Journal of International Conference Proceedings (JICP) Vol. 4 No. 1 (2021)
Print ISSN: 2622-0989 / Online ISSN: 2621-993X
DOI: https://doi.org/10.32535/jicp.v4i1.1132

Development of Safety Plan Building Based on Work Breakdown Structure (WBS) in Campus Area of UI Depok to Reduce Work Accident

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ABSTRACT

There is very little discussion about the needs of occupational health within the University area. In fact, the University is a place where interaction occurs not only for lecturers and students, but also employees, contractors and other visitors with very varied backgrounds and cultures. The lack of application of OHSMS in the construction sector in the University area causes a high number of work accidents. Making a safety plan at the initiation stage can reduce and prevent potential hazards that will occur. One of the methods can be used to reduce work accidents is by developing a safety plan using WBS (Work Breakdown Structure). This study aims to develop a WBS-based construction occupational safety and health plan for structural and architectural work buildings. This study develops a safety plan based on Regulation of Minister of PUPR No. 21 of 2019. This study uses literature study techniques for risk identification and questionnaires validation by experts with a minimum of 5 years experiences in OHS construction project. The result of this study is identification of hazards, impacts, prevention, OHS objective and programs. The results will be used for the development of a safety plan, intending to improve occupational safety and health performance and reduce occupational accidents in construction projects.

Keywords: Risk Identification, Safety Plan, Work Breakdown Structure

JEL Classification Codes: L70, L74, Y90

INTRODUCTION

Universities in most countries are large sector with highly varied backgrounds and cultures resulting in a high risk of various workplace accidents. In addition to organizing in the academic field, the University is a place where various interactions and activities occur between lecturers, students, employees, contractors, and visitors in various places such as lecture halls, parks, libraries, laboratories, parking areas, and canteens (Karim & Hariyono, 2018). Universitas Indonesia (UI) is one of the universities that has developed an Occupational Health and Safety Management System (OHSMS) which is useful for managing and preventing risks in the UI area. OHSMS at UI is compiled based on Government Regulation No. 50 of 2012 and ISO 45001:2008.

However, the implementation of the OHSMS is still not optimal. Based on research conducted by Nugroho (2020), it is stated that there are only 4 of the 14 faculties that already have a OHS (Occupational Health and Safety) unit formally, while the others only have OHS officers and employees. Then, only 2 out of 14 faculties have OHSMS standard certification. Furthermore, Nugroho (2020) also stated that the fulfillment of OHS goals and targets in 2019 only reached an average of 45%. The OHS goals and objectives in 2019 include:

1) Fulfillment of the OHS Management System in the Faculty, reaching 40%.
2) Fulfillment of Emergency Response Management at the Faculty, reaching 45%.
3) Fulfillment of OHS Aspects in Buildings and Contractors OHS Guidelines at the Faculty reaches 50%.

Based on the data of Nugroho (2020), work accidents due to construction in UI area are classified as miscellaneous incidents and not specifically described. Even so, work accidents due to construction often occur due to the increasing construction of buildings in the UI area. For example, in 2016, there was an incident when the roof collapsed during the renovation work on the Menwa Wira Makara Building and injured three construction workers. Then in 2018, an accident occurred where one worker was killed by lightning during the construction of the UI Pusgiwa Building, and in 2019 the severity increased to 3 fatalities. Employees are the core of management (Uloli et al., 2019). The International Labor Organization (ILO) states that every year there are more than 250 million accidents at work and more than 160 million workers become ill due to hazards in the workplace. The high number of work accidents is due to the construction industry having special characteristics that are not the same as other industries, namely high uncertainty in each construction project. Chiang et al. (2018) also stated that 100,000 workers die on construction sites each year due to poor and illegal working conditions.

The phenomenon of work accidents has an impact on many things, namely project success, people, costs, time and law (Han et al., 2014; Chantawit et al., 2004; Hinze et al., 1998; Yi & Langford, 2006). In addition to the impact on the project itself, work accidents also have an impact on institutions. Some of them are financial losses, material damage, environmental damage to image degradation (Lestari et al., 2019). Meanwhile in China, the increasing number of accidents in the university area has caused public concern (Gong, 2019).

