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Development of a Risk-Control Safety Program as an Architectural Contractor Guideline on Flats Project

Rossy Armyn Machfudiyanto*, Yusuf Latief, Ratih Fitriani, Amira Syifa

Department of Civil and Environmental Engineering, Faculty of Engineering, Universitas Indonsesia, Kampus Baru UI Depok, West Java 16424, Indonesia

Corresponding Author Email: rossyarmyn@eng.ui.ac.id

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ABSTRACT

Construction Safety Planning is an element in the CSMS (Construction Safety Management System), which needs to be developed by the Contractor. Irrespective of this condition, the guidelines for preparing a safety program have not been appropriately disseminated by the project owner. This shows that many contractors are yet to appropriately implement the construction safety program. Therefore, this study aims to develop a safety program for Indonesian flat projects, especially architectural work. A qualitative method and secofndary data were used and obtained from a literature review, respectively. This was to determine the breakdown structure of architecture, which was then identified by hazards and operational risks. These processes led to the acquisition of the risk control used in preparing safety program targets, regarding resource analysis. The results showed that the resources needed in this architectural program included safety signs, PPE, warehouse construction, and transportation carts, which should be completed before work inception. In this case, an individual needs to be responsible for all the operational processes, namely the Safety Inspector/Supervisory Officer. These results are expected to be used as a guideline for contractors and project owners, to prepare a safety program and monitor the implementation of CS (construction safety).

1. INTRODUCTION

The Indonesian community was 3.51% of the world's population in 2021 [1], with continuous elevation capable of increasing the primary and secondary needs of the people. This shows that a house is a basic human need [2], although the housing backlog reportedly reaches 8.2 million with an increase of about 500,000 yearly. According to the Ministry of Public Works and Public Housing (PUPR, 2020), this backlog reached 7.64 million units in early 2020 [3]. In the project of high-rise buildings, the Director General of Construction Development of the Ministry of PUPR also stated that accidents should no longer be encountered in infrastructure development. In this context, various parties such as planners, implementers, supervisors, and construction managers need to consider and anticipate the non-occurrence of work hazards. Based on the Ministry of PUPR, a total of 14 (fourteen) infrastructure project accidents were encountered in the past two years, with at least five major causal points detected as follows: (1) Human error, (2) Building material disruptions, (3) Multiple uncertified equipment, (4) Field construction implementation methods, especially occupational safety and health (OSH) programs, and (5) Budget efficiency. In this case, the most suspected cause of work accidents emphasized the construction method [4].

The impact of construction accidents is divided into 3 (three) levels, namely the macro, meso, and micro. At the macro level, accidents often influence a country's competitiveness and the cost of implementing construction safety by 4% of GDP. A company's performance is also affected by these constructive hazards at the meso level. Meanwhile, construction accidents influence project performance and quality, as well as cost and time overrun at the micro level [5].

In the CSMS (Construction Safety Management System), a total of 5 integrative elements are found, namely Leadership, Planning, Safety Support, Operations, and Evaluation [6]. Based on Symbersky's theory, the potential occurrence of construction accidents was observed due to the inappropriate design at the conceptual stage, regarding noncompliance to the standards and regulations [7]. This leads to the focus on one element of the CSMS, namely Construction Safety Planning, whose indicators include Hazard/Risk Identification and SPT (Safety Program Targets). In developing SPT, the analysis of resources needs to be conducted regarding the calculation of construction safety cost values [8]. Therefore, this study aims to develop a construction safety program through a resource analysis, to estimate costs in apartment projects.

2. THEORETICAL STUDY

2.1 Construction safety plan

An occupational health and safety management plan is a document detailing construction risks and their controlled/preventive measures at the project site [9]. It is also a project document used to develop an effective safety program, through specific goal-oriented objectives, targets, and methods [10]. Furthermore, a safety plan is known as RKK (Construction Safety Plan) in Indonesia, based on the

Minister of Public Works and Public Housing Regulation No. 10 of 2021, which contains the identification of risk hazards from each activity. This regulation subsequently contains the configuration of SPT (safety program targets) through a resource analysis, to determine construction safety costs.

