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## Analysis Of Work Accident Risks in The Construction Of Sutet Steel Towers Using the JSA (Job Safety Analysis) Method

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### ABSTRACT

Construction activities inherently carry risks that can lead to accidents, causing delays, injuries, and financial losses. In high-risk projects such as High Voltage Direct Current (HVDC) transmission tower construction, inadequate safety practices and low awareness of Occupational Health and Safety (OHS) increase the potential for workplace accidents. This qualitative descriptive study analyzes potential work hazards in HVDC tower construction using secondary data and the Job Safety Analysis (JSA) method. Four main work processes—tower leg, body, and cross arm installation, and cable pulling—were assessed. Results show that all activities involve significant risks, with falls from height, falling objects, and puncture/scratch injuries being the most common. There are 6 activities in the Extreme category, 3 activities in the High category, 14 activities in the Moderate category, and 8 activities in the Low category. The main risks are falling from heights, being struck by materials, and injuries caused by work tools, which are exacerbated by low use of PPE, weak supervision, and lack of worker compliance. The solution to this problem lies in control priority, where there are four solutions: elimination, engineering, administration, and personal protective equipment control.

### 1. Introduction

Workplace safety is a basic human need that instinctively serves to protect us from dangers in our surroundings. In the construction sector, potential hazards are almost always present at every stage of work, requiring systematic risk management with a preventive and participatory approach [1]. Unfortunately, in some projects, the implementation of Occupational Safety and Health (OSH) is still considered an additional cost burden, so that



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basic facilities such as rest rooms, first aid kits, and routine health checks are often unavailable. This condition is exacerbated by weak supervision from the authorities who are supposed to ensure that OSH standards are met. In fact, workplace accidents can cause significant losses for workers and companies, so that risk control from the outset is important.

Risk control is only effective if hazards are accurately identified, risks are systematically evaluated, and controls are applied according to the level of danger. In recent research, methods such as HIRARC have proven effective in mapping hazards in construction work such as earthwork and geosynthetics [1]. In addition, research from Civilla shows that workers' knowledge of OSH significantly improves compliance with safety protocols in the field [2]. Without such a systematic approach, risk analysis is less targeted, and accident prevention is less effective [3]. Risk assessment is crucial in decision-making to determine whether risks are acceptable or need to be immediately controlled according to safety standards.

## **2. Research Method**

This study uses a descriptive approach with the Job Safety Analysis (JSA) method to identify potential hazards, evaluate risk levels, and determine appropriate control measures in SUTET tower construction. The research process consists of three stages: (1) hazard identification, (2) risk evaluation to classify risk levels, and (3) formulation of prevention and control measures [4].

### **2.1 Literature Review**

Previous studies have shown that the construction of SUTET steel towers involves significant occupational safety risks. One study highlighted that work accident risks commonly occur during tower body and cross arm installation, which require careful hazard identification and risk management [5].

### **2.2 Data Used**

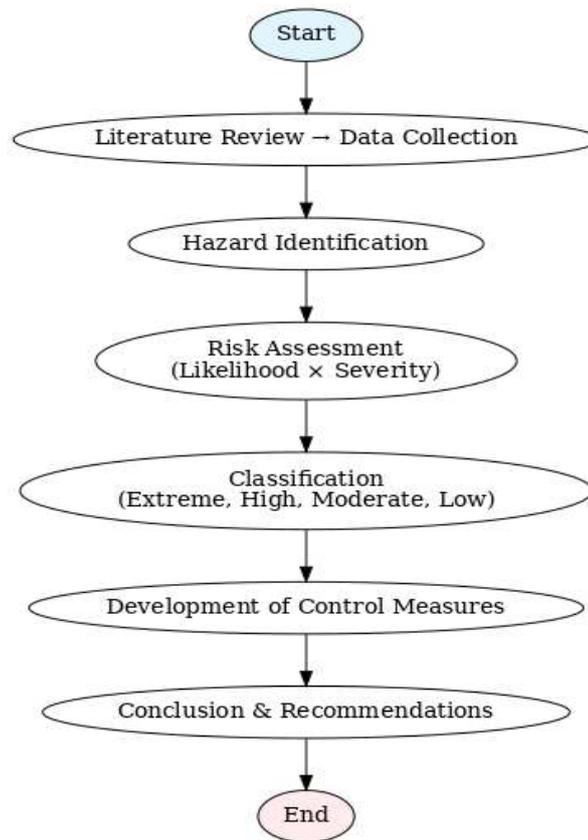
This study uses the Job Safety Analysis (JSA) method to identify potential hazards, assess risk levels, and determine control measures. Data was collected from SUTET tower construction activities, including the type of work (installation of tower legs, cross arms, cable pulling), a list of potential risks and their risk index values, and accident classifications such as falls, electric shocks, or burns [4].

