CALAMITY
Calamity: A Journal of Disaster Technology and Engineering
CALAMITY 3(1): 33–45
ISSN 3025-4140

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

Probability analysis of occupational accidents in housing construction projects using the hazop method: A risk-based approach to safety performance improvement

Muhammad Shafiudin[1,*], Celvin Setya Prayoga[1], Richo Alivyan Firmanda[1], Ferdika Rahmad Juliawan[1], Robertus Yunico Septian[1]
[1] *Department of Civil Engineering and Planning, Institut Teknologi Adhi Tama Surabaya, Surabaya, East Java, 60117, Indonesia.*
*Correspondence: muhshafiudin@gmail.com

Received Date: May 11, 2025 Revised Date: June 30, 2025 Accepted Date: July 25, 2025

ABSTRACT
Background: In construction work, occupational accidents remain one of the most critical issues in the construction industry, particularly in housing development projects that involve various high-risk activities. An occupational accident is an undesired and unexpected event that occurs in the workplace, resulting in worker injuries, equipment damage, workflow disruption, or even fatalities. **Methods:** This study aims to analyze the probability of work accidents using the Hazard and Operability Study (HAZOP) approach to identify potential hazards and operational failures in each stage of construction work at the XYZ housing project. The method is applied to systematically review various risk scenarios based on field observations, interviews, and available safety documentation. **Findings:** The HAZOP analysis successfully identified six critical hazards in the XYZ housing development project, including material-related accidents, falls from heights, heavy material intrusion, and respiratory disorders from dust, primarily caused by worker negligence, lack of proper procedures, and inadequate use of Personal Protective Equipment (PPE). **Conclusion:** The implementation of integrated preventive measures such as the provision of complete PPE, structured Standard Operating Procedure (SOP) development, continuous training, and strict supervision has proven to be an effective strategy in mitigating occupational accident risks in construction environments. **Novelty/Originality of this article:** This study presents a systematic HAZOP-based approach combined with the 5S methodology and enhanced SOP enforcement as a practical and replicable model for risk evaluation in residential construction projects.

KEYWORDS: construction; hazop; housing project; occupational accident; occupational risk; occupational safety.

1. Introduction

The phenomenon of globalization is expected to significantly influence global social structures, including the increasingly competitive business and industrial sectors (Buckley, 2020; Jain, 2024; Porter, 2023). In this context, both the quality and quantity of products become crucial factors, which must be supported by compliance with Occupational Health and Safety (OHS) standards (Yaqoob et al., 2024). In this regard, risk can be interpreted as the gap between expected and actual outcomes. Occupational accidents refer to health issues or diseases experienced by workers as a result of unsafe working environments or operational procedures (Dodoo & Al-Samarraie, 2023; Duarte et al., 2021; Najla et al., 2025).

Cite This Article:
Shafiudin, M., Prayoga, C. S., Firmanda, R. A., Juliawan, F. R., & Septian, R. Y. (2025). Probability analysis of occupational accidents in housing construction projects using the hazop method: A risk-based approach to safety performance improvement. *Calamity: A Journal of Disaster Technology and Engineering, 3*(1), 33-45. https://doi.org/10.61511/calamity.v3i1.2025.2066

These incidents generally occur suddenly, without warning, and may take place during production or field operations especially in conditions influenced by environmental disturbances or technological disasters.

Occupational accidents may lead to severe consequences, including fatalities, operational disruptions, infrastructure damage, and financial losses, both in the form of direct compensation and indirect costs due to productivity loss (Debela et al., 2022; Jaździk-Osmólska et al., 2024; Sari, 2024). Therefore, implementing OHS principles serves not only as regulatory compliance but also as a proactive effort to mitigate risks and prepare for potential disasters within the work environment. The main goal of OHS implementation is to create a safe, healthy, and resilient work environment capable of withstanding various hazards and external disruptions, thereby ensuring operational efficiency and continuity (AlMarri et al., 2025; Benson et al., 2024; Farras et al., 2025; Sarbiah, 2023).

The XYZ residential construction project, located in a densely populated housing area, represents a high-activity construction site. This project frequently faces occupational safety challenges, with increasing risks during environmental disturbances or emergency situations such as extreme weather. Accidents at the site continue to occur, ranging in severity from minor injuries to major incidents (Gleeson & Mackway-Jones, 2022). Hence, proactive mitigation of operational risks and environmental hazards is essential. According to interviews with the Health Safety Environment (HSE) team, several work accidents were still recorded at this location throughout 2022–2023. Detailed information on these incidents is presented in Table 1 as part of the risk evaluation in the XYZ residential construction project.

