the correlation level between risk events against risk agents was decided first with the standard provisions of values 0, 1, 3, 9, where 0 indicates no correlation (no correlation) and values 1, 3, and 9 show low (low), moderate and high (high) correlations. The result is shown in Figure 2.

| Risk Event (Ei) | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | A13 | A14 | A15 | A16 | A17 | A18 | A19 | A20 | A21 | Sev. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E1 | 9 | 1 | 3 | 0 | 3 | 0 | 1 | 0 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 4.1 |
| E2 | 9 | 0 | 3 | 3 | 0 | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 1 | 1 | 0 | 3 | 0 | 1 | 3.8 |
| E3 | 9 | 0 | 0 | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 9 | 9 | 0 | 0 | 3.9 |
| E4 | 3 | 0 | 3 | 1 | 0 | 0 | 1 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 1 | 3 | 1 | 3.8 |
| E5 | 9 | 1 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 0 | 3.7 |
| E6 | 3 | 1 | 1 | 3 | 1 | 0 | 9 | 0 | 3 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 3.8 |
| E7 | 9 | 0 | 9 | 3 | 0 | 0 | 0 | 1 | 3 | 1 | 1 | 3 | 0 | 0 | 0 | 1 | 3 | 3 | 3 | 1 | 3 | 4.3 |
| E8 | 9 | 1 | 9 | 1 | 0 | 1 | 3 | 1 | 1 | 3 | 3 | 3 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 3 | 0 | 4.1 |
| E9 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 3 | 1 | 1 | 1 | 0 | 1 | 0 | 9 | 3 | 3 | 1 | 3 | 0 | 3.8 |
| E10 | 3 | 9 | 3 | 3 | 0 | 0 | 3 | 1 | 1 | 1 | 0 | 3 | 3 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 3.7 |
| E11 | 0 | 9 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.6 |
| E12 | 0 | 9 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 9 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3.7 |
| E13 | 0 | 9 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 3.3 |
| E14 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 0 | 0 | 3.3 |
| E15 | 3 | 9 | 1 | 3 | 0 | 0 | 3 | 9 | 3 | 3 | 1 | 3 | 3 | 1 | 1 | 0 | 0 | 3 | 0 | 1 | 3 | 3.8 |
| E16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 3 | 0 | 3 | 0 | 3.4 |
| E17 | 1 | 3 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 9 | 0 | 1 | 1 | 1 | 1 | 3 | 3.9 |
| E18 | 1 | 1 | 3 | 3 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 3 | 0 | 3 | 3 | 0 | 3 | 9 | 0 | 0 | 9 | 3.4 |
| Occ. | 3.13 | 3.13 | 3.00 | 3.13 | 3.00 | 3.33 | 3.40 | 3.07 | 3.20 | 3.40 | 2.93 | 3.33 | 3.27 | 2.53 | 2.93 | 3.20 | 3.53 | 2.93 | 2.80 | 2.67 | 2.40 | |
| ARP | 860 | 607 | 518 | 308 | 83 | 51 | 347 | 232 | 248 | 317 | 150 | 487 | 134 | 54 | 217 | 180 | 228 | 492 | 294 | 173 | 178 | |
| Rank | 1 | 2 | 3 | 8 | 19 | 21 | 6 | 11 | 10 | 7 | 17 | 5 | 18 | 20 | 13 | 14 | 12 | 4 | 9 | 16 | 15 | |

