Tec Empresarial
P-ISSN: 1659-2395; E-ISSN: 1659-3359

Occupational Risk Assessment of High-Rise Building Construction Projects

Om Prakash Giri[A], Dipesh Dhakal[B], Madhav Prasad Koirala[C], Sandeep Poddar[D]

Abstract

The construction of high-rise building projects is inherently risky due to the unique nature of the activities and the complexity of the working environment. Despite this, safety issues persist as critical concerns in the construction sector. In this research, the primary objective was to explore the nature of occupational risks associated with high-rise building construction projects. The study employed a comprehensive approach, utilizing field observation, questionnaire surveys, and Key Informant Interviews (KII) to collect primary data. SPSS was employed for data analysis, facilitating the identification and assessment of risks in a study involving 75 respondents in high-rise building construction projects. This research reveals significant insights, pinpointing major effects like falls, injuries, and lower back pain. The risk assessment matrix identifies working at height as the riskiest activity, emphasizing the need for intensified safety measures. Activities such as noise, overloading circuits, and job dissatisfaction also pose substantial risks. The study underscores the crucial role of contractors and clients/developers in accident prevention. Addressing specific risks and their associated effects contributes to cultivating a safer and healthier working environment for construction workers, thereby reducing the potential for accidents and promoting overall well-being within the construction industry.

Keywords: *Construction Projects, Occupational Hazard, Risk Assessment, Preventive Measures.*

INTRODUCTION

Nepal strategically focuses on achieving development through enhancing and expanding its physical infrastructure (Rimal et al., 2015). However, the construction industry, a vital contributor to economic growth, poses significant occupational hazards due to the various activities involved during the construction process (Manzoor et al., 2022). The sector's influence on a nation's development is substantial (Durdyev & Ismail, 2012). Yet, construction work is inherently dangerous, involving heavy equipment, rotating machinery, moving vehicles, height work, varying environments, and a considerable proportion of temporary and untrained workers (Ajith et al., 2019).

[A]*Assistant Professor at the School of Engineering, Faculty of Science and Technology, Pokhara, Nepal, Email: omgpkr5@gmail.com*
[B]*Research scholar M.Sc. in Construction Management, School of Engineering, Pokhara, Nepal*
[C]*Professor at the School of Engineering, Faculty of Science and Technology, Pokhara, Nepal*
[D]*Professor Lincoln University College, Petaling Jaya, Malaysia*

As construction activities increase, the oversight of hazards and engagement of untrained labor to expedite projects raise the risk of accidents, with workers constantly facing the threat of fatal injuries (Shaikh et al., 2021). Ignoring safety requirements can lead to severe human losses (Mitropoulos et al., 2005). The key to addressing these challenges lies in effective occupational safety and health management, which heavily relies on competent risk assessment processes. Workplace hazards, whether physical, chemical, biological, mechanical, electrical, physiological, or psychological, can result in incidents and work-related injuries, impacting organizational productivity and profitability (Patel et al., 2022). According to the International Labour Organization (ILO), with over 337 million on-site accidents annually and more than 2.3 million deaths from occupational diseases (Memon et al., 2023).

Hazard identification and risk assessment are integral processes in enhancing construction site safety. These methods involve recognizing potential undesirable events, analyzing associated hazards, and estimating the extent and likelihood of harmful effects. Widely embraced in the industry, these techniques play a crucial role in preventing accidents and promoting overall safety. By systematically evaluating risks, construction professionals can implement effective measures to mitigate potential dangers, fostering a secure working environment (Purohit, et al., 2018). Health and safety hazards originate from diverse sources, encompassing substances, materials, processes, and practices capable of causing harm to individuals (Mihić, 2020).

The current construction trend leans heavily towards high-rise buildings, driven by their convenience, architectural attraction, elevated grade, and luxurious attributes. High-rise construction often hides safety risks, unknown to many, due to its complexity and height (Omar et al., 2023). Constructed on scarce and costly urban land, this multistory building addresses the high demand for space, reflecting the challenges of limited availability and the need for efficient land use (Katong et al., 2023). Rapid population growth and the imperative for urban expansion have led to a surge in high-rise construction, driven by the necessity to overcome finite land resources. Consequently, the demand for high-rise buildings is escalating at unprecedented rates. High-rise construction projects bring about intricate structural designs, increased work complexity, and heightened risks (Ratnaningsih et al., 2018). Construction workers engaged in building these structures often encounter serious safety threats, with high-altitude operations and deep foundation excavations leading to higher accident rates and more severe injuries than in moderate or low-rise buildings (Lakhiar & Lakhiar, 2021). The consistent threat of falls and falling objects highlights significant safety challenges in high-rise construction (Li et al., 2018). Worker exposure varies across trades and jobs, fluctuating daily or even hourly. Exposure to specific hazards is often intermittent but recurrent. Workers not only face the primary hazards of their tasks but may also be exposed to risks generated by nearby or upwind workers, emphasizing the complexity and dynamic nature of construction site safety (Peñaloza et al., 2020).

