Identify of Occupational Health and Safety (OHS) cost component for Flyover Project by developing of safety plan based on Work Breakdown Structure (Case study: Erection girder using tandem crane)

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Abstract. Occupational, Health, and Safety (OHS) issues in Indonesia are still often overlooked. It appears that the number of work accidents is still high. Therefore, in early 2018 the government has decided to suspend all the elevated construction projects in Indonesia including Flyover Project. It causes negative impacts such as casualties, material, time, cost, etc. Two factors that most hinder OHS implementation in the project based on the contractor's point of view are the high cost of OHS implementation and the safety cost provided for OHS implementation by the owner is inadequate or even none at all. Safety cost planning can be done accurately if the activities based on the Work Breakdown Structure (WBS) on the project can be well defined. The Activity-Based Costing method provides more accurate information especially on complex structures while can provide information on cost items. This study aimed to identify the OHS cost component of the Flyover Project based on standardized Work Breakdown Structure in erection girders application using the tandem crane, which is supported with archival analysis, expert judgment, and survey to obtain a decent budget and specifically allocated for the implementation of OHS to improve working safety conditions.

1. Introduction
The Construction Industry has an important role in the development of a country [1]. The development of infrastructure in Indonesia is quite massive nowadays. In the last few years, there are numerous projects have been built and quite a few are also being built especially flyover infrastructure. Amidst its complexity and high risk, the flyover project must get more attention, especially on the safety aspect. In the implementation of construction projects in Indonesia, the number of work accidents has been increased. According to the Labour Social Service Agency (2019), the number of total work accidents in 2018 equaled 173,000 cases with 32% dominated by the construction sector. In early 2018 the government has decided to suspend all the elevated construction work in Indonesia, it causes negative impacts such as casualties, material, time, cost, etc.

Compared to other sectors, the construction industry has the highest risk of accidents, while OHS issues in Indonesia are still often overlooked, indicated by a high number of work accidents [2]. A low level of construction safety would result in a high accident rate in the projects. One of the causes of the rise in accident rates is the lack of cost safety allocation [3]. The contractors assess two factors that
most hinder OHS implementation in the project are the high cost of OHS implementation and the cost of safety provided for OHS implementation by the client/owner is inadequate or even not provided at all [4]. One aspect that is believed to improve working safety conditions is the availability of a decent budget and specifically allocated for the implementation of SMK3 (OHS Management System) in construction projects [5].

OHS costs can be considered as the sum of 3 components namely prevention (ex-post costs), insurance and accidents (ex-ante costs) [6]. To obtain an accurate calculation of OHS cost in order to improve safety performance in construction projects can be identified based on existing activities in the safety program using the bottom-up estimating method, namely, the method of estimating costs that are influenced by the size and complexity of individual activities, work packages, and work components [7].

A work breakdown structure is necessary to be able to identify the work package and its activities [8,9], where each activity has its own potential hazard. Potential hazards are identified subsequently to determine risk control and develop a safety plan (OHS Objectives and Programs) [10]. A safety plan is regulated under the Minister of Public Works Regulation No. 05/PRT/M/2014 concerning Guidelines for the OHS Management System [11,12]. After developing the safety plan the cost component can be identified by referring to Regulation of Minister of Public Works No. 11/SE/M/2019 concerning technical instructions on the cost of implementing a construction safety management system Regulation of the Minister of Public Works No. 28/PRT/M/2016 concerning guidelines for analyzing the unit price of public works [13]. Hence, OHS cost component is necessary for calculating the amount of OHS to obtain a decent and specifically allocated budget within the implementation of OHS in order to improve safe working conditions especially in high-risk construction projects such as flyover projects.

The objective of this research as follow:

- To identify and analyze work packages and activities in the Flyover Project.
- To identify and analyze potential hazards and risk control in each activity of the Flyover Project.
- To develop safety plan in the Flyover Project based on standardized WBS.
- To identify safety cost components in the Flyover Project based on standardized WBS.
- Conceptually calculate the OHS cost of the Flyover Project based on standardized WBS.

This research used a limitation with a case study of erection girders using the tandem crane method.

2. Research methodology

The research methods used are archival analysis, survey and data collection from expert. Data will be analysed using descriptive analysis with a qualitative approach. The flow process of the research consists of 4 stages as shown in figure 1.

The first stage, using questionnaire to validate the work package and activities from WBS of the Flyover project. The second stage, using questionnaire to identify potential hazards and OHS risks from the activities. The third stage, using questionnaire to identify the safety plan which consist of objectives, program and the resources. The fourth stage is to determine the OHS cost components needed in the safety plan.