### **2.3 Data Collection Methods**

Documentation and data coding studies were conducted by reviewing [4] to extract a list of tasks, potential hazards, and risk levels that had been calculated using the AS/NZS 4360 method, then classifying them based on the sequence of work stages to match the JSA analysis format.

## **3. Description and Technical**

This study employed a systematic approach to analyze work accident risks in SUTET steel tower construction through the Job Safety Analysis (JSA) method. The research was conducted in three main phases: hazard identification, risk assessment, and control measure development. The following is the flow of this research.



### 3.1 Identification of Work Steps

Break down the stages of activities based on tower construction work (e.g. lifting of materials, installation of tower parts, etc.).

### 3.2 Identify Potential Hazards

Match each work step with the hazard type from the previous journal [5].

### 3.3 Risk Analysis

Assess the likelihood and impact of the hazard (with reference to the risk index in the original journal).

### 3.4 Preventive Action Plan

Develop hazard prevention and control measures based on OHS principles and safe work practices. The object of research taken is on one of the jobs being carried out in the city of Surabaya, namely the Implementation of the 500kV Grati - TX Kalanganyar SUTET Construction. Below are shown the results of filling out the questionnaire with 20 respondents.

## 4. Result and Discussions

### Validation Test

Each stage of transmission tower installation work has the potential for accidents. The following table shows the risk variables for various work activities.

**Table 1.** Risk Variables in Various Worker Activities

Worker Activities		Risk Variables
X1	<i>Leg tower</i> installation process	1 Manual <i>box crane</i> falls on worker
		2 Cut rope hits worker
		3 Iron material / dropped bolts
		4 Eyes damaged during welding
		5 Worker falls from a height
		6 Skin exposed to sparks during welding
		7 Work equipment fell on a worker
		8 Worker's foot tripped on metal material

Worker Activities		Risk Variables	
X2	Body tower installation process	1	Manual <i>box crane</i> falls on worker
		2	Cut rope hits worker
		3	Iron material / dropped bolts
		4	Dehydration
		5	Worker falls from a height
		6	Hand injury from equipment while cutting conductor wire
		7	Foot injured by a hoe
X3	Cross arm installation process	1	Manual <i>box crane</i> falls on worker
		2	Cut rope hits worker
		3	Iron material / dropped bolts
		4	Dehydration
		5	Worker falls from a height
		6	Struck by lightning
		7	Work equipment fell on a worker
		8	Worker's foot tripped on metal material
X4	Transmission Cable Pulling Process	1	Worker falls from a height
		2	Dehydration
		3	Hand injured by rope
		4	Worker's foot tripped over a rope
		5	Worker's foot tripped over conductor wire
		6	Hand injury from equipment while cutting conductor wire
		7	Foot injured by a hoe
		8	Hands scratched by the end of the conductor wire
		9	Hand pierced by conductor wire
		10	<i>Roller</i> falls on worker
		11	Isolator falls on worker

Note: This table contains risk variables identified in various transmission tower installation work activities. Source: [4].

The following table shows the criteria for the likelihood of an incident occurring at work.

**Table 2.** Likelihood Criteria

Level	Criteria	Description Qualitative
1	Rarely Occurs	Incidents were expected to occur but only in critical circumstances
2	Small Chance happens	Incidents that are likely to occur at any given time
3	May occur	Incidents that will occur and are likely to occur somewhere
4	Most likely happens	Incidents that occur easily and regularly in all conditions
5	Almost certain to happen	Incidents that often occur in almost all conditions

Note: This table shows the criteria for the likelihood of an incident occurring. Source: [5].

The following table describes the severity of injuries resulting from workplace incidents, ranging from minor to fatal.