The current state of occupational hazard identification and prevention in the construction of high-rise buildings is critically deficient, and demanding urgent attention. Safety, a pivotal project indicator, lacks systematic procedures in existing high-rise construction projects, resulting in a lack of effective measures for accident and disease control (Mishra et al., 2021). In Nepal, the construction industry struggles to implement safety and health protocols, marked by informal practices due to the absence of organizational policies, adequate resources, and effective management (Giri et al., 2023). To address these challenges, adopting management standards such as quality management systems, occupational health and safety management systems, and risk management systems becomes crucial for reducing and mitigating risks in high-rise construction projects (Lu et al., 2020). Establishing safe working environments is imperative not only for project success but also for safeguarding human lives and minimizing the substantial costs associated with accidents.

Current research primarily investigates the correlation between occupational hazards and diseases (Li et al., 2020). While extensive studies explore risk management in various construction domains like subway tunnels and highways, there's a noticeable scarcity of research on the safety risks associated with high-rise building construction. For any industry to bloom, ensuring safe, reliable, and sustainable operations is important (Lakhiar, 2021). The development of technologies and strategies to prevent injuries and enhance worksite safety reflects the ongoing commitment to mitigating construction-related risks (Afzal et al., 2021). Critical accidents in building construction are directly influenced by factors such as the physical complexity of the construction, urgency in project timelines, and inadequate responses to unexpected on-site situations (Ahn et al., 2022).

METHOD

This research employs both quantitative and qualitative approaches for data collection. The quantitative process involves systematically gathering data from observation, checklists, and questionnaire surveys, facilitating statistical analysis. Qualitative data is obtained through literature reviews and Key Informant Interviews (KII), providing a comprehensive research perspective. The study focuses on high-rise building construction projects in Pokhara Metropolitan City, Kaski, Nepal. Across four construction sites surveyed, the population comprises approximately 317 individuals, including clients/developers, contractors, and their representatives such as site engineers, architects, project managers, supervisors, and workers actively engaged in the construction sites. 76 respondents were selected using a stratified random sampling technique. A set of 5-point Likert Scale questionnaires was prepared based on different literature reviews. The pilot test was done to validate the clarity and alignment of the questionnaire with objectives. Addressing feedback, a final questionnaire set was prepared. Additionally, field observation was conducted for risk evaluation, with project managers utilizing checklists. Data from primary and secondary sources were summarized, tabulated, and categorized using SPSS. A risk assessment matrix and checklist were devised to evaluate and categorize risk levels.

Degree of Risk Calculation

Risk = Likelihood X Consequence

Table 1 presents a risk assessment matrix, categorizing risks based on their consequences and likelihood. Consequence levels, ranging from minor (1) to catastrophic (5), intersect with likelihood levels from almost certain to rare. Numeric values represent the risk scores, with higher scores indicating elevated risk. For instance, if a risk has a minor consequence (1) and is almost certain (5), the risk score is 5. This matrix offers a structured approach to assess and prioritize risks, aiding decision-makers in understanding the potential impact and likelihood of various scenarios, ultimately facilitating effective risk management strategies within a given context. Similarly, Table 1 outlines a risk rating system, categorizing risks into extremely high risk (20-25), high risk (12-18), moderate risk (6-10), and low risk (1-5). For extremely high risk, immediate cessation is recommended. High-risk instances prompt notification of supervisors and safety representatives, with immediate action needed, and remedial steps within two working days. Moderate risk calls for immediate measures to minimize harm, with subsequent remedial action within five days. Low risk suggests remedial action within a month, with the supervisor's attention necessary. This system provides a clear framework for assessing and responding to risks, ensuring timely and appropriate interventions.

Table 1. Risk Assessment Matrix

Consequence	**Likelihood**	**Minor 1**	**Moderate 2**	**Major 3**	**Severe 4**	**Catastrophic 5**
Almost Certain	5	5	10	15	20	25
Likely	4	4	8	12	16	20
Possible	3	3	6	9	12	15
Unlikely	2	2	4	6	8	10
Rare	1	1	2	3	4	5
Risk Rating	**Descriptor**	**Actions**				
20-25	Extreme High Risk	Immediate action is required. If possible, the activity should be ceased immediately				
12-18	High Risk	Notify the supervisor and safety and health representative and implement immediate action to minimize injury. Remedial action is required within two working days.				
6-10	Moderate Risk	Implement immediate action to minimize injury e.g. Signs, supervisor remedial action required within five working days				
1-5	Low Risk	Remedial action is required within one month (if possible), and supervisor attention is required.				

