Analysis on risk management of occupational health and safety on ongoing building project

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Abstract. The issue of handling occupational safety and health is an important aspect of construction projects around the world. The purpose of this study is to find the dominant risk aspects that affect occupational safety and health accidents in high rise building projects. This study used a survey method through questionnaire with analytical hierarchy process (AHP) type. Respondents at minimum must have relevant education background in the construction sector and had at least 3 - 4 years of work experience in the construction sector of high-rise building projects in the Greater Jakarta area. Through literature study, there were 3 aspects with its own sub-criteria that was analysed in this research. Those 3 aspects are Technical Aspects (A), Human Resource Aspects (B), and Unexpected Events aspects (C). With technical Aspects (A) has seven sub-criteria, Human Resource Aspects (B) has six sub-criteria, and Unexpected Events aspects (C) has seven sub-criteria. These variables were compiled into an analytical hierarchy process type questionnaire. The survey used an online media, which is the use of Google Drive (Google Sheets), where each respondent filled in the questionnaire in Google Sheets, stored in an online database. The data from the questionnaire were analysed using a program called Expert Choice to determine which aspects have the highest scored and then each aspect was ranked based on the score. Each sub-criteria of the aspects were also analysed and was ranked based on the score. Based on the results of the analysis carried out, the dominant risk aspects that affect work accidents in high rise building construction projects is human resources (Criteria B).

Keywords: analytical hierarchy process, survey, questionnaire, occupational safety and health, expert choice

1. Introduction

OHS (Occupational Health and Safety) or also known as OSH (Occupational Safety and Health) is one of the important factors that needed to be considered during construction work because the impact of occupational accidents and health hazards is not only detrimental to employees, but the company as well, either directly or indirectly.

The purpose of OHS (Occupational Health and Safety) risk management is the creation of well-defined OHS management in the workplace which involves all parties in the workplace to reduce and/or prevent the number of occupational accidents and health hazards so that a safe, efficient, and productive workplace can be created.
The purpose for this research is: to identify and ranked the Risk Aspects; to find/identify several ways to reduce the risk of Occupational Safety and Health (OSH) accidents at an ongoing high-rise building construction project and ranked each of it; and to find several methods or actions to help mitigate the identified risk Aspects through literature study. The result of the analysis for Risk Aspects and its sub-criteria/variables was re-evaluated using literature study by past research and/or articles to better understand the results. Limitation for this research are: The research on this paper discussed the risks of OSH (Occupational Safety and Health) which is the level of safety for risks handling that exist in a high rise building construction projects; this research discusses 3 aspects which are: the technical aspects, human resources aspects, and unexpected events aspects; this research was carried out in a high rise building projects, and; research respondents are people who have experience in the field of civil engineering projects and high rise building projects with a minimum work experience of at least 3 – 4 years and at minimum education of Vocational High School in construction education or other education fields related to the research.

2. Methods

The method for this research is survey using questionnaire (quantitative research). Quantitative research is a type of research that requires the use of a structured questions where the answer/choices for the questions have been provided, it also required many respondents [1]. The survey method is used to obtain data in certain natural (not artificial) places [2]. With this method, researchers collect research data using questionnaires, structured interviews, direct observation, and other surveying methods. The research location for this research was in an ongoing high-rise building project in Jakarta. The type of questionnaire for the survey is an Analytic Hierarchy Process (AHP) questionnaire, which paired each variable wherein the respondents choose their preferred variables that best represent their answer/opinion.

2.1. Research Data

The followings are data collection techniques for this research.

2.1.1. Research Respondents. The number of respondents targeted in this study are 30 people, with the minimum number of respondents targeted are 20 people. The requirements of the targeted respondents are those who have at least 3 - 4 years of experience in construction, have experience in handling High Rise Building projects, and education in civil engineering or other educational fields related to the world of construction, with a minimum education of Vocational High School degree in Construction. The decision on the minimum number of respondents is based on several previous studies using the AHP method. The sample size needed to achieve a margin of error/CR value <0.05 of which the questionnaire is deemed valid needs a minimum of 19 samples [3]. AHP can also be used with a smaller sample if the respondents are an expert in their respective field, namely 19 samples [4]. In other sources research in Myanmar also used a small sample because it was difficult to conduct online surveys with large samples [5]. There are also other sources that used 4 research samples [6], and 13 research samples [7].

