

Potential Hazards and Risk Factors Architectural Works in Rental Apartment Building Construction Project to Arrange Goals and Programs Construction Safety

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Abstract

Indonesia is ranked fourth with the largest population in the world according to the worldometer's report in December 2020, as the population in Indonesia increases the basic human needs in the form of housing also increase. Quoted from the Association of Indonesian Housing and Settlement Developers in 2021, the housing backlog reaches 8.2 million with an increase in the backlog of around 500 thousand/year. To resolve that problem, The Ministry of Public Works and Housing Indonesia implements a program, namely the "1000 Tower Project" to build vertical housing in rental apartments. But in its implementation, several construction accidents were found. In this kind of rental apartment building construction project, architectural works on building construction have the highest number of work items compared to other types of work items, so further analysis is needed to mitigate construction accidents. The first step is to identify the list of architectural works, and then identify the potential hazards, risk factors, and controls so that goals and programs can be drawn up with plans for construction safety. The research method used is qualitative with secondary data or literature study. This research aims to arrange goals and programs for construction safety architectural works in a rental apartment construction project by identifying potential hazards and risk factors. According to the results based on the research question, there are 258 architectural work activities and 12 potential hazards and risk factors, of which there are 3 dominant potential hazards and risk factors, getting hit by falling/moving objects etc., inhalation/absorption of harmful substances into the body, through breathing/skin and vertical operator overload. By potential hazards and risk factors, specific goals and programs were made to prevent construction accidents with the right safety risk control for potential hazards and risk factors dominant.

Keywords

Work Activities, Potential Hazards, Risk Factors, Architectural Works, Rental Apartment

1. Introduction

Indonesia is ranked fourth with the largest population in the world. In 2021, the total population in Indonesia will be 276,534,274 people or 3.51% of the world's total population. With the increase in population in Indonesia, housing needs have also increased. Quoted from the Association of Housing and Settlement Developers (Apersi) throughout Indonesia in 2021, the housing backlog reaches a value of 8.2 million with an increase in the backlog of around 500 thousand / year. The government is working with the Ministry of Public Works and Public Housing to promote a program, namely the "One Million Houses Program". The program aims to meet the housing needs of the Indonesian people. The rental apartment will be built in the form of vertical housing, this is due to the availability of less land. The rental apartment construction process consists of several scopes of work, including structural, landscaping, architectural, mechanical, and electrical work. Among all these jobs, one of them is architectural work which has 258 work activities based on work breakdown structure (WBS). Architectural work types are ceiling, wall, floor, door &

window work, hardware, roofing, and others. With many work activities, it will have the potential to cause various potential hazards and risk factors for construction accidents.

In 2020, the Minister of Manpower stated that referring to Labor Social Service Agency (BPJS), work accidents in construction increased from 114,000 to 177,000 accidents. According to the Secretariat of the Indonesian Construction Safety Committee, there were 30 construction accidents in 2018-2020. The study is aiming to identify the potential hazards and risk factors of 258 architectural work activities. The potential hazards and risk factors are analyzed quantitatively to determine the assessment of the potential hazards and risk factors. From the results of quantitative analysis, goals, and programs for construction safety for rental apartment building construction projects can be arranged.

1.1 Objectives

This study aims to identify work activities in architectural works in rental apartment building construction projects that have the most work activities compared to other scopes of work, identify potential hazards and risk factors so that they can find out the right safety risk control and arrange goals and programs to prevent construction accidents. The methodology used in this research is to study the literature review and validate with experts who have experience in carrying out apartment rental projects using the Delphi method. These results are expected to help contractors or owners as a guide in building rental apartment projects to achieve zero accidents.

2. Literature Review

2.1 Architectural Works in Rental Apartment Building Project

A rental apartment is a multi-storey building that is built in an environment that is divided into functionally structured parts, both horizontally and vertically, and are units that each can be owned and used separately, especially in residential areas, which are equipped with common parts, common objects, and common land. Rental apartments are included in the category of high-rise buildings. Important factors that must be considered when constructing tall buildings are load on the building, strength and stability, stiffness and drift limits, comfort, creep-shrinkage and temperature, fire prevention and protection (Smith 1982). Architectural work is work with the scope of beautifying the appearance of a building without affecting the strength of the building (Prasetyo 2012).

