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Hazard Analysis Using JSA on Workers at Height Making the Dome of Mosque X, Semarang City

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Abstract: This study aims to analyze the hazards for workers at the height of making the dome of Mosque X in Menoreh Tengah, Semarang City. This study uses a mixed-method approach that combines observational descriptive research and systematic review. Data processing uses the Job Safety Analysis (JSA) methodology to identify risks and hazards. Data is collected through direct observation, interviews, secondary data analysis of company documents, and procedural documentation. The results of the study identified five stages of work: (1) construction of dome foundation, (2) installation of ceiling and waterproof membrane, (3) installation of dome frame, (4) installation of Makara, and (5) installation of dome panels. The results of the analysis showed that there were four categories of hazards: physical hazards, chemical hazards, ergonomic hazards, and psychosocial hazards. Risk control is carried out through a control hierarchy, including engineering control (installation of safety nets, scaffolding), substitution (use of engine pulleys), administrative control (SOP, safety sign), and the use of PPE (full body harness, safety helmet). This study has provided recommendations for developing risk control systems, special training programs, increased supervision, and more detailed work procedures to improve occupational safety and health in workers at height.

Keywords: dome, height workers, job safety analysis (JSA), mosque construction, occupational safety and health (OSH), risk control

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INTRODUCTION

The construction sector is one of the fields of work with the highest risk of work accidents, especially in work involving heights. The construction sector in Indonesia ranks first with the highest number of work accidents, with a proportion of work accidents reaching 32% in all types of project work (Damayanti & Wahyuningsih, 2023). Construction work, especially that involving work at heights, such as the construction of mosque domes, has a very high complexity and requires special attention in occupational safety and health management (Roy et al., 2002).

According to the International Labor Organization (ILO), in 2023, the number of work accident cases in Indonesia was recorded at 370,747 cases. Around 93.83 percent were cases of wage earners, 5.37 percent were cases of non-wage earners, and 0.80 percent were cases of construction service participants (International Labour Organization, 2024). Data from the Central Statistics Agency (BPS) shows that work accidents in Indonesia have increased, and the construction sector is one of the most significant contributors, where more than 30% of accidents occur due to falls from a height (BPS, 2022). in 2022, there was an increase in the number of work accidents by 139,258. This underlines the need for in-depth research on hazard identification and risk control to prevent similar incidents in the future (BPS, 2022).

In a study, it was shown that 85% of the causes of work accidents are due to human factors because human factors are influenced by psychological factors, which play a huge role in determining human actions. According to Ramli (2020), who quoted Heinrich's opinion, 88% of unsafe acts contribute to work accidents, 10% are caused by unsafe conditions, and 2% are unavoidable. Thus, accidents are caused mainly by unsafe human actions. Unsafe actions are dangerous actions or behaviors that can be detrimental to oneself or others and trigger accidents. Unsafe

Action is a dangerous action carried out by the worker because it is motivated by internal factors such as lack of knowledge, skills (Lack of Knowledge and Skill), attitude, and worker fatigue (Bayu, 2019).

METHODS

The problem faced in this study is the lack of attention to occupational safety and health standards in constructing the dome of Mosque X in Menoreh Tengah, Semarang City. The mosque construction project was carried out without adequate supervision and without the implementation of proper safety procedures. This has the potential to cause serious work accidents, which not only harm workers but can also hurt the surrounding community. Therefore, it is important to conduct in-depth research on hazard identification and risk control in mosque construction work—lack of understanding and implementation of effective safety procedures. Many workers lack adequate knowledge of the risks they face and inappropriate personal protective equipment (PPE). Research by Alvianshah(2023) shows that 75% of work accidents occur due to the lack of a transparent supervision system and work procedures. Therefore, it is important to develop a systematic analysis method, such as JSA, to identify and manage risks (Alvianshah et al., 2023).

This research is relevant considering the increasing number of mosque construction projects in various regions. By understanding and analyzing the OSH aspects in constructing the X Mosque dome in Menoreh Tengah, Semarang City, it is hoped that it can provide practical recommendations to improve occupational safety. The literature review shows that previous studies, such as those conducted by Karimah (2019) and Fitrialita (2021), have identified various hazards in building construction. However, this study will develop these findings explicitly focusing on work at height in the context of mosque dome construction (Fitrialita, 2021; Karimah, 2021).

