

WORK ACCIDENT ANALYSIS USING FISHBONE DIAGRAM AND SYSTEMATIC CAUSE ANALYSIS TECHNIQUE (SCAT) AS A BASIS FOR IMPROVING WORKER SUPERVISION AT PT XYZ

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Abstract

Work accidents in manufacturing industries remain an important occupational safety issue because production activities involve manual handling, lifting operations, moving materials, heavy equipment, and work environments with potential pinch points. PT XYZ is a precast concrete utility pole manufacturer that experienced five work accident cases during July-August 2025, including hands caught between objects, a concrete pole striking a crane cabin, a hand crushed by a wire coil, and a palm punctured by wire. This study aimed to identify accident contributing factors, analyze their root causes, and formulate improvements to worker supervision to prevent recurrence. A descriptive qualitative approach was applied using observation, interviews with injured workers, witnesses, and Health, Safety, and Environment personnel, Focus Group Discussion, company accident reports, and source triangulation. The Fishbone Diagram was used to classify contributing factors, while the Systematic Cause Analysis Technique (SCAT) was used to trace accident events from contact, immediate causes, basic causes, to recommended controls. The findings show that the five accidents were influenced by human, method, machine/equipment, environmental, material, and management factors. The dominant problems were weak supervision, absence of detailed standard operating procedures, inadequate communication and confirmation during lifting and transport activities, unsafe work positioning, insufficient warning devices, and inadequate preventive maintenance. The SCAT results indicate that unsafe acts and unsafe conditions were strongly linked to job factors, particularly inadequate work standards, equipment maintenance, task observation, and safety control. This study recommends an integrated worker supervision system consisting of pre-operational supervision, operational supervision, and post-operational supervision supported by toolbox meetings, standardized communication signals, safe work procedures, critical equipment inspection, preventive maintenance, warning systems, exclusion zones, and continuous incident learning

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1. Introduction

Occupational accidents remain a major concern in industrial activities because workers interact with machines, materials, tools, energy sources, and workplace conditions that can cause injuries when risk controls are not properly implemented. Global and national accident trends show that accident prevention still requires systematic improvement. In Indonesia, work accident claims increased from 234,370 cases in 2021 to 297,725 cases in 2022, then continued to 370,747 cases in 2023 and 462,241 cases in 2024. These figures indicate that accident

prevention cannot rely only on individual worker awareness but must be supported by structured hazard identification, safe work standards, supervision, and continuous corrective actions.

The same issue was found at PT XYZ, a manufacturing company that produces precast concrete utility poles. The production process still involves manual activities and material handling, including wire caging, moulding and demoulding, lifting, spinning, steam curing, and stock-yard loading and unloading. During July-August 2025, five work accident cases occurred in the factory area. The accidents involved caught-between injuries, struck-by events, a wire coil crushing injury, and a wire puncture injury. These cases were concentrated in production, wire caging, and stock yard areas.

Preliminary information from PT XYZ indicated that the accidents were associated with low safety awareness, inadequate standard operating procedures, weak communication, insufficient job-specific training, unsuitable lifting and transport equipment, and supervision that had not been fully effective. Therefore, accident investigation needed to move beyond the visible injury event and examine the relationship between unsafe acts, unsafe conditions, job factors, and management controls.

Fishbone Diagram and Systematic Cause Analysis Technique (SCAT) were selected because both methods support structured accident analysis. Fishbone Diagram helps organize contributing factors into categories such as human, machine, method, environment, material, and management. SCAT then deepens the analysis by identifying the loss event, contact, immediate causes, basic causes, and control actions. The novelty of this study lies in combining these methods to develop a worker supervision improvement model for a precast concrete utility pole factory, a context that has not been widely discussed in previous occupational safety studies.

This study aimed to identify contributing factors of work accidents at PT XYZ using Fishbone Diagram, analyze root causes using SCAT, and propose improvements to the worker supervision system to prevent similar accidents in the future.

