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Construction Sustainability of Building Based on WEB

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Abstract

Construction with a floor height of over 20m has high complexity and risk. Almost all activities have dangerous risks that must be planned early so that they can be anticipated and controlled during implementation, including the availability of standard operational procedures (SOP) and personal protective equipment (PPE). The construction safety management system containing the construction safety plan must be designed earlier and more accessible to apply. Construction safety planning has received less attention and more focus on implementation because the provider does not understand it, which is considered difficult to implement. Based on these problems, it is necessary to carry out construction safety planning for building work to minimize construction accidents at the project site so that it runs optimally and has zero accidents during construction. The WEB-based application aims to make it easier to use in planning construction sustainability. This article aims to design construction safety stages in building projects and analyze factors in construction safety planning in WEB-based building projects. The data analysis and discussion were carried out with 5 (five) explanations regarding the preparation stages in making a Construction Safety Plan, namely Leadership and Workforce Participation in Construction Safety, Construction Safety Planning, Construction Safety Support, Construction Safety Operations, and Implementation Performance Evaluation. Construction safety planning needs to plan and complete construction safety according to the conditions of the building project. In construction safety planning, it is necessary to analyze using the HIRARC method to prevent and minimize potential dangers. Hazard identification, risk assessment, and risk control are part of the risk management analysis, which is the basis of the Occupational Safety and Health Management System (SMK3).

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Then, the HIRARC method assessment results were obtained: 26 variables with low risk, 57 with medium risk, and 21 with high risk. The WEB design results begin with needs analysis, system design, implementation, testing, maintenance, and monitoring.

Keywords: Building; Construction Safety; HIRARC Method.

1. Introduction

Construction safety is a crucial thing to note; nowadays, almost every year, it always happens due to various factors; almost 20% of accidents due to construction are caused by human negligence. Currently, construction implementation is only focused on completing work without paying attention to the risk factors of construction accidents that will occur, even those that have already occurred. Another factor is the absence of planning related to construction safety before construction is carried out. Information systems related to construction safety risks that are very easy to apply have yet to be available. The urgency of this study is that preparing an information system related to construction safety plans based on WEB will make it easier for providers to design all risks that will occur in each work to be carried out up to risk handling strategies to minimize the risks.

During the construction process of high-rise buildings, potential hazards are activities that are likely to occur in general. The application of safety is what helps in creating a work area that is free from construction accidents. Embodiment can be implemented by all parties to the project. Then, an attitude of concern among workers needs to be present in the implementation of safety on the project and reduce cases of work accidents [1].

Accidents are things that cannot be planned and unpredictable events. Loss, damage, injury, and death are the risks of harm that will be received due to work accidents. Every company must want Occupational Health Safety to achieve the goal of zero accidents [2]. The Domino Theory popularized by HW Heinrich explains that dangerous actions cause 88% of work accidents, unsafe conditions cause 10%, and 2% are caused by other problems besides unsafe actions and conditions [3]. Then, according to [4], the causes of work accidents in construction work are the state of the project site and different characteristics, weather, limited duration of work time, poor endurance, and not hiring poorly trained and less skilled labor. The causes of work accidents in the project consist of 3 aspects, namely humans, the environment, and work safety equipment.

The existence of the risk of work accidents, it is necessary to control the risk of work accidents, so in designing ways of controlling a risk, an analysis of the causes of the risk is needed. Based on the causes of the risks caused, an appropriate risk control plan can be made. Then it is necessary to conduct a risk assessment aimed at determining the level of risk. This is because the level of risk can affect a construction project [5].

The need for risk management in the project and control of potential risks is expected to be implemented properly and smoothly during construction. Because smoothness in development will produce appropriate quality, there is no loss in terms of cost and time. So that way it will also avoid the risk of failure in the implementation of development [6].

Work accidents in Indonesia every year there is an increase. Therefore, construction safety planning is needed in

order to prevent and reduce the potential for work accidents that will occur. So that good construction safety planning is needed in order to prevent and reduce the potential for work accidents that will occur [7].