Table 1. Types of work accidents and number of incidents

No	Type of Work Accident	Number of Incidents
1	Fall from height	3
2	Struck by material	5
3	Hit by material	4
4	Exposed to dust	15
5	Collided	10
6	Occupational disease	8
Total		45

Based on the data presented in Table 1, the frequency of occupational accidents was determined through interviews with construction workers, revealing various potential risks that could lead to workplace incidents. These accidents often result in injuries, sometimes causing temporary disability among workers (Jeong, 2021; Kurnianto et al., 2023). This indicates the importance of understanding the probability of work-related accident risks encountered by construction personnel (Alkaissy et al., 2022; Ghosh et al., 2025; Olcay et al., 2022). This study seeks to evaluate the types of occupational hazards using the Hazard and Operability Study (HAZOP) method.

The HAZOP method is applied to systematically identify potential hazards and operational failures, including accident risks that could be worsened by external conditions such as natural disasters or unexpected environmental disruptions (Cvetković et al., 2024; Marhavilas et al., 2020; Nguyen et al., 2022). The findings from this analysis serve as the basis for developing improvement strategies aimed at preventing workplace incidents. As a follow-up, risk control recommendations are formulated by enhancing the OHS system at PT XYZ in the residential construction project. Strengthening the OHS system is considered urgent, not only to minimize work-related injuries but also as part of broader risk mitigation efforts in anticipation of disaster-related impacts that could threaten the safety and continuity of construction activities.

2. Methods

This study applies the Hazard and Operability Study (HAZOP) method to identify and manage potential hazards in the work environment. The selection of this method is based on its qualitative, systematic nature, and its ability to provide in-depth understanding and careful evaluation of results. The HAZOP approach uses worksheets that cover aspects of deviations, causes, impacts, and handling steps. The research method used is descriptive quantitative, which aims to describe conditions or events based on data from observations, interviews, documentation, and relevant data analysis.

The following are the procedures for implementing the research that will be carried out; (1) identifying problems by analyzing potential accident risks, (2) literature Reflection containing relevant information and knowledge regarding risk management, OHS system, and risk identification, assesment and control methods, (3) the main discussion is directed at compiling research questions that focus on identifying work accident hazard and developing risk management strategies at the XYZ location, using the HAZOP method approach, (4) the aim of research is to identify potential hazards, evaluate the level of risk, and provide appropriate solutions to reduce the risk of accidents, (5) conducting interviews with construction workers in the field in real time, (6) the data analysis process in this study includes a review of work procedures that include recognizing potential risks that arise and linking them to the criteria in the HAZOP worksheet, (7) selecting Probability figures from accident risk type data. The following matrix table used to determine the category of work accident risk types, (8) form the risk matrix above, it can be seen that the probability numbers consist of 1 to 5 with risk type categories from very light to very heavy, after which a solution matrix grouping will be carried out which will be determined based on filling in the probability matrix in Table 2.

Table 2. Risk matrix and grouping of risk consequences

Probability	Risk Category	Color	Description
1	Very Low	Light Green	Very low risk, rarely occurs. Minor injuries such as small cuts or minor bruises.
2	Low	Old Green	Low risk, Possibility of occurrence is low. Moderate injuries requiring simple P3K
3	Moderate	Yellow	Moderate risk, possibility of occurance is moderate. Minor injuries requiring medical attention
4	High		High risk, high possibility of occurance. Serious injuries requiring hospitalization
5	Very High		Critical risk, almost certain to occur. Fatl injury or permanent disability

The analysis and discussion were conducted to explain the origins and causes of work accidents or process disruptions. Suggestions for improvement and design refinements involve developing procedures that can be applied at specific locations in the workplace where there is a risk of work accidents. The primary goal is to minimize or completely eliminate these hazards. In conclusion, this study aims to address all the research questions that were raised.

Table 3. Risk level and description

Risk Level	Description
Extreme Risk	Immediate action is required
High Risk	Managerial attention is necessary
Medium Risk	Management tasks include regular monitoring
Low Risk	Managed under standard protocol

3. Results and Discussion

3.1 Type of construction work

Based on the results obtained through direct observation of the housing development project carried out by PT. XYZ, several work activities were identified. The risk identification process was carried out for all these activities to describe the potential risks that might arise. This process helps in understanding the level of risk associated with each potential threat. By assessing the number of risks present, the organization can identify which hazards have the most significant impact so that their handling can be prioritized more effectively.

