Safety cost component development of risk-based standardized work breakdown structure to determine safety cost on road construction project (Case study: At-grade road works)

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Abstract. The last five years in Indonesia, the toll road construction project has become one of the most massive developments. However, the number of work accidents has also increased 54.5% of the number of construction accidents came from toll road projects between 2017 and 2019. This results in significant losses such as loss of life, time, and cost. Safety construction is still hampered from the budget side. Many contractors only apply basic occupational health safety and ignore hazard prevention training during construction in order to save costs and increase profits. The aspect that can improve working safety conditions is the availability of a decent budget and specifically allocated for the implementation of occupational health and safety in construction projects. An accurate budget for construction safety costs can be prepared using the Activity-Based Costing (ABC) method. ABC method can provide information on neglected cost items in the construction method. So the safety cost information on road construction projects can be available accurately starting from defining work activities based on Work Breakdown Structure (WBS). The WBS is compiled into a safety plan, after that the safety plan is developed and translated into components of the safety costs needed in construction projects.

1. Introduction

The last five years in Indonesia, the toll road development project has become one of the most massive developments, as evidenced in the list of national strategic projects (PSN) regulated in Presidential Regulation No. 56 of 2018 concerning the Acceleration of National Strategic Project Implementation, there are 65 toll road sections and 4 national (non-toll) road sections included in the PSN list.

Based on data and facts, the number of work accidents in construction projects also increased. According to BPJS Employment, total work accidents in 2017 with a claim value of Rp 971 billion. This figure increased from 2016 with a claim value of only Rp 792 billion.

Safety Construction is still hampered from the budget side. In line with previous research which states that in order to be able to compete economically and get maximum benefits, many contractors only apply basic occupational health and safety (OHS) and eliminate a lot of hazard prevention training during construction [1]. For this reason it is necessary to make a safety cost analysis in order to be able to make a budget for the costs needed in the initial stages of the project.
The regulations and provisions regarding safety cost in Indonesia have not yet been clearly and measurably regulated. Existing regulations regarding safety cost are regulated in three regulations namely Minister Regulation No. 31 of 2015 concerning the Third Amendment to the Regulation of the Minister of Public Works Number 07 / PRT / M / 2011 concerning Standards and Guidelines for Procurement of Construction Works and Consultancy Services, in this regulation safety costs enter into overhead costs Minister of Public Works Regulation Number 21 / PRT / M / 2019, in this regulation safety costs are allocated within general costs and are calculated based on the level of safety risk. And the last in the Minister of Public Works and Public Housing Regulation No. 28 of 2016, in this regulation safety costs are influenced by general safety costs, special safety costs and security costs.

Activity-Based Costing (ABC) or activity-based cost calculation has emerged as a new approach that connects costs directly related to business activities. ABC provides more accurate information especially in complex structures and allows one to obtain information about cost items that are ignored in traditional methods. By allocating appropriate funds for OHS Management System on road infrastructure construction projects, the safety performance in building construction projects will increase, with safety risks that can be more controlled and the occurrence of work accidents that are more controlled [2].

In making activity-based cost calculations, Work Breakdown Structure (WBS) divides the project into several parts so that planning, cost estimates, observations and controls can be done through these sections. It can be concluded, that WBS is an important thing in the planning phase to define a work package with quality project objectives.

Therefore, based on the above findings, this study focuses on the cost of safety based on risk-based standardization WBS for road infrastructure construction project work that can be a solution for the prevention of work accident accidents on road infrastructure construction projects in Indonesia.

The objective of this research as follow:
- To identify work packages, work methods and work activities on road infrastructure projects.
- To identify potential hazards and risk control in road infrastructure projects.
- To identify safety plan on road infrastructure projects.
- To identify the component of safety cost in road infrastructure projects.
- To determine the amount of safety cost used in road infrastructure projects.

2. Research methodology
This research is a qualitative research using descriptive analysis. There are five stages and two research instruments in this research. In this study the main research instrument used was a questionnaire. The first 4 stages out of a total of 5 stages using a questionnaire. Figure 1. shows the process of the research, the first stage, use a questionnaire to validate the activities of the Road work on WBS. The second questionnaire to find data about potential hazards and safety risks. The third questionnaire is to identify the safety program. And the last questionnaire to determine the components needed in the safety program. In taking primary data collection questionnaires will be given to respondents in accordance with the requirements. Respondents have special requirements, namely having a background or work related to road construction projects and experience in applying the Occupational Safety and Health Management System to the project being undertaken. Respondents are also expected to have work experience of more than 10 years.