**Table 3.** Severity Criteria

Level	Description	Description of Injury Severity
1	Insignificant	Incidents that do not result in loss or injury to workers
2	Minor	Incidents that result in minor injuries, minor financial losses
3	Moderate	Incidents that result in serious injury and need for treatment and moderate financial loss
4	Major	Incidents that result in severe injuries and permanent disabilities as well as major financial losses and disrupt business continuity.
5	Catastrophic	Incidents that result in fatalities and severe financial losses.

Note: This table describes the severity of injuries resulting from work incidents, ranging from minor to fatal. Source: [5].

The following table presents a risk level scale based on a combination of likelihood and severity.

**Table 4.** Risk Level Scale

Scale		Severity				
		1	2	3	4	5
Likelihood	1	H	H	E	E	E
	2	M	H	H	E	E
	3	L	M	H	E	E
	4	L	L	M	H	E
	5	L	L	M	H	H

Note: This table shows the risk scale based on a combination of likelihood and severity. Source: [5].

The following table describes the results of risk analysis and the control measures that need to be taken for each potential hazard in the transmission tower installation process.

**Table 5.** Risk Analysis and Control Table

No	Jobs	Potential Hazard/ Injury	Consequences	Risk Matrix		Matrix Analysis	Control	Reference
				L	C			
<b>X1</b>	<b>Leg tower installation process</b>							
1.1	Manual box crane falls on worker	Falling on heavy materials, broken bones, serious injuries	Serious injury/death	4	5	E (20) - Extreme	- Use complete personal protective equipment (helmet, safety harness) - Install safety net in the work area - Define safety zones for workers - Coordination of trained lifting teams	[6] [7] [8] [9]
1.2	Cut rope hits worker	Rope cut, cut wounds	Moderate-heavy injury	3	4	H (12) - High	- Regular inspection of rope condition - Use rope with specifications according to SWL - Periodic rope replacement - Proper rigging taining	[9] [9] [9] [5]
1.3	Fallen iron/bolt material	Hit by small material, head injury	Mild-moderate injury	3	3	M (9) - Moderate	- Use a safety helmet - Install the toe board on the platform - Tool bag for small materials - Barricade the work area	[10] [11] [6] [7]
1.4	Eyes damaged during welding	Eye burn, blindness	Permanent injury	2	4	M (8) - Moderate	- Use a welding helmet - Safety glasses - Adequate ventilation	[12] [12] [13]

No	Jobs	Potential Hazard/ Injury	Consequences	Risk Matrix		Matrix Analysis	Control	Reference
				L	C			
							- Welding safety training	[5]
1.5	Worker falls from a height	Fall from tower, multiple fractures	Serious injury/death	3	5	E (15) - Extreme	- Full body harness + lanyard - Lifeline system - Safety platform with railing - Work at height training	[13] [6] [13] [13]
1.6	Skin exposed to sparks during welding	Skin burns	Minor injury	3	2	M (6) - Moderate	- Welding apron - Heat-resistant gloves - Closed work clothes - Fire blanket standby	[12] [7] [14] [13]
1.7	Work equipment falls on workers	Hit by tools, head/body injuries	Moderate injury	2	3	M (6) - Moderate	- Tool lanyard system - Secure tool bag - Hard hat for all workers - Organized tool management	[9] [5] [6] [9]
1.8	Worker's foot tripped on metal material	Falls, abrasions, sprains	Minor injury	4	2	M (8) - Moderate	- Good House-keeping - Adequate lighting - Safety boots - Organized material storage	[8] [15] [14] [8]
<b>X2 Tower Body Installation Process</b>								
2.1	Manual box crane falls on worker	Falling on heavy materials, broken bones	Serious injury/death	4	5	E (20) - Extreme	- Exclusion Zone during lifting - Radio communication between teams - Spotter to watch the area - Tag line for load control	[7] [8] [7] [5]
2.2	2.2 Cut rope hits worker	Cut/pinched rope	Moderate heavy injury	3	4	H (12) - High	- Daily inspection of ropes and rigging - Certificate for lifting equipment - Proper rigging technique - Backup safety system	[16] [6] [16] [7]
2.3	Fallen iron/bolt material	Falling material, head trauma	Mild moderate injury	3	3	M (9) - Moderate	- Debris net installation - Tool tethering system - Hard hat mandatory - Material securing method	[17] [17] [7] [18]
2.4	Dehydration	Fainting, heat stroke	Health problems	2	2	L (4) - Low	- Take regular breaks - Provision of	[18] [5]

