Analysis of Relation Between Safety Cost and OHS Performance in Building Construction to Improve Safety Performance

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Abstract—Number of accidents in construction sector in Indonesia is high, including building construction. The high number of accidents indicates that a good system of safety and health management is required. The purpose of this study is knowing the relationship of safety cost and OHS performance in building construction in Jabodetabek with statistical methods. The result shows that safety cost' components which have the most influence to control OHS' risks are rotary lamp, life line, and tools license permit. Moreover, safety cost' components that influence accidents the most are evacuation route, BPJS, safety vest, and worker’s identity cards.

Index Term—Safety Cost, Safety Performance, OHS Risk Control, Accidents

I. INTRODUCTION

Occupational Safety and Health (K3) is a very important aspect, especially in the construction sector. In its work, the construction sector involves jobs with substantial risk of harm. K3 management system in Indonesia can be said still not well implemented, indicated from the high number of work accidents that occurred in Indonesia. Based on data of accident cases from PT. Social Security of Workers (Jamsostek), there were 95,624 cases in 2006, 83,714 cases in 2007, 94,736 cases in 2008, 96,314 cases in 2009, 98,711 cases in 2010, and 99,491 cases in 2011. Of 31.9 % of the cases are from the construction sector. These figures support the argument of high occupational accident risk in the construction sector, including building construction.

Construction organizers tend to underestimate the OSH management system as it is considered to only add to the cost budget in construction works. Safety and Health Expenditures for construction sector are regulated in Circular Letter no. 66 / SE / M / 2015 on the Cost of Operation Management System Occupational Safety and Health (SMK3) Construction of Public Works. However, because it is considered as a burden, construction operators tend to ignore the implementation of SMK3.

In a study of 25 building projects undertaken by Gurcanli et al. (2015), some construction service firms actually allocate lower K3 costs along with increased project size and height. In fact, the cost of K3 does not reach 5% of the total cost, ie the research is 2.6% of the total cost. Based on research conducted by Muhammad, et. al. (2015), explained that according to Smallwood, J. (2004), the estimated cost allocation for OHS management implementation in construction companies is 0.5% to 3% of the total project cost, and work accident costs exceed 5% of the total project cost.

Based on some existing research, the cost of running SMK3 in building construction projects is often allocated very small to reduce total cost burden. Construction companies usually consider allocating funds for OSH management for construction projects, including building construction projects, as one indicator that could harm the company. This is unfortunate, because the high number of occupational accidents in the construction sector needs to be overcome by the improvement of OHS performance.

The purpose of this study are:
1. Identify the cost component of the implementation of SMK3 allocated to the building construction project.
2. Identify the components of the cost of implementing SMK3 in building construction projects to improve OSH performance.
3. Identify the cost component of the implementation of SMK3 which is a priority to improve K3 performance.
4. Analysis the effect of SMK3 implementation cost on the performance of K3 in building construction project.

II. THEORITICAL REVIEW

OSH performance, by definition from OHSAS 18001: 2007, is a measurable outcome of the management of OSH risks in an organization. Measurements of OHS performance include measuring the effectiveness of control carried out by the organization. OHS performance can also be measured by comparing against OSH policy, OHS objectives, and other OHS performance requirements.

The organization shall establish, implement and maintain procedures to monitor and measure the OHS performance on a regular basis. Such procedures are important for qualitative and quantitative measurement according to the needs of the organization; monitor extensions that enable the organization's OH & E objectives to be achieved; monitor the effectiveness of controls for health and safety, proactively measure...
performance to monitor compliance with OHS management programs, controls and operational criteria; measure performance reactively to monitor accidents, illness, accidents and other records evidence of K3 performance deviations; record data and monitoring results and measure adequacy to undertake an analysis of further corrective and preventive actions (OHSAS 18001: 2007, chap 4.5.1).

Cost of construction SMK3, pursuant to Regulation of Minister of Public Works no. 05 / PRT / M / 2014, is the cost required to apply the SMK3 in any construction work that should be taken into account and allocated by the Service Provider and Service User. The cost of implementing SMK3 is allocated in general cost which includes RK3K preparation, socialization and promotion of K3, work protective equipment, personal protective equipment, insurance and licensing, OSH personnel, health facility facilities, signs and others related to OHS risk control.

Cost of Occupational Safety and Health (K3) consists of three elements, namely inspection, preventive, and accident. Inspection costs include inspection or supervision of OHS program implementation. Preventive costs include preventing the occurrence of accident risk. And the cost of accidents is the cost of events resulting from risks (Husin, 1999).