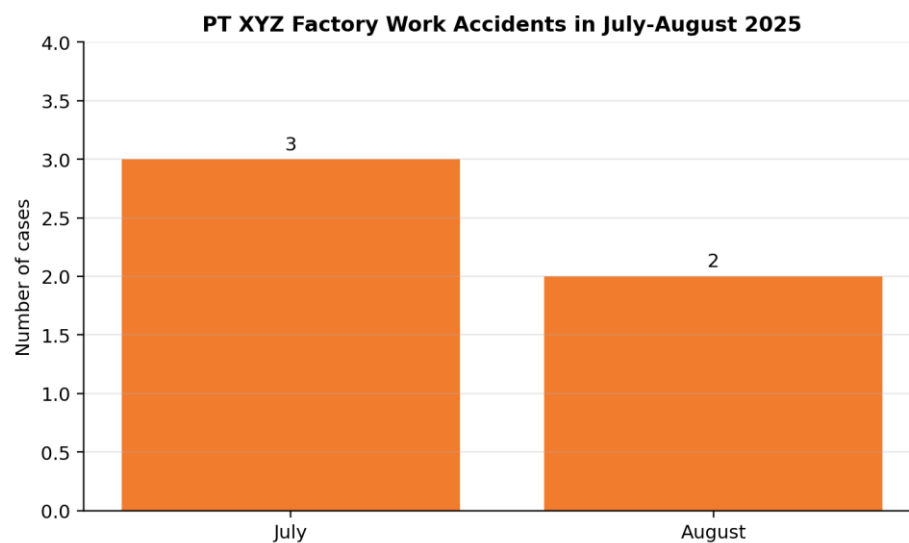


Figure 1. Work accident cases at PT XYZ by month

Source: Processed from PT XYZ accident data, 2026

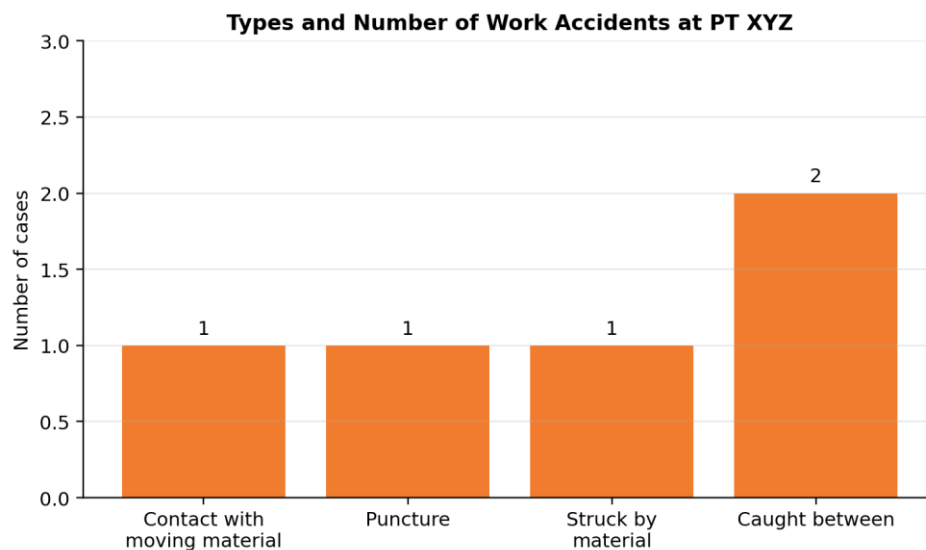


Figure 2. Types and number of work accidents at PT XYZ

Source: Processed from PT XYZ accident data, 2026

2. Method

A. Research Design and Object

This study used a descriptive qualitative design to analyze five work accident cases at PT XYZ. The object of analysis was the accident process in factory areas, particularly the stock yard, production area, and wire caging area. The unit of analysis consisted of accident chronology, unsafe acts, unsafe conditions, job factors, existing controls, and supervision weaknesses found in each case.

B. Data Collection and Validation

interviews with injured workers, accident witnesses, and HSE personnel, and Focus Group Discussions (FGDs) involving workers, supervisors, and HSE personnel. Secondary data were collected from the company's occupational accident investigation reports and related documentation. To ensure the credibility and validity of the findings, source triangulation was employed by comparing and validating information obtained from the injured worker, witnesses, and HSE personnel through interviews. The interview findings were subsequently cross-checked with company accident records to verify the consistency of the accident chronology, contributing factors, and underlying causes. Only information that demonstrated consistency across these sources was used as the basis for the Fishbone Diagram and Systematic Cause Analysis Technique (SCAT) analyses.

C. Data Analysis Procedure

The analysis was performed in four main stages. First, the accident chronology was arranged from the available evidence. Second, contributing factors were grouped with Fishbone Diagram. Third, SCAT was applied to identify the type of contact, immediate causes, basic causes, and control actions. Fourth, the findings were integrated into recommendations for worker supervision improvement. The simplified research flow is presented in Figure 3.