No	Jobs	Potential Hazard/ Injury	Consequences	Risk Matrix		Matrix Analysis	Control	Reference
				L	C			
							drinking water	
							- Worker rotation	[6]
							- Monitor weather conditions	[8]
2.5	Worker falls from a height	Fall from tower, fatal injury	Serious injury/death	3	5	E (15) - Extreme	- Personal fall arrest system	[19]
							- Clear rescue plan	[20]
							- Medical standby	[20]
							- Regular safety inspection	[8]
2.6	Hand injury from welding equipment	Burns, cuts	Mild moderate injury	3	2	M (6) - Moderate	- Welding gloves	[7]
							- Tool maintenance	[14]
							- Proper tool handling	[14]
							- First aid kit available	[5]
2.7	Foot injured by a hoe	Puncture wounds, infection	Minor injury	2	2	L (4) - Low	- Safety boots with steel toe	[6]
							- Proper tool storage	[14]
							- Tool awareness training	[14]
							- Tetanus vaccination	[14]
<b>X3</b>	<b><i>Cross arm installation process</i></b>							
3.1	Manual box crane falls on worker	Falling under heavy loads	Serious injury/death	3	5	E (15) - Extreme	- Load chart compliance	[16]
							- Crane operator certification	[16]
							- Signal person training	[7]
							- Pre-lift safety meeting	[16]
3.2	Cut rope hits worker	Whiplash from rope break	Moderate heavy injury	3	4	H (12) - High	- Wire rope inspection program	[16]
							- Proper rigging accessories	[5]
							- Load testing certification	[6]
							- Emergency response plan	[20]
3.3	Fallen iron/bolt material	Struck by small materials	Minor injury	3	3	M (9) - Moderate	- Catch platform installation	[19]
							- Material handling procedure	[16]
							- PPE compliance monitoring	[14]
							- Housekeeping protocol	[14]
3.4	Dehydration	Loss of concentration	Risk of accident	2	2	L (4) - Low	- Heat illness prevention program	[7]
							- Scheduled rest breaks	[14]
							- Electrolyte replacement	[18]

No	Jobs	Potential Hazard/ Injury	Consequences	Risk Matrix		Matrix Analysis	Control	Reference
				L	C			
							- Work/rest cycle adjustment	[5]
3.5	Worker falls from a height	Falling from the structure	Fatal injury	3	5	E (15) - Extreme	- 100% tie-off policy - Fall protection inspection - Rescue equipment available - Emergency medical response	[6] [19] [20] [20]
3.6	Struck by lightning	Electric shock, burns	Serious injury/death	1	5	M (5) - Moderate	- Weather monitoring system - Lightning protection system - Work suspension protocol - Emergency shelter available	[8] [8] [7] [8]
3.7	Work equipment fell on a worker	Struck by tools	Mild moderate injury	2	3	M (6) - Moderate	- Tool tethering mandatory - Tool inspection program - Proper tool selection - Worker awareness training	[9] [5] [6] [14]
3.8	Worker's foot tripped on metal material	Falls, sprains	Minor injury	2	2	L (4) - Low	- Workplace organization - Adequate lighting - Non-slip footwear - Regular site cleanup	[14] [15] [14] [14]
X4	<b>Transmission Cable Pulling Process</b>							
4.1	Worker falls from a height	Fall from tower/structure	Fatal injury	4	1	E (15) - Extreme	- Comprehensive fall protection  - Rescue plan implementation - Medical team standby - Fall protection training	[7]  [20] [20] [5]
4.2	Dehydration	Heat exhaustion	Health problems	2	2	L (4) - Low	- Hydration monitoring - Cool-down areas - Work schedule adjustment - Health monitoring	[6] [18] [18] [14]
4.3	Hand injured by rope	Rope burn, cuts	Minor injury	3	2	M (6) - Moderate	- Proper gloves selection - Rope handling technique - Regular glove replacement	[14] [9] [7]

No	Jobs	Potential Hazard/ Injury	Consequences	Risk Matrix		Matrix Analysis	Control	Reference
				L	C			
							- Hand protection training	[12]
4.4	Worker's foot tripped over rope	Fall, ankle sprain	Minor injury	2	2	L (4) - Low	- Cable management system - Clear walkways - Proper cable routing - Area marking/warning	[13] [5] [6] [8]
4.5	Worker's foot tripped over conductor wire	Snagging, falling	Mild moderate injury	2	2	L (4) - Low	- Cable protection covers - Temporary cable supports - Path planning - Visual inspections	[13] [13] [16] [16]
4.6	Hand injury from equipment while cutting conductor wire	Cuts, stab wounds	Mild moderate injury	2	3	M (6) - Moderate	- Cut-resistant gloves - Proper cutting tools - Tool maintenance program - Safe cutting procedures	[7] [16] [16] [5]
4.7	Leg injured by a hoe	Stab wound of the leg	Minor injury	1	2	L (2) - Low	- Steel-toed boots - Tool storage protocol - Ground conditions check - Basic first aid available	[6] [8] [16] [20]
4.8	Hand exposed to the end of the conductor wire	Hand stab wounds	Minor injury	2	2	L (4) - Low	- End protection caps - Handling procedures - Puncture resistant gloves - Awareness training	[19] [16] [7] [14]
4.9	Hand pierced by conductor wire	Deep stab wounds	Mild moderate injury	2	3	M (6) - Moderate	- Wire end management - Protective equipment - Safe handling technique - Immediate medical care	[19] [5] [6] [20]
4.10	A cable fell on a worker	Struck by heavy cables	Moderate injury	2	3	M (6) - Moderate	- Cable support systems - Load distribution - Team coordination - Temporary restraints	[19] [17] [16] [11]
4.11	Falling insulator regarding workers	Struck by an insulator	Mild moderate injury	2	3	M (6) - Moderate	- Secure attachment method - Material handling plan - Personal protective equipment - Safe work	[7] [18] [21] [5]

No	Jobs	Potential Hazard/ Injury	Consequences	Risk Matrix		Matrix Analysis	Control	Reference
				L	C			

procedures

Note: This table summarizes potential hazards, consequences, risk matrix analysis results, and control measures. Source: Research Data (2025)

**SUMMARY OF RISK CATEGORIES**

Extreme Risk (E): 6 activities

- Requires work stoppage until risk is mitigated
- Immediate implementation of controls is required
- Senior management review and approval

High Risk (H): 3 activities

- Needs attention from senior management
- Specific action plan required
- Close monitoring during implementation

Moderate Risk (M): 14 activities

- Acceptable with existing controls
- Improved control recommended
- Periodic review is required

Low Risk (L): 8 activities

1. Acceptable with minimal control
2. Regular monitoring
3. Incident/near miss documentation

**CONTROL PRIORITY**

1. Elimination Control:

- Use cranes with automatic safety systems
- Substitution of hazardous materials with safer ones

2. Engineering Control:

- Safety net and catch platform installation
- Integrated fall protection system
- Lightning protection system
- Automated material handling system

3. Administrative Control:

- Permit to work system
- Worker training and certification
- Standard Operating Procedures (SOP)
- Emergency response plan
- Weather monitoring protocol

4. Personal Protective Equipment (PPE):

- Full body harness system
- Hard hat and safety boots
- Cut-resistant and heat-resistant gloves
- Welding protection equipment
- High-visibility clothing

**5. Conclusion and Suggestion**

**5.1 Conclusion**

Research using the Job Safety Analysis (JSA) method shows that all stages of SUTET tower construction have potential hazards. From the risk classification, there are 6 activities in the Extreme category, 3 activities in the High category, 14 activities in the Moderate category,

and 8 activities in the Low category. The main risks are falling from heights, being struck by materials, and injuries caused by work tools, which are exacerbated by low use of PPE, weak supervision, and lack of worker compliance. The solution to this problem lies in control priority, where there are four solutions: elimination, engineering, administration, and personal protective equipment control.

## 5.2 Suggestion

It is recommended to implement a fall protection system, accompanied by routine equipment inspections, improved discipline in the use of PPE, and worker training and certification. In addition, work scheduling is also important to prevent fatigue and reduce risks due to weather conditions. With these measures, the rate of workplace accidents can be reduced, thereby ensuring greater project safety.

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