Analysis of safety cost structure in infrastructure project of cable stayed bridge based on Work Breakdown Structure (WBS)

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Abstract. The development of infrastructure in Indonesia is currently quite massive, in accordance with the Government of Indonesia's policy in accelerating infrastructure developments. However, along with the increase in the construction sector, work accidents in the construction sector also increased. Cable Stayed Bridge is one of the excellent technologies in connecting islands but has a high potential hazards and risks and it can cause fatal accidents. Accidents can be prevented through a good occupational safety and health management system (OHSMS). The application of OHSMS financing in Indonesian construction sector, especially in the cable stayed bridge has not been clearly and measurably regulated. In its implementation, the existing regulations have not yet been fully followed by the construction actors. This study aims to develop the safety cost based on Work Breakdown Structure (WBS). The research method are survey research and descriptive analysis. The study results are the cable stayed bridge standardized WBS, potential hazard sources, the preventive action to each potential hazards in each activity, finding the safety cost components based on WBS and the calculation of safety cost percentage in order to improve the OHSMS quality and reducing work accidents in the cable stayed bridge projects.

1. Introduction
The development of infrastructure in Indonesia is currently quite massive, in accordance with the Government of Indonesia's policy in accelerating infrastructure developments. Infrastructure is very important element in developing a country. Infrastructure increase the development construction industri also. In developing country, development of economic is influenced by role of construction industry [1]. Indonesia is an archipelago state, so long span bridge like cable stayed bridge is needed to connect each island. Long span bridge is included in government policy in infrastructure acceleration program. Cable Stayed Bridge is one of the excellent technologies in connecting islands but has a high potential hazards and risks and it can cause fatal accidents. And it is supported with the construction company that do not aware about construction safety. There were 110,285 accidents in 2015 and it is decreasing to 101,367 cases with 2,375 accidents fatalities, and the total claim until 792 billion rupiahs [2].

OHSMS is one of performance measurement in construction projects, and it is very important [3]. There are 4 components in safety management, the first is safety policy from top management, second safety risk management, third is safety implementation, and the last is safety inspection [4]. Risk is defined as an activities or conditions which have a potential hazard to be able to make an effect such as
illness, injury or death. Risk can be defined also as a dangerous activity or condition which has a probability to happened and the total impact [5]. Project scope, schedule, cost and quality of the project can be affected by risk [6].

In developing and implementing good OHMS, company should make a good safety plan and provide a budget for that. Safety planning documents has been regulated by Indonesian government through The Ministry of Public Works and Housing and Called (RK3K) [7]. The guideline has informed clearly in the Ministry regulation 05 / PRT / M / 2014. Good safety plan is developed from the work breakdown structure of the project. Work Breakdown Structure (WBS) is a divided level of works into smaller scope of work in order to be easy to manage [8]. The smallest or lowest level is used to plan all project is work package [9]. Activity is defined from the standardized WBS [10].

After developing a good safety plan, providing a enough budget for safety is also important. But the fact, there are many construction company not providing safety budget, because there are no safety budget which determined clearly [11]. In Indonesia, there are regulation which regulate the safety cost such as Regulation of the Minister of Public Works Number 28/PRT/M/2016 and Letter of the Minister of Public Works Number 11/SE/M/2019. According to Regulation of the Minister of Public Works Number 28/PRT/M/2016, safety cost divided by 3, general cost, specific cost and security cost. In the other regulation said that safety cost divided to 9 aspects, 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. From the regulation, this research is planned, and this research is very important to analyze a safety cost structure in order to achieve project safety performance.

2. Methodology
Generally, the method which used in this research is survey method and case study. There are 4 stages to achieve the main purpose of this research. First stages is to develop a standardized WBS. A questionnaire is used to get information from the construction safety experts. Descriptive analysis is the method to analyze the results. Second stages is to identify the potensial hazards and determine risk controls. Questionnaire with Guttmann scale is used to get the answer form the construction safety experts. Descriptive analysis is the method to analyze the results. After that, developing a safety plan is required. Questionnaire is used to get perception of construction safety expert. Fourth stage is to develop safety cost structure in each activity base on safety plan. Questionnaire with Guttmann scale is used to get the answer form the construction safety experts. Descriptive analysis is the method to analyze the results. The final stage is to calculate the safety cost percentage in two projects.

There are 7 variables, consist of 6 variables X (Work Package, Activity, Potensial Hazard, Risk Control, Safety Objective and Program) and 1 variable Y (Safety Costs). Non probability sampling is used to choose sample of experts. The requirements of the experts are more than 10 years’ experience in construction, and other requirements according to Project Management Institute [9].

3. Result and Discussion

3.1. Standardized Work Breakdown Structure (WBS) of cable stayed bridge
Work Breakdown Structure (WBS) is a divided level of works into smaller scope of work in order to be easy to manage [8]. The standardized WBS form the previous research which done [12]. The results of expert judgment and validation is shown in Figure 1. Form the figure we can see that standardized WBS consist of 6 levels of works, start form project name until the lowest level is resources. The limitation of the research is only study the upper structure work with the shoring system.
3.2. Hazard Identification, Risk Assessment, and Determining Control (HIRADC)

After validating the WBS, the next stage of the research is doing hazard identification, risk assessment and determining control base on WBS. Table 1 below show the HIRADC of girder lifting.

| WBS Level 5 Activities | Potential Hazards | Probability | Impact | Risk Rating | Risk Level | Risk Control |
|------------------------|-------------------|-------------|--------|-------------|------------|--------------|
| Girder Lifting         | Girder            | 4           | 5      | 20          | High       | Sling check, Rigging check creating, socializing and evaluating SOP |

From the table 1 above, we can see that the basis of HIRADC is starting from activity of cable stayed bridge, or in other word activity is WBS level 5. Activity of girder lifting can cause the girder fall down and it is the high risk which have risk control administrative control [13].

3.3. Safety plan and safety cost structure base on WBS

Safety plan is developed after doing HIRADC. Safety plan is consist of safety objectives and safety programmes. Safety objectives is divided 2, description and measurements, and the safety programmes is divided 4, Duration of the programmes, achievement indicator, monitoring and person in charge [14]. Figure 2 below is showing safety plan of girder lifting. Safety cost structure in cable stayed bridge for the girder lifting activity are specific cost and the structure are inspection and audit program, documents, induction direction, meeting, training, etc.
3.4. Safety cost calculation
The calculation is following Letter of the Minister of Public Works Number 11/SE/M/2019. The average of total percentage is 0.97%, this percentage is still under policy in stated owned company in Indonesia max 2% for bridge [15]. So this calculation is still make sense.

4. Conclusion
Base on the analysis, we can conclude some points as follows:

- Standardized WBS for Cable stayed bridge consist of 6 level of works, Level 1: Project Name, Level 2: Work Section, Level 3: Sub – Work Section, Level 4: Work Package, (Alternative Methods / Design), Level 5: Activities, and Level 6: Resources.
- Girder lifting activity has dangerous potensial hazards, that is girder fall down with risk rating 20 and risk level high. The risk control are sling check, rigging check and creating, socializing and evaluation of standard operational procedure.
- Specific cost is identified as a safety cost in girder lifting activity. Then the component is only administration control such as inspection and audit programs, documents, induction, direction, meeting, training, banner, and information board.
- The average percentage of total safety cost 0.97%. This percentage is under the policy of construction state owned company in Indonesia max 2% for bridge.

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