Analysis of safety cost structure for electrical work in rental aparments projects in special capital district of Jakarta based on Work Breakdown Structure (WBS)

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Abstract. With the lack of rental housing needs still very large, the need for building rental apartments in the future is still very high. In the implementation of construction projects in Indonesia in general the number of work accidents also increased. The construction industry is a dangerous industry that often takes its toll. Referring to the Manpower Social Service Provider (BPJS) data, nationally the number of occupational accidents in the construction sector is recorded as the highest national sector work accident rate. Especially in electrical work, there are many work accidents during electrical work that endanger electrical workers. For this reason, it is necessary to make a simulation of SMK3 cost modeling in order to estimate the costs needed with minimum project information at an early stage. Activity-based cost calculation has emerged as a new approach that connects costs directly related to business activities with manufactured products. To make activity-based cost calculations, making WBS and determining work items appropriately is a useful effort and is needed for effective activity-based risk assessment. So based on the above findings, given the high plan of building rental flats, the high number of occupational accidents and the lack of comprehensive OSH funding, this study focuses on developing OSH costs for the electrical component work in rental flats in DKI Province. Jakarta-based WBS.

1. Introduction
Jakarta is not only a province but also a city. The population’s growth is 1.03% per year and more than 10 million peoples live there in 2017 [1]. Housing is very important to each people who lives in Jakarta and it is become a big problem. DKI Jakarta planning to construct 15.564 units rental apartment in fulfill the needs of homestay. Rental apartment construction project is a part of policy in accelerating infrastructure projects. So, growth of rental apartment project is supporting the growth of construction industry in Jakarta. But, it is cause a new problem. Safety is a new problem because bad implementing construction safety management systems.

The one of most dangerous industry is construction especially electrical works [2,3]. In August 2017 to January 2018 there were more than 10 construction accidents in projects and cause dead and injury in Indonesia [4]. Negative impact will have caused disadvantages to construction company [5]. Safety is a big problems and a big challenge in all construction industry around the world [6]. Implementing a good safety management system is a solution in facing the challenge and solving the problems and it has a close correlation with project performance [7]. Work Breakdown Structure (WBS) become a basis...
to measure a project performance [8]. In Indonesia, implementing of safety management system in construction has been regulated in Permen PU No. 05/2014. In the regulation, preparing a good safety planning is a must. Implementation of a good safety management system in Indonesia is difficult because the construction company should provide a budget and it will reduce their profits.

The implementation of safety management system is still influenced by budgeting side and also the mindset that safety is additional cost [9]. Safety cost has been included in project cost, so it will be reduced the profits and cause a bad implementation of safety management system [10]. Nowadays, economic become important things to be considered in making decision and forgetting about human rights and safety [11]. So, preventing accidents must make economic sense for contractors [12]. Government has tried to change the contractor mindset with issuing a letter (SE PUPR) No. 11/2019 which regulating safety cost. There are 9 aspects which mention in the letter, i.e. Personal Protective Equipment’s, Safety Plan, Socialization, Promotion and Training, Working Protective Equipment’s, Workers Insurance, Environmental Permissions and Licensing, Safety Officer Personnel’s, Medical Facilities, Infrastructures and Medical Devices, Safety Signs, Consultation with Experts Related to Construction Safety [13]. The other regulation Permen PUPR No. 28/2016, safety cost grouped by 3 aspects, i.e. general cost, specific cost and security cost [14].

By doing research about construction safety cost for electrical works in rental apartment project is one most important things to do in order to facing the challenge of construction safety. The purpose of this research are developing safety plan, identifying safety cost components and calculating safety cost in order to reduce work accident, to maximize implementing a good safety management system and to increase safety project performance.

2. Methodology

This is a survey research with qualitative approach. Survey is used to get information from the respondents, where the respondents are construction safety experts. Non probability sampling is used to selected the sampling of respondents [15]. The requirements of construction safety expert are minimum education background is bachelor degree, having experience in the field of construction safety and MEP works, respondents are practitioners, member of professional associations, or academic member from university or other institutions and having minimum of 10 years’ experience and practitioners should be qualifying as a Project Manager, Site Engineering Manager, Site Manager and Safety Manager. Table 1 is shown 4 stages of the research. The output of first stage is safety plan (HIRADC), the second stages is safety plan (objectives and programs), the third is safety cost structure and the last is safety cost percentages. There are 2 variables in stages 1 (Potensial Hazard (X1) and Risk Control (X2)), 2 variables in stages 2 (Safety Objective (X4), and Safety Program (X5)) and stages 3 and 4 are 1 variable (Safety Cost (Y)). Questionnaires are distributed base on stages of the research.

| Stage | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|-------|---------|---------|---------|---------|
| Code  | X1      | X2      | X3      | X4      | Y       | Y       |
| Variable Name | Potensial Hazard | Safety Risk Control | Safety Specific Target | Safety Program | Safety Cost | Safety Cost |
| Sampling | Non Probability, Expert Judgement | Non Probability, Expert Judgement | Non Probability, Expert Judgement | Project Calculation |
| Instrument | Questionnaire | Questionnaire | Questionnaire | Project Calculation |
| Analysis | Descriptive | Descriptive | Descriptive | Descriptive |
| Output | Safety Plan (HIRADC) | Safety Plan (Objectives and Programmed) | Safety Cost Structure | Safety Cost Percentage |

Table 1. Stages of the research.
3. Results and discussions

3.1. Hazard identification, risk assessment and risk control base on work breakdown structure

Hazard Identification, Risk Assessment and Risk Control is developed from WBS. There are 12 sub work section of electrical works in standardized WBS which has been developed in previous research i.e. high electrical current works, fire alarm works, sound system works, telephone works, data works, CCTV works, MATV works, access control systems work, communication radio works, signal works, audio videophone works, and building automation systems works [16,17] and show in figure 1.

Figure 1. Tree diagram of standardized WBS for electrical works in rental apartment project.

The basis of hazards identification is activity at WBS level 5. Risk assessment is done to calculate the risk rating and to categorize risk level after hazards identification. Then risk control is selected to respond the risk and reduce the risk rating. An example of hazard identification, risk assessment and also determine risk control in on of activities in electrical works is shown in Table 2.

Table 2. Hazard identification, risk assessment, and risk control.

| WBS Level 5 Activities | Potensial Hazards | Probability | Impact | Risk Rating | Risk Level | Risk Controls |
|------------------------|-------------------|-------------|--------|-------------|------------|--------------|
| Installation of Cable and Cable Tray | Fall From Height | 4 | 5 | 20 | High | 1. PPE 2. Creating, socializing, and evaluating SOP |
Testing and commissioning is a must in electrical works to ensure the system works well. High current electrical systems test is one of activities in test and commissioning. And it is dangerous activity in electrical works with potential hazard electrocution. The scale of probability is 4 and scale of impact is 5 because it can cause death. The risk rating is 20 and the risk level is high. PPE are selected to prevent the risk of electrocution then creating, socializing, and evaluating SOP is also risk control. Those are included in administrative control and PPE in controlling risk hierarchy [18].

3.2. Safety plan and safety cost components identification based on work breakdown structure
Safety plan is developed and made after doing HIRADC. Safety plan to be developed are Safety objectives and safety programmes. Safety objectives are consist of description and measurements, and safety programmes are consist of duration of the programmes, achievement indicators, monitoring, and person in charge [19]. Safety plan for installation of cable and cable tray activities is shown in Table 3. The identification of safety cost components is made after making safety plan. Safety cost components is shown in Table 4.

### Table 3. Safety plan.

| WBS Level 5 | Potensial Hazards | Risk Controls | Objectives | Program |
|-------------|-------------------|---------------|------------|---------|
| Activities  |                   |               | Description | Measurements | Duration | Achievement Indicator | Monitoring | PIC               |
| Installation of Cable and Cable Tray | Fall From Height | 1. PPE | There is no injury | Workers using PPE | Before works | There is no injury to workers | Supervisory report per term of work/ safety report | Safety Officers, Supervisors |
|             |                   | 2. Creating, socializing, and evaluating SOP | There is no injury | Documents, inductions, direction, meeting, training, banner, information board | Along duration of work | There is no injury to workers | Supervisory report per term of work/ safety report | Safety Officers, Supervisors |

### Table 4. Safety cost components.

| WBS Level 5 | Potensial Hazards | Risk Controls | Safety Cost Components |
|-------------|-------------------|---------------|------------------------|
| Activities  |                   |               |                        |
| Installation of Cable and Cable Tray | Fall From Height | 1. PPE 2. Creating, socializing, and evaluating SOP | Specific Cost | PPE Documents, inductions, direction, meeting, training, banner, information board |

3.3. Safety cost calculation
Letter of the Minister of Public Works Number 11/SE/M/2019 are regulated the calculation of safety cost in construction. In this research, a safety cost calculation format with a modification is proposed. The modifications are grouping the safety cost components in to safety general cost, safety specific cost and security cost base on Permen PUPR No. 28/2016. Basically, the calculation of safety cost in electrical works become a unity with the safety cost calculation for rental apartments project. The calculation format table with a modification is shown in Table 5. which can be used to calculate total and percentage of safety cost.
### Table 5. Safety cost calculation format.

| No | Item Description                   | Unit | Volume | Unit Price (IDR) | Total Amount (IDR) |
|----|------------------------------------|------|--------|------------------|--------------------|
| A  | General Cost                       |      |        |                  |                    |
| 1  | Personal Protective Equipment      |      |        |                  |                    |
| B  | Specific Cost                      |      |        |                  |                    |
| 1  | Safety Plan Preparation            |      |        |                  |                    |
| 2  | Socialization, Promotion, and Training |      |        |                  |                    |
| 3  | Working Protective Equipment       |      |        |                  |                    |
| 4  | Insurance and License              |      |        |                  |                    |
| 5  | Safety Personnel                   |      |        |                  |                    |
| 6  | Medical Facility, Infrastructures and Devices | | | | |
| 7  | Safety Signs                       |      |        |                  |                    |
| 8  | Consultation to Expert regarding Construction Safety | | | | |
| 9  | Others                             |      |        |                  |                    |
| C  | Security Cost                      |      |        |                  |                    |
| 1  | Safety Unit Price Analysis         |      |        |                  |                    |
| I  | Total Safety Cost                  |      |        |                  |                    |
| ii | Project Amount                     |      |        |                  |                    |
| iii| % Safety Cost/Project Amount       |      |        |                  |                    |

### 4. Conclusion

Based on the results of data analysis above, those can be concluded as follows:

- Installation cable and cable tray is one of activities which have potential hazards such as fall from height. The risk rating is 20 and the level is high because it can cause death. The risk controls which selected are using PPE and creating, socializing, and evaluating SOP. Those are categorized as PPE and administrative control in risk control hierarchy.
- Safety cost components for installation cable and cable tray are grouped into specific cost. And the components are PPE, documents, induction, direction, meeting, training, banner, and information board.
- The total and percentage of safety cost for mechanical works can be calculated based on modification calculation format which is proposed. The total and percentage of safety cost for electrical work can be calculated with the calculation format proposed.

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