2.1.2. Survey. There are two steps of survey in this research, a preliminary survey questionnaire and the survey itself. Through the preliminary phase there are several variables that needed to be revised and eliminated, based on the feedback of several respondents. The continuation of the survey (which was the survey itself) resulted in a total of 25 results from the respondents that fit the requirements. The margin error of CR (Consistency Ratio) on each questionnaire (each research Criteria) is < 0.05, which indicated that the results is valid. CR is the result of a comparison between the CI (Consistency Index) and the RI (Random Index) [8]. CR <0.10 means that the respondents answer is consistent, so the solution is optimal. In one of the sources, it is said that a matrix can only be accepted as consistent matrix if CR <0.1 [9].
2.2. Research Process
The following is the process for this research

2.2.1. Research Variable. Research variables are the properties/attributes/value of a subject, object, or activity that has a variation determined by a researcher to be studied and for the researcher to draw a conclusion from the results [2].

2.2.2. Criteria for the Survey. The criteria and sub-criteria of this study were formed based on a literature study and from a discussion with the Supervisor of a High-Rise Building project in Jakarta. From the literature study that was carried out, there are several OHS aspects that can be reviewed for this research on a High-Rise Building project. It was stated on an article that there are two factors that influenced the occurrence of accidents in a construction project, they are: mechanical and environmental factors, and the human factor itself [10]. It was also stated by another article that the factors that influence work accidents in a construction project consist of two, which are technical causes and human causes [11]. In addition, the International Labour Organization states that the factors that cause work accidents in a project are worker factors, management factors and work environment factors [12]. Based on the literature study mentioned before, three criteria were determined in this study, they are Technical Aspect (Criteria A), Human Resources Aspect (Criteria B), and Unexpected Events Aspect (Criteria C). This research selects the three criteria based on discussion with one of the Supervisors of the High-Rise projects that were reviewed for this research, another consideration on why the three criteria were chosen is: from the literature study that has been carried out where most of the study sources are listed in this paper, these three are the ones that appear most frequently. Regarding the Unexpected Events Aspect, which are accidents that occurred due to various unwanted and unexpected circumstances, in this study the Unexpected Events Criteria also covers environmental causes, where several environmental variables such as dust disturbance [13] and other variables were considered as Unexpected Events Aspect (Criteria C).

2.2.3. Priority Ranking for AHP Questionnaire. Priority ranking is the measurement method for the questionnaire in this research. The priority rank in this study uses a pairwise comparison scale of 9 – 1 – 9 where the number 1 shows that the responses of the respondents stated that the two elements/variables are equally important. While the number 9 stated that an absolute element is more important than other elements. Table 1 is an Importance Level table to better visualize the ranking system.

| Scale | Definition                   |
|-------|------------------------------|
| 1     | Equal                        |
| 2     | Very little is more important|
| 3     | Relatively More Important    |
| 4     | Slightly More Important      |
| 5     | More Important               |
| 6     | Almost Much More Important   |
| 7     | Much More Important          |
| 8     | Almost Absolutely More Important |
| 9     | Absolutely More Important    |

2.2.4. Literature Study. Through literature study, several methods/action suitable for risk mitigation on a High-Rise Building Project were identified based on the object of this research and paper.
3. Results and Analysis

3.1. Questionnaire Validity
From the results of the analysis by using a program called Expert Choice, the Overall Consistency of all data produced is below the value of 0.1 and 0.05, meaning the data is consistent and valid. Bar charts and Analysis from the results of the AHP analysis using Expert Choice program can be found in the section below.

3.2. Prioritizing Criteria Aspect that influences OHS with Expert Choice
There are 3 criteria that were analysed using the Expert Choice in this analysis, the 3 criteria are Technical Aspects, Human Resources Aspects and Unexpected Events Aspects. Figure 1 are the results of the analysis from the analytical hierarchy process (AHP) questionnaire using Expert Choice.

![Figure 1](image)

**Figure 1. Score and Consistency Ratio of Pairwise Comparison Matrix Between Aspects (Criteria)**

From the results of the analysis, the value of Consistency Ratio (CR) for the analysis between the Criteria is 0.02 (which is less than 0.1), meaning that this is a valid result. The criteria for Human Resources Aspects (Criteria B) have the highest score, 0.470 (47%). Which means, the Human Resources Aspect is the aspect that most causes accidents on the High-Rise Building project. The second highest is Unexpected Events Aspects (Criteria C) of 0.298 (29.8%), and the lowest is Technical Aspect (Criteria A) which is 0.232 (23.2%).