Based on Table 4, it can be identified that there are seven main types of activities that take place during the construction process of a housing project. These activities include; foundation work, structure, ceramic installation, wall and partition construction, roof or ceiling work, plumping installation, and finishing. These seven categories of work cover a total of 24 specific activities carried out during the implementation of the project. Furthermore, a hazard identification analysis is carried out for all of these activities. This process aims to describe the potential risks that may arise from each activity, so as to provide a more comprehensive understanding of the possibility of hazards at the work site.

Table 4. Types of activities in housing development work

No	Work Activities	Type of Activity
1	Foundation Work	Land excavation process
2		Building foundation laying
3		Existing work implemention
4		Building concreate column casting
5	Structural Work	Concrete sab casting
6		Structural beam casting
7		Plastering and mixing work
8	Ceramic Work	Sand mortar work on floors
9		Concrete rabat casting under vinyl floors
10		Granit ceramic installation
11	Wall and Partition Work	Vinyl floor installation
12		BTC board installation on HPL walls
13		BTC board installation on HPL and rockwool layers
14		Decorative WPC installation for siding
15	Ceiling/Roof Work	Hollow galvanized steel installation for siding
16		Gypsum board ceiling installation
17		WPC ceiling installation
18		Drop ceiling grid installation with gypsum materials
19		WPC ceiling list installation
20	Plumbling Utilities	Clean water system installation
21		Dirty water drainage installation
22		New ceiling installation
23	Finishing Work	Wall surface painting
24		Door primer finishing application

This process helps in understanding the level of risk associated with each potential threat. By assessing the number of risks present, the organization can identify which hazards have the most significant impact, so that their handling can be prioritized more effectively.

Table 5. Types of risks in housing construction activities

No	Activities	Code	Hazard Identify	Risk
1	Foundation Work	A1	Ground Excavation	Land Subsidence due to soil movement
		A2	Electrical cable in soil	Electric shock from underground power lines

		A3	Scattered materials	Slip due to unstable work area (minor injury)
		A4	Heavy steel failing	Severe injury due to falling structural elements (Serious injury)
		A5	Accident/collision with materials	Exposed to severe worker injury
		B1	Fall from weight	Fatal injury (Broken bones)
		B2	Scattered materials for heavy steel	Slip on work path
2	Structural Work	B3	Broken claws when breaking steel	Minor injury in fingers (Serious Injury)
		B4	Getting hit by falling materials	Serious injury due to falling hazardous materials
		C1	Exposed to water splash	Slips due to irritation from liquid spills
		C2	Exposed to nail scratches	Minor injury due to work accidents
3	Ceramic Work	C3	Falling trapped hand	Minor injury due to pinched or trapped material
		C4	Inhailing dust	Respiratory disturbance due to dust exposure
		C5	Dust entering eyes	Same at risk C4
		D1	Trapped material	Eye irritation due to flying particles
4	Wall and Partition Work	D2	Falling Trapped hand	Severe injury due to falling trapped hand
		D3	Materials hittung body	Minor injury due to hit by falling objects
		D4	Minor injury due to sanding work	Minor injury due to hit by work tools
		E1	Head Collision	Minor injury due to head impact with structure
		E2	Exposed to electrical shock	Minor injury due to electrical contact
5	Celling/Roof Work	E3	Fall from scaffolding	Severe injury due to fall from height
		E4	Falling trapped hand	Minor injury due to trapped hand while working
		E5	Injury due to pipe cutting	Minor injury due to trapped hand while working
		F1	Fall down stairs	Bone injury due to falling down stairs
6	Plumbing Work	F2	Falling trapped hand a bender	Minor injury when using pipe installation tools
		F3	Injury by pipe cutting	Minor injury due to combination of pipe construction not suitable
		G1	Scattered Electrical Cables	Fall or hurt due to scattered cables
		G2	Inhaling finishing dust	ISPA (respiratory tract) due to dust exposure
7	Finishing Work	G3	Inhiling material dust	ISPA (respiratory tract) due to harmful building chemical finishing
		G4	Material splashing into eyes	Eye irritation due to material contac
		G5	Head Collision	Minor injury due to head impact with building structure

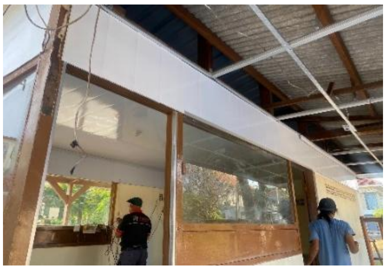
Based on Table 6, potential risks can be identified from 7 types of work activities in the housing development project. Of the total risks, it was found that 13 risks were in the low category, 12 risks were classified as moderate, and 6 risks were included in the high hazard level. After the risk assessment process is completed, the next step is to design and implement appropriate mitigation strategies. This risk management process aims to control and minimize the impact of hazards, by considering various handling alternatives based on actual conditions in the field and internal company policies (Aprilia et al., 2020).