OSH analysis in the construction of the X Mosque dome in Menoreh Tengah, Semarang City, needs to be carried out with a systematic approach, such as Job Safety Analysis (JSA), to identify risks and hazards comprehensively. The JSA method allows researchers to evaluate each stage of work and develop effective risk control strategies. The results of this study are expected to provide a significant contribution to improving OSH in the informal development sector, as well as being a reference for stakeholders in formulating occupational safety policies. This study aims to analyze the hazards and risks faced by workers in the construction of the dome of Mosque X in Menoreh Tengah, Semarang City, and provide recommendations for better risk control. Thus, this study will not only contribute to the academic literature but also have practical implications for improving working conditions in the construction project of the dome of Mosque X in Menoreh Tengah, Semarang City.

RESULT AND DISCUSSION

Based on the job safety analysis (JSA) conducted while constructing the X Mosque dome in Menoreh Tengah, Semarang City, various important aspects of occupational safety and health were identified. This work includes five main stages, namely the construction of the dome foundation, installation of the ceiling and waterproof membrane, installation of the dome frame, installation of the Makara, and installation of the dome panel. Each stage has unique risk characteristics and similarities in the potential hazards that can occur. The analysis shows four main categories of hazards that often appear at each stage of the work. Physical hazards are the most dominant, including the risk of falling, tripping, slipping, hitting, being pinched, being hit by materials, and being exposed to UV radiation. Research by Ramadhan (2017) entitled "Occupational Safety and Health Risk Analysis on the X Building Construction Project in Jakarta" identified the highest risk of being hit by construction materials (45%), while in this study, the risk of falling from a height was the main focus considering the characteristics of the dome work which is predominantly carried out at heights. However, both studies consider physical hazards the most dominant risk in construction work. The chemical hazards identified include exposure to dust, corrosive materials, and panel paint. In addition, ergonomic hazards are mainly related to the risk of Low Back Pain due to non-ergonomic work postures (Ramadhan, 2017). There is an ergonomic hazard, namely when lifting the pulley manually, this can result in musculoskeletal disorders; this is in line with research conducted by Garg & Kapellusch 2009, where the use of assistive devices can reduce the danger of musculoskeletal disorders (Garg & Kapellusch, 2009).

Risk control refers to a hierarchy of control approach that includes various layers of security to ensure worker safety. At the engineering control level, the steps implemented include the installation of safety nets to prevent workers or materials from falling from a height and temporary flat-roof edge protection to reduce the risk of falling when working in hazardous areas. The use of temporary flat-roof edge protection is in line with research conducted (Xu et al., 2023). Their study," A case study on new high-strength temporary support technology of incredibly soft coal seam roadway," emphasizes the importance of a temporary support system as the primary engineering control. This aligns with the findings of the JSA mosque dome, which implements iron scaffolding and safety nets as a safety system. Iron scaffolding is designed to provide safe structural support during the work process (Long Peng et al., 2023). Substitution can be done by replacing manual and machine pulleys to reduce the risk of falls and ergonomic hazards (Khan et al., 2023). The results of the study by (Alvianshah et al., 2023) on "Evaluation of the Implementation of OSH in High-altitude Construction Work" show that 75% of work accidents occur due to the lack of a supervision system and unclear work procedures. JSA dome mosque has anticipated this by emphasizing the importance of SOP for work at height and a supervision system, but it still requires development in terms of periodic monitoring and evaluation. Thus, in terms of administrative control, an exceptional standard operating procedure (SOP) is applied for work at height, which includes systematic steps in carrying out tasks so that risks can be minimized. A first aid box is also provided at the work site for quick handling in the event of an accident, and safety signs are installed in the work area to provide information and warnings to workers about potential hazards (Raihan Muhammad Dzulkarnaen et al., 2024).

The use of personal protective equipment (PPE) is an important component of this risk control strategy, by requiring workers to use a full body harness connected to a lifeline, a safety helmet to protect the head, a safety vest to increase worker visibility, safety gloves to protect hands from injury, safety shoes to prevent the risk of foot injury, an N95 mask for breathing from exposure to dust or hazardous particles, and a back support belt to reduce the risk of back injury due to heavy work (OSHA, 2024). This approach ensures that every aspect of worker safety, from the work environment to personal equipment, is well managed to minimize risk. This project is unique in the complexity of working at heights that require special attention to the implementation of fall protection systems. The risk control implemented integrates various approaches comprehensively, including engineering control, administrative control, and complementary use of PPE. The identified psychosocial aspects show the importance of awareness of the human factor in occupational safety, an element often overlooked in similar studies. A more detailed approach is seen from the emphasis on the use of PPE that is tailored to the specific type of work, thus providing more optimal protection for workers.