3.3. Prioritizing the Sub Criteria

3.3.1. Sub Criteria of the Technical Aspect (Criteria A). There are seven sub criteria/variables in the Technical Aspect (Criteria A). The seven sub-criteria/variables are factors that influence the selection of alternative technical aspects in an effort on reducing the number of accidents at a High-Rise Building project.

![Figure 2](image)

**Figure 2. Score and Consistency Ratio of Pairwise Comparison Matrix Between Technical Aspects**

The questionnaire for this sub-criterion asked the respondents to choose which sub-criteria/variables that most able to prevent an OHS accident in the Technical Aspects of OHS.
From the results of the analysis, the CR value of the Technical Aspect is 0.02, meaning that the matrix of these criteria is consistent and valid. In addition, on the figure above, the result shows that the sub-criteria “the person in charge of OHS is able to control the work environment (temperature of the work room, lighting, cleanliness, availability of Personal Protective Equipment (PPE), first aid equipment) in the work environment (A6)” has the highest score, 0.222 (22.2%). Meaning that variable A6 is the sub-criteria/variable that most capable of preventing an OHS accident in the Technical Aspect (Criteria A) at the observed/surveyed High-Rise Building Project. It can also be interpreted that the control of work environment and the role of the person in charge of it is considered the most capable to prevent OHS Technical Aspects’ accidents.

3.3.2. Human Resource Aspect (Sub Criteria of Criteria B). There are six sub-criteria/variables in the Human Resource Aspect. The six sub-criteria/variables are the factors that influence the selection of alternative Human Resources Aspects in reducing the number of work accidents on a high-rise building project.

![Figure 3. Score and Consistency Ratio of Pairwise Comparison Matrix Between Human Resource Aspects](image)

The questionnaire for this sub-criterion asked the respondents to choose which sub-criteria/variables that most able to prevent an OHS accident in the Human Resource Aspects of OHS.

From the results of the analysis, the CR value of the Human Resources aspect is 0.02 meaning that the result of the analysis is valid. The picture above shows that the sub-criteria of “construction workers follows a predetermined OHS procedure (B4)” has the highest score compared to other criteria, which is 0.269 (26.9%). Meaning that variable B4 is the variable that the most capable of preventing an OHS accident in the Human Resource Aspect (Criteria B) at the observed/surveyed High-Rise Building Project. It can also be interpreted OHS procedure and the workers ability to follow it is considered the most capable to prevent OHS Technical Aspects’ accidents.

3.3.3. Unexpected Events Aspect (Sub Criteria of Criteria C). There are seven sub-criteria/variables in Unexpected Events Aspect. The seven sub-criteria/variables are the factors that influence the selection of Unexpected Events Aspect in the most frequent case of work accidents on a high-rise building project.
Figure 4. Score and Consistency Ratio of Pairwise Comparison Matrix Between Unexpected Events Aspects

The questionnaire for this sub-criterion asked the respondents to choose which sub-criteria/variables that happened to be the most often causes of OHS accidents in a High-Rise Building Project.

As seen on the figure above, the result shows the CR value for the Unexpected Events Aspects is 0.02, meaning that the result is valid and consistent. The figure above shows that the criteria of “dust or fog disturbance (C7)” has the highest score compared to other sub-criteria with the score of 0.186 (18.6%). This showed that variable C7 is the variable that caused the most OHS accident in the Unexpected Events Aspect (Criteria C) at the observed/surveyed High-Rise Building Project. It can also be interpreted that dust and fog disturbance is considered to be mostly the cause of OHS accidents in the Unexpected Events Aspects.

3.4. Literature Review on the Analysis Results

3.4.1. Criteria Aspect That Influence OHS. Based on the analysis, it can be concluded that the highest ranked aspect that affects the occurrence of work accidents on a High-Rise Building project that was observed/surveyed according to this research’s limitation is the Human Resources Aspects (Criteria B). This conclusion is supported by a research [14] which stated that human factor (human resources) is an important part in causing work accidents (between 80-85%). This statement is also supported by previous research which stated that human factors are significant for employee/workers work area accidents [15] [16] [17].