According to [8] article 28 paragraph 1 which explains if at the time of construction of the building must meet the provisions or requirements on the aspects of safety, health, and comfort of the building. Then according to [9] article 1 paragraph 14, the Construction Safety Plan (RKK) regarding construction safety which contains a Construction Safety Management System (SMKK) which is inseparable from contract documents, in conducting RKK it is necessary to identify risks using methods.

There are several kinds of methods, namely *the Job Safety Analysis (*JSA*) Method, the Fault Tree Analysis (FTA) Method, the Event Tree* Analysis (ETA) Method, the *Failure Mode Effects and Criticality Analysis* (FMECA) *Method, and* the Hazard Identification Risk assessment and Risk Control (HIRARC) Method. According to [10], *the Job Safety Analysis* (JSA) method has the advantage that the research method is carried out to reduce the risk of hazards that have a high level of risk. The JSA Method has a drawback, namely that it cannot be carried out risk assessment of work that may occur. Then according to [11], the *Fault Tree Analysis* (FTA) method has the advantage of being a method that can find out the origin of the cause of potential hazards that may occur, then carry out appropriate control. While the disadvantage of the FTA method is that in applying the FTA method, quite a lot of data is needed to produce good analysis. Then according to [12], the *Event Tree Analysis* (ETA) Method has the advantage of being a method that can determine the impact of potential hazards can be work accidents or can be controlled with pre-designed safety procedures. Meanwhile, the disadvantages of the ETA method are focusing on the causes that trigger the risk of harm only. The *Failure Mode Effects and Criticality Analysis* (FMECA) method according to [13], has the advantage of being a method used to evaluate components in the system by paying attention to the possibility of failure. As for the shortcomings of FMECA, the analysis is carried out by taking into account the level of criticality to risk.

From several risk assessment methods described earlier, the appropriate method for identifying, assessing, and controlling risk is *Hazard Identification Risk assessment and Risk Control* (HIRARC). The method is used when determining the possibilities or opportunities and consequences that occur from identified and dangerous risks to workers in accordance with the existing work [14].

In building construction projects, there is a high probability of work accidents resulting from unsafe actions and circumstances, by identifying hazards and risks and controlling them using *Job Safety Analysis* (JSA) which is expected to reduce work accident cases. However, JSA has the disadvantage that it cannot conduct risk analysis and risk assessment in infrastructure repair and maintenance analysis. Therefore it is necessary to use the HIRARC method in analyzing the risks that occur [15].

In assessment with the HIRARC Method, there are two parts, namely analyzing risk and evaluating risk at risk of danger. The parameters used for this level of risk are based on the probability of occurrence (*probability*) and the level of severity of things caused (16). Risk assessment stages using AS/NZS 4360:2004 risk control matrix. In assessing risk is carried out with a qualitative scale which is explained using numbers used as a scale for assessment of work that poses a risk of danger. The AS/NZS 4360:2004 matrix can be reviewed in Table 1 and

Table 2 [15]. In the two assessments, Table 1 and Table 2 are calculated by multiplying to obtain the value of the risk level. The risk values are categorized into levels ranging from low risk to very high risk, as in Table 3 as follows:

Table 1: Scale Probability

Level	Criterion	Explanation
1	*Insignification*	- No loss - Small material losses
2	*Minor*	- Minor injuries requiring - On-site handling - Moderate material losses
3	*Moderate*	- Loss of working days - Requires medical treatment - Material losses are considerable
4	*Major*	- Injuries resulting in disability - Material losses are huge
5	*Extreme*	Caused a considerable material disaster

Table 2: Skala Severity

Level	Criterion	Explanation
1	*Rare*	Can only occur under certain circumstances
2	*Unlikely*	Likely or rare
3	*Possible*	Possibility of happening at any time
4	*Likely*	It is very likely to happen and almost all circumstances
5	*Almost Certainly*	Can occur in all circumstances