Table 6. Risk assessment of housing construction activities

No	Activities	Code	Severity	Frequency	RRN	Risk Priority
1	FoundationWork	A1	3	2	6	Moderate
		A2	3	2	6	Moderate
		A3	2	4	8	High
		A4	3	2	6	Moderate
		A5	3	2	6	Moderate
		B1	4	1	4	High
		B2	2	5	10	High
2	Structural Work	B3	4	2	8	High
		B4	2	3	6	Moderate
		C1	2	2	4	Low
		C2	2	2	4	Low
3	Ceramic Work	C3	1	1	1	Low
		C4	2	3	6	Moderate
		C5	2	3	6	Moderate
4	Wall and Partition work	D1	2	2	4	Low
		D2	1	1	1	Low
		D3	1	2	2	Low
		D4	1	2	3	Low
		E1	2	3	6	Moderate
		E2	3	2	6	Moderate
5	Celling/Roof Work	E3	2	5	10	Low
		E4	1	3	3	Low
		E5	1	3	3	Low
		F1	3	2	6	Moderate
6	Plumbing Work	F2	1	1	1	Low
		F3	2	3	6	Moderate
		G1	2	2	4	Low
		G2	2	4	8	High
7	Finishing Work	G3	2	2	4	Low
		G4	2	2	4	Low
		G5	2	3	6	Moderate

Table 6 presents the results of the identification of potential hazards, accompanied by a scale of severity and frequency of occurrence. The data in the table was obtained through a brainstorming process involving the company, including HSE staff, project foremen, and project managers. The determination of the severity and frequency scales in this identification refers to Table 2 and Table 3 as the main guidelines.

a



b

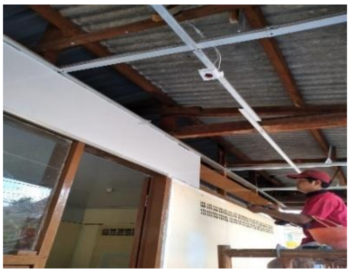


Fig. 3 (a) Roof Installation; (b) Installation of electrical installations

Determination of priorities in risk control is carried out by referring to risk mapping, which is the main reference in designing appropriate preventive measures. The goal is to ensure the effectiveness of risk control implementation, especially against potential threats that have been identified. To support this process, a HAZOP (Hazard and Operability Study) worksheet is prepared as an analysis tool (Isnaini et al., 2022; Nur, 2020; Pujiono et al., 2013; Retnowati, 2017).

The issues described above involve multiple potential risks, especially within the XYZ residential construction project, which not only encounters operational challenges but also faces external environmental factors and unpredictable conditions, including natural disasters. Therefore, the researcher aims to classify types of occupational accident risks using the Hazard and Operability Study (HAZOP) method while also formulating preventive and adaptive solutions as a follow-up to the identified risks. Further explanation and classification are presented in Table 7.

Table 7. Types of risk, classification, actions

No	Hazard Finding	Risk	Hazard Source	Action
1	Material stuck accident	Minor injury	• Moving material • Unfocused worker • Worker carelessness • Lack of spatial awareness	• Tidy up scattered materials • Arrange materials properly • Provide safety guidelines for workers • Apply 5S methodology in workplace • Implement methodical procedures at work site • Use proper APD equipment
2	Fall form height	Serious injury	• Not using APD • Worker negligence • Unsafe working conditions • No available SOP for proper work procedures	• Use complete APD • Stay focused while working • Work according to SOP
3	Scattered materials	Accident on access	• No proper material • Lack of spatial awareness • Lack of disipline	• Tidy up scattered materials • Arrange materials properly • Provide safety guidelines for workers • Apply 5S methodology in workplace • Implement methodical procedures at work site • Use proper APD equipment
4	Heavy material entering	Serious injury	• Other workers • Heavy iron breaking loose • Loose steel mesh • Damaged scaffolding	• Inspect work methods • Select workers with appropriate skills and experience • Conduct safety briefing on APD usage • Use proper APD equipment • Use proper APD equipment
5	Fall from scaffolding	Serious injury	• Poor concentration • Not using APD • Not following SOP	• Create Standard Operational Procedure (SOP) for safe work execution with proper integration