Despite the complexity and risks, there has been little discussion of occupational health needs within the University area (Venables & Allender, 2007; Gong, 2019). The same thing was expressed by Karim and Hariyono (2018) where the application of occupational safety and health is more often emphasized in companies engaged in industries where there are complex processes and high risks. Often the educational environment is considered a safe and comfortable place for academic activities so that there is no need for the implementation of the K3 program at the institution. Mohyi (2020) stated that worker performance is influenced by internal factor and external factor. Accidents at universities are closely related to safety behavior, safety attitudes and safety awareness, which are the main aspects of an organization's safety culture (Gong, 2019). In fact, according to Hasan and Younos (2020) safety culture plays an important role in reducing accidental deaths and injuries in educational institutions, especially in developing countries. Construction activities that take place in the university area have a high risk for people who are active in the vicinity so that special supervision is needed (Tymvios & Gambase, 2016; Yanar et al., 2019). Accidents on campus can occur due to the use of unsafe chemicals and electrical equipment triggered by lack of awareness, unsafe handling, mismanagement (Su & Hsu, 2008; Walters et al., 2017). Therefore, an understanding of safety culture and actions to improve safety culture are the right ways to prevent accidents at universities (Gong, 2019). Amaya et al. (2019) also states that managing safety management and organizational culture can improve safety indicators. Work accidents that occur in the UI area are the responsibility of UI management because they will have a direct impact on the safety performance of UI management (Herzanita, 2020).

Kamardeen (2015) citing Szymberski suggests that the risks inherent in projects are mostly determined at the conceptual or project planning stage. Behm (2005) analyzed 224 occupational accidents and determined that 41% of these accidents could have been avoided if the concept of prevention through planning was implemented. Kim et al. (2013) stated from a planning perspective, project managers need to plan work well and avoid planning work for days when the rate of work accidents is higher. Gambatese et al. (2005) stated that design for construction safety includes handling the safety of construction workers in a permanent design on a project. It can be concluded that considering safety in the design stage is very important in construction and hence the design concept for construction safety has been officially proposed in the global construction research agenda.

A good strategy provides goals set according to the plans (Suwandari, et al., 2020). One of form to reduce work accidents in the UI campus area is to make a safety plan. According to Wong et al. (2016), OHS planning needs to be improved better to reduce the occurrence of the same accident in the future. Blair et al. (2004) also stated that a systematic and effective safety program should be placed in educational institutions to ensure safety on campus.

Safety plan itself has been regulated in the Regulation of the Minister of PUPR No. 21 of 2019. In this regulation, safety planning requires the establishment of construction safety targets and programs, which are based on the stages of work, namely the Work Breakdown Structure (WBS). Therefore, it is mandatory to make a WBS to develop a safety plan. This study aims to create a WBS-based safety plan. It is hoped that the use of WBS in the safety plan can reduce work accidents in university area, and to improve safety performance.

RESEARCH METHOD

This research strategy used archive analysis and survey methods. The archive analysis carried out in this study used documents related to research, namely project documents, documents related to OHSMS UI obtained from OHS UPT UI, and regulations related to OHSMS namely Regulation of the Minister of PUPR No. 21 of 2019. While in survey method using questionnaires to validate the potential risks, prevention, objective and programs by experts/experts.
To achieve the research objectives, the stages of the research to be carried out are as follows:

1. Identification of problems: this study identifies problems in building construction projects, one of which is about work accidents, where work safety is the focus of this research. The aim is to determine the relationship between the development of WBS-based safety planning on safety performance.
2. Data input: the data collection method in this study uses the literature study method. The literature study method is secondary data used to obtain research variables related to research topics based on previous research, scientific journals, books, and so on. Beside literature study, this study also uses archive resource available to develop the standardized work breakdown structure and hazard identification based on the activity on the work breakdown structure before bringing them to the expert for depth-in interview. The archive was from the other colleagues who has done the similar study before.
3. Tools: used a questionnaire as an instrument for data validation. Questionnaires are primary data obtained from experts based on the required analytical parameters. The type of questionnaire used is a mixture of open and closed questionnaires. Closed questionnaire is a collection of questions where respondents answer according to the provided answer, while open questionnaire respondents can answer questions according to respondents' opinions. Each questionnaire validated by 4 experts on the required filed with a

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minimum of 5 years experiences in OHS construction project field. Expert validation aims to determine whether or not the variables of risk activities, impacts and controls have been determined, as well as responses to the risks, impacts and controls of each variable.

4. Output: the results of this study are identification of hazards, impacts, prevention, OHS objective and programs.
5. Conclusion: It is hoped that the development of this safety plan can provide benefits to the construction sector, especially in the University areas.