Table 3: Risk Assessment Matrix

AS/NZS 4360:2004		*SEVERITY*					
		Insignification	*Minor*	*Moderate*	*Major*	*Extreme*	
PROBABILITY	*Almost Certainly*	5	10	15	20	25	5
	Likely	4	8	12	16	20	4
	Possible	3	6	9	12	15	3
	Unlikely	2	4	6	8	10	2
	Rare	1	2	3	4	5	1
		1	2	3	4	5	

Information:

Low	=	Grades 1 through 2
Moderate	=	Grades 3 through 6
High	=	Grades 7 to 12
Very High	=	Scores greater than 12

Then the purpose of the research carried out is the stages of construction safety planning in the WEB based Building project and analyzing factors in construction safety planning in the Building project.

2. Method

2.1 Research Concept

The research to be carried out uses quantitative methods that are expected to reveal events and facts that occur when the research takes place in the field. Research is carried out by building a WEB design that anyone, especially providers, can easily apply. WEB construction safety planning with risk analysis to risk response is presented in one menu display in the WEB smart engine. RKK.

2.2 Research Location

The research location in Jember Regency with target data is a building contractor member of the GAPENSI association in Indonesia.

2.3 Data

Research is conducted with data provided with primary data and secondary data. Primary data were obtained through field observations and interviews with workers and staff, and questionnaires were distributed to specified respondents. Then, the secondary data obtained are previous research, the internet, journals using *bibliometric auxiliary programs,* and project documents from related companies. The project documents are *Job Safety Analysis* (JSA), DED, BoQ, and implementation methods.

2.4 Stages of Research

The stages of research to be discussed are as follows:

1. Data Collection

The collection consists of primary data and secondary data. The primary data were obtained through field observations, questionnaires, and interviews. Then, secondary data was collected from implementing contractors, such as JSA, DED, *Bill Of Quantity*, and implementation methods.

2. Membuat *Work Breakdown Structure* (WBS)

Creating a Work Breakdown Structure (WBS) is made aware of the potential hazards that may occur in each job done.

3. Membuat *Risk Breakdown Structure* (RBS)

Creating a Risk Breakdown Structure (RBS) is created to identify possible risk hazards.

4. Taking the Risk Variables of Construction Safety Planning

Determine risk variables adjusted for potential hazards on the job that are likely to occur.

5. Designing Preliminary Questionnaires and Determining Respondents

Design a preliminary questionnaire and determine the number of respondents using Purposive Sampling techniques because it can be adjusted to the desired criteria.

6. Questionnaire Dissemination

Introduction The preliminary questionnaire is distributed to predetermined respondents.

7. Validity Testing

Validity testing is used to measure how accurate the measuring instrument is in measuring whether or not what is assessed; it is said to be valid if the calculation is < table.

8. Reliability Testing

Reliability testing is used to measure the relevance and accuracy of a questionnaire; it is done to determine the consistency of measuring instruments to produce reliable measurements of the tests performed.

9. Distribution of the Main Questionnaire

The validity results are followed by creating a main questionnaire to determine the severity of risks likely to occur with an assessment scale of 1-5.

10. Risk Control Interview

Interviewing respondents about risk control carried out to overcome existing problems.

11. Construction Safety Analysis Using the HIRARC Method

Analyzing using the HIRARC method is expected to determine the high level of work accident hazards contained in building construction projects and understand the losses caused by each hazard risk.

12. Construction Safety Operations

Construction safety operations can be performed regarding construction safety, security, development, and health management of the project environment.

13. Conclusions and Suggestions

Conclusions are made by answering the formulation of the problem underlying the research objectives. Then, I adjusted my expectations for the next author based on the suggestion.