				• Ensure proper scaffolding conditions • Organize scaffolding properly
6	Dust inhaled while breathing	Respiratory disturbance (Silicosis)	• Not wearing mask • Minimum mask supply • Damaged mask	• Use proper dust mask • Provide dust protection equipment • Create Work Instructions • Implement work supervision • Inspect work methods

Based on Table 7, the HAZOP analysis identified six critical hazards with the potential to occur in the construction work environment, including tripping over materials, falling from heights, scattered debris, falling heavy objects, falling from scaffolding, and respiratory disturbances due to excessive dust exposure. Each hazard has varying levels of severity, ranging from minor injuries to serious respiratory conditions such as silicosis. The main contributing factors include worker negligence, lack of concentration, failure to use personal protective equipment (PPE), low environmental awareness, unsafe working conditions, and the absence of adequate standard operating procedures (SOPs). In construction settings that are vulnerable to external disturbances such as extreme weather or localized natural disasters, these hazards may become even more complex and difficult to control if not addressed from the outset. Therefore, comprehensive preventive measures are essential, including the provision of appropriate PPE, implementation of the 5S principle (Sort, Set in order, Shine, Standardize, Sustain), structured SOP development, ongoing safety training, strict on-site supervision, and long-term investment in safety infrastructure (Aktar et al., 2023; Jiménez et al., 2020; Oktavera & Wardaya, 2023; Shahin et al., 2023). These efforts aim not only to reduce the incidence of workplace accidents but also to serve as a strategic approach to mitigate risks related to potential disasters that could disrupt construction project stability.

4. Conclusions

The study highlights that occupational accidents remain a significant challenge in residential construction projects, particularly in high-activity sites such as the XYZ housing development. Using the HAZOP (Hazard and Operability Study) method, six critical hazards were identified, including tripping over materials, falls from heights, scattered debris, heavy objects falling, scaffold-related accidents, and respiratory disorders from dust exposure. These hazards were primarily caused by worker negligence, insufficient use of personal protective equipment (PPE), lack of concentration, unsafe working conditions, and the absence of comprehensive standard operating procedures (SOPs).

The analysis further revealed that construction work activities, ranging from foundation laying to finishing, each carry varying degrees of risk, with some classified as high-priority hazards requiring immediate intervention. The risk assessment process, involving direct observations, interviews, and documentation review, enabled systematic classification of hazards and identification of preventive measures. By linking hazard severity and probability, the study provided a clear roadmap for prioritizing risk control and enhancing occupational safety in the construction environment.

To mitigate these risks, the study recommends an integrated approach combining proper PPE provision, structured SOP development, continuous safety training, strict on-site supervision, and the application of the 5S methodology (Sort, Set in order, Shine, Standardize, Sustain). These preventive strategies not only aim to reduce workplace accidents but also serve as a proactive measure to address potential disruptions caused by environmental disturbances or natural disasters. The HAZOP-based model presented in this research offers a practical and replicable framework for improving occupational health and safety management in residential construction projects.

Acknowledgement

All authors, would like to thank the XYZ housing development project implementation team who were willing to allow us as authors to conduct research on the risks of work accidents that occurred, thanks also to the lecturers in charge of the OHS and disaster management course who provided materials that can be used in the effort to complete this report, and not forgetting also to friends who have helped in the preparation of this journal, enthusiasm and persistence in preparing this report. We hope that the preparation of this report can help students and teaching teams in making quotations in discussions on OHS and disaster management in future sessions and can be of benefit to the community.

Author Contribution

The five authors jointly conducted real-time field observations and interviews with construction workers to collect primary data on working conditions and potential hazards, and obtained work accident data based on direct testimony from workers on site. M.S., and C.S.P. were responsible for conducting risk analysis and hazard assessments from the collected data, while R.Y.S. and F.R.J. focused on compiling HAZOP tables using Excel software for calculations and probability tables. R.A.F. was responsible for compiling conclusions from all analyses conducted, while M.S. provided suggestions and recommendations for work safety solutions based on the findings.

The report writing process was carried out collaboratively by the five authors with an even division of tasks, and the entire research process received regular guidance and supervision from the supervisor of the Occupational Health and Safety Management course who conducted weekly progress evaluations to ensure the quality and accuracy of the resulting HAZOP analysis.