Based on the results of the analysis, several recommendations for improvement have been identified. First, it is necessary to implement a periodic monitoring and evaluation system to ensure the effectiveness of risk control. Second, developing a unique training program for work at height with more in-depth material. Third, an efficient emergency communication system between workers in the height area should be implemented; and fourth, supervision should be increased at high-risk work stages. Fifth, developing more detailed work procedures to deal with extreme weather conditions. Overall, the JSA analysis of the X Mosque dome construction project shows a systematic and comprehensive approach to identifying hazards and controlling risks. However, there is still room for improvement, especially in the aspects of monitoring, evaluation, and developing more specific work procedures. By implementing these recommendations, it is hoped that the level of occupational safety and health on the project can be significantly improved.

CONCLUSION

Based on research using the Job Safety Analysis method conducted on workers in the construction of the X mosque dome in Central Menoreh, with the first process being the construction of the dome foundation, marketing of the ceiling and waterproof membrane, installation of the dome frame, installation of Makara and installation of the dome panel. It can be concluded that this work has a high safety risk that requires various hazard controls. Identification includes physical hazards, chemical hazards, ergonomic hazards, and psychosocial hazards, which include potential safety threats ranging from the risk of falling, tripping, exposure to corrosive materials, and work posture problems to psychosocial problems. The risk control system implemented shows a tiered strategy that follows the risk control hierarchy, with the main focus being substitution, engineering control, administrative, and using personal protective equipment (PPE) as the last hazard control. A systematic approach reflects the seriousness of the commitment to ensuring occupational safety and health during the construction process of the mosque dome. The success of JSA implementation is highly dependent on the awareness, compliance, and active participation of all workers in implementing the established safety procedures. Thus, JSA is not just an administrative document but also an instrument for creating a sustainable safety culture in a high-risk construction work environment.

DECLARATION OF GENERATIVE AI

The authors declare that no generative AI or AI-assisted technologies were used in the writing process of this manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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APPENDIX

Table 1. JSA Analysis on Workers Height Making The Dome of the X Menoreh Mosque in the Center of Semarang City

NO	WORK SEQUENCE	HAZARD TYPE		RISK		CONTROL	
1	Foundation Construction Dome	1.1	Physical Hazards	1.1.1	Falling, tripping, slipping, hitting something and getting stuck	1.1.1.1	**Engineering Control:** • Installation of safety net, usage of temporary flat-roof edge protection, and the use of iron scaffolding **Administrative** • Work according to SOP working at height • First Aid Kit Provision • Safety Sign **PPE:** • Full-body harness, lifeline, safety helmet, safety vest, safety gloves, safety shoes, an N95 mask, and a back support belt.
				1.1.2	Hit by the material at the time, use a pulley	1.1.2.1	**Substitution:** • Replacing a manual pulley with a machine pulley **Administrative** • First Aid Provision • Safety Sign **PPE** • Safety helmet, safety vest, safety gloves, safety shoes, dan back support belt.
				1.1.3	Terpapar Radiasi UV	1.1.3.1	**PPE:** • Safety helmet, safety vest, safety glasses, and safety shoes
		1.2	Chemical Hazards	1.2.1	Exposed to dust	1.2.1.1	**PPE:** • Safety helmet, safety vest, safety gloves, mask N95, and safety shoes
				1.2.2	Scratched material corrosion (rust)	1.2.2.1	**PPE:** • Use of safety vests, safety gloves, and safety shoes

		1.3	Ergonomic Hazards	1.3.1	Low Back Pain	1.3.1.1	**PPE:** • Back support belt
		1.4	Psychosocial Hazard	1.4.1	Fatigue	1.4.1.1	**Administrative:** • Establish a clear division of roles and responsibilities
2	Installation of Ceiling and Membrane Waterproof	2.1	Physical Hazards	2.1.1	Falling, tripping, slipping, hitting something and getting stuck	2.1.1.1	**Engineering Control:** • Installation of safety net, Usage of temporary flat-roof edge protection, and the use of iron scaffolding **Administrative:** • Work according to SOP working at height • First Aid Kit Provision • Safety Sign **PPE:** • Full body harness, lifeline, safety helmet, safety vest, safety gloves, safety shoes, N95 mask, and back support belt.
				2.1.2	Overflowing Material	2.1.2.1	**Administrative:** • Work according to SOP working at height • First Aid Kit Provision • Safety Sign **PPE:** • Safety helmet
				2.1.3	Exposed UV Radiation	2.1.3.1	**PPE:** • Safety helmet, safety vest, safety glasses, and safety shoes
		2.2	Chemical Hazards	2.2.1	Exposed dust	2.2.1.1	**PPE:** • Safety helmet, safety vest, safety gloves, N95 mask, and safety shoes
		2.3	Ergonomic Hazards	2.3.1	Low Back Pain	2.3.1.1	**PPE:** • Back support belt
		2.4	Psychosocial Hazard	2.4.1	Fatigue	2.4.1.1	**Administrative:** • Establish a clear division of roles and responsibilities
3	Installation Framework Dome	3.1	Physical Hazards	3.1.1	Falling, tripping, slipping, hitting something and getting stuck	3.1.1.1	**Engineering Control:**