The organizers and construction workers assume that the occupational safety and health program has an impact on the rising cost of the project, so the issue of occupational safety and health in the construction project is underestimated (Muhammad et al., 2015).

For the prevention of work accident in the construction sector, the provision of safety equipment (safety tools) and controlling the use of security tools is very important. In the provision of safety tools, it is necessary to allocate the safety costs made in the planning, supply and construction (Sarireh and Taruwneh, 2014) phases.

According to Muhammad, et. al. (2015), explained that according to Smallwood, J. (2004), the estimated cost allocation for OHS management implementation in construction companies is 0.5% to 3% of the total project cost.

III. RESEARCH METHODS

The initial phase of the study was literature study, to identify problems, to determine variables, to assign titles, to formulate problems and to determine research objectives, and to establish hypotheses. In this study, independent variables obtained from the Regulation of the Minister of Public Works, precisely based on Circular Letter no. 66 / SE / M / 2015 on the Cost of Operation Management System Occupational Safety and Health (SMK3) Construction of Public Works.

Data collection for this study used questionnaire as research instrument. The first stage questionnaire is an expert validation questionnaire to answer validate the research variables, given to 4 experts of K3. The second stage questionnaire is a survey pilot questionnaire to ensure that each variable is easy to understand, given to 10 respondents. The third stage questionnaire is a research questionnaire, to answer the research problem formulation, and given to 40 respondents, that is 40 building safety project manager around Jabodetabek.

Data analysis method used by writer in this research is quantitative method or method of statistical analysis. Quantitative methods are methods that use statistics as a means of data analysis (Silalahi, 2006). The statistical test chosen by the writer for this research is Delphi Analysis for variable validation by expert, Descriptive Statistic Analysis for Problem Formulation 1, Correlation Analysis for Problem Formulation 2, Factor Analysis for Problem Formulation 3, and Regression Analysis for Problem Formulation 4. Correlation analysis is analysis used to determine the relationship between variables. Correlation between these variables is obtained by bivariate product moment pearson correlation method using SPSS. Factor Analysis is an analysis used to collect variables into components of new variables, to determine the main factors of the components of variables that exist. Regression analysis is an analysis used to test the linear relationship between independent variables to the dependent variable. Regression used in this study is multiple linear regression, because it has more than one independent variable. Having obtained the results of research in the cost component of SMK3 most influential on the performance of K3, the results are validated by expert K3. In addition, interviews were also conducted on several projects related to the cost of K3 components that have the most influence on OSH performance, based on research results.

IV. RESEARCH RESULT

Based on the results of filling questionnaires by 37 safety managers Jabodetabek building project, data analysis, until the final validation by experts, the results obtained from the descriptive analysis found that all the variable cost components of SMK3 in this study allocated to building projects in Jabodetabek. The cost components of SMK3 allocated to the building project include:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Safety Cost Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td>HSE PLAN PREPARATION (CONTRACT SAFETY PLAN)</td>
</tr>
<tr>
<td>X1.1</td>
<td>Manual Making, Procedures, Work Instructions, Work Permits and Forms</td>
</tr>
<tr>
<td>X1.2</td>
<td>Working Identity Card</td>
</tr>
<tr>
<td>X6</td>
<td>SAFETY PERSONNEL</td>
</tr>
<tr>
<td>X6.1</td>
<td>Occupational Health and Safety Expert and / or Occupational Safety Officer</td>
</tr>
<tr>
<td>X6.2</td>
<td>Emergency Response Officer</td>
</tr>
</tbody>
</table>