Some details of the main types of work in architectural work are as follows (Rianty et al. 2017):

1. Floor Work
The floor is the foundation of a room or building. The main function of the floor is the base of the room that can withstand all the loads on it (Tangoro et al. 2007).
2. Wall Work
The wall is the part of the building that functions as a separator between the outdoor and indoor spaces, and as a divider from one room to another, as well as to bear the load on it (Tangoro et al. 2007).
3. Ceiling Work
The ceiling or ceiling is the upper layer of a room. The function of the ceiling of a room is as an upper room divider, to withstand or reduce hot air due to radiation that penetrates the roof, stiffen the structure of a room or building, a place to hang lighting lamps and beautify the room (Tangoro et al. 2007).
4. Door and Window Work
The frame is a part of the wall that functions as a supporting material to form a good relationship between the wall and the door or shutters and is usually installed between the pairs of walls (Tangoro et al. 2007).
5. Sanitary Work
Sanitary is the completeness of clean water disposal in the plumbing system. In simple buildings, plumbing/sanitary equipment must meet the needs of building occupants, for example, bathroom/toilet equipment (Tangoro et al. 2007).
6. Facade work
The work of the facade or outer shell of the building is an external wall and support without load as a building block (Barry 1971).
7. Roof Work
The roof is a building element located at the top of a building. Its main function is as a barrier/protection from the sun's heat, a barrier/protection from rainwater, a protective barrier from wind gusts, as well as for beauty and environmental adjustment (Tangoro et al. 2007).
8. Miscellaneous work

Other work includes all architectural work that has not been listed in the main types of work described previously. Contract value, project duration, number of works, and total construction area need to be considered in the initial planning of safety costs (Gurcanli et al. 2015)

2.2 Work Breakdown Structure (WBS) Architectural Works

Based on the sixth edition of PMBOK 2018, the Work Breakdown Structure (WBS) is a hierarchical decomposition of work-oriented deliverables to be carried out by the project team to achieve project objectives and produce the required deliverables. WBS is a system of dividing projects into work packages that can be managed and managed to provide a common framework for scope scheduling, costs, responsibility allocation, communication, risk assessment, monitoring, and control.

Each WBS-level derivative represents increasingly detailed project work. In the preparation of the WBS there are several levels consisting of:

- Level 1: Project Name
- Level 2: Construction Primary Element
- Level 3: Type of Work
- Level 4: Work Package
- Level 5: Work Activities
- Level 6: Resources (Material, Equipment and Labor Resources)

The type of work and work package for architectural work can be divided into:

- Ceiling Work
 - o Ceiling
- Wall Work
 - o Wall
 - o Wall Panels
 - o Toilet
- Floor Work
 - o Floor
 - o Embankment
- Door and Windows Work
 - o Door
 - o Window Door
 - o Window
- Hardware Work
 - o Door Hardware
 - o Window Hardware
- Roof Work
 - o Roof Insulation
 - o Roof Coating
 - o Gutter
- Facade Work
 - o Secondary Skin
- Miscellaneous Work
 - o Grill
 - o Railing
 - o Parking Marking Paint
 - o Island Floor Raising
 - o Wheel Stopper
 - o Corner Guard Column
 - o Convex Mirror
 - o Vehicle Height Marking Portal
 - o Signpost
 - o Gutter
 - o Canopy
 - o Column Cover
 - o Crown Installation

- Skylight Installation
- Helipad Mark

2.3 Potential Hazards and Risk Factors

Hazard is everything including situations or actions that have the potential to cause accidents or injury to humans, damage, or other disturbances (Ramli 2010). Potential hazards in the world of construction are good conditions or conditions for people, equipment, machines, aircraft, installations, materials, working methods, nature of work, production processes and the environment that have the potential to cause a disturbance, damage, loss, accident, fire, explosion, pollution, and occupational illness. Occupational diseases are caused by work, tools, materials, processes, and the work environment. Identification of potential hazards is based on a job description on a project that has a hazardous impact on workers, equipment, materials, or the environment. One of the main mechanical works is sprinkler installation. With the main potential danger is falling from a height (Purwanti et al. 2020) Identifying risk factors that affect the safety of the project work can reduce the number of accidents and reduce compensation costs (Abas, Yusuf et al., 2021)