Funding

Funding for this research was taken from each individual's personal funds, such as purchasing equipment used to record data during the survey, searching for survey locations, selecting work locations in compiling this report.

Ethical Review Board Statement

This HAZOP analysis study was conducted in accordance with generally accepted research ethics principles. All observations and interviews with construction workers were conducted with the voluntary consent of the participants, while maintaining the confidentiality of their identities and personal information. The data collection process was conducted transparently by explaining the research objectives to the workers, ensuring no pressure or coercion in providing information, and ensuring that the data obtained was used only for academic purposes and to improve occupational safety.

This study did not involve procedures that could harm or harm participants, and all information collected was kept confidential by not including the names, addresses, or specific identities of the workers in the research report. Although not subject to formal ethical review by a board, this study still adhered to basic research ethics standards that prioritize the principles of beneficence, non-maleficence, autonomy, and justice at every stage of its implementation

Informed Consent Statement

Consent for participation was obtained verbally from all construction workers involved in this study. Prior to conducting observations and interviews, the research team clearly explained that this activity was part of a college assignment aimed at analyzing occupational safety and identifying potential hazards at construction sites. Workers were informed that their participation was voluntary, that the information provided would be kept confidential and would not be identified in the report, and that they had the right to not answer certain questions or to discontinue participation at any time if they felt uncomfortable. All workers interviewed demonstrated a good understanding of the study's objectives and gave their consent to share their experiences regarding working conditions, potential hazards, and any history of workplace accidents they had experienced or witnessed at the construction site.

Data Availability Statement

The data used in this HAZOP analysis study was obtained through direct observation at construction sites and interviews with construction workers. Therefore, most of the data is primary and was collected in real time during the research process. Given that the data contains sensitive information related to occupational safety and the personal experiences of construction workers, the raw data cannot be shared publicly to maintain the privacy and confidentiality of participants, in accordance with the commitments made to respondents

Conflicts of Interest

The authors declare no conflicts of interes.

Open Access

References

Aktar Demirtas, E., Gultekin, O. S., & Uskup, C. (2023). A case study for surgical mask production during the COVID-19 pandemic: continuous improvement with Kaizen and 5S applications. *International Journal of Lean Six Sigma*, *14*(3), 679-703. https://doi.org/10.1108/IJLSS-02-2022-0025

Alkaissy, M., Arashpour, M., Wakefield, R., Hosseini, R., & Gill, P. (2022). The cost burden of safety risk incidents on construction: A probabilistic quantification method. *Risk analysis*, *42*(10), 2312-2326. https://doi.org/10.1111/risa.13865

AlMarri, M., Al-Ali, M., Alzarooni, M., AlTeneiji, A., Al-Ali, K., & Bahroun, Z. (2025). Enterprise resource planning systems for health, safety, and environment management: Analyzing critical success factors. *Sustainability*, *17*(7), 2947. https://doi.org/10.3390/su17072947

Aprilia, S P., Suhardi., B., & Astuti, R. D. (2020). Analisis risiko keselamatan dan kesehatan kerja menggunakan metode Hazard and Operability Study (HAZOP): Studi kasus PT. Nusa Palapa Gemilang. *Performa: Media Ilmiah Teknik Industri, 19*(1), 1–8133. https://digilib.uns.ac.id/dokumen/detail/76039/

Benson, C., Obasi, I. C., Akinwande, D. V., & Ile, C. (2024). The impact of interventions on health, safety and environment in the process industry. *Heliyon*, *10*(1). https://doi.org/10.1016/j.heliyon.2023.e23604

Buckley, P. J. (2020). The theory and empirics of the structural reshaping of globalization. *Journal of International Business Studies*, *51*(9), 1580. https://doi.org/10.1057/s41267-020-00355-5

Cvetković, V. M., Renner, R., & Jakovljević, V. (2024). Industrial disasters and hazards: From causes to consequences—A holistic approach to resilience. *International Journal of*

Disaster Risk Management, *6*(2), 149-168. https://doi.org/10.18485/ijdrm.2024.6.2.10

Debela, M. B., Azage, M., Deyessa, N., & Begosaw, A. M. (2022). Economic costs and predictors of occupation-related injuries in Ethiopian sugar Industries from the employer's perspective: top-down approach and friction method. *BMC public health*, *22*(1), 2103. https://doi.org/10.1186/s12889-022-14519-5