**Figure 2.** Correlation level between risk events and risk agents

Paretto diagram was developed to sort the score of ARP and the percentage cumulative of ARP. The result is shown in Figure as following.
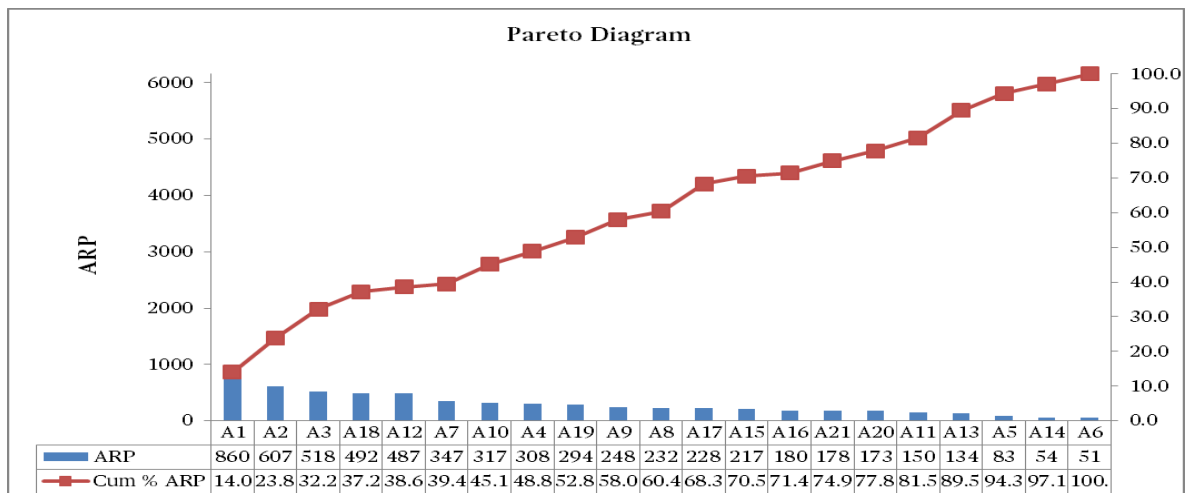


**Figure 3.** Paretto Diagram HOR Phase 1

Based on Figure 3, with the Paretto 80/20 diagram principle (means that 80% of risk events are caused by 20% of risk agents), it was found that 80% of these risk events are caused by 2 risk agents, namely A1 (poor supplier performance) and A2 (Low contractor capacity).

*4.4. Identification of mitigation actions*

Identification of mitigation actions was carried out to mitigate the 15 risk agents, which constitute 75% of the total ARP accumulation. Table 8 shows all the 15 (fifteen) items according to rank are A1, A2, A3, A18, A12, A7, A10, A4, A19, A9, A8, A17, A15, A16 and A21 respectively.

**Table 7.** Risk Agents Mitigation Actions Identified

| Code | Mitigation Strategy |
|---|---|
| PA1 | Proper supplier selection method. |

| Code | Mitigation Strategy |
|---|---|
| PA2 | Alternative suppliers preparation. |
| PA3 | Observe and monitor tightly toward the supplier performance. |
| PA4 | Proper contractor selection method. |
| PA5 | Provide the management project assistance. |
| PA6 | Bad weather predictions, see the BMKG Weather prediction time scale starting from the daily prediction to 6 months prediction. |
| PA7 | Prepare for disruption or natural disaster handling facilities. |
| PA8 | Adding the resources and schedules when natural conditions are good. |
| PA9 | Conducting the strict evaluation during procurement process. |
| PA10 | Creating a schedule list according to the suppliers' capacity. |
| PA11 | Strengthen the management tools. |
| PA12 | Conducting a strict schedule recording. |
| PA13 | Early coordination with related parties. |
| PA14 | Creating a better schedule process. |
| PA15 | Good information and communication system. |
| PA16 | Adjusting the level of joblessness based on the predicted fluctuations of rupiah exchange rate toward dollar. |
| PA17 | Adjusting the team strength with compiling projects. |
| PA18 | Preparing SOP with a time limits. |
| PA19 | Anticipating the changes before starting the project. |

### 4.5. The data processing by HOR phase 2 method

HOR Phase 2 processing matrix was produced based on the score of correlation between the risk agent and mitigation action. The result is shown in Figure 4.