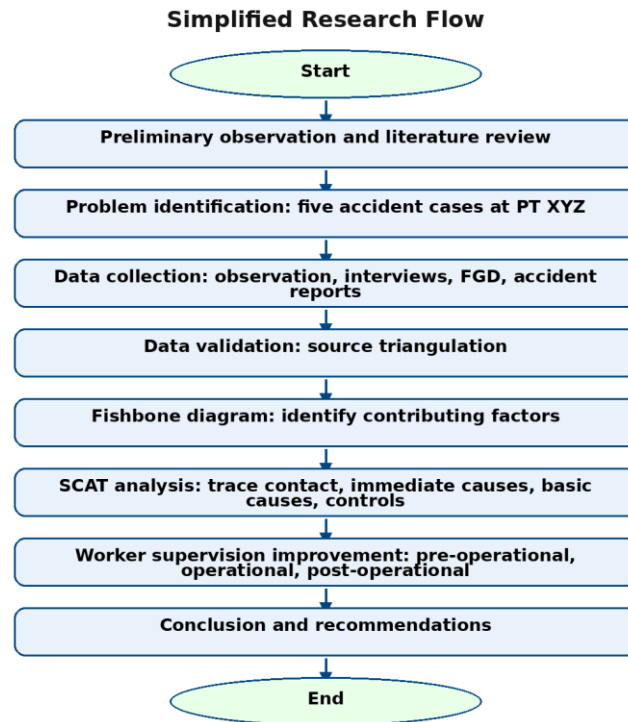


Figure 3. Simplified research flow

Source: Processed by the author based on the research procedure, 2026

3. Result and Discussion

A. Overview of Work Accident Cases

Five accident cases were analyzed in this study. The cases occurred within a relatively short period, namely July-August 2025, which indicates that the factory needed immediate evaluation of supervision, work procedures, communication, and equipment readiness. Table 1 summarizes the accident cases used as the basis for the Fishbone and SCAT analyses.

Table 1. Summary of work accident cases at PT XYZ

No.	Time and Area	Accident Event	Consequence
1	07 July 2025, 10:30 WITA - Stock yard	Hand caught between crowbar and concrete pole	Palm bruise; temporary work interruption
2	16 July 2025, 13:55 WITA - Production	Hand caught between mould and mould clamp	Right middle finger laceration; 4 workdays lost
3	25 July 2025, 13:55 WITA - Stock yard	Concrete pole struck mobile crane cabin	Cabin damage; minor injury from broken glass; 1 day lost
4	20 August 2025, 14:50 WITA - Wire caging	Hand crushed by wire coil during forklift lowering	Left middle finger laceration and fracture; 1 week lost
5	21 August 2025, 15:25 WITA - Production	Palm punctured by snapped wire during stretching	Palm laceration; surgery; 2 weeks lost

Source: Processed from PT XYZ accident data, 2026

B. Case 1: Worker Hand Caught Between Crowbar and Concrete Pole

The first accident occurred on 07 July 2025 at 10:30 WITA in the stock yard during loading and unloading of concrete utility poles. The worker shifted a concrete pole placed on a transport vehicle by inserting a crowbar

between the poles and applying force to move the pole. Because the truck bed had side walls, the worker had limited movement and could not maintain an optimal body position and grip. When the grip slipped, the worker's hand entered the pinch point and was caught between the crowbar and the pole, causing a palm bruise.

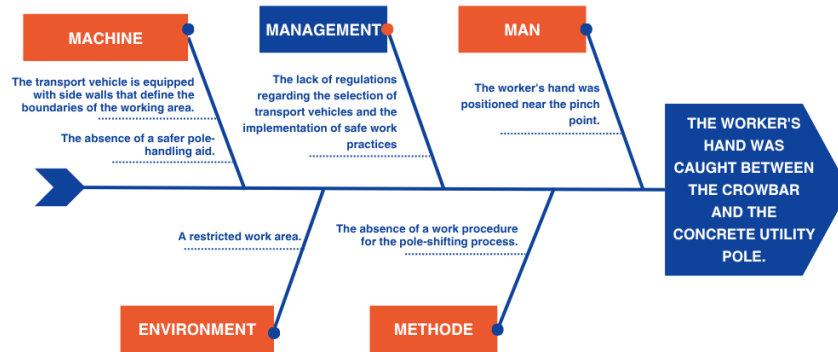


Figure 4. Fishbone diagram for Case 1

Source: Adapted and translated from the thesis illustration, 2026

Triangulation of information obtained from the injured worker, witness, and HSE personnel consistently identified several key contributing factors, including restricted workspace, the use of an unsafe shifting method, the absence of a safer engineered shifting aid, and the lack of a documented work procedure. The consistency of these findings across all respondents strengthens the reliability of the accident investigation results. As illustrated in the Fishbone Diagram (Figure 5), the incident cannot be attributed solely to the worker's positioning during the shifting activity. Instead, it resulted from the interaction of multiple systemic factors, particularly the inappropriate selection of the transport vehicle, the absence of engineered controls to facilitate safer shifting operations, insufficient supervisory oversight, and the lack of standardized operating procedures to ensure safe work practices.