RESULTS AND DISCUSSION

Standardized Work Breakdown Structure

Work Breakdown Structure (WBS) is a hierarchical decomposition of the total scope of work that will be carried out by the project team to achieve the project objectives and create the required results. WBS can be made in various ways, one of it is the decomposition technique. The definition of decomposition according to Project Management Institute (2017) of PMBOK is a technique used to divide and divide the project scope and project results into smaller, more manageable parts. A work package is a job defined at the lowest level of the WBS whose cost and duration can be estimated and managed. The degree of decomposition is often guided by the level of control required to manage the project effectively. The level of detail for work packages will vary according to the size and complexity of the project. The decomposition of the total project work into work packages generally involves the following activities:

- Identify and analyze work results and related work,
- Develop and manage WBS,
- Breaking down the upper level WBS into lower-level detail components,
- Develop and assign identification codes to WBS components, and
- Verify that the post decomposition rate is appropriate.

The standardized WBS results for buildings consist of:

- WBS Level 1 Project Name: The highest level and representation of the entire project.
- WBS Level 2 Construction Primary Element: Decomposition of project construction elements as a whole.
- WBS Level 3 Location/Zone: Experts suggest that the working part of the high-rise building is divided by physical area or location vertically to indicate level and also horizontally to indicate tower zone.
- WBS Level 4 Type of Work: This is a further decomposition of structural and architectural work. Structural works are Soil Works, Bottom Structures, Upper Structure, and Roof Structures. While architectural work is Ceilings, Walls, Floors, Doors & Windows, Hardware, Façades, Roofs, and Others.
- WBS Level 5 Work Package: Represents the extent to which the performance of each work package can be assigned to an individual or organization.
- WBS Level 6 Activity: This was added to the WBS template to help project managers identify work to be done at lower levels of the work package. Project managers can add as many activities as they want because they need to understand the details of the work that must be done to deliver the project properly.

WBS will be used as a guidance to identify the safety risks. In this paper, WBS is obtained from the results of a literature study. This WBS that has been validated by experts in previous research. This standardized WBS is used for high-rise building projects. In this study only take samples of the ceiling work package for architectural work, and soil leveling activity for structural work.

Print ISSN: 2622-0989 / Online ISSN: 2621-993X
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Figure 1. Standardized Work Breakdown Structure for Structural Works

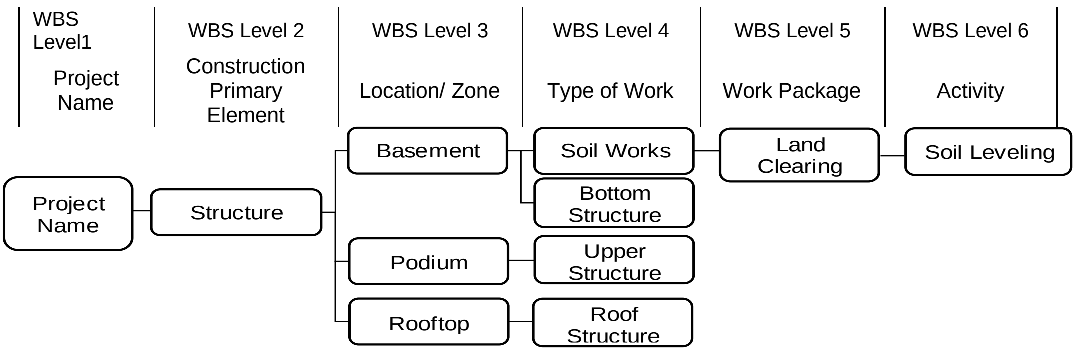
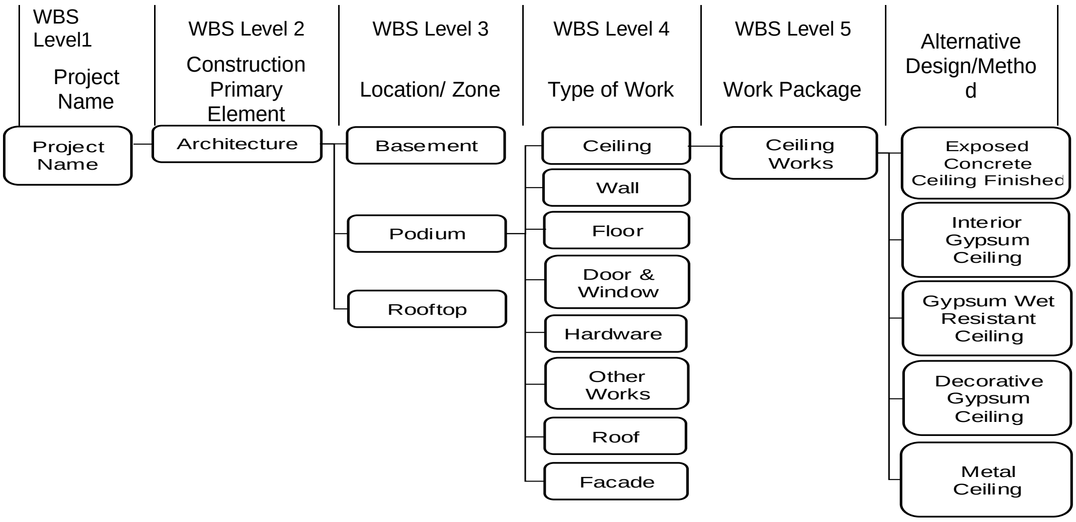