Risk management is a risk management process that starts with identifying hazards, assessing risk levels, and controlling risks. The construction safety risk is a measure of the possibility of loss to public safety, property, human life, and the environment that can arise from certain sources of danger that occur in construction work. The risk assessment is based on calculations by assessing the frequency of occurrence of OHS hazard events with the severity or impact of the damage they cause. The construction safety risk assessment category is divided into high risk, medium risk, and small risk. One of the challenges faced by contractors in construction projects is that the costs incurred because of injuries and hazards at the construction site are very high (Bima et al. 2015)

Table 1. List of Potential Hazards and Risk Factors Based on References

No	Potential Hazards and Risk Factors
1	Falling from the height of the building
2	Getting hit by falling/moving objects etc
3	Collision, contact with sharp objects / hard objects
4	Have inhalation/absorption of harmful substances into the body, through breathing/skin
5	Slipping
6	Exposed to electric current
7	Be sprained
8	Eyes exposed/splashed with spray
9	Squeezed, caught between things
10	Exposed to temperature, air pressure, vibration, radiation, sound, light
11	Fire Hazard
12	Vertical Carrier Overload

3. Methods

In research, the selection of research strategies is an important thing that needs to be done first by using certain methods to get relevant results so that they can achieve research objectives. In the bookcase “Study Research Design and Methods”, it is explained that in research there are several considerations in choosing a research strategy based on the type of research question (research question), control of events and focus on current events (Robert K. Yin 2002). Among all several considerations in choosing a research strategy, this research uses survey methods and case studies.



Figure 1. Research Flow

3.1 Expert Judgement

Expert judgment is a technique in the project planning process that refers to making a judgment based on skill, expertise, or specialized knowledge in a particular area. The expertise can be based on an individual's training or educational background, career experience, or knowledge of the product/market. In this study, the selected experts are those who are experienced in carrying out rental apartment building construction projects, especially architectural works for more than 5 years. The method used is the Delphi method. The Delphi method is a process used to arrive at a group opinion or decision by surveying a panel of experts. Experts respond to several rounds of questionnaires, and the responses are aggregated and shared with the group after each round. The purpose of this method is to obtain the most reliable mutual agreement from the experts.

3.2 Questioner Form

A questionnaire is a data collection technique that is done by giving a set of questions or written statements to respondents to answer (Sugiyono, 2011). The type of questionnaire is divided into two, namely open and closed questionnaires. In this study, a closed questionnaire was used, namely, a questionnaire that was formed by limiting respondents to giving answers in the form of several choices or only one answer.

4. Data Collection

The data needed to identify work activities in architectural works in rental apartment buildings is a list of work packages and work activities from previous studies. That list is validated by expert judgment from the construction or architectural engineer.

Table 2. List of Experts

User	Position	Work Experiences		Academic Title
Expert 1	Director of Engineering	43 years		PhD
Expert 2	Architectural Engineer	12 years		Magister
Expert 3	Project Manager	10 years		Magister

The sampling technique is a way to determine the number of samples by the sample size that will be used as the actual data source, considering the characteristics and distribution of the population to obtain a representative sample (Margono 2004). In the questionnaire form, an assessment is carried out on an ordinal scale, which is the number given where the numbers contain the meaning of the level. This scale is used to sort objects from lowest to highest or vice versa.

Table 3. The scale of Frequency Rating for Questionnaire Form

Scale (1-5)	Frequency Rating
1	Never
2	Seldom
3	Sometimes
4	Often
5	Always

Table 4. The scale of Impact Rating for Questionnaire Form

Scale (1-5)	Impact Rating
1	No Influence
2	Less Influence
3	Quiet Influence
4	Influence
5	Very Influence

There are various methods for conducting data analysis, but this needs to be adjusted to the type of data that has been obtained and the purpose of the research. Data types are divided into two types, namely quantitative data, and qualitative data. Quantitative data is data related to numbers or quantity, while qualitative data is more subjective data because it comes from surveys or interviews. In this study, the types of data to be obtained are qualitative data from several surveys, expert validation, and interviews.

5. Results and Discussion

In this part, from a literature study carried out from books, journals and previous research, interview and validating experts. Furthermore, there was a standardized work breakdown structure for architectural works, especially for rental apartment building construction projects.