| Risk Agent | PA1 | PA2 | PA3 | PA4 | PA5 | PA6 | PA7 | PA8 | PA9 | PA10 | PA11 | PA12 | PA13 | PA14 | PA15 | PA16 | PA17 | PA18 | PA19 | ARP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Mitigation Action | | | | | | | | | | | |
| A1 | 9 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 860 |
| A2 | 0 | 0 | 0 | 9 | 3 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 607 |
| A3 | 9 | 9 | 9 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 518 |
| A18 | 1 | 0 | 1 | 1 | 0 | 9 | 3 | 9 | 1 | 0 | 0 | 0 | 0 | 9 | 1 | 0 | 0 | 0 | 0 | 492 |
| A12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 9 | 0 | 0 | 487 |
| A7 | 9 | 9 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 9 | 1 | 0 | 0 | 0 | 0 | 347 |
| A10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 317 |
| A4 | 3 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 308 |
| A19 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 294 |
| A9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 9 | 0 | 0 | 0 | 3 | 248 |
| A8 | 3 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 232 |
| A17 | 9 | 0 | 1 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 3 | 1 | 0 | 0 | 0 | 0 | 228 |
| A15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 9 | 9 | 217 |
| A16 | 3 | 0 | 9 | 9 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 180 |
| A21 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 9 | 0 | 0 | 9 | 178 |
| Total Effectifness (TEK) | 21,289 | 10,597 | 10,815 | 13,970 | 2,361 | 5,003 | 1,476 | 4,428 | 12,749 | 3,123 | 2,646 | 2,772 | 2,052 | 11,920 | 13,096 | 2,253 | 4,383 | 1,953 | 5,181 | |
| Degree of Difficulty (Dk) | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | |
| Effectifness to Difficulty (ETD) | 21,289 | 5,299 | 10,815 | 13,970 | 1,181 | 5,003 | 738 | 4,428 | 12,749 | 3,123 | 1,323 | 2,772 | 1,026 | 11,920 | 13,096 | 2,253 | 4,383 | 1,953 | 5,181 | |
| Rank of Priority | 1 | 7 | 6 | 2 | 17 | 9 | 19 | 10 | 4 | 12 | 16 | 13 | 18 | 5 | 3 | 14 | 11 | 15 | 8 | |

**Figure 4.** Correlation level between risk agent and mitigation action

Based on the HOR matrix phase 2 in Figure 4, a Pareto diagram was produced and shown in following Figure 5.
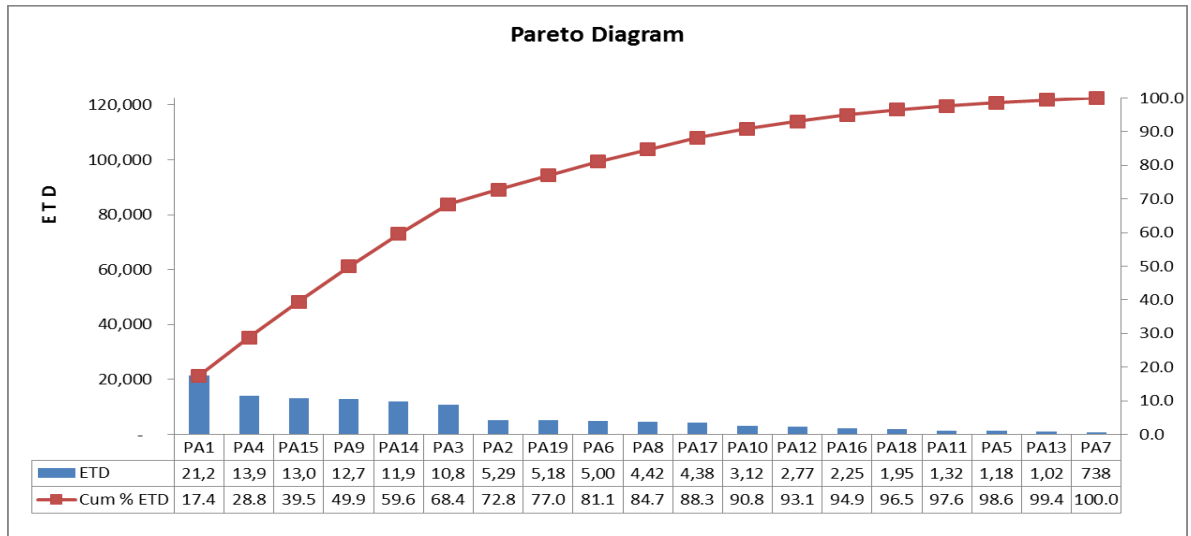


**Figure 5.** Paretto Diagram HOR Phase 2

Based on Paretto diagram in Figure 5, the 80/20 principle suggests that 80% of risk agents can be overcame by 20% accumulation of mitigation strategies which represented by ETD, namely PA1 (the right method of supplier selection) and PA4 (the right method of selecting contractors). These strategies are inline with the result of HOR phase 1 in Figure 2, where 80% of risk events are caused by 2 risk agents namely: Poor supplier performance (A1) and Low contractor capacity (A2).