Figure 2. Standardized Work Breakdown Structure for Architectural Works



Safety Risk Identification and Risk Prevention

Every work package has a risk of work accidents. The risk in question is construction safety risk to determine the need for construction K3 experts and/or construction safety officers, not to determine the complexity or segmentation of the construction services market. Therefore, WBS affects the safety plan. Standardized WBS that has been obtained above will be used as a guidance to identify the safety risks in construction project. After the risk is being listed, the risk prevention also being identified. The process of creating the risk identification table will be explained as follows:

a) First of all, make a work package in accordance with the WBS that has been obtained.
b) Identify the activities of each work package.
c) Describe whether there are risk/hazards from the 4 classifications (people, property, environment, public safety) to work activities.
d) Identify controls that can be carried out against the risk/hazards of the activity.

Once identified, these risks and prevention will be validated by 4 experts, where all the experts are certified in safety construction and have minimum 5 years experience. The results of risk validation and risk prevention for one of structural work activities namely soil leveling can be seen in table 1 below.

Table 1. Risk Identification for Structural Works

Activity	Risk Identification		Impact of Risk	Risk Prevention
	Type of Risk	Description		
Soil Works (Work Package: Land Clearing Work-Mechanical Method)				
Soil Leveling	Human	Heavy equipment hit workers (bulldozer dan combine harvester)	Muscle injury, bone injury, brain injury, can cause death	Use a helmet, reflector vest, and safety shoes
				Installing heavy equipment hazard signs
	Property	Heavy equipment hit nearby facilities (bulldozer and combine harvester)	Damaged facilities and tools	Create a barrier area
				Provide adequate lighting
	Environ-ment	Soil compaction using tools	The texture and structure of the soil becomes damaged, affecting the capacity of the soil to hold water and nutrients	Work method according to implementation
		Dust and smoke from heavy equipment	Air pollution	Create a barrier area
				Installing heavy equipment hazard signs
	Public Safety	Heavy equipment hit people (bulldozer dan combine harvester)	Muscle injury, bone injury, brain injury, can cause death	Create a barrier area
				Provide adequate lighting

The format of table 1 above is taken from the example of the IBPRP table format in Regulation of Minister of PUPR No. 21 of 2019. The IBPRP contains matters related to the implementation of construction work made by the Person in Charge of Construction Safety and approved by the Head of the Construction Work Executor. The stages of activities in IBPRP are in accordance with routine work (according to the Work Breakdown Structure).

Explanation of table 1:

- Activity description: Stages of work implementation activities in accordance with routine and non-routine work.
- Risk Identification: Determine the characteristics of the risk condition/ risk action in accordance with the relevant regulations. Risk identification classified as ‘human’, ‘property’, ‘environment’, and ‘public safety’.
- Impact of Risk: Exposure/consequences arising from risk conditions and risk actions.
- Risk Prevention: Activities that can control both reduce and eliminate the impact of risk that arise.

Print ISSN: 2622-0989 / Online ISSN: 2621-993X
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It should be noted that the method used also affects safety performance. Conventional methods and modern methods of using machine have different safety risks. The damage that might be done by machines is much worse than tools used in conventional methods.

Meanwhile, the stages carried out in architectural work are the same as the stages carried out in structural work. The difference is, on architectural work does not use 'activity', but using 'alternative design' based on WBS. This is because in each architectural work activity, the materials used are different so that the 'human' risk type has different risks based on the materials. The results of the risk validation for architectural work can be seen in table 2 below.