The research has 7 of X variables and 1 of Y variable as shown in table 1.

| Stage | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|-------|---------|---------|---------|---------|
| Code  | X1      | X2      | X3      | X4      | X5      | X6      | X7      | Y       |
| Name  | Work Packages | Alt. Method | Activities | Potential Hazard | Safety Risk Control | Safety Specific Target | Safety Program | Safety Cost Component |

The main data collection was carried out by giving questionnaires to the respondents who met the requirements and criteria in accordance with the objectives of this study. The Guttman scale is applied in each questionnaire to validate the answer [14], respondents also can give the comments if there is advice. This research required a sample from 3 to 5 experts which the requirements.
The respondent has at least 10 years of professional experience in flyover project and construction safety with a minimum bachelor’s degree and having an educational background and occupation related to construction and safety. The Respondent can be a Project Manager, Site Manager, Safety Manager, Engineering Manager, Academic, or Professional in associations and practitioner.

![Flow diagram of research.](image)

**Figure 1.** Flow diagram of research.

3. **Results and discussion**

The result of the research as follows:

- Identifying the Work Packages, and Activity of the Flyover Works based on the previous standardized WBS [15] by asking the expert to validate the standardized WBS.

![Standardized WBS of Flyover.](image)

**Figure 2.** Standardized WBS of Flyover.
Figure 2 shows the levels of standardized WBS. Erection Girder is WBS Level 4 (Work Package) which has 4 Alternative Method, Erection Girder using the Tandem Crane is one of the activities of Flyover Project (WBS Level 5).

- To identify the Potential Hazard and Risk Control of Erection Girder activity using tandem crane method. Potential Hazard and Risk Control from the whole activities of Flyover Works can be identified in the same way.

Table 2 shows the Erection Girder using the Tandem Crane has potential hazards which are the worker(s) hit by the crane when maneuvering, and Girder falls down / crane accident (collapsed/rolled) with high severity.

- To Develop Safety Plan of Flyover Project based on the Minister of Public Works No. 05/PRT/M/ 2014 as shown below.

| WBS LEVEL 2 | WBS LEVEL 3 | WBS LEVEL 4 | Alt. Method | Work Activity | Potential Hazard | Probability | Severity | Risk Level | Risk Control |
|-------------|-------------|-------------|-------------|---------------|------------------|-------------|----------|------------|--------------|
| Structure Work | Upper Structure | Erection Precast Concrete | Tandem Crane Method | Erection Girder Using Tandem Crane | hit by crane when maneuvering | 2 | 3 | 6 (high) | Installation of safety signs |
| | | | | | Girder fall down / crane accident (collapsed / rolled) | 2 | 3 | 6 (high) | Creating, socializing and evaluating SOP |

Table 2 shows the Erection Girder using the Tandem Crane has potential hazards which are the worker(s) hit by the crane when maneuvering, and Girder falls down / crane accident (collapsed/rolled) with high severity.

- To Develop Safety Plan of Flyover Project based on the Minister of Public Works No. 05/PRT/M/ 2014 as shown below.

Table 3. Development safety plan of erection girder using tandem crane.

| Risk Control | Objectives | Program | Safety Cost Component |
|--------------|------------|---------|-----------------------|
| Installation of safety signs | Not hit by crane | Workers following the Safety Signs | Safety Signs | During work activity | There is no injury to workers | Supervisory report per term of work / Safety report | Safety officers, Supervisors | Specific Cost | Safety Signs |
| Creating, socializing and evaluating SOP | Workers follow SOP & WI | Documents, Induction, Directions, Meetings, Banner, Information Boards | Documents, Induction, Directions, Meetings, Banner, Information Boards | During work activity | There is no injury to workers | Supervisory report per term of work / Safety report | Safety officers, Supervisors, QC Engineer | Specific Cost | Documents, Induction, Directions, Meetings, Banner, Information Boards |
| Training and Certification Operator | There is no accident | Operator shall be certified | SIA & SIO, training | Prior to commence the work | There is no injury to workers | Supervisory report per term of work / Safety report | Safety officers, Supervisors | Specific Cost | SIA & SIO, training |
| Make a proper working space | There is no accident | Workers follow safety signs | Safety Signs | During work activity | There is no injury to workers | Supervisory report per term of work / Safety report | Safety officers, Supervisors | Specific Cost | Safety Signs |
| Evacuation and Handle the accident victim | reduce the impact | Worker(s) survived | Safety personnel, first aid box | During work activity | The work is not suspend and worker(s) survived | Supervisory report per term of work / Safety report | Safety officers, Supervisors | Specific Cost | Safety personnel, first aid box |
Table 3. Cont.

| Rigging Check | Carrying out inspections and ensure load of girder not exceeding crane capacity |
|---------------|---------------------------------------------------------------------------------|
| Girders not fall down | Crane not collapsed or rolled |
| Workers has protected by insurance | Workers following SOP & WI |
| Inspection and Audit Program | Inspection and Audit Program |
| During work activity | During work activity |
| The work is not suspend and worker(s) survived | There is no injury to workers |
| Supervisory report per term of work / Safety report | Supervisory report per term of work / Safety report |
| Safety officers, Supervisors, QC Engineer | Safety officers, Supervisors, QC Engineer |
| Specific Cost | Specific Cost |
| Inspection and Audit Program | Inspection and Audit Program |

Table 3 shows the safety plan from the erection girder using tandem crane activity which consists of objectives and program. OHS cost component can be identified from the resources in objectives and program.