14. Build a construction safety plan (RKK) smart engine website.

3. Results and Discussion

3.1 Leadership and Workforce Participation in Construction Safety

Leadership and labor participation consist of concern for personnel with existing construction safety. This sub-chapter explains the Leader's Concern for External Issues and Internal Issues, containing issues that may occur according to existing categories. From the existing issues, desires, and expectations are made in internal and external conditions. Then there is also the SMKK Management Organization on the project, Construction Safety Commitment and Workforce Participation, Supervision, Training, Accountability, Resources, and Support.

3.2 Construction Safety Planning

Before carrying out construction safety planning, it is necessary to know the work's method. The implementation method contains the way of work used in the implementation of development by determining and selecting the tools used to carry out the work. A Work Breakdown Structure (WBS) can be created in the implementation method used to know the work carried out during project construction. So, it is expected to be able to suspect the variable risk of danger that is likely to occur.

On construction safety planning in risk assessment using the HIRARC method. The risk assessment has been

carried out by determining the value of the probability of occurring *(probability*) and the severity caused (*severity*). The assessment was carried out on risk variables totaling 105 (one hundred-five) derived from validity test data totaling 59 (fifty-nine) and variable values that had the highest value but were invalid, amounting to 45 (forty-five).

There are four risk assessments in the HIRARC method, namely low (L), medium (M), high (H), and very high (VH). From the calculations that have been carried out on the validity test data variables totaling 59, it is known that 1 variable has low risk (L), 40 variables have medium risk (M), and 18 variables have high risk (H). Then, in the assessment carried out on the highest but invalid value variables totaling 45, it was known that 25 variables had low risk (L), 17 variables had medium risk (M), and 3 variables had high risk (H).

After that, risk control is carried out and adjusted to the standards of laws and regulations. Hazard risk control is structured based on a control hierarchy. The implementation also requires interviews and data collection of control questionnaires to staff of building construction project contractors who are members of the GAPENSI association in the Jember Regency area

Then, the targets and programs regarding construction safety in the building construction project were carried out using case studies of the Regent's Office and the Regional Secretariat of Pasuruan Regency. Targets carried out regarding safety, health, environmental management, and work environment security. For an explanation, see Table 4 below:

Table 4: Targets and Programs

No	Goal	Supervision Program
A	Work Safety Performance	
	• No work accidents resulting in loss of time and work interruption • Increase and expand workers' knowledge about K3 on projects	• safety training for all workers • Regular construction safety meetings • *Briefing* in the morning before starting work
B	Occupational Health Performance	
	Workers are not exposed to disease and minimize the spread of disease	Check the health of workers regularly and maintain physical health
C	Work Environment Management Performance	
	No pollution to the environment around the construction of the project	• Analyze the environmental impact that occurs • There are efforts in managing and monitoring the condition of the surrounding environment • Management of waste and waste in the area around the development
D	Security Performance	
	There are no security problems that result in losses and cessation of work	There are security officers on guard during the construction of the project

3.3 Construction Safety Support

In this construction safety support, there is an explanation of support during the construction implementation, such as the resources used, including a list of equipment used, imported materials, and costs incurred for the implementation of construction sustainability. So, in implementing construction safety support, it is necessary to know the competence of the existing safety workforce.

Construction safety support contains organizational concern contains company support in carrying out construction work, which is one form of concern about construction safety that is expected to cause an attitude of concern for construction safety to all workers; the following is a construction safety training plan addressed to workers can be seen in Table 5 below:

Table 5: Construction Safety Training Plan

No	Types of Training	Target Participants	Person in Charge	Time
1	Construction Safety Basics	All Construction Workers	HSE	Every week
2	Construction Safety Guidelines	All Construction Workers	HSE	Every week
4	Emergency	All Construction Workers	HSE	As needed
5	P3K Introduction	All Construction Workers	HSE	As needed
6	K3 Cleaning Work	All Construction Workers	HSE	As needed
7	K3 Machine Operations	All Construction Workers	HSE	As needed

To reduce misunderstandings in implementation, it is necessary to carry out communication management. Communication management is done orally through safety talk and in writing through banners. Communication management is carried out orally with the creation of an appropriate program schedule in Table 6 as follows:

Table 6: Communication Program Schedule

No.	Types of Communication	Implementation Time	Person in Charge
1	Construction Safety *Induction*	As needed	HSE
2	Safety *Morning*	Every morning before the start of work	HSE
3	Toolbox *Meeting*	As needed	HSE
4	Construction *Safety Meeting*	Every week	HSE

3.4 Construction Safety Operations

Construction safety operations contain the planned implementation of the Safety Plan, which contains the organizational structure of the construction of the case study project of the Regent Office Building and the Regional Secretariat of Pasuruan Regency. Then, the operation control is done by making a Job Safety Analysis (Job Safety Analysis). Security management is also carried out in the work environment in controlling operations. This security management is very important to maintain the smooth running of construction work without any problems from outside the project. It aims to protect existing workers and construction sites. This security management is carried out by filling out a work permit formula containing work procedures made by safety and conducting daily checks.

Operations control also manages work safety, which aims to maintain worker safety during project construction following existing standards. So, workers are expected to use complete and appropriate PPE for their work. The following is Figure 2 which contains recommendations for the use of Personal Protective Equipment (PPE) in the project, which is as follows:

Figure 1: Recommended Personal Protective Equipment Worn

Appeal in the use of Personal Protective Equipment: there is only 1 banner located near the project door. The appeal is considered insufficient, so it is expected that there will be additional banners urging the use of Personal Protective Equipment. Then there are no safety signs, so to complete the operation control, it is planned to place safety signs and banners urging the use of Personal Protective Equipment. The following is Figure 3, which is about planning to add signs as follows:

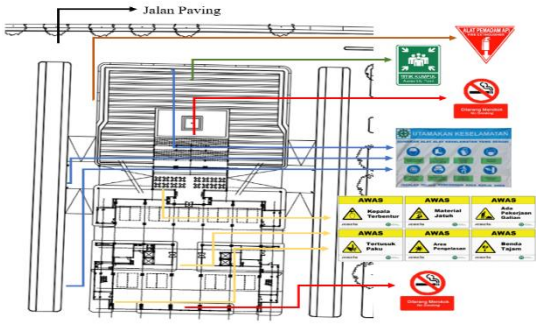

Figure 2: Addition of K3 Signs and Appeal for the Use of PPE

Then, the implementation of emergency readiness and response needs to be completed because the readiness and emergency response in the Regent Office Building and Regional Secretariat project of Pasuruan Regency still do not exist. So it is expected to reduce the risk of work accidents during construction implementation. Potential hazards resulting in emergency response to projects include fires and earthquakes. So that the things that need to be done by the safety project of the Regent Office Building and the Regional Secretariat of Pasuruan Regency to reduce work accidents that occur during emergencies are as follows:

- Prepare what is needed during emergency response conditions, such as Light Fire Extinguishers, the location of gathering points, water taps, water hoses, and accommodations to evacuate workers
- Explain the things that are done when an emergency response occurs and how to overcome it
- There is an emergency response simulation carried out in practice by all workers
- Conduct regular Tool Box Meetings to keep reminding workers about safety and health while on project

3.5 Performance Evaluation of Construction Suistanability Implementation

The evaluation is carried out by examining the suitability of implementing construction sustainability in the project. Performance evaluation is still incomplete on the Pasuruan Regency Regent Office Building and Regional Secretariat project, so it needs to be completed. This can be seen from the absence of management review and improvement in construction safety performance. Completing this evaluation is expected to prevent and reduce work accidents that may occur due to the actions taken, which are expected to improve the work on the project's construction to completion.

Monitoring the Regent Office Building and Regional Secretariat of Pasuruan Regency project is carried out to find faulty work that is not based on the standards applied—unsuitable work results in potential hazards that are likely to occur. Monitoring is carried out with work instructions containing work performances, which are expected to minimize errors in monitoring and construction safety patrols by contractors, supervisory consultants, and project owners to prevent daily work accidents.