Table 5. Work Breakdown Structure of Architectural Works in Rental Apartments

WBS Level 2 Construction Primary Element	WBS Level 3 Type of Work	WBS Level 4 Work Package	WBS Level 5 Work Activities
Architectural Work	Ceiling	• Ceiling	13 elements
	Wall	• Wall • Wall Panels • Toilet	58 elements
	Floor	• Floor • Embankment	46 elements
	Door and Windows	• Door • Window Door • Window	32 elements
	Hardware	• Door Hardware • Window Hardware	27 elements
	Roof	• Roof Insulation • Roof Coating • Gutter	17 elements
	Facade	• Secondary Skin	31 elements
	Miscellaneous	• Grill • Railing • Parking Marking Paint • Island Floor Raising • Wheel Stopper • Corner Guard Column • Convex Mirror • Vehicle Height Marking Portal • Signpost • Gutter • Canopy • Column Cover	51 elements

WBS Level 2 Construction Primary Element	WBS Level 3 Type of Work	WBS Level 4 Work Package	WBS Level 5 Work Activities
		• Crown Installation • Skylight Installation • Helipad Mark	

After identifying a list of work activities from table 5 given above will be used as a guide to identifying potential hazards and risk factors, there are 12 potential hazards and risk factors that have been validated from the literature study and expert judgement,

Table 6. List of Potential Hazards, Risk Factors and Safety Risk Control for Architectural Works in Rental Apartments

Potential Hazards and Risk Factors	Safety Risk Control
Falling from the height of the building	Put up a "Watch Out" sign
	There is a strong and wide workbench
	Construction of safety fence
	Horizontal safety net fabrication
	Lighting in the staircase area
	Using a safety belt/safety body harness when working
	Installation of safety screens and railings
Getting hit by falling/moving objects etc	Using HT communication devices
	Handling and binding of materials are done with care
	Wearing Standard PPE (Helmet, Vest, and Shoes)
	Put up a sign "Beware of Falling Materials"
	Certified rigging operator
	Consider material lifting and handling
Collision, contact with sharp objects / hard objects	Use gloves when working
	Put up a "Be Careful" sign
	Analyze job safety analysis
Have inhalation/absorption of harmful substances into the body, through breathing/skin	Wearing a mask at work
	B3 is placed in a special area and separated from non-B3 materials
	Handling of B3 materials following MSDS
Slipping	Material placement is neat and there is access for people to walk
	Put up a "Be Careful" sign
	Periodic cleaning site area
Exposed to electric current	Install the "Electricity Hazard" sign
	Avoid multiple flow-sharing connections
	Provision of safety insulation on the chipped cable
	The electrical connection is coordinated with an electrician
	Prevent/avoid standing water
	Wear rubber gloves and safety shoes
	Periodic checks for electrical installations
	Make sure the cable has been hung and does not stick to the floor, especially the wet one
	Make sure the use of the cable is adjusted to the power capacity

Potential Hazards and Risk Factors	Safety Risk Control
	Make sure the electrical connection uses a socket and is connected to a predetermined panel
	Decide the person in charge (PIC) in the electrical panel segment
	Conduct electrical training
Be sprained	Using carts for material transport
	Do not transport materials more than the cartload
	Material transportation should not exceed the person's load
	Handling is done in the right position
	Ergonomics training
Eyes exposed/splashed with spray	Use safety glasses
	Using a welding mask
	Keep a safe distance from getting splashed
Squeezed, caught between things	Wearing Standard PPE (Helmet, Vest, Shoes, etc.)
	Wear gloves when working
	Put up a "Be Careful" sign
Exposed to temperature, air pressure, vibration, radiation, sound, light	Noise measurement is carried out
	Use standard PPE and follow the work method & HSE plan
Fire Hazard	Adequate fire extinguishers are available
	Fire warning signs
	Handling of B3 materials following MSDS
	Periodic inspection of fire extinguishers
	Do fire training
Vertical Carrier Overload	Initial load test
	Periodic checking of tools
	Make sure the safety device (alarm) is functioning properly
	Maximum load sign installation
	Make sure the operator has a license

After analyzing the qualitative data from the questionnaire form, there are 3 potential hazards and risk factors dominant in architectural work on a rental apartment building construction project:

1. Getting hit by falling/moving objects etc.
2. Have inhalation/absorption of harmful substances into the body, through breathing/skin
3. Vertical Operator Overload

These three are potential hazards and risk factors that often occur and have a very influential impact on architectural works to be of greater concern to contractors and owners in implementing projects. The main components of construction safety are signs, fire extinguishers and internal audit program inspections to improve safety performance (Armyn 2017)

In the sub-appendix of the construction safety plan, Regulation of the Minister of Public Works and Public Housing Number 10 of 2021, there are goals and programs which are divided into general and specific. General goals and programs are a continuation of hazard identification, and general or low-risk assessment, while specific goals and programs are carried out based on hazard identification, and specific risk and opportunity assessment, which have medium and large priority scales.

Table 7. Specific Goals and Programs to Prevent Construction Accidents

Rank	Potential Hazards and Risk Factors	Specific Goals	Specific Programs		
			Resources	Time	Person in Charge (PIC)
1	Getting hit by falling/moving objects etc.	Workers carry out material transfer using HT communication tools	HT Communication Device	During Construction	HSSE Officer, Site Manager
		The distribution of materials in large quantities will be tied	Strap	During Construction	HSSE Officer, Site Manager
		All workers use PPE according to regulations	PPE (Helmet, Vest, Shoes, etc.)	During Construction	HSSE Officer, Site Manager
		Installing signs for all locations	Warning Sign	Before Construction	HSSE Officer
		Conduct certified training for rigging operators	Training for Rigging Operators	Before Construction	HSSE Officer, Site Manager
2	Have inhalation/absorption of harmful substances into the body, through breathing/skin	Workers wear masks under certain conditions	Masks	During Construction	HSSE Officer
		Develop material handling procedures	MSDS Document	During Construction	HSSE Officer
		Installing warning signs for all locations	Warning Sign	During Construction	HSSE Officer
		Carry out cleaning site area regularly	Water tank	During Construction	HSSE Officer
3	Vertical Carrier Overload	All heavy equipment is tested	Work Tool Procedure Documents	Before Construction	HSSE Officer
		Carry out regular inspections of heavy equipment	Work Tool Procedure Documents	Before Construction	HSSE Officer, Site Manager
		Ensure safety devices can function properly	Work Tool Procedure Documents	Before Construction	HSSE Officer, Site Manager
		Install a “maximum load” warning sign	Warning Sign	Before Construction	HSSE Officer
		Conduct certified training for lifting operators	Training for workers to lift something	Before Construction	HSSE Officer, Site Manager

6. Conclusion

In this study, we have identified work activities in architectural works in rental apartment building construction projects with 258 work activities including ceiling, wall, floor, door & windows, hardware, roof, and miscellaneous works. Also from these work activities, we have identified 12 potential hazards and risk factors, of which there are 3 dominant potential hazards and risk factors, getting hit by falling/moving objects etc., inhalation/absorption of harmful substances into the body, through breathing/skin and vertical operator overload. We can arrange specific goals and programs to prevent construction accidents with the right safety risk control for potential hazards and risk factors dominant. Therefore, the specific goals and programs include the use of PPE according to procedures, carrying out all work activities according to principles, conducting certified training for operators, and providing for health and safety needs. For future study, research can be done with different types of object research by types of construction projects to suggest possible future construction accidents.

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Biographies

Amirah Syifa joined as a master's student at the University of Indonesia in 2021. She completed her bachelor's degree in civil engineering. Her interest in continuing postgraduate studies is to escalate the field of civil engineering especially the concentration on construction management. She is currently completing her thesis on the topic of developing construction safety strategies in Indonesia. The expectation for completing the postgraduate thesis is to arrange the goals and programs for construction safety for architectural work in high-rise building construction projects.

Prof. Yusuf Latief is a professor in civil engineering that focuses on construction and project management. He is one of the best lecturers at the University of Indonesia and already achieved more than 170 publications in both reputable international journals and conferences. He also guides many undergraduate, postgraduate, and doctoral students. His persistence in guiding has led many students to graduate. His love for education has led him to become a professor in the field of civil engineering majoring in construction and project management. He is also a role model in the engineering faculty at the University of Indonesia.