2.2 Construction safety resource

A safety program is an output of CSP (construction safety planning) [11], whose developmental processes include the analysis of preventive resources. In managing these resources, a good safety management system is required for optimal utilization. The resource component also contains the facilities needed to carry out projects toward the effective and efficient achievement of goals and objectives, through the development of zero accidents. In the architectural work of high-rise flats, resources are reportedly needed to realize construction safety, namely SR (safety resources). According to the study of Ferakhim and Latief [12], the required resources are described in Table 1.

Table 1. Construction safety resource type

No	Construction Safety Resource Component	Resource Type
	Personal protective equipment	Equipment
1	Safety Helmet	Equipment
2	Goggles, Spectacles	Equipment
3	Face Shield	Equipment
4	Ear Plug, Ear Muff	Equipment
5	Masks	Equipment
6	Safety Gloves	Equipment
7	Safety Shoes	Equipment
8	Full Body Harness	Equipment
9	Safety Vest	Equipment
10	Fall Arrester	Equipment
	Safety Plan Development	
11	Manufacture of Manuals, Procedures, Instructions, as well as Work Permits and Forms	Labor
	Safety Socialization and Promotion	
12	Safety Briefing and Meeting	Labor
13	Safety Simulation	
	Work Protective Equipment	
14	Safety Net	Equipment
15	Safety Rope	Equipment
16	Safety Deck	Equipment
17	Safety Fence	Equipment
	Insurance and Licensing	
18	Equipment Eligibility Permit	Labor
19	Operator Permit	Labor
	Safety Personnel	
20	Safety Expert and Officer	Labor
	Signs	
21	Hint	Equipment
22	Prohibition	Equipment
23	Warning	Equipment
24	Obligation	Equipment
	Others related to Risk Control	
25	Light Fire Extinguisher	Equipment
	Additional Components, including Others related to Risk Control	
1	Ear protector	Equipment
2	Noise measurement	Equipment
3	Material transport cart	Equipment

Based on Table 1, these resources were used to determine construction safety programs and estimate costs. From several previous reports, the identified resources contained PPE, Safety Plan Development, Personnel, and Signs, as well as Other Related Risk Control and Additional Components. In this context, the Additional Components included ear protection and noise measurements, which were only used for Exposed Concrete-Ceiling Finishing work. This was due to the utilization of a loud grinding tool for a long period. Additionally, the provided transport carts used for masonry and ceramics are quite large, with the transported load slightly heavy.

From the analysis of the CSR (construction safety resources) planning needs, a safety program is proposed for development. The required safety costs are also calculated for each multi-storey building architectural activity, regarding the Flat or Apartment project.

3. METHODOLOGY

A literature review was initially conducted to determine the activity of construction projects in Flats or Apartments, using WBS. This was accompanied by the identification, assessment, and control of hazards and risks in each project activity. From the risk control process, the development of safety targets and programs was highly possible regarding the analysis of the resources needed for each construction activity. This analysis subsequently involved 3-5 Safety Experts, which validated each process through the Delphi Method, to produce a CSP (construction safety plan) for architectural work on Flats or Apartment projects. Figure 1 shows the study flow methodology.

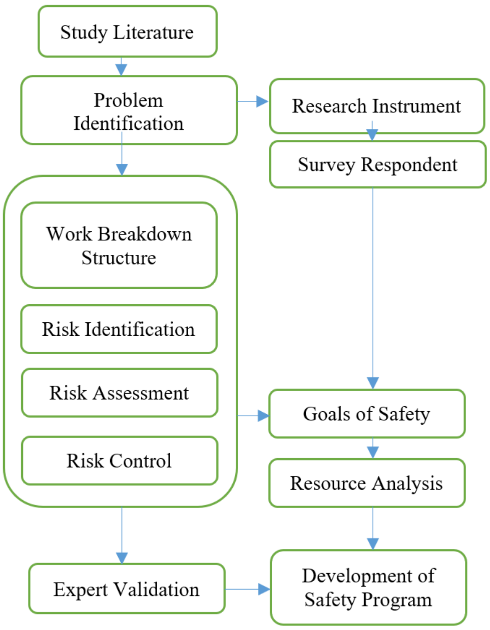

Figure 1. Study flow methodology

4. RESULT AND DISCUSSION

The study process emphasized the continuation of previous reviews, leading to the development of WBS, as well as the risk identification, assessment, and control of each architectural activity in the flat project. Based on the questionnaire responses and the experts' validation, the job description of the architectural project included the following activities [13]:

1. Floor Work
2. Wall Work
3. Ceiling Work
4. Sanitary Work
5. Facade work
6. Roof Work
7. Other Jobs

According to the study of Ferakhim and Latief [12], a total of 17 potential hazards and risk factors were observed in the architectural work of the Rusunawa/Rusunami project. In this context, the following low-risk factors were identified:

1. Workers fall from heights.
2. Inhalation/absorption of harmful substances through the nose or skin.
3. Broken conveyance.

A total of 9 medium-level risk factors were also observed as follows:

1. Collision of workers with falling/moving objects.
2. Eyes exposed to/splashed with spray.
3. Workers are trapped in the screed layer.
4. Workers are exposed to temperature, air pressure, vibration, radiation, sound, light, and others.
5. Fire.
6. Damages to equipment due to vertical overload.
7. Tool collision with other hard objects.
8. Damage to public facilities.
9. Split materials.

Additionally, 5 high-risk factors were identified as follows:

1. Workers' collisions with falling and sharp objects.
2. Inhalation/absorption of harmful substances through breathing/skin.
3. Workers slip.
4. Workers' exposure to electric current.
5. Worker sprains.

Table 2. Development of construction safety program

No.	Risk Control	Reference	Goals				Program		
			Activity	Benchmark	Resource	Duration	Indicator	Monitoring	PIC
Potential Risk: Workers' collision with falling and sharp objects									
1	Using gloves when working	Project Document	All workers wear appropriate PPE	SNI/Indonesian National Standard gloves and the number of workers	Gloves	Before work	100% standard	Checklist	Safety inspector/supervisor of work implementation
2	Display "Careful" signs	Project Document	All locations are marked	Standard sign	Warning sign	Before work	100% standard	Checklist	Safety Officer
3	Complete use of PPE	Expert Judgment	All workers wear appropriate PPE	PPE according to SNI / Indonesian National Standard	Standard PPE (Helmet, Vest, and Shoes)	Before work	100% standard	Checklist	Safety inspector/supervisor of work implementation
Potential Risks: Inhalation/absorption of harmful substances into the body, through breathing/skin									
1	Wearing a mask at work	Project Document	All workers wear appropriate PPE	SNI masks and the number of workers	Mask	Before work	100% standard	Checklist	Safety inspector/supervisor of work implementation
2	B3 is placed in a special area and separated from non-B3 materials	Project Document	All placements of B3 and non-B3 materials are neatly arranged	Amount and type of material	Warehouse building materials	Before work	B3 materials are not scattered	K3 officer conducts area inspection	Safety inspector/supervisor of work implementation
3	Handling of B3 materials according to MSDS (Materials Safety Data Sheet)	Project Document	All materials are handled according to procedures	Amount and type of material	MSDS Document	Before work	Orderly implementation according to MSDS	The supervisors carry out supervision	Safety inspector/supervisor of work implementation
4	Use eye protection	Expert Judgment	All workers wear safety glasses	SNI safety glasses and the number of workers	Safety glasses	Before work	100% standard	Checklist K3 officers carry out periodic checks	Safety inspector/supervisor of work implementation
5	Installing information boards regarding	Expert Judgment	An information board is installed in the B3 area	B3 information board	B3 information board	Before work	100% standard	Checklist K3 officers carry out periodic checks	Safety inspector/supervisor of work implementation