Dodoo, J. E., & Al-Samarraie, H. (2023). A systematic review of factors leading to occupational injuries and fatalities. *Journal of Public Health*, *31*(1), 99-113. https://doi.org/10.1007/s10389-020-01427-4

Duarte, J., Marques, A. T., & Santos Baptista, J. (2021). Occupational accidents related to heavy machinery: a systematic review. *Safety*, *7*(1), 21. https://doi.org/10.3390/safety7010021

Farras, F., Jumhana, E., Fadilah, A., Adha, A., Novrio, M. J. A., & Haki, U. (2025). Keselamatan Dan Kesehatan Kerja (K3): Pilar utama dalam produktivitas dan keberlanjutan. *Bureaucracy Journal: Indonesia Journal of Law and Social-Political Governance*, *5*(1), 619-633. https://doi.org/10.53363/bureau.v5i1.548

Ghosh, S., Nourihemadani, M., & Reyes, M. (2025). Effect of previous accidents and near-miss incidents on risk perceptions of construction workers. *International Journal of Construction Education and Research*, *21*(2), 213-229. https://doi.org/10.1080/15578771.2024.2365206

Gleeson, T., & Mackway-Jones, K. (Eds.). (2022). *Major incident medical management and support: the practical approach at the scene*. John Wiley & Sons.

Isnaini, M., Umam, H., & Sanjaya, G. A. (2022). Analisa risiko kecelakaan kerja karyawan pada pekerjaan dalam keadaan bertegangan menggunakan metode Hazard and Operability (HAZOP) (Studi kasus: PT. PLN (Persero) UP3 Pekanbaru). *SITEKIN, 19*(2), 161–171. http://dx.doi.org/10.24014/sitekin.v19i2.16991

Jain, S. (2024). Impact of Globalisation on different sectors of Society. *International Research Journal of Humanities and Interdisciplinary Studies, 5*(3), 270-284. https://doi-ds.org/doilink/03.2024-94496516/IRJHIS2403031

Jaździk-Osmólska, A. M., Kalbarczyk, M. K., Trzaskowski, D., Wojtachnik, R., & Trzaskowska-Dmoch, A. (2024). Economic impact of road accidents on costs of employee turnover: A quantitative study from Poland. *Archives of Transport*, *72*(4), 151-165. https://doi.org/10.61089/aot2024.tvnay379

Jeong, B. Y. (2021). Prevalence of occupational accidents and factors associated with deaths and disabilities in the shipbuilding industry: Comparisons of novice and skilled workers. *Work*, *69*(3), 997-1005. https://doi.org/10.3233/WOR-213530

Jiménez, M., Romero, L., Fernández, J., Espinosa, M. D. M., & Domínguez, M. (2020). Application of lean 6s methodology in an engineering education environment during the SARS-CoV-2 pandemic. *International Journal of Environmental Research and Public Health*, *17*(24), 9407. https://doi.org/10.3390/ijerph17249407

Kurnianto, A. A., Khatatbeh, H., Prémusz, V., Nemeskéri, Z., & Ágoston, I. (2023). Managing disabled workers due to occupational accidents in Indonesia: a case study on return to work program. *BMC public health*, *23*(1), 943. https://doi.org/10.1186/s12889-023-15930-2

Marhavilas, P. K., Filippidis, M., Koulinas, G. K., & Koulouriotis, D. E. (2020). A HAZOP with MCDM based risk-assessment approach: Focusing on the deviations with economic/health/environmental impacts in a process industry. *Sustainability*, *12*(3), 993. https://doi.org/10.3390/su12030993

Najla, P. T., Safani, E. Z., & Marniati, M. (2025). Mencegah Kecelakaan Kerja dengan Strategi Efektif untuk Meningkatkan Keselamatan di Tempat Kerja: Literatur Review. *Antigen: Jurnal Kesehatan Masyarakat dan Ilmu Gizi*, *3*(3), 228-240. https://doi.org/10.57213/antigen.v3i3.749

Nguyen, H. T., Safder, U., Kim, J., Heo, S., & Yoo, C. (2022). An adaptive safety-risk mitigation plan at process-level for sustainable production in chemical industries: An integrated fuzzy-HAZOP-best-worst approach. *Journal of Cleaner Production*, *339*, 130780. https://doi.org/10.1016/j.jclepro.2022.130780