Table I

SMK3 cost component of building project
<table>
<thead>
<tr>
<th>Variable</th>
<th>Safety Cost Component</th>
<th>Variable</th>
<th>Safety Cost Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>X2</td>
<td>SOCIALIZATION AND SAFETY PROMOTION</td>
<td>X6.3</td>
<td>First Aid Officer</td>
</tr>
<tr>
<td>X2.1</td>
<td>Safety Induction</td>
<td>X6.4</td>
<td>Traffic Management Officer</td>
</tr>
<tr>
<td>X2.2</td>
<td>Safety Briefing, Safety Talk and / or Tool Box Meeting,</td>
<td>X6.5</td>
<td>Medical Officer</td>
</tr>
<tr>
<td>X2.3</td>
<td>Safety Training</td>
<td>X7</td>
<td>HEALTH FACILITIES</td>
</tr>
<tr>
<td>X2.4</td>
<td>Safety Simulation</td>
<td>X7.1</td>
<td>First Aid Kit (First Aid Kit, Stretcher, Oxygen Tube, Wound Drug, Bandage, etc.)</td>
</tr>
<tr>
<td>X2.5</td>
<td>Banner</td>
<td>X7.2</td>
<td>First Aid Room (Patient Beds, Stethoscope, Weighing Scales, Tension Meter, etc. )</td>
</tr>
<tr>
<td>X2.6</td>
<td>Poster</td>
<td>X7.3</td>
<td>Fogging Equipment</td>
</tr>
<tr>
<td>X2.7</td>
<td>Safety Information Board</td>
<td>X7.4</td>
<td>Smoking Drugs</td>
</tr>
<tr>
<td>X3</td>
<td>WORK PROTECTION EQUIPMENT</td>
<td>X7.5</td>
<td>Medical Check Up Beginning</td>
</tr>
<tr>
<td>X3.1</td>
<td>Safety Net</td>
<td>X7.6</td>
<td>Larvaeciding abate</td>
</tr>
<tr>
<td>X3.2</td>
<td>Life Line</td>
<td>X8</td>
<td>SIGNS</td>
</tr>
<tr>
<td>X3.3</td>
<td>Safety Deck</td>
<td>X8.1</td>
<td>Guidance Notes</td>
</tr>
<tr>
<td>X3.4</td>
<td>Guard Railing</td>
<td>X8.2</td>
<td>Prohibition Rules</td>
</tr>
<tr>
<td>X3.5</td>
<td>Restricted Area</td>
<td>X8.3</td>
<td>Warning sign</td>
</tr>
<tr>
<td>X4</td>
<td>PERSONAL PROTECTIVE EQUIPMENT</td>
<td>X8.4</td>
<td>License Sign</td>
</tr>
<tr>
<td>X4.1</td>
<td>Safety Helmet</td>
<td>X8.5</td>
<td>Sign Information</td>
</tr>
<tr>
<td>X4.2</td>
<td>Eye Protection (Goggles, Spectacles)</td>
<td>X8.6</td>
<td>Temporary Employment Signs</td>
</tr>
<tr>
<td>X4.3</td>
<td>Face Shield</td>
<td>X8.7</td>
<td>Traffic Management Staff</td>
</tr>
</tbody>
</table>

The results of factor analysis indicate whether the component on the cost of implementing SMK3 is a priority to improve the performance of K3 in the building construction, namely:
- The main factor of SMK3 cost component to improve OHS risk control:
  - Component 1 = Signs, Light Fire Extinguishers (APAR), and Inspection and Internal Audit Program.
Component 3 = Security Fence, Safety Helmet, Face Shield, Safety Shoes, and Feasibility License Tool.

- The main factor of SMK3 cost component related to work accident:
  Component 1 = Signs, Rotary Lamp, Light Fire Extinguisher (APAR), K3 Flag, Escape Route, Internal Audit and Inspection Program, and Incident Reporting and Investigation
  Component 2 = Induction K3, Safety Vest, BPJS, Feasibility License Tool, License Operator, and First Aid Officer
  Component 3 = Security Fence, Safety Helmet, Face Shield, Safety Shoes
  Component 4 = Establishment of Worker Identity Card

The result of factor analysis is then used for regression analysis to get cost component of SMK3 which have the most influence to K3 performance. The regression performed is a combination of the variables of factor analysis, so there are 605 regression combinations, consisting of 270 combinations for Y1 and 335 combinations for Y2. Result of regression analysis used in this research is biggest result from 605 regressions, that is equation as follows:

\[ Y_1 = 1.187 + 0.465X_A + 0.274X_D \]
\[ Y_1 = 2.237 + 0.507X_C \]

Information:

- Y_1 = OHS risk control
- X_A = Rotary Lamp (Rotary Lamp)
- X_B = Life Line
- X_C = Feasibility License Tool.

\[ Y_2 = 0.180 + 0.455X_A + 0.511X_C \]
\[ Y_2 = 0.439 + 0.491X_A + 0.418X_B \]
\[ Y_2 = 0.797 + 0.537X_A + 0.318X_D \]

Information:

- Y_2 = Work Accident
- X_A = Evacuation Line (Escape Route)
- X_B = BPJS Employment and Occupational Health
- X_C = Safety Vest (Safety Vest)
- X_D = Manufacture Worker Identification Card

The regression equation shows that the most influential components of SMK3 on OHS risk control are turning lights, safety straps, and equipment permit permits. Then, the most important components of SMK3 cost for work accident are evacuation route, BPJS Employment and Occupational Health, safety vest, and identity card making.