	the presence of B3 materials								
				Potential Risk: Workers Slip					
1	Material placement is neat and accessible for people to walk	Project Document	Material placements are arranged and accessible to people	Amount and type of material	Work Instructions document	During the execution of the work	Availability of access roads for people	K3 officer conducts area inspection	Safety officer
2	Display "Careful" signs	Project Document	All locations are marked	Standard sign	Warning sign	Before work	100% standard	Checklist	Safety officer
3	Perform regular cleaning of the work area/field	Expert Judgment	Work area cleaning	Regular cleaning of the work area	Water tank	During the execution of the work	100% standard	Report	Safety officer
				Potential Risk: Workers' exposure to electric current					
1	Install the "Electricity Hazard" sign	Project Document	All locations are marked	Standard sign	Warning sign	Before work	100% standard	Checklist	Safety officer
2	Avoid multiple flow-sharing connections	Project Document	Avoiding multiple flow-sharing connections	Electric current	Work instructions document	During the execution of the work	No excessive electrical load	K3 officer conducts area inspection	Safety officer
3	Provision of safety insulation on the chipped cable	Project Document	Ensure no exposed wires	Power cable	Work instructions document	During the execution of the work	No exposed wires	K3 officer conducts area inspection	Safety officer
4	The electrical connection is coordinated with an electrician	Project Document	Coordinate electrical connections with electricians	Power cable	Work instructions document	During the execution of the work	Presence of the electrician when connecting the electricity	Supervisors carry out supervision	Safety officer
4	Prevent/avoid puddles	Project Document	Ensure no puddles	The entire area has no stagnant water	Work instructions document	During the execution of the work	No puddles	K3 officer conducts area inspection	Safety officer
5	Wear rubber gloves and safety shoes	Project Document	All workers wear appropriate PPE	SNI for gloves and safety shoes, as well as the number of workers	Rubber gloves and safety shoes	Before work	100% standard	Checklist	Safety inspector/supervisor of work implementation
6	Periodic checks for electrical installations	Project Document	Carry out periodic inspections of electrical installations	Electrical installation	Work instructions document	During the execution of the work	Periodic check notes	K3 officer conducts area inspection	Safety officer
7	Ensure that the cable is hung and not sticking to the floor, especially the wet one	Project Document	Hangs all cables and no floor stickers	Power cable	Work instructions document	During the execution of the work	No cables sticking to the floor	K3 officer conducts area inspection	Safety officer
8	Ensure that the cable used is adjusted to the power capacity	Project Document	Using the cable according to its capacity	Power cable	Work instructions document	During the execution of the work	Cable usage according to capacity	K3 officer conducts area inspection	Safety officer
9	Ensure that the electrical connection uses a socket and is connected to the specified panel	Project Document	Ensure all electrical connections use sockets and are connected to the specified panel	Cable connection	Work instructions document	During the execution of the work	The electrical connection is appropriately connected	K3 officer conducts area inspection	Safety officer
10	Assign an electrician's PIC to facilitate electrical coordination	Expert Judgment	PIC of electrician from ME team	Electrician PIC	PIC	During the execution of the work	Min. 1 person	Report	PIC of electrician
				Potential Risk: Workers' Sprain					
1	Using carts for material transport	Project Document	All material transportation in large quantities and long distances using carts	Amount of material and transport distance	Transport cart	During the execution of the work	Carts are used to transport materials	Supervisors carry out supervision	Safety officer
2	Consider the material's carrying capacity of the wagon load	Project Document	Transportation of materials by cart does not exceed the hauling load	Material load and quantity	Work instructions document	During the execution of the work	The cart is used easily	Supervisors carry out supervision	Safety officer
3	Material lifting should not exceed the person's load	Project Document	Workers lifting materials do not exceed the weight of people	Material load and quantity	Work instructions document	During the execution of the work	Heavy materials are transported by assistive devices (carts)	Supervisors carry out supervision	Safety officer
4	Handling is carried out in suitable positions	Project Document	Workers lift material in an appropriate position	Material load and quantity	Work instructions document	During the execution of the work	Workers are easy to handle	Supervisors carry out supervision	Safety officer
5	Conduct ergonomics training for all workers or socialize through the safety weight load (SWL) sign	Expert Judgment	Ergonomics training	Implemented min. 1 time	Instructor	During the execution of the work	100% standard	Activity Report	Safety officer

Based on this review, all 5 high risks were analyzed and subsequently identified, to develop targets and programs for the Rusunawa/Rusunami architectural project. This emphasized comprehensive risk control on construction safety resource requirements. From these architectural high-risk factors and potential hazards, the preparation of targets and programs was carried out to mitigate construction accidents, as shown in Table 2.