							• Installation of safety net, Usage of temporary flat-roof edge protection, and the use of iron scaffolding **Administrative:** • Work according to SOP working at height • First Aid Kit Provision • Safety Sign **PPE:** • Full body harness, lifeline, safety helmet, safety vest, safety gloves, safety shoes, N95 mask, and back support belt.
				3.1.2	Overflowing Material	3.1.2.1	**Administrative:** • Work according to SOP working at height • First Aid Kit Provision • Safety Sign **PPE:** • Safety helmet
				3.1.3	Exposed welding beam	3.1.3.1	**PPE:** • Apron, helmet /welding mask, gloves welding gloves, and safety shoes
				3.1.4	Stung electricity	3.1.4.1	**Engineering Control:** • Installation grounding protector **PPE:** • Safety helmet, safety glove, safety vest, and safety shoes
				3.1.5	Fire	3.1.5.1	**Administrative:** • Provision of CO2 type APAR
				3.1.6	Exposed UV Radiation	3.1.6.1	**PPE:** • Safety helmet, safety vest, safety glasses, and safety shoes
		3.2	Chemical Hazards	3.2.1	Exposed dust	3.2.1.1	**PPE:** • Safety helmet, safety vest, safety gloves, N95 mask, and safety shoes
				3.2.2	Scratched material corrosion (rust)	3.2.2.1	**PPE:** • Use of safety vests, safety gloves, and safety shoes

		3.3	Ergonomic Hazards	3.3.1	Low Back Pain	3.3.1.1	**PPE:** • Back support belt
		3.4	Psychosocial Hazard	3.4.1	Fatigue	3.4.1.1	**Administrative:** • Establish a clear division of roles and responsibilities
4	Installation of Makara	4.1	Physical Hazards	4.1.1	Falling, tripping, slipping, hitting something and getting stuck	4.1.1.1	**Engineering Control:** • Installation of safety net, Usage of temporary flat-roof edge protection, and the use of iron scaffolding **Administrative:** • Work according to SOP working at height • First Aid Kit Provision • Safety Sign **PPE:** • Full body harness, lifeline, safety helmet, safety vest, safety gloves, safety shoes, N95 mask, and back support belt.
				4.1.2	Exposed UV Radiation	4.1.2.1	**PPE:** • Safety helmet, safety vest, safety glasses, and safety shoes
		4.2	Ergonomic Hazards	4.2.1	Low Back Pain	4.2.1.1	**PPE:** • Back support belt
		4.3	Psychosocial Hazard	4.3.1	Fatigue	4.3.1.1	**Administrative:** • Establish a clear division of roles and responsibilities
5	Dome Panel Installation	5.1	Physical Hazards	5.1.1	Falling, tripping, slipping, hitting something and getting stuck	5.1.1.1	**Engineering Control:** • Installation of safety net, Usage of temporary flat-roof edge protection, and the use of iron scaffolding **Administrative:** • Work according to SOP working at height • First Aid Kit Provision • Safety Sign **PPE:** • Full body harness, lifeline, safety helmet, safety vest, safety gloves, safety shoes, N95 mask, and back support belt.
				5.1.2	Exposed UV Radiation	5.1.2.1	**PPE:**

							• Safety helmet, safety vest, safety glasses, and safety shoes
	5.2	Chemical Hazards	5.2.1	Exposed Panel Paint	5.2.1.1	**PPE:** • Safety vest, safety gloves, and N95 mask
			5.2.2	Exposed Dust	5.2.2.1	**PPE:** • Safety helmet, safety vest, safety gloves, N95 mask, and safety shoes
	5.3	Ergonomic Hazards	5.3.1	Low Back Pain	5.3.1.1	**PPE:** • Back support belt
	5.4	Psychosocial Hazard	5.4.1	Fatigue	5.4.1.1	**Administrative:** • Establish a clear division of roles and responsibilities