- The amount of OHS cost can be calculated by inserting the unit price and quantity for each item (See table 4) [16].

Table 4. Example of OHS cost calculation for erection girder using tandem crane method.

| Sub Variable | Code | Indicator | Code | Sub Indicator | Activity | Qty | Time | Unit Price | Amount |
|--------------|------|-----------|------|--------------|----------|-----|------|------------|--------|
| General Cost | Y.1  | Personal Protective Equipment | Y.1.1 | Safety Hemet | Creating SOP / WI | ✓   |       | Rp. ....   | Rp. .... |
|              |      |           |      | Googles      |           | ✓   |       | Rp. ....   | Rp. .... |
|              |      |           |      | Masker       |           | ✓   |       | Rp. ....   | Rp. .... |
|              |      |           |      | safety gloves |           | ✓   |       | Rp. ....   | Rp. .... |
|              |      |           |      | safety shoes  |           | ✓   |       | Rp. ....   | Rp. .... |
|              |      |           |      | full body harness |       | ✓   |       | Rp. ....   | Rp. .... |
|              |      |           |      | safety vest   |           | ✓   |       | Rp. ....   | Rp. .... |
| Socialization, Promotion and Training | Y.2.2 | Safety Induction | ✓ | Rp. .... | Rp. .... |
|                                             |       | Safety Briefing | ✓ | Rp. .... | Rp. .... |
|                                             |       | Tool Box Meeting | ✓ | Rp. .... | Rp. .... |
|                                             |       | Training | ✓ | Rp. .... | Rp. .... |
|                                             |       | Banner | ✓ | Rp. .... | Rp. .... |
|                                             |       | Poster | ✓ | Rp. .... | Rp. .... |
|                                             |       | Information boards | ✓ | Rp. .... | Rp. .... |
| Working Protective Equipment | Y.2.3 | Restricted Area | ✓ | Rp. .... | Rp. .... |
| Specific Cost | Y.2  | Insurance and Licensing | Y.2.4 | Insurance | Equipment use Permit (SIA) | ✓ | Rp. .... | Rp. .... |
|              |      |           |      | Heavy Equipment operator license (SIO) | ✓ | Rp. .... | Rp. .... |
| Safety Personnel | Y.2.5 | Safety Manager | ✓ | Rp. .... | Rp. .... |
|                                             | Safety Officer/Svp. | ✓ | Rp. .... | Rp. .... |
|                                             | Flagman | ✓ | Rp. .... | Rp. .... |
| Medical Facilities, Infrastructure and Devices | Y.2.6 | First Aid Box, medicine, etc | ✓ | Rp. .... | Rp. .... |
|                                             | Fogging | ✓ | Rp. .... | Rp. .... |
|                                             | Ambulance | ✓ | Rp. .... | Rp. .... |
| Safety Sign | Y.2.7 | Safety signs (traffic cone, Warning Lights stick, etc) | ✓ | Rp. .... | Rp. .... |
| Security Cost | Y.3  | Sheet pile | Y.3.1 | Rp. .... | Rp. .... |

4. Conclusion
Research and analysis results obtained from this research are:

- To identify OHS cost by Developing Safety Plan based on Standardized WBS, WBS shall be identified to Level 5 (activity). Standardized WBS is determined after compiling and analyzing data based on previous research and has been validated by experts.
• Minister of Public Works Regulation No. 05/PRT/M/2014 as a basis to develop a safety plan using the Standardized WBS.
• Erection Girder using The Tandem Crane is a high risk activity, therefore improper crane operation procedures, uncertified operator, and improper working method can affect to fatality. The Rigging check, creating, socializing and evaluating SOP, training and operator certification, installation of safety signs, and make a proper working space are necessary to prevent the accident.
• OHS cost components of Erection Girder using Tandem Crane is a specific cost consists of Inspection and Audit Program, Documents, Induction, Directions, Meetings, Trainings, Banner, Information Boards, SIA & SIO, training, safety personel, first aid box, and also Accident and Health Insurance.
• To calculate the amount of OHS cost can be done by inserting the unit price and quantity for each item as shows in table 4.

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