In architecture, workers often highly perform and use quite a lot of equipment. In this process, potential hazards and risk factors such as workers slipping, need to be avoided. According to the experts' validation, periodically cleaning the work area/field was necessary as a risk-control measure. This indicated that the required resources included water tanks and cleaners for cleaning processes during the project period. These processes should subsequently be monitored through a work report supervised by safety officers [14].

Based on the high-risk factors, the following are the construction safety resource requirements needed to mitigate hazard occurrences [15-17]:

1. Warning signs or information boards, listed in the PUPR Ministerial Regulation No. 10 of 2021.
2. PPE and APK, enacted in the PUPR Ministerial Regulation No. 10 of 2021.
3. Manufacturing warehouses, provided to activities and equipment related to construction safety risk control.
4. Water tanks.
5. PIC of the electrician, added to Socialization, Promotion, and Training.
6. Transport carts, integrated into the activities and equipment related to construction safety risk control.
7. Lifting, electric current, and MSDS documents, added to the construction safety plan preparation document.
8. Ergonomics training instructor, provided to Socialization, Promotion, and Training.

These requirements, especially those included in the PUPR Ministerial Regulation No. 10 of 2021, should be recommended for use as construction safety resources [18].

Based on the results, flats were arranged regarding the normal and advanced risk control obtained from project documents and experts' validation, including 70 targets and programs for architectural projects. Most of these developments emphasized the control of risk factors for workers, materials, equipment, and the environment/public. These results were in line with the study [19], where CSPs (construction safety programs) were explained as safety planning elements, which improved the preventive culture in construction projects.

The results also showed that flats generally prioritized the PUPR Ministerial Decree No. 10 of 2021, which contained 9 components and 74 subcomponents/items of the construction safety resources. In this case, 30 of the sub-components were generally used to mitigate all common risk factors as follows:

A. Construction safety plan preparation
1. Preparation of a Construction Safety Plan document.
2. Work procedures and instructions planning.
3. Preparation of reports on the implementation of the construction safety management system (daily, weekly, monthly, final).

B. Socialization, Promotion, and Training
1. Construction Safety Induction.
2. Construction Safety Briefing.
3. Safety Meetings, Talk, and/or Tool Box Gathering.
4. Safety patrol.
5. Construction Safety Training.
6. Construction Safety Simulation.
7. Banners.
8. Posters.
9. Safety information board.

C. Insurance and Licensing
1. Insurance.
2. Inspection or testing of equipment fitness to obtain permits.

D. Health Facilities
1. First aid kits.
2. First aid room.

E. Signs
1. Directional.
2. Prohibition.
3. Warning.
4. Obligation.
5. Information.
6. Temporary Job.

F. Consultation with Construction Safety Experts
1. Environmentalist.
2. Building engineering expert.

G. Construction Safety Risk-Control Activities and Equipment (Others)
1. Inspection of the work environment.
2. Safety flag.
3. Emergency lights (Emergency Lamps).
4. Environmental inspection and testing/Sampling test.
5. Making Worker Identity Card (KIP).
6. External audit.
7. CCTV.

5. CONCLUSIONS

Based on the results, an improvement was detected in the construction safety program (CSP) prepared according to the required policy, namely the Minister of Public Works and Housing Regulation No. 10/2021. This indicated that the CSP was the output of the construction safety planning implemented by the Project Owner or Contractor in Flats or Apartments Architecture. In preparing the CSP, the performance of a Resource Analysis was highly necessary as an important part of construction cost estimations. From these results, a role model was provided in the development of a construction safety program. This was obtained from the determination, identification, and assessment of architectural activities, hazards and risks, as well as risk-control measures. These results are then used as guides for contractors in architectural work, especially in Flat and Apartment projects.

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