Source: Mishra (2021)

Relative Important Index (RII)

RII, a non-parametric technique, is utilized to assess the importance of sustainable criteria. The formula for calculating RII involves assigning a weight to each response category, ranging from 1 to 5, and then computing the average weight for each factor. The RII value ranges from 0 to 1 with 0 not inclusive. It shows that the higher the value of RII, the more important the risk factor and vice versa (Sakhare & Chougule, 2019).

$$RII = \frac{\sum W}{A \times N} = \frac{5n5 + 4n4 + 3n3 + 2n2 + n1}{5(n+n2+n3+n4+n5)}$$

Where:
W = Weightage that is assigned to each variable by the respondent
A = Highest weight
N = Total number of respondents.

RESULT AND DISCUSSION

Table 2 categorizes the values of Cronbach's Alpha into different ranges and assigns qualitative descriptors to each range. An Alpha value of 0.9 or greater is deemed excellent, indicating a high level of internal consistency. A range of 0.8 to 0.9 is considered good, while values between 0.7 to 0.8 are deemed acceptable. Internal consistency becomes questionable when Alpha falls between 0.6 to 0.7, and poor if it ranges from 0.5 to 0.6. An Alpha value below 0.5 is categorized as unacceptable, suggesting inadequate internal consistency in the measured constructs (Saidi & Siew, 2019). The Coefficient of Cronbach's Alpha for different hazards, evaluating internal consistency. The Effects of Chemical Hazards exhibit good consistency with a Cronbach's Alpha of 0.815, signifying reliability. Other hazard categories, including Physical, Electrical, Physiological, and Psychological Hazards, demonstrate acceptable internal consistency, ranging from 0.784 to 0.797. These values suggest the questionnaire items related to each hazard type are reliable and internally coherent, providing a foundation for dependable data collection and analysis in occupational safety assessments.

Table 2. Coefficient of Cronbach's Alpha

Different Hazards	Cronbach's Alpha	Internal consistency
Effects of Physical Hazards	0.797	Acceptable
Effects of Chemical Hazards	0.815	Good
Effects of Electrical Hazards	0.795	Acceptable
Effects of Physiological Hazards	0.784	Acceptable
Effects of Psychological Hazards	0.790	Acceptable

Table 3, the risk rating Matrix of four construction projects, systematically evaluates the risk associated with various activities. Activities with elevated risk levels include "Working at height," "Noise," "Overloading circuit," and "Job dissatisfaction," indicating both significant potential consequences and likelihood. Emphasizing the imperative for targeted risk management strategies and heightened safety measures in these specific areas. Conversely, activities like "Pesticides," "Continuous and overtime work," and "Alcoholism" exhibit lower risk levels, suggesting comparatively reduced potential consequences and likelihood.

Table 3. Risk Rating Matrix of Combined 4 Construction Projects

No	Activity	Consequence (1-5)	Likelihood (1-5)	Risk Source	Risk Level Rating
1.	Working at height	4	4	16.00	High
2.	Slip, trip, and low fall	2.75	4	11.00	Moderate
3.	Noise	3.75	4.25	15.94	High
4.	Poor lighting and ventilation	2.25	3.25	7.31	Moderate
5.	Defective equipment, machines, and tools	3.25	3	9.75	Moderate
6.	Cement and stone dust	3.5	4.5	15.75	High
7.	Toxic gases	3	2	6.00	Moderate
8.	Solvent and chemicals	3.25	3.25	10.56	Moderate
9.	Flammable substance	3.5	2.75	9.63	Moderate
10.	Pesticides	2.5	1.75	4.38	Low
11.	Live wires (Naked electric wire)	3.75	3.5	13.13	High
12.	Overhead power lines	3.25	3	9.75	Moderate
13.	Improper earthing	2.5	1.5	3.75	Low
14.	Overloading circuit	3.75	4.25	15.94	High
15.	Faulty wiring	3.5	3.75	13.13	High
16.	Lifting of heavyweight	4	3.75	15.00	High
17.	Elderly people and underage children	2.5	1.75	4.38	Low
18.	Hit by equipment and object	3.5	3	10.50	Moderate
19.	Continuous and overtime work	3.25	4	13.00	High
20.	Poor health	3.5	3.25	11.38	Moderate
21.	Job dissatisfaction	3.75	4	15.00	High
22.	Overconfident	2.5	2.75	6.88	Moderate
23.	Wages and leave	3.25	4.25	13.81	High
24.	Discrimination	2.25	2	4.50	Low
25.	Alcoholism	3.0	1.5	4.50	Low