3.4.2. Sub Criteria of Criteria A. Based on the analysis from the data gathered from the survey, the sub-criteria/variable “the person in charge of OHS is able to control the work environment (temperature of the work room, lighting, cleanliness, availability of Personal Protective Equipment (PPE), first aid equipment) in the work environment (A6)” is ranked to be one of the most important factors to reduce OHS accidents based on the observed/surveyed High-Rise Building Project. This statement is supported by a research [18] that stated it is the company's responsibility to make sure the working conditions are in accordance with OHS standards. Therefore, if the person in charge of OHS can control the work environment properly, work accidents can be avoided and will directly increase the work productivity of workers.

3.4.3. Sub Criteria of Criteria B. In this sub criteria, the sub-criteria/variable that ranked first to be able to reduce the occurrence of work accidents on a High-Rise Building project is
“construction worker follows a predetermined OHS procedure (B4)” based on the observed/surveyed High-Rise Building Project. This result is supported by a research [19] that stated most workers have great behaviour/attitude regarding OHS safety and standards, such as the required use of personal protective equipment in carrying out their work, in accordance with the provisions provided by the company and the work procedures for hazardous work.

3.4.4. Sub Criteria of Criteria C. In this sub criteria, “Dust or fog disturbance (C7)” is ranked as the most frequent cause of unexpected events in OHS accidents at a High-Rise Building Project based on the observed/surveyed High-Rise Building Project. This result is supported by a research [20] which stated that one of the highest risks causes of work accidents is respiratory distress due to dust. Because the object observed for this research is a high-rise building, material debris, dust, and small materials cannot be avoided due to strong winds blowing in the project environment which will disturb workers. It can be concluded that due to dust and/or fog disturbances, workers on High-Rise Building Project must be careful and use proper safety such as safety glasses, masks, and other safety equipment to anticipate dust and/or fog disturbance in the work area.

3.5. Risk Mitigation for the Criteria Aspects Based on Literature Study

There are several risk mitigations that could be implemented to help mitigate the risk from each Criteria Aspects. According to several sources [21] [22] [23], several act to mitigate OHS risk of each Criteria Aspects said in this paper that could be used are: mitigation through safety induction, which is a way to coordinate workers and other employees about OHS, house keeping, and project rules, the safety induction itself is performed at the start of the project or when there are new workers; always follow OHS standards related to High-Rise Building and other related safety rules/standards and always use Personal Protective Equipment; follow established work methods; and install safety/OHS signs at relevant locations. There are several more of mitigation in their respective sources, in this section the mitigation acts that were written are those that were repeated between the sources.

4. Conclusions

From the results from the analysis, it can be concluded that from highest ranked to lowest, the aspects that most likely caused Occupational Safety and Health accidents/failure are: Human Resources Aspects (Criteria B) with a score of 0.470, then the Unexpected Events Aspects (Criteria C) with a score of 0.298, and lastly Technical Aspects (Criteria A) with a score of 0.232. In those aspects, the most important variables/sub-criterion/factor to look after are: in Technical Aspects, the most important variables/sub-criterion/factor in preventing OHS accidents is “The Person in Charge (PIC) of Occupational Safety and Health is controlling the work area (A6)” with a score of 0.222; in Human Resources Aspects, the most important variables/sub-criterion/factor in preventing OHS accidents is “Builders follow the established OHS procedures (B4)” with a score of 0.269; and in Unexpected Events Aspects, the most important variables/sub-criterion/factor which is the variable/sub-criteria that most often causes OHS accidents is “Disruption caused by dust and/or smokes (C7)” with a score of 0.186. Several mitigation methods that could be taken are safety induction, follow OHS standards and use Personal Protective Equipment; follow the work methods; and install safety signs at relevant locations. For future research or a continuation of this particular one, is to have a direct observation on the project, since in this research, a direct observation could not be taken because of the lockdown relating to the global pandemic. A more direct survey could also be taken, meaning the respondents are the workers/builders/constructors who have a great extent of experience, not the contractor, consultants, or any others, but the workers/builders/constructors themselves. Of course, the type of survey must be altered, either into a structured interview or a simpler questionnaire supported by interview.
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