CONTACT		IMMEDIATE CAUSE		BASIC CAUSE		CONTROL
Caught in / Between	→	Unsafe working position while using a crowbar	→	Limited work space, inadequate supervision, and lack of work procedures	→	Develop work procedures, use proper tools, and improve supervision

Figure 5. SCAT diagram for Case 1

Source: Processed from interview, FGD, and accident report data, 2026

The SCAT analysis classified the contact as a caught-between/pinch-point event, indicating that the worker's hand was trapped between the crowbar and the utility pole during the shifting operation. The immediate causes identified were the worker's hand being positioned within the pinch point while using a crowbar in a confined workspace, which significantly increased the likelihood of hand injury. The basic causes were associated with deficiencies in the work management system, including the absence of standardized work procedures, inadequate provision of suitable tools for safely shifting the utility pole, and insufficient supervisory oversight to ensure that safe work practices were consistently implemented. Based on these findings, several corrective measures are recommended, including the provision of safer engineered pole-shifting devices, the development and

implementation of a standard operating procedure (SOP) for loading and unloading activities, the establishment of clear guidelines for vehicle selection and pole arrangement, and the strengthening of pre-task planning and ongoing supervisory monitoring throughout the operation.

C. Case 2: Worker Hand Caught Between Mould and Mould Clamp

The second accident occurred on 16 July 2025 at 13:55 WITA in the production area. A new worker received an instruction from the leader to install a mould clamp, while at the same time the overhead crane operator received an instruction to lift the mould. The worker held and positioned the clamp on the mould body. The operator then lifted the mould without confirming whether the area was safe and whether the worker had moved away from the danger zone. As the mould started to move, the worker's hand was caught between the mould and the clamp, resulting in a laceration to the right middle finger and four lost workdays.

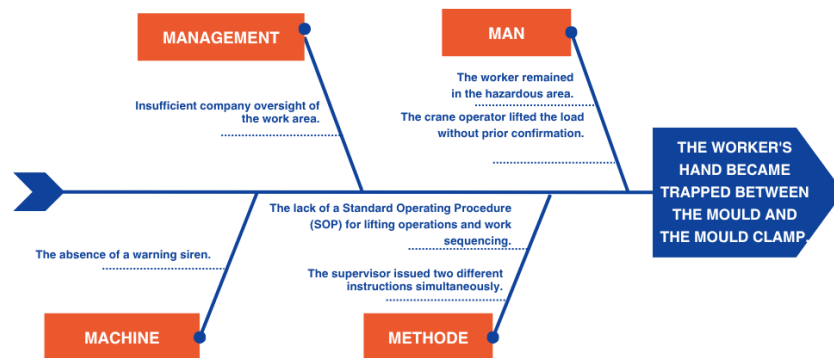


Figure 6. Fishbone diagram for Case 2

Source: Adapted and translated from the thesis illustration, 2026

The primary issue identified in this case was ineffective communication and the absence of a clearly defined work sequence during the lifting operation. Information gathered through interviews indicated that the worker and the overhead crane operator received different instructions simultaneously, creating confusion regarding the timing and execution of the lifting activity. Furthermore, no standardized communication or confirmation procedure was implemented to verify that all personnel were in safe positions before the load was lifted. This communication breakdown increased the likelihood of unsafe actions occurring during the operation. In addition, the absence of an audible warning siren on the overhead crane limited the worker's ability to recognize the initiation of the lifting process, reducing situational awareness and contributing to the occurrence of the accident.

CONTACT		IMMEDIATE CAUSE		BASIC CAUSE		CONTROL
Caught in / Between	→	Worker remained in the danger zone during lifting operation	→	Poor communication, inadequate training, and absence of lifting procedures	→	Implement lifting SOP, improve communication, and provide training

Figure 7. SCAT diagram for Case 2

Source: Processed from interview, FGD, and accident report data, 2026

The SCAT analysis classified the incident as a caught-between contact, indicating that the worker's hand was trapped during the lifting operation. The immediate causes included the lifting activity being initiated without prior confirmation that the work area was clear, the worker remaining within the lifting zone while the load was being moved, and the absence of an effective audible warning system to alert personnel before the lifting process

commenced. These conditions collectively increased the worker's exposure to the moving load and contributed directly to the accident. The basic causes were associated with deficiencies in the work management system, including the absence of a comprehensive lifting standard operating procedure (SOP), inadequate communication protocols for coordinating lifting activities, weak supervisory control over changes in work-area conditions, and insufficient orientation and safety training for newly assigned workers. Based on these findings, recommended corrective actions include developing and implementing a comprehensive lifting SOP, conducting mandatory pre-lift briefings, establishing standardized signal communication and confirmation procedures before every lifting operation, strengthening direct supervisory oversight throughout the activity, and installing an audible warning siren on the overhead crane to improve hazard awareness and worker safety.

D. Case 3: Concrete Utility Pole Struck the Mobile Crane Cabin

The third accident occurred on 25 July 2025 at 13:55 WITA in the stock yard. During loading and unloading, a mobile crane lifted a concrete utility pole to be moved to the storage area. The suspended pole became caught on the crane outrigger. The operator attempted to release the snagged pole by raising the crane boom. This action made the load unstable, causing the pole to swing toward the mobile crane cabin and strike the glass. Part of the pole entered the operator cabin area, damaging the cabin and causing minor injury to the operator from broken glass.

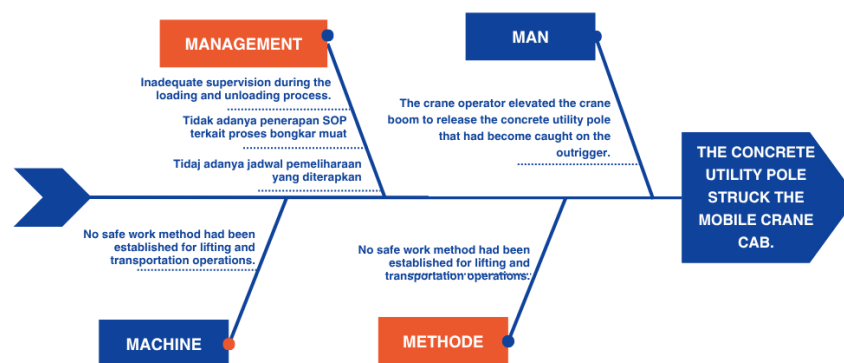


Figure 8. Fishbone diagram for Case 3

Source: Adapted and translated from the thesis illustration, 2026

Triangulation of information obtained from the injured worker, witness, and HSE personnel confirmed that the accident was associated with an unsafe response to an abnormal lifting condition, the continued operation of the mobile crane despite an overheating condition, and the absence of preventive maintenance practices to ensure equipment reliability. The consistency of these findings across multiple sources strengthens the validity of the identified causal factors. These results indicate that the root cause of the accident extended beyond the operator's immediate actions and was closely related to deficiencies in the work management system, particularly the lack of a standardized procedure for handling snagged suspended loads, inadequate decision-making regarding equipment operation under abnormal conditions, and weak control over equipment readiness through systematic inspection and preventive maintenance.

CONTACT		IMMEDIATE CAUSE		BASIC CAUSE		CONTROL
Struck By Moving Object	→	Crane continued operating despite equipment malfunction	→	Inadequate preventive maintenance and	→	Implement preventive maintenance, routine

				insufficient supervisio		inspections, and operator training
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Figure 9. SCAT diagram for Case 3

Source: Processed from interview, FGD, and accident report data, 2026

The SCAT analysis classified the incident as a struck-by event resulting from uncontrolled movement of the suspended load. The immediate causes included the decision to raise the crane boom in an attempt to release a snagged load and the continuation of lifting operations despite the mobile crane operating in a suboptimal condition due to overheating. These actions increased the instability of the suspended load and ultimately led to the impact event. The basic causes were associated with deficiencies in the work management system, including the absence of a specific procedure for responding to abnormal lifting conditions, inadequate implementation of preventive maintenance to ensure equipment reliability, and weak supervisory oversight of equipment condition prior to and during lifting operations. Based on these findings, several corrective measures are recommended, including the implementation of stop-work authority whenever a suspended load becomes snagged, the development of a dedicated standard operating procedure (SOP) for loading, unloading, and abnormal load handling, routine pre-use and periodic equipment inspections, a structured preventive maintenance program, and direct supervisory task observation during high-risk lifting activities to ensure compliance with safe work practices.

E. Case 4: Worker Hand Crushed by Wire Coil

The fourth accident occurred on 20 August 2025 at 14:50 WITA in the wire caging area during wire coil transfer using a forklift. The injured worker directed the forklift operator and adjusted the support at the placement location. The worker instructed the operator regarding load lowering, but the instruction was not understood or was not responded to properly. While the worker was still adjusting the support, the operator lowered the wire coil without confirmation. The worker's left middle finger was caught between the wire coil and the support, causing a laceration and fracture and resulting in one lost workweek.

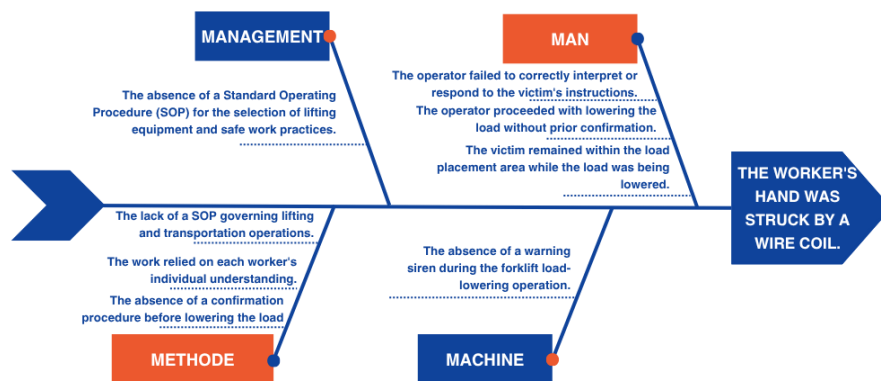


Figure 10. Fishbone diagram for Case 4

Source: Adapted and translated from the thesis illustration, 2026

This case demonstrates how occupational accidents can occur in the absence of a standardized communication protocol between the forklift operator and the ground worker during load-handling operations. The lifting and transport activities relied primarily on habitual work practices and individual interpretation rather than clearly defined procedures, increasing the potential for miscommunication and inconsistent execution of critical tasks. As a result, the operator initiated the load-lowering process without receiving explicit confirmation that the ground worker had moved to a safe position. Furthermore, the absence of an audible warning siren on the forklift further diminished the effectiveness of hazard communication by providing no additional alert to personnel that

the load was about to be lowered. Collectively, these deficiencies reduced situational awareness and contributed to the occurrence of the accident.

The SCAT analysis classified the incident as a caught/crushed-by event, indicating that the worker's hand was trapped between the load and the supporting structure during the load-lowering process. The immediate causes included lowering the load without first confirming that the placement area was clear, the worker remaining within the designated load placement zone, and the absence of an effective warning signal to notify personnel before the lowering operation commenced. These conditions collectively increased the worker's exposure to the moving load and directly contributed to the injury. The basic causes were associated with deficiencies in the work management system, including the absence of a documented standard operating procedure (SOP) for lifting and transport activities, inadequate communication and confirmation protocols between the operator and ground personnel, insufficient operator understanding of safe load-handling procedures, and inadequate provision of warning devices to support hazard communication. Based on these findings, recommended corrective measures include developing and implementing a documented lifting and transport SOP, establishing exclusion zones during load-lowering operations, enforcing mandatory pre-lowering confirmation between the operator and ground personnel, assigning a trained spotter or rigger to coordinate lifting activities, installing an audible warning siren on the forklift, and strengthening direct supervisory oversight to ensure compliance with established safe work procedures.

CONTACT		IMMEDIATE CAUSE		BASIC CAUSE		CONTROL
Caught in / Between	→	Worker remained in the loading area during load lowering	→	Lack of warning system, inadequate supervision, and unsafe work procedure	→	Install warning alarms, establish safe work procedures, and improve supervision

Figure 11. SCAT Diagram for Case 4

Source: Processed from interview, FGD, and accident report data, 2026

F. Case 5: Worker Palm Punctured by Wire

The fifth accident occurred on 21 August 2025 at 15:25 WITA in the production area during the wire stretching process. Before stretching, the wire end had undergone a heating process to support pulling. However, the heating result was inadequate because components of the combustion machine were worn and the bushing was loose. The weakened wire end could not withstand the tensile force during stretching. When the worker adjusted the tension ring, the stretched wire suddenly snapped and struck the worker's palm, causing a laceration and requiring medical treatment and surgery. The event resulted in two lost workweeks.

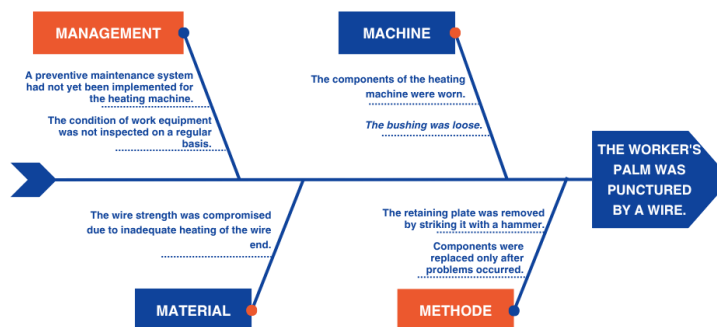


Figure 12. Fishbone diagram for Case 5

Source: Processed from interview, FGD, and accident report data, 2026

Unlike the previous cases, which were predominantly associated with communication failures during lifting operations, this incident was primarily attributed to deficiencies in equipment condition and maintenance management. The investigation revealed the use of worn machine components, a loose bushing, inadequate heating of the wire end prior to the stretching process, and the practice of replacing components only after they had failed. These findings indicate that preventive maintenance activities and pre-use equipment inspections were not effectively implemented to ensure the reliability and integrity of critical equipment. Consequently, the root cause of the accident extended beyond the immediate equipment failure and was closely associated with weaknesses in the maintenance management system, including inadequate planning of preventive maintenance, insufficient monitoring of equipment condition, and ineffective supervisory control over equipment readiness before production activities commenced.

CONTACT		IMMEDIATE CAUSE		BASIC CAUSE		CONTROL
Contact With Equipment Failure	→	Worn burner components and loose bushing caused wire failure	→	Inadequate preventive maintenance and lack of routine inspection	→	Conduct preventive maintenance, routine inspections, and timely component replacement

Figure 13. SCAT diagram for Case 5

Source: Adapted and translated from the thesis illustration, 2026

The SCAT analysis classified the incident as an equipment/material failure event, indicating that the injury resulted from the failure of the wire during the stretching process rather than from direct human contact with moving equipment. The immediate causes included the continued use of worn machine components, a loose bushing that compromised equipment stability, inadequate wire-end strength resulting from an ineffective heating process, and the subsequent failure of the wire under tensile loading. These conditions collectively reduced the structural integrity of the wire and increased the likelihood of sudden failure during operation. The basic causes were associated with deficiencies in the maintenance management system, including inadequate implementation of preventive maintenance, insufficient periodic inspection of critical equipment components, the absence of clearly defined component replacement criteria, and inadequate monitoring of equipment condition throughout its service life. Based on these findings, recommended corrective measures include implementing routine inspections of critical components, establishing a structured preventive maintenance schedule, adopting condition monitoring practices to detect equipment degradation at an early stage, developing clear acceptance and replacement criteria for wear-prone components, and enforcing stop-work procedures whenever the quality of the wire end fails to meet the specified acceptance criteria before stretching operations commence.

G. Integrated Fishbone and SCAT Findings

Across the five cases, the Fishbone Diagram showed that management and method factors appeared in all accident cases. Human factors appeared in four cases, machine/equipment factors appeared in four cases, environmental factors appeared in one case, and material factors appeared in one case. This pattern indicates that the dominant problem was not only unsafe worker behavior but a broader weakness in work planning, procedure availability, equipment readiness, communication control, and field supervision.

Table 2. Integrated summary of Fishbone Diagram findings

Case	Main factor categories	Key contributing factors
Case 1	Human, machine/equipment, method, environment, management	Hand was close to pinch point; truck bed restricted movement; no safe shifting aid; no SOP; no rule for transport selection.
Case 2	Human, machine/equipment, method, management	Worker remained in danger zone; crane lifted without confirmation; no siren; no lifting SOP; conflicting instructions; weak supervision.
Case 3	Human, machine/equipment, method, management	Operator attempted to release a snagged pole by lifting the boom; crane overheated; no safe abnormal-load method; weak maintenance and supervision.
Case 4	Human, machine/equipment, method, management	Forklift lowered without confirmation; worker stayed in placement area; no warning siren; no lifting/transport SOP; work relied on habit.
Case 5	Machine/equipment, material, method, management	Worn combustion machine components, loose bushing, inadequate wire-end heating, replacement after failure, weak preventive maintenance.

Source: Processed from PT XYZ accident data, 2026

SCAT strengthened this finding by showing that immediate causes were repeatedly connected to basic causes related to job factors. Inadequate work standards, inadequate supervision, inadequate maintenance, lack of warning devices, weak task observation, and lack of standard communication methods appeared repeatedly. Table 3 presents the integrated SCAT summary for all accident cases.