Effect of Occupational Hazards in Construction Projects

Effect of Physical Hazard

The findings from the questionnaire survey reveal the respondents' perspectives on the impact of physical hazards on their health, as depicted in Table 4. Falls, injuries, and lower back pain emerged as the primary effects of physical hazards, securing the top rank with an RII value of 0.800. Hearing loss was identified as the second most significant effect, with an RII value of 0.768. Cut, dislocation, and fractures of bones claimed the third position with an RII value of 0.752. Additionally, discomfort leading to increased blood pressure and issues related to visibility and respiratory problems occupied the fourth and fifth ranks, respectively, with RII values of 0.701 and 0.688. This study highlights a substantial proportion of respondents experienced adverse effects, particularly falls, injuries, and lower back pain, emphasizing the importance of addressing and mitigating physical hazards in the workplace.

Table 4. Effect of Physical Hazard in Construction Projects

No	Effect of Physical Hazards	RII	Rank
1	Falls, injuries, and lower back Pain	0.800	1
2	Hearing loss	0.768	2
3	Cut, dislocation, and fracture of bones (finger, hand and leg)	0.752	3
4	Discomfort, and an increase in blood pressure	0.701	4
5	Visibility and respiratory problems	0.688	5

Effect of Chemical Hazards

Table 5 provides a detailed analysis of the effects of chemical hazards in construction projects based on the RII and corresponding ranks. Respiratory problems emerged as the most significant effect, securing the top rank with an RII of 0.813. Following closely, the wrinkling and layering of the skin claimed the second position with an RII value of 0.779. Allergic reactions, manifested as skin rashes, were ranked third with an RII of 0.744. Eye irritation and skin burning effects occupied the fourth and fifth positions, respectively, with RII values of 0.693 and 0.680.

Table 5. Effect of Chemical Hazard in Construction Projects

No	Effect of Chemical Hazards	RII	Rank
1	Respiratory Problem	0.813	1
2	Wrinkle and layer of skin	0.779	2
3	Allergic (skin rashes)	0.744	3
4	Eye Irritation	0.693	4
5	Skin burning effect	0.680	5

Chemical hazards from cement and stone dust in high-rise building construction projects can cause severe skin issues. Exposure may lead to skin problems like wrinkles and layers peeling off. These substances can irritate and damage the skin, impacting its moisture and elasticity, resulting in the development of wrinkles and shedding outer layers. Implementing robust safety measures, including protective clothing and barriers, is essential to minimize these harmful effects on workers' skin.

Effect of Electrical Hazards

Table 6, revealed that muscle, nerve, and tissue destruction ranked as the primary effect, holding the top position with an RII value of 0.824. Numbness, representing a loss of sensation, secured the second position with an RII of 0.789. Thermal burns claimed the third rank with an RII value of 0.755. Additionally, infertility problems and cardiac arrest were identified as the fourth and fifth-ranked effects, with RII values of 0.712 and 0.683, respectively. Electrical hazards can lead to serious consequences, including muscle, nerve, and tissue damage. When accidents occur due to electrical hazards, the powerful electrical currents can cause severe harm to the human body, potentially destroying muscles, nerves, and surrounding tissues.

Table 6. Effect of Electrical Hazard in Construction Projects

No	Effect of Electrical Hazards	RII	Rank
1	Muscle, nerve, and tissue destruction	0.824	1
2	Numbness (loss of sensation)	0.789	2
3	Thermal burns	0.755	3
4	Infertility	0.712	4
5	Cardiac arrest	0.683	5

Effect of Physiological Hazards

Table 7 shows that fatigue was identified as an effect of physiological hazard holding a first rank, with an RII value of 0.819. Similarly, muscle strain has been ranked as the second effect with an RII value of 0.781. Dizziness was found as a third-rank effect of physiological hazard with an RII value of 0.776. Likewise, arm and leg pain and trigger finger were found as fourth and fifth rank with RII values of 0.707 and 0.699 respectively. The study found that fatigue was the major effect of physiological hazards. In building construction projects, fatigue and Physiological problems that workers can experience due to the demanding nature of the job. Fatigue occurs when workers become extremely tired from long hours of work, which can lead to reduced concentration and increased risk of accidents. At the same time muscle strain happens when muscles are overworked or improperly used, causing pain and potential injuries. These effects of physiological hazards highlight the importance of proper rest, ergonomic work practices, and safety measures to ensure the well-being of construction workers in tall building projects.