For the final stage after obtaining the components needed for the work safety program, which compares the existing components with examples of road construction projects that have been completed. Previous project provisions for case studies are the scope of the project already exists in the WBS standard road works project and the project is a completed project, not on going project.
In 5 stages of research, there are 4 X-variable and 1 Y-variable as shown in Table 1. In Y-variable there are 3 sub-variables and 11 indicators as shown in Table 2.

### Table 1. Research variables.

| Stage | Stage 1 | Stage 2 | Stage 3 | Stage 4 | Stage 5 |
|-------|---------|---------|---------|---------|---------|
| Code  | X1      | X2      | X3      | X4      | Y       |
| Variable Name | Activities Road Construction WBS Level 5 Hazard Potential & Safety Risk Control in Road Construction Safety Program in Road Construction Safety Cost Components in Road Construction Safety Cost |
| Reference | Amini, 2018 [3] Permen PU No. 05/2014 & PMI, 2017 [4] OHSAS 18001 [5] Permen PU No. 05/2014 Permen PUPR No. 28/2016 & SE PUPR No. 11/2019 |

### Table 2. Sub-variables and indicators in Y-variables.

| Sub Variable | Code | Reference | Indicator | Code | Reference |
|--------------|------|-----------|-----------|------|-----------|
| General Cost | Y.1  | Permen PUPR No. 28/2016; Surat Edaran Menteri PUPR No. 11/2019 | Personal Protective Equipment | Y.1.1 | Permen PUPR No. 28/2016, SE PUPR No. 11/2019 |
|              |      |           | Safety Plan | Y.2.1 | SE PUPR No. 11/2019 |
|              |      |           | Socialization, Promotion and Training | Y.2.2 | SE PUPR No. 11/2019 |
| Specific Cost | Y.2  | Permen PUPR No. 28/2016; Surat Edaran Menteri PUPR No. 11/2019 | Working Protective Equipment | Y.2.3 | SE PUPR No. 11/2019 |
|              |      |           | Insurance and Licensing | Y.2.4 | SE PUPR No. 11/2019 |
|              |      |           | Safety Personnel | Y.2.5 | SE PUPR No. 11/2019 |
|              |      |           | Medical Facilities, Infrastructure and Devices | Y.2.6 | SE PUPR No. 11/2019 |
|              |      |           | Safety Sign | Y.2.7 | SE PUPR No. 11/2019 |
|              |      |           | Consultation with Experts Related to Construction Safety | Y.2.8 | SE PUPR No. 11/2019 |
|              |      |           | Others | Y.2.9 | SE PUPR No. 11/2019 |
| Security Cost | Y.3  | Permen PUPR No. 28/2016 | Security | Y.3.1 | Permen PUPR No. 28/2016 |
3. Results and discussion
The results of the research as follows:

3.1. Research objective number 1
Standardized WBS of road work activities, as shown in Table 3., is achieved by validating road work activities from the WBS standardization from Amini and Latief [3], by asking experts such as the first questionnaire.

3.2. Research objective number 2
Potential hazards and risk control, as shown in Table 3, is achieved by searching for potential hazards and risk control in any road work activities that have been validated by experts, from the literature then re-validated by experts whether the risk hazards are appropriate or not. From the list of potential hazards and risk control, as shown in Table 3, can determine which potential hazards are the high risk activities, and what should be do for the prevents.

| WBS Level 4 (Work Package) | WBS Level 5 (Work Activities) | Risk Factors | Potential Hazards | Frequency | Severity | Risk Level (FXS) | Risk Control |
|---------------------------|------------------------------|--------------|------------------|-----------|----------|-----------------|--------------|
| Mobilization Program      | Material Mobilization        | Physics/ Mechanics | Hit when maneuvering | 2         | 3        | (High)         | Installation of Safety Signs |
|                           |                              |              |                  |           |          |                 | Creating, Socializing, and Evaluating SOP |
|                           |                              |              |                  |           |          |                 | Make A Proper Working Space |
|                           |                              |              |                  |           |          |                 | Installation of Safety Signs |
|                           |                              |              | Heavy Equipment Overturned | 1         | 3        | (Moderate)     | Load check |

3.3. Research objective number 3
Safety plan, as shown in Table 4, is achieved by compiling a safety plan based on following the Regulation of the Minister of Public Works Number 05 / PRT / M / 2014, then the safety plan is validated by experts. This is used to determine the suitable safety plan.