V. DISCUSSION

The cost components of the Occupational Safety and Health Management System (SMK3) contained in the Regulation of the Minister of Public Works, through the Circular Letter of the Minister of Public Works and Public Housing No. 66 / SE / M / 2015 on the Cost of SMK3 Operation of Public Works, preparation of RK3K, socialization and promotion of K3, work protective equipment, personal protective equipment, insurance and licensing, OSH personnel, health facility facilities, signs and others related to OHS risk control.

RK3K Preparation (Contract HSE Plan) consists of manual making, procedures, work instructions, work permits and forms, and the creation of employee identity cards.

Socialization and promotion of K3 consist of K3 induction, K3 direction, safety talk, K3 training, K3 simulation, banner, poster, and K3 information board. Working protective equipment consists of safety net, life line, safety deck, guard railing, and restricted area.

Personal protective equipment consists of a safety helmet, goggles, face shield, breathing apparatus, ear plug, respirator and mouth (masks), gloves (safety gloves), safety shoes, full body harness, life vest, safety vest, coveralls, and fall arrestors.

Insurance and licensing consists of BPJS Employment and Occupational Health, equipment permit permit, operator license, license for approval of Working Committee on Occupational Safety and Health (P2K3). OSH personnel consist of OSH experts and / or OSH officers, emergency response officers, First Aid officers, traffic regulators, and medical personnel. Health facility facilities include first aid equipment, first aid room, fogging equipment, and fumigation drugs. According to the expert, there are other health facilities that have not been included in the Circular Letter of Minister of Public Works and People's Housing Number: 66 / SE / M / 2015, namely Larvae-cidding-abate.

Then, the signs consist of guidance signs, warning signs, warning signs, liability signs, information signs, temporary work signs, warning lights sticks, traffic cones, rotary lamps, , and traffic hose lights. According to experts, these signs are components that must be allocated to every building construction project.

Furthermore, in relation to other OHS risk control, the expert explains that the monthly OH & S report also includes components that must be present with other components listed in the Ministry of Public Works such as light fire extinguishers, sirens, OSH flags, evacuation routes, emergency lights, inspection programs and internal audits , incident reporting and investigation.

The K3 cost components that are always allocated to each project are OHS training, OHS information board, safety net, life line, safety deck, guard railing, safety helmet , respirator and mouth protector (mask), safety gloves, safety shoes, full body harness, first aid kits, guidance signs, warning signs, warning signs, liability signs , and Fire Extinguishers (APAR). Meanwhile, the least costly K3 cost component allocated to the building project is the life vest. Safety managers on building projects argue that the life jacket is not very necessary for the building safety management K3, unless the project is located close to the water.

Of these components, there are 3 main components of OHS cost components to improve OHS risk control, namely the first signs, Fire Extinguishers (APAR), and internal inspection and audit programs. The second main component is the simulation, banners, information boards K3, safety net, life line, and full body harness. The third main component is safety fence, safety helmet, face shield, safety shoes, and tool permit permit.

Related work accidents, there are 4 main components. The first components are fogging, larvaecidding-abate, signs, rotary lamps, Fire Extinguishers (APAR), K3 flags, escape routes,
internal inspection and audit programs, incident reporting and investigation, as well as employee identity cards. The second component is K3 induction, safety vest, BPJS, tool permit permit, operator license, and first aid officer. The third component is the safety fence, safety helmet, face shield, and safety shoes. The fourth component is the creation of a worker's identity card.

According to experts, signs and APARs are mandatory for budgeting in the project, as they are a basic component of OSH implementation and have a major impact on OSH risk prevention. In addition, internal inspection and audit programs are part of the monitoring tools for implementing K3 implementation, so it needs to be allocated. With the inspection and audit program, the risk of K3 will be more controllable. Simulation, banners, information boards K3, safety net, life line, and full body harness when allocated for K3 will play a direct role in efforts to increase risk control K3. For work at altitude, need a safety net, life line, and full body harness as it will improve the safety of workers to move and move. In addition, safety helmet and safety shoes shall be provided and used by everyone in the project environment to prevent undesired risks. A safety fence should be installed to prevent unauthorized persons from entering the project. This is accompanied by a security management system.