Table 7. Effect of Physiological Hazard in Construction Projects

No	Effect of Physiological Hazards	RII	Rank
1	Fatigue	0.819	1
2	Muscle strain	0.781	2
3	Dizziness	0.776	3
4	Arm and leg pain	0.707	4
5	Trigger finger	0.699	5

Effect of Psychological Hazards

Table 8 shows that headache was identified as the main effect of psychological hazard holding a first rank, with an RII value of 0.816. Similarly, insomnia (sleep disorders), has been ranked as second rank, with an RII value of 0.784. Mental Illness (Depression and anxiety) was taken as the third rank, with an RII value of 0.747. Likewise, memory loss and chest pain were found as fourth and fifth rank with RII values of 0.688 and 0.683 respectively. The study found that headache was the main effect of psychological. Headaches are a common and significant effect of psychological hazards, when workers are unhappy with their jobs, it can lead to stress, frustration, and mental strain. These negative feelings can manifest physically in the form of headaches. The stress and dissatisfaction associated with the job can create tension in the body, which can result in head pain.

Table 8. Effect of Psychological Hazard on Construction Projects

No	Effect of Psychological Hazards	RII	Rank
1	Headache	0.816	1
2	Insomnia (Sleep disorders)	0.784	2
3	Mental Illness (Depression and anxiety)	0.747	3
4	Memory loss	0.688	4
5	Chest pain	0.683	5

CONCLUSIONS

This research examines occupational hazards in high-rise building construction and yielded significant insights. Major effects of hazards were identified through RII: falls, injuries, and lower back pain for physical hazards, respiratory problems for chemical hazards, muscle, nerve, and tissue destruction for electrical hazards, fatigue for physiological hazards, and headache for psychological hazards. The risk assessment matrix highlighted high-risk activities, with working at height scoring 16.00, followed by noise, overloading circuits, cement, and stone dust, lifting heavy weight, job dissatisfaction, wages and leave, live wires, faulty wiring, and continuous and overtime work, all scoring above 13.00. Moderately risky activities included poor health, slip trips and low falls, solvent, and chemicals, hit by equipment and objects, poor lighting and ventilation, overhead power lines, flammable substances, defective equipment, machines and tools, and toxic gases. Hazards like alcoholism, discrimination, pesticides, elderly people, underage children, and improper earthing presented lower risks. Working at height emerged as the riskiest activity, emphasizing the need for heightened safety measures. Contractors and clients/developers were identified as pivotal in accident prevention. This study contributes valuable insights, suggesting measures for a safer high-rise building construction environment. By addressing these risks, the industry can work towards ensuring the well-being of workers and minimizing accidents.

REFERENCES

Afzal, M., Shafiq, M. T., & Al Jassmi, H. (2021). Improving construction safety with virtual-design construction technologies review. *Journal of Information Technology in Construction*, *26*. https://dx.doi.org/10.36680/j.itcon.2021.018

Ahn, H., Son, S., Park, K., & Kim, S. (2022). Cost assessment model for sustainable health and safety management of high-rise residential buildings in Korea. *Journal of Asian Architecture and Building Engineering*, *21*(3), 689-700. https://doi.org/10.1080/13467581.2021.1902334

Ajith, S., Sivapragasam, C., & Arumugaprabu, V. (2019). Quantification of risk and assessment of key safety factors for safe workplace in Indian building construction sites. *Asian Journal of Civil Engineering*, *20*(5), 693-702.

Durdyev, S., & Ismail, S. (2012). Role of the construction industry in the economic development of Turkmenistan. *Changes*, *64*(0).

Giri, O. P., Poudel, K., & Shrestha, S. K. (2023). Safety management in public building construction: A case study of Pokhara Valley. *Journal of Business and Management*, *7*(01), 90-101. https://doi.org/10.3126/jbm.v7i01.54548

Katong, N., Junaedy, S. P., Sendow, D. C., & Abas, A. Y. (2023). Analysis of Multi-Storey Buildings and Occupational Safety in an Environmental Law Perspective. *Devotion Journal of Community Service*, *4*(3), 813-818. https://doi.org/10.36418/devotion.v4i3.442

Lakhiar, M. T., & Lakhiar, M. T. (2021). Occupational health and safety performance in high-rise building projects in Pakistan: a systematic literature review. *Operