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

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Abstract. Since the implementation of the policy of accelerating infrastructure projects, the construction industry has also increased in Indonesia. The construction industry is a dangerous industry that often takes casualties. In recent years there have been many construction accidents in the construction of rental apartments, which have caused moral and material losses, projects that were stopped and projects that were delayed. Lack of separate budgets that are specifically prepared in implementing the Occupational Safety and Health System is one of the causes of the poor implementation of SMK3 in construction projects and create high rates of accidents in the workplace. In Indonesia, although there are several regulations governing the implementation of SMK3, there are no specific regulations that regulate how to prepare a reasonable budget for the implementation of SMK3. The aims of the study are determining the work breakdown structure in mechanical work in rental apartments identifying risks, developing risk control, identifying components of cost of safety and calculating of safety cost. This research is a survey research with respondents of experts and actors in the field of construction safety, descriptive analysis is used to determine variables. A case study approach is also used to calculate the cost of safety. This research is expected to be able to produce a cost of safety calculation in rental apartments projects so that it can maximize the application of SMK3, in order to reduce accidents in workplace and achieving good safety performance.

1. Introduction
Jakarta is one of big city in Indonesia and have more than 10 million peoples live there in 2017 [1]. The needs of housing is very significant problems to be able to solved. DKI Jakarta solve the problem in planning to construct 15.564 units rental apartment. Rental apartemt project is one of the project which including in accelerating in infrastructure project, especially in Jakarta. The growth of construction industry in Indonesia has increased because of the policy in accelerating infrastructure projects. But the acceleration of infrastructure projects is not accompanied by implementing a good safety management system.

Construction industry is very dangerous industry [2,3] especially mechanical works. There were more than 14 construction accidents in projects and cause fatality in Indonesia [4]. The high number of work accidents and fatalities can give negative impact to company [5]. Safety become a challenge in Indonesia construction industry and all around the world [6]. The key to solve the problem and to face
the challenge is implementing a good safety management system. Safety management system has a
correlation with project performance and it is an important role [7]. Project safety performance
measurement based on the results of work breakdown structure (WBS) identification [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. But in implementing a good
safety management system, a construction company should provided budget for that.

The implementation of safety management system is still constrained in budgeting side and also the
mindset that safety is additional cost [9]. In many project, safety cost is included in project cost so it
cause a problem in implementing a good safety management system [10]. In other side, the decision
related to safety may not be based on human rights but economics [11]. So, preventing accidents must
make economic sense for contractors [12]. In order to solve the problems and change the contractors
mindset, the Indonesian government through the ministry of public works and public housing issued a
letter (SE PUPR) No. 11/2019 which regulating safety cost. In the letter mentioned there are 9 aspects,
i.e. Personal Protective Equipments, Safety Plan, Socialization, Promotion and Training, Working
Protective Equipments, Workers Insurance, Environmental Permissions and Licensing, Safety Officer
Personnels, Medical Facilities, Infrastructures and Medical Devices, Safety Signs, Consultation with
Experts Related to Construction Safety, Others [13]. Safety cost grouped by 3 aspects, i.e general cost,
specific cost and security cost which are regulated in Permen PUPR No. 28/2016 [14].

Conducting further analysis of safety cost structure for mechanical works in rental apartment projects is
very important to solve one of construction safety problem. The aim of this research are developing
safety plan, identifying safety cost components and calculating safety cost so that it can maximize the
implementation of safety management system, in order to reduce accidents in workplace and achieving
good safety performance.

2. Methodology
This is a qualitative research. This study is using survey research to collect primary data. There are 4
stages to answer the research questions. First stages is to develop safety plan (HIRADC), second stages
is to develop safety plan (Safety Objective and Program), third stages is to identify safety cost
components and the last stages is to calculate safety cost. Each stages is used questionnaire to get
primary data or expert judgement from construction safety experts. Guttman scale is used in all
questionnaire. Descriptive analysis will use to analyze the data results. There are 4 variable X (Potential
Hazard (X1), Risk Control (X2), Safety Objective (X4), and Safety Program (X5)) and 1 variable Y
(Safety Cost). In choosing sample of construction expert, non-probability sampling is used [15]. The
requirement of construction safety expert are respondents are construction safety expert form 5 to ten
peoples, 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 qualify as a Project Manager, Site Engineering Manager, Site Manager and
Safety Manager. Figure 1 show the research flow process.
3. Results and discussion

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

Developing of Hazard Identification, Risk Assessment and Risk Control start from WBS. There are 4 sub work section of mechanical works in standardized WBS which has been developed in previous research i.e. VAC works, fire fighting works, lift works and plumbing works (see figure 2) [16,17].