However, as the studied project will be the first toll road project in the region, it is better to anticipate as much as possible of the risks. The authors suggested to take some more actions such as: Good information and communication system (PA15), Conducting the strict evaluation during procurement process (PA9), Creating a better schedule process (PA14), Observe and monitor tightly toward the supplier performance (PA3), Alternative suppliers' preparation (PA2), and Anticipating the changes before starting the project (PA19). All of these mitigation actions will cover 75% of the total accumulated ETD value and overcome more than 80% of the risk events.

## 5. Conclusions and recommendations

An analysis of supply chain risk of pavement material for West Sumatera – Riau toll road project has been conducted using House of Risk (HOR) Method. It was found that the critical risk agent on supply chain materials process of West Sumatera – Riau toll road project were supplier bad performance and low contractor capacity. In order to overcome the risk, some mitigation actions were proposed such as to conduct a proper supplier selection method and proper contractor selection method. Both action could overcome 80% of risk agents that appears on supply chain materials process of West Sumatera – Riau toll road project. However, as the project will be the first toll road project in the region, it suggested to do 75% of the possible mitigation actions such as applying a good information and communication system, conducting the strict evaluation during procurement process, creating a better schedule process, observing and tightly monitored the supplier performance, preparing alternative suppliers, and anticipating the changes before starting the project. All of these actions could overcome more than 80% of risk events.

## 6. References

[1]    Yosritzal, Purnawan, Putri, E. E., and Ratu, E. K., 2018, Priority setting for competency development training topics for road construction site managers to reduce the risk of

construction failure. MATEC Web of Conference 229, 01003 (2018), https://doi.org/10.1051/matecconf/201822901003.

[2] Yosritzal, Purnawan and Asmery, V., 2017, Competency of West Sumatera Provincial Road Construction Project Supervising Consultants in Owner Perception. International Journal of Civil Engineering and Technology (IJCIET) Vol. 8, Issue 10, October 2017, pp. 743-752. ISSN Print: 0976-6308 and ISSN Online: 0976-6316.

[3] Juwita, W., Yosritzal and Rinaldi, D., 2016, The Leadership Assessment Study on the Level of Road Technical Personnel Competence at Dinas Prasarana Jalan Tata Ruang dan Pemukiman (Road Infrastructure, Spatial and Settlement Agency) Province of West Sumatera Using Requirement-Satisfaction Analysis. Proceeding of Sustainable Civil Engineering Structures and Construction Materials; Special Topics in Public Works Research and Technology, September 5, 2016 in Bali.

[4] The Association for Project Management (APM), 2000, *Project Risk Analysis And Management*, APM, Buckingham, 12p, ISBN: 0953159000

[5] Vaughan, E. J., T. M. Vaughan, 2007, *Fundamentals of Risk and Insurance, 10th edition*, John Wiley & Sons, Inc, United States, 745p, ISBN-13 978-0-470-08753-4

[6] Manuj, I., J. T. Mentzer, 2008, Global Supply Chain Risk Management, *Jurnal Logistik Bisnis* University of North Texas Denton, Vol. 29 No. 1, p133-155

[7] KBBI, 2018, *Pengertian Risiko* (Definition of Risk), (https://kbbi.web.id/risiko), accessed on 2nd February 2018

[8] Badan Pembinaan Konstruksi Kementerian Pekerjaan Umum, 2013, *Kajian Rantai Pasok Materi dan Peralatan Konstruksi Dalam Mendukung Investasi di Bidang Konstruksi Berkelanjutan (Construction Material and Equipment Supply Chain Study to Support Investment in Sustainable Construction)*, Pusbin SDI, Bandung, 142p

[9] Pujawan, I.Ny., L.H. Geraldin, 2009, House of The Risk: A Model for Proactive Supply Chain Risk Management, *Jurnal Management Proses Bisnis* Teknik Industri ITS Surabaya, Vol. 15 No. 6, p953-967

[10] Hatmoko, J. U. D, F. Kistiani, 2017, *Model Simulasi Risiko Rantai Pasok Material Proyek Konstruksi Gedung* (Simulation risk model of Supply Chain of Material for Building Construction Project), *Jurnal Teknik Sipil* Undip Semarang, Vol 23 No. 1, p1-13