The audit is carried out to ensure that the management of K3 in the project follows existing standards and applies; input is provided to related parties if inappropriate. In assisting the implementation of audits and inspections, it is necessary to make a schedule. Table 7 is the inspection and audit schedule as follows:

Table 7: Inspection and Audit Schedule

No	Activity Description	Person in Charge	Month to -						
			1	2	3	4	5	6	7
1	Construction Safety Inspection	Person in Charge of K3							
2	Construction Safety Patrol	Person in Charge of K3							
3	Audit Internal	Person in Charge of K3							

3.6 Smart Engine Website Development Scheme

The website was created using the Codeigniter Framework, which used the WordPress system previously. The schematic structure comprises several parts: the Front End, Middle End, and Back End. Front End consists of 2 parts of Class Controller: Site and System. The Middle End consists of 1 part Main Controller Class that sets the output to the Front End. Back End is part of the Service Server that serves Requests from the Middle End in the form of PHP and MySQL Services as databases. This scheme is known to have safer and faster access than the previous Website scheme. The website schematic is illustrated in Figure 3 below.

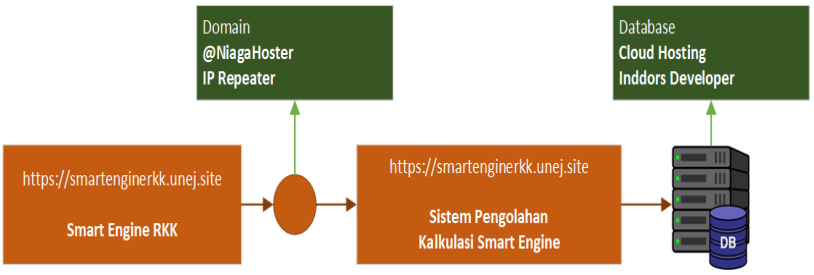

Figure 3: Website System Development Scheme

The Menu Hierarchy of the RKK Smart Engine Website is illustrated in Figure 4 below

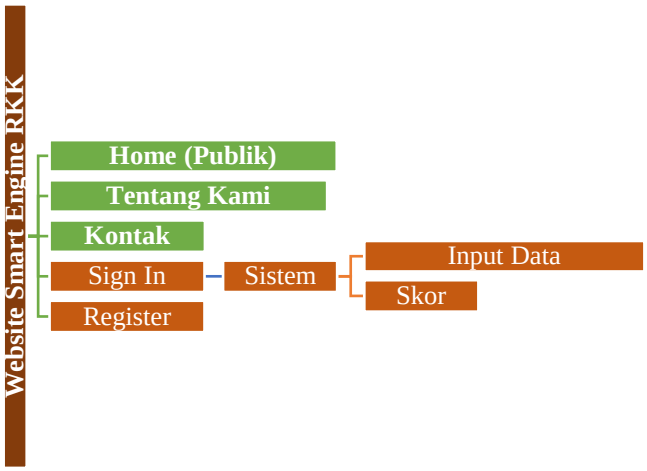

Figure 4: Website Menu Hierarchy

4. Knot

After conducting research results on the Regent Office Building project and the Pasuruan Regency Regional Secretariat regarding construction safety planning, it was concluded *that Work breakdown structure* (WBS) Building Construction work is grouped into structure, architecture, MEP, and infrastructure groups: construction safety planning with risk analysis using risk breakdown with the HIRARC method, 3 main variable elements were obtained, namely, support construction safety, construction safety operations, and performance evaluation of the implementation of construction suistainibility, there are 104 variables (59 valid variables and 45 highest value variables) so that the results of the assessment of 26 low-risk variables, 57 medium risk variables, and 21 high-risk variables are obtained. RKK Web design planning starts from the stages of needs analysis, system design design, implementation, testing, maintenance, and monitoring

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