Table 2. Risk Identification for Architectural Works based on Human

Alternative Design	Risk Identification		Impact of Risk
	Type of Risk	Description	
Ceiling (Work Package: Ceiling Works)			
Exposed Concrete Ceiling Finished	Human	Falling from a height	Injured, died
		Slipped	Injured
Interior Gypsum Ceiling	Human	Falling from a height	Injured, died
		Exposed to electric current	Damaged muscle tissue, impaired nerves, decreased/increased blood pressure
Gypsum Wet Resistant Ceiling	Human	Falling from a height	Injured, died
Decorative Gypsum Ceiling	Human	Falling from a height	Injured, died
Metal Ceiling	Human	Falling from a height	Injured, died
		Eyes hit/splashed with spray	Eye irritation, can cause blindness

Meanwhile, the type of risk of 'property', 'environment' and 'public safety' is the same in each 'alternative design' for one 'work package', so all the risk listed is based on the work package. More details can be seen in table 3 below.

Table 3. Risk Identification for Architectural Works based on Property, Environment and Public Safety

Work Package	Risk Identification		Impact of Risk
	Type of Risk	Description	
Ceiling Works	Property	Damaged ceiling due to installation error	Material loss
	Environment	Residual & waste material that is bad for the environment	Air pollution, material waste, environmental pollution
	Public Safety	Traffic caused by material arrival	There is a traffic jam around project area which causes inconvenience

Print ISSN: 2622-0989 / Online ISSN: 2621-993X
DOI: https://doi.org/10.32535/jicp.v4i1.1132

		and disturbs the community

Meanwhile, the identification of risk prevention in the architectural work is slightly different from the structural work. Risk prevention in the architectural work is based on the potential risks that have been previously identified in previous research. The potential risks that will be explained in this paper only discuss the ceiling work from table 2 and table 3 above. The result of risk prevention for architectural works that have been validated by experts can be seen in table 4.

Table 4. Potential Risk and Risk Prevention for Architectural Works

No	Potential Risk	Risk Prevention
I.	**Risk Type: Human**	
1	Falling from a height	Install signs "Beware of Falling"
		Safety fence
		Using safety body harness when working
2	Slipped	Material placement is neat and there is access for people to walk
		Install signs "Be careful"
3	Exposed to electric current	Install the "Electricity Hazard" sign
		Electrical connection system planning with Electrical OHS Expert
4	Eyes hit/splashed with spray	Use safety glasses
		Using a welding mask
		Keep a safe distance from getting splashed
II.	**Risk Type: Property**	
1	Damaged ceiling due to installation error	Installation is carried out according to the work method
III.	**Risk Type: Environment**	
1	Residual/ waste material that is bad for the environment	Waste of the material are collected and placed in a closed place
IV.	**Risk Type: Public Safety**	
1	Traffic caused by material arrival	Provide flagman so that when handling material, traffic can be controlled

After identifying the risks and prevention, the risks are assessed for likelihood and severity by experts. Once assessed, the results of the risk level for soil leveling and ceiling work have high risk level. Therefore, soil leveling for structural works and ceiling work for architectural works will be discussed further for the preparation of a safety plan.

Component of Safety Plan based on Work Breakdown Structure

The development of the safety plan in this study is based on the Regulation of Minister of PUPR No. 21 of 2019. In the regulation itself, OHS planning requires making:

1. Identification of hazards/risks.

Print ISSN: 2622-0989 / Online ISSN: 2621-993X
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2. Risk assessment and risk/opportunity control (Hazard Identification Risk Assessment Opportunity) Construction Works.
3. Construction safety objectives and programs, which are based on the stages of work (Work Breakdown Structure).

It can be seen in Figure 3 below regarding the stages of developing a safety plan.

Figure 3. Flow of Safety Plan Development

After the safety risk and prevention being validated by the experts, the next step is to look for objectives and programs for each risk and prevention. After that, the objectives and programs of risk and prevention are being validated by experts and ask for feedback on how to control the risks. The responses from the experts will be summarized into one so that information regarding the control, targets and OHS risk programs for structural and architectural activities becomes more complete.
The objectives and programs based on on the Regulation of Minister of PUPR No. 21 of 2019 contains a table of specific objectives and special programs based on hazard/risk identification, risk assessment and opportunities that are specific in nature, namely having medium and large priority scales. The results of validated objectives and programs for structural work can be seen in table 5 and table 6.