Table 3. Integrated summary of SCAT analysis - contact and immediate causes

Work Activity	Contact	Immediate Causes
Pole shifted using crowbar	Caught between / pinch point	Hand near pinch point, restricted workspace, use of crowbar as shifting aid
Mould lifting	Caught between mould and clamp	Crane lifted before area was clear; worker stayed in lifting zone; no warning signal
Mobile crane loading/unloading	Struck by swinging concrete pole	Operator raised boom to release snagged pole; unstable suspended load; crane overheated
Forklift wire coil transfer	Caught/crushed by lowered wire coil	Forklift lowered without confirmation; worker remained in placement area; no siren
Wire stretching	Equipment/material failure	Worn combustion machine, loose bushing, weak wire end, wire snapped under tension

Source: Processed from PT XYZ accident data, 2026

Table 4. Integrated summary of SCAT analysis - basic causes and controls

Work Activity	Basic Causes	Recommended Controls
Pole shifted using crowbar	No safe shifting tool, no SOP for pole shifting, inadequate selection of transport vehicle, weak supervision	Provide safe pole-shifting aids, regulate loading arrangements, issue SOP, supervise unloading activity
Mould lifting	No lifting SOP, simultaneous/conflicting instructions, weak communication standard, inadequate supervision	Lifting SOP, pre-lift confirmation, standardized hand signals, crane siren, direct supervision
Mobile crane loading/unloading	No abnormal-load procedure, insufficient preventive maintenance,	Stop-work rule for snagged loads, preventive maintenance,

Forklift wire coil transfer	weak supervision of equipment condition No lifting-transport SOP, poor communication and confirmation process, inadequate warning system	loading/unloading SOP, equipment inspection Forklift siren, exclusion zone, confirmation protocol, spotter/rigger roles, SOP and supervision
Wire stretching	Preventive maintenance not optimal, no periodic inspection, no replacement criteria	Inspection of critical components, preventive maintenance schedule, equipment monitoring, replacement criteria

Source: Processed from PT XYZ accident data, 2026

H. Proposed Improvement of Worker Supervision System

The proposed supervision system was designed based on the repeated weaknesses found in the five accident cases. The recommended approach divides supervision into three stages: pre-operational, operational, and post-operational supervision. This structure ensures that supervision is not only performed after an accident occurs but begins before work starts, continues during high-risk activities, and ends with evaluation and feedback for improvement.

Table 5. Proposed worker supervision improvement system

Supervision Stage	Main Focus	Application at PT XYZ
Pre-operational supervision	Confirm worker readiness, work permits or job assignment, safe tool selection, equipment inspection, hazard identification, availability of SOP, and toolbox meeting/safety talk.	The supervisor/leader checks whether lifting equipment, forklift, crane, transport vehicle, combustion machine, bushing, wire, and work area are safe before work starts.
Operational supervision	Monitor compliance with SOP, communication signals, exclusion zone, body position, load movement, abnormal conditions, and equipment condition during work.	Work is stopped when a load is snagged, a worker is inside the drop zone, equipment overheats, warning devices do not function, or wire quality is doubtful.
Post-operational supervision	Evaluate task completion, record unsafe acts/conditions, investigate incidents and near misses, review maintenance findings, and update SOP/training needs.	Findings become feedback for maintenance schedules, replacement criteria, communication protocols, and future supervision planning.

Source: Processed from PT XYZ accident data, 2026

Pre-operational supervision should ensure that workers understand the task, the work method is clearly defined, equipment is safe and suitable, and the work area has been checked before the activity starts. For lifting and material handling activities, this means confirming the availability of SOP, communication signal, warning device, exclusion zone, and suitable lifting or shifting aids. Operational supervision should ensure that workers follow the procedure during the task. The supervisor must stop the job when the load is unstable, a worker remains in the danger zone, the operator does not receive clear confirmation, or equipment condition is abnormal. Post-operational supervision should document unsafe conditions, near misses, maintenance findings, and corrective actions so that the organization can learn from each task and prevent recurrence.

4. Conclusion

The Fishbone Diagram analysis of five accident cases at PT XYZ showed that the causes of work accidents were related to human, method, machine/equipment, environmental, material, and management factors. Management and method factors were the most dominant because all five cases involved weak supervision, insufficient SOP, inadequate work planning, or inadequate maintenance control.

The SCAT analysis showed that each accident involved a relationship between immediate causes and basic causes. Immediate causes included unsafe worker positioning, lifting without confirmation, unstable load movement, inadequate warning, and equipment or material failure. Basic causes were mainly related to job

factors, such as inadequate work standards, inadequate communication control, inadequate task observation, insufficient preventive maintenance, and lack of equipment inspection or replacement criteria.

The recommended improvement is an integrated worker supervision system consisting of pre operational, operational, and post-operational supervision. Pre-operational supervision focuses on readiness of workers, tools, equipment, SOP, hazard identification, and safety briefing. Operational supervision focuses on compliance with SOP, communication, exclusion zones, equipment condition, and stop-work action for unsafe conditions. Post-operational supervision focuses on evaluation, incident and near-miss documentation, corrective action, and feedback for SOP, training, and maintenance improvement. Implementation of these three supervision stages is expected to reduce the possibility of similar accidents at PT XYZ.

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