3.4. Research objective number 4
Components of safety cost as shown in Table 4. The safety cost component is identified based on the Minister of Public Works Regulation 28/2016 and Minister of Public Works Regulation 21/2019. Where safety costs divided into 3: general costs, special costs, and security costs. Based on the Minister of Public Works Regulation 21/2019 shows that safety cost consist of: Personal Protective Equipment, Safety Plan, Socialization, Promotion and Training, Working Protective Equipment, Insurance and Licensing, Safety Personnel, Medical Facilities, Infrastructure and Devices, Safety Sign, Consultation with Experts Related to Construction Safety, Others. After the component is identified, then validated by experts.
Table 4. Safety cost components of material mobilization.

| WBS Level 5 (Work Activities) | Potential Hazard | Risk Control | Objectives | Program | Safety Cost Component |
|-------------------------------|------------------|-------------|------------|---------|-----------------------|
| Material Mobilization Hit when maneuvering | Creating, socializing and evaluating SOP | There is no accident | There is no injury to workers | Supervisory report per term of work / Safety report | Safety officers, Supervisor, QC Engineer | Specific Cost Documents, Induction, Directions, Meetings, Trainings, Banner, Information Boards |
| Installation of safety signs | Not hit by heavy equipment | There is no injury to workers | Supervisory report per term of work / Safety report | Safety officers, Supervisors | Specific Cost Safety Signs |

3.5. Research objective number 5

Amount of safety Cost, as shown in Table 5, is achieved by calculating the amount of cost of each safety component based on the Minister of Public Works Circular Letter no. 11/2019, and from the safety plan that has been developed into safety cost components. And then the result is compared with the previous project case study examples. The case study will show the percentage of the safety cost is needed from the entire value of the road works.

Table 5. Safety cost calculation.

| No | Safety Cost Components | Quantity | Volume | Unit Price (IDR) | Amount (IDR) |
|----|------------------------|----------|--------|-----------------|--------------|
| A  | General Cost           |          |        |                 |              |
| 1  | Personal Protective Equipment |      |      |                 |              |
| B  | Specific Cost          |          |        |                 |              |
| 1  | Safety Plan            |          |        |                 |              |
| 2  | Socialization, Promotion and Training | |  | | |
| 3  | Working Protective Equipment | |  | | |
| 4  | Insurance and Licensing | |  | | |
| 5  | Safety Personnel       |          |        |                 |              |
| 6  | Medical Facilities, Infrastructure and Devices | |  | | |
| 7  | Safety Sign            |          |        |                 |              |
| 8  | Consultation with Experts Related to Construction Safety | |  | | |
| 9  | Others                 |          |        |                 |              |
| C  | Security Cost          |          |        |                 |              |
| 1  | Security               |          |        |                 |              |

Safety Cost Total
Contract Value
Percentage of Safety Cost to Contract Value

4. Conclusion

Research and analysis results obtained from this research are:
- Standardization of WBS from road works based on 6 levels: level 1 (Project Name), level 2 (Work Section), level 3 (Sub-Work Section), level 4: (Work Package, (Alternative Methods / Design)), level 5 (Activities).
- Identification of potential hazards and risk control in every road work activity. So the risk of road work can be minimized.
- Safety plan based on WBS road works that are already risk based and developed according to Minister of Public Works Regulation 5/2014.
• Safety cost components based on the Safety Plan. These components are in accordance with Minister of Public Works Regulation 28/2016 and Minister of Public Works Regulation 21/2019.
• The amount of safety costs on road projects is calculated based on several previous project case studies.

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References
[1] Gurcanli G E, Bilir S and Sevim M 2015 Activity based risk assessment and safety cost estimation for residential building construction projects Safety Science 80 1-12
[2] Devi T R and Reddy V S 2012 Work breakdown structure of the project Int J Eng Res Appl 2 683-686
[3] Amini R A and Latief Y 2018 Development of Risk-Based Standardized WBS (Work Breakdown Structure) for Quality Planning of Road Construction Project 8th International Conference on Industrial Engineering and Operations Management, Bandung, Indonesia
[4] PMI 2017 Project Management Body of Knowledge (Project Management Institute, Inc.)
[5] OHSAS 18001 2007 Occupational Health and Safety Management System – Requirements