According to the expert, Foggung and Larvaeciding-abate is a component that prevents the onset of occupational diseases, and has no direct effect on the control of occupational accidents, so it is not included in the main component. signs, rotary lamps, Fire Extinguishers (APAR), K3 flags, escape routes, internal inspection and audit programs, incident reporting and inquiry, K3 induction, safety vests, , BPJS, equipment permit permit, operator permit, first aid officer, safety fence, safety helmet, face shield, safety shoes, and the creation of worker identity card are very influential on the work accident so that it is approved as the main component. Furthermore, the main factors of the cost components of SMK3 are reprocessed so as to obtain the cost component of SMK3 most influential on the performance of K3. To obtain the most influential component of SMK3 cost, a regression analysis is performed.

The result of regression analysis of the main factor X component to Y1 shows the most influential component of SMK3's cost of controlling K3 risk. Furthermore, the cost component of SMK3 that has the most influence on the work accident is obtained from regression analysis of variable X to Y2.

There are 7 cost components of SMK3 that have the most influence on OHS performance. 3 cost component of SMK3 most influential to effectivity of risk control, 4 components of SMK3 most influence to work accident. The most influential components of SMK3's cost effectiveness are the revolving lights, safety straps, and equipment permit permits. The most important components of SMK3's cost to work accident are evacuation route, BPJS, safety vest, and identity card making. Here are the costs needed to allocate these components:

The results showed that the total cost of allocation of the 7 components of SMK3 operating cost that most influenced on the OHS performance was only 0.088% - 0.14% of the contract value of the project construction. The cost is very low, but if the components are allocated, the performance of K3 will increase. Other SMK3 fee components should also be allocated in accordance with the OSH program applied to each project. According to project experts and safety managers, the overall cost allocated for OSH is usually the greatest at only 5% of the contract value of the project construction.

VI. CONCLUSION

After doing research on cost component of SMK3 in case study of building project in Jabodetabek, the conclusion obtained are as follows:

1) Based on the results of descriptive analysis to answer the first problem formulation, all variable cost component of SMK3 in this research is allocated to building project in Jabodetabek.

2) Based on the results of correlation analysis to answer the formulation of the second problem, it can be seen the relationship of each component of the cost of SMK3 in the building construction project on efforts to improve the performance of K3. There are 4 strongly correlated SMK3 cost components, 38 correlated cost components are sufficient, 14 correlated cost components are very weak, and 4 components of SMK3 cost are not correlated to risk control. In addition, related to work accidents, there are 7 components of SMK3 cost are strongly correlated, 34 components of SMK3 cost is correlated enough, 11 components of SMK3 cost are very weak correlated, and 8 components of SMK3 cost that is not correlated.

3) Based on the results of factor analysis to answer the formulation of the third problem, it can be seen the cost component of the implementation of SMK3 which become the priority to improve the performance of K3 in the building construction. To increase the effectiveness of OHS risk control, the priority component of SMK3 cost is 3 components. The first component consists of signs, Fire Extinguisher (APAR), and internal inspection and audit programs. The second component consists of simulations, banners, information boards K3, safety net, life line, and full body harness. The third component consists of safety fence, safety helmet, face shield, safety shoes, and permit permit tool. For workplace accidents, the cost component of the priority SMK3 is 4 components. The first component consists of signposts, turning lights, Light Fire Extinguishers (APAR), K3 flags, evacuation routes, inspection and internal audit programs, and incident reporting and investigation. The second component consists of K3 induction, safety vest, instrument permission license, operator permit, and first aid officer. The third component consists of safety fence, safety helmet, face shield, and safety shoes. The fourth component is the creation of a worker's identity card.
VII. SUGGESTION

Suggestions from this research are as follows:

1) For construction service companies:
   a) Allocation of the cost of SMK3 implementation can be more effective by making recommendations which have been given by this research.
   b) This research can be used as the basis for monitoring the procurement of cost components of SMK3 in building projects, so that the performance of K3 in the building project can continue to increase and sustainable.

2) For further research, can be developed about:
   a) SMK3 cost component outside PU Workstation which may affect K3 performance.
   b) The minimum cost quantity that must be allocated to achieve good K3 performance.
   c) Comparison of research findings with research on other construction projects, such as bridges, roads, etc.

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