Figure 1. Research flow process.

Figure 2. Work breakdown structure.
Activity at WBS level 5 is a basis for potential hazards which will happen. After that, risk assessment is done to calculate the risk rating and to categorize risk level. Then risk control is chosen to reduce the risk. Table 1. Below show an example of hazard identification, risk assessment and also determine risk control in on of activities in mechanical works.

Table 1. Hazard identification, risk assessment, and risk control.

| WBS Level 5 Activities | Potential Hazards | Probability | Impact | Risk Rating | Risk Level | Risk Controls |
|------------------------|-------------------|-------------|--------|-------------|------------|---------------|
| Procurement & Installation Sprinkler Head | Fall from height | 4           | 4      | 16          | Middle     | 1. PPE        |

Procurement and installation sprinkler head are one of dangerous activities in mechanical works with potential hazard fall from height. The scale of probability is 4 and scale of impact is 4. The risk rating is 16 and the risk level is middle. The risk controls are using PPE and creating, socializing, and evaluating SOP and those are included in administrative control and PPE in controlling risk hierarchy [18].

3.2. Safety plan and safety cost components identification base on work breakdown structure

After doing HIRAD, safety plan is developed. Safety objectives and safety programs are part of safety plan to be developed. Safety objectives are consist of description and measurements, and safety programs are consist of duration of the programs, achievement indicators, monitoring and person in charge [19]. Table 2. is showing safety plan of procurement and installation sprinkler head activities. After safety planning are made, the identification of safety cost components which show in Table 3.

Table 2. Safety plan.

| WBS Level 5 Activities | Potential Hazards | Risk Controls | Objectives | Program |
|------------------------|-------------------|---------------|------------|---------|
| Procurement & Installation Sprinkler Head | Fall from height | 1. PPE: There is no injury | Workers using PPE | Before works |
| | | 2. Creating, socializing, and evaluating SOP | Documents, inductions, direction, meeting, training, banner, information board | Along duration of work |
| | | | There is no injury to workers | 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 | Safety Officers, Supervisors |

Table 3. Safety cost components.

| WBS Level 5 Activities | Potential Hazards | Risk Controls | Safety Cost Components |
|------------------------|-------------------|---------------|------------------------|
| Procurement & Installation Sprinkler Head | Fall from height | 1. PPE: Specific Cost | PPE |
| | | 2. Creating, socializing, and evaluating SOP | Documents, inductions, direction, meeting, training, banner, information board | Specific Cost |
3.3. Safety cost calculation
The safety cost calculation is following Letter of the Minister of Public Works Number 11/SE/M/2019 with a slice modification is proposed. The modification shows the main grouping of safety cost structure in Permen PUPR No. 28/2016 i.e. safety general cost, safety specific cost and security cost. Table 4. is showing the calculation format table which can be used to calculate total of safety cost and the percentage.

Table 4. 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     |      |        |                  |                    |
| 7  | Safety Signs                          |      |        |                  |                    |
| 8  | Consultation to Expert regarding     |      |        |                  |                    |
| 9  | Construction Safety                   |      |        |                  |                    |
| C  | Security Cost                         |      |        |                  |                    |
| 1  | Safety Unit Price Analysis            |      |        |                  |                    |
| i  | Total Safety Cost                     |      |        |                  |                    |
| ii | Project Amount                        |      |        |                  |                    |
| iii| % Safety                              |      |        |                  |                    |
|    | Cost/Project Amount                   |      |        |                  |                    |

4. Conclusion
The conclusion of this study base on the results of data analysis are:

- Mechanical works have so many dangerous activity such as procurement & installation sprinkler head. The one of potential hazard is falling from height with risk rating 16 and middle risk level. The risk controls to response and reduce risk are using PPE and creating, socializing, and evaluating SOP. The risk controls hierarchy are PPE and administrative control.
- Safety cost components for procurement & installation sprinkler head are categorized 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 base on modification calculation format which is proposed.

Acknowledgement
The author would like to thank the financial support provided by the University of Indonesia through PUTI Proceedings of the Fiscal Year 2020 with the contract number: NKB-1184 / UN2.RST / HKP.05.00 / 2020 managed by the Directorate of Research and Community Engagement (DRPM) Universitas Indonesia.

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