Nur, M. (2020). Analisis keselamatan dan kesehatan kerja menggunakan metode Hazard and Operability Study (HAZOP) di PT. XYZ. *Jurnal Teknik Industri: Jurnal Hasil Penelitian dan Karya Ilmiah dalam Bidang Teknik Industri*, *4*(2), 133. https://doi.org/10.24014/jti.v4i2.6627

Oktavera, A. T., & Wardaya, I. I. (2023). Relationship of Compliance of Personal Protective Equipment Usage and Housekeeping with Near Miss among Nurses. *Indones J Occup Saf Heal*, *12*(2), 176-84. https://doi.org/10.20473/ijosh.v12i2.2023.176-184

Olcay, Z. F., Sakalli, A. E., Temur, S., & Yazici, A. (2022). A study of the shift in fatal construction work-related accidents during 2012–2019 in Turkey. *International journal of occupational safety and ergonomics*, *28*(3), 1522-1532. https://doi.org/10.1080/10803548.2021.1900503

Porter, M. E. (2023). Changing patterns of international competition. In *International Strategic Management* (pp. 61-86). Routledge.

Pujiono, B. N., Tama, I. P., & Efranto, R. Y. (2013). Analisis potensi bahaya serta rekomendasi perbaikan dengan metode Hazard and Operability Study (HAZOP) melalui perangkingan OHS Risk Assessment and Control (Studi kasus: Area PM-1 PT. Ekamas Fortuna. *Jurnal Rekayasa dan Manajemen Sistem Industri, 1*(2), 253–264*.* https://jrmsi.studentjournal.ub.ac.id/index.php/jrmsi/article/view/32

Retnowati, D. (2017). Analisa risiko K3 dengan pendekatan Hazard and Operability Study (HAZOP). *Teknika Engineering Sains Journal, 1*(1), 41–46*.* https://doi.org/10.51804/tesj.v1i1.67.41-46

Sarbiah, A. (2023). Penerapan pelaksanaan keselamatan dan kesehatan kerja (K3) pada karyawan. *Health Information: Jurnal Penelitian*, e1210-e1210. https://myjurnal.poltekkes-kdi.ac.id/index.php/hijp/article/view/1210

Sari, I. Y. (2024). Analisis Penyebab Kecelakaan Kerja Pada Pekerja Konstruksi. *Journal of Industrial Hygiene and Occupational Health*, *9*(1), 22-30. https://doi.org/10.21111/jihoh.v9i1.11185

Shahin, M., Chen, F. F., Hosseinzadeh, A., Khodadadi Koodiani, H., Bouzary, H., & Shahin, A. (2023). Enhanced safety implementation in 5S+ 1 via object detection algorithms. *The International Journal of Advanced Manufacturing Technology*, *125*(7), 3701-3721. https://doi.org/10.1007/s00170-023-10970-9

Yaqoob, M., Asghar, W., & Anwar, S. (2024). Weak Occupational Health & Safety (OHS) Compliance in the Manufacturing Sector in Pakistan: Recommendations for Improvement. *Journal of Development and Social Sciences*, *5*(2), 11-18. https://doi.org/10.47205/jdss.2024(5-II)02

Biographies of Authors

Muhammad Shafiudin is an undergraduate student at the Institut Teknologi Adhi Tama Surabaya. He is currently pursuing a Bachelor's degree and has a strong interest in writing, particularly in academic and research contexts. His academic work reflects a dedication to learning and knowledge-sharing.

- Email: mushafiudin@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Celvin Setya Prayoga is an undergraduate student at the Institut Teknologi Adhi Tama Surabaya. He is currently pursuing a Bachelor's degree and has an interest in travelling, which broadens his perspective and supports his academic development.

- Email: celvin.prayoga69@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Richo Alivyan Firmanda is an undergraduate student at the Institut Teknologi Adhi Tama Surabaya. He is currently pursuing a Bachelor's degree and has a personal interest in fishkeeping, which reflects his patience, attention to detail, and appreciation for environmental balance.

- Email: alivyanfirmanda@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Ferdika Rahmad Juliawan is an undergraduate student at the Institut Teknologi Adhi Tama Surabaya. He is currently pursuing a Bachelor's degree and has a strong interest in photography, which supports his creativity and attention to visual detail both in academic and personal contexts.

- Email: Ferdikrj12@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Robertus Yunico Septian is an undergraduate student at the Institut Teknologi Adhi Tama Surabaya. He is currently pursuing a Bachelor's degree and has a strong interest in learning, reflecting his enthusiasm for academic growth and personal development.

- Email: yunicoseptian@gmail.com
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A