Table 5. Objective Structural Works based on Risk

Type of Risk	Risk Description	Prevention	Objective	
			Description	Benchmark
Activity: Soil Leveling (Work Package: Land Clearing Work-Mechanical Method)				
Human	Heavy equipment hit workers (bulldozer dan combine harvester)	Use a helmet, reflector vest, and safety shoes	The land leveling process can run safely for all related resources	Workers have to wear PPE before land leveling is done
Property	Heavy equipment hit nearby facilities (bulldozer and combine harvester)	Create a barrier area	The leveling process can run safely for surrounding facilities	Signs have been installed before land leveling is done
Environ ment	Soil compaction using tools	Work method according to implementat ion	Does not affect and damage the surrounding environment	Clear job instructions

Print ISSN: 2622-0989 / Online ISSN: 2621-993X
DOI: https://doi.org/10.32535/jicp.v4i1.1132

Public Safety	Heavy equipment hit people (bulldozer dan combine harvester)	Create a barrier area	No accidents and disturbing the surrounding community	The area divider has been installed before the land leveling is done

Table 6. Program Structural Works based on Risk (Continuation from Objective)

Type of Risk	Program				
	Resource	Time period	Achievement Indicator	Monitoring	PIC
Activity: Soil Leveling (Work Package: Land Clearing Work-Mechanical Method)					
Human	Helmet, reflector vest, safety shoes	Before and during the work process	There are no injuries to workers	Supervisory report/ OHS report	OHS Officer/ Supervis or
Property	Signs	Before and during the work process	Doesn’t hit the surrounding facilities	Supervisory report/ OHS report	OHS Officer/ Supervis or
Environ ment	Ground leveling work instructions	Before work starts and during work	Work takes place without damaging the environment	Supervisory report/ OHS report	OHS Officer/ Supervis or
Public Safety	Area divider	Before and during the work process	No accidents happened to the community	Supervisory report/ OHS report	OHS Officer/ Supervis or

Meanwhile for architectural works, 2 of the 7 risks taken from the previous table 4 for further analysis to obtain objectives and programs of architectural works. The validated objectives and programs can be seen in table 7 and table 8 below.

Table 7. Objective Architectural Works based on Risk

Prevention	Objective	
	Description	Benchmark
Potential Risk : Falling from a height (Human)		
Install signs "Beware of Falling"	All locations are marked	Standard sign
Safety fence	Make a safety fence in every opening	Safety fence standard
Potential Risk: Slipped (Human)		
Material placement is neat and there is access for people to walk	Materials are arranged and make access roads for people	Amount of material and type of material

Print ISSN: 2622-0989 / Online ISSN: 2621-993X
DOI: https://doi.org/10.32535/jicp.v4i1.1132

Install signs "Be careful"	All locations are marked	Standard sign

Table 8. Program Architectural Works based on Risk (Continuation from Objective)

Prevention	Program				
	Resource	Time period	Achievement Indicator	Monitoring	PIC
Potential Risk: Falling from a height (Human)					
Install signs "Beware of Falling"	Warning sign	Before work must be complete	100% fit to standard	Checklist	OHS Officer
Safety fence	Safety fence	Before work must be complete	100% fit to standard	Checklist	OHS Officer
Potential Risk: Slipped (Human)					
Material placement is neat and there is access for people to walk	Work instructions document	During the execution of the work	Availability access road for people	OHS officer conducts area inspection	OHS Officer
Install signs "Be careful"	Warning sign	Before work must be complete	100% fit to standard	Checklist	OHS Officer

With the conclusion of objectives and programs of structure and architectural works based on table 5-8, it can be clearly seen what components are needed for the development of the safety plan.

CONCLUSIONS

This study proposed the development of a safety plan for structural and architectural work in UI buildings based on the work breakdown structure. Toward this purpose, potential risks and prevention are identified based on WBS of structural and architectural work. OHS risk identification is the main component in making a safety plan as well as decisions for evaluating appropriate safety actions. Then based on the risk identification, objectives and programs are determined so that a safety plan can be made for the UI construction building. The limitation of this research is the lack of use of technology in the development of safety plans. In future research, this research can be developed by combining technology for safety plans, such as Building Information Modelling (BIM). This research helps to identify risks to be more accurate with the use of WBS so as to improve safety performance by reducing the number of work accidents.

Print ISSN: 2622-0989 / Online ISSN: 2621-993X
DOI: https://doi.org/10.32535/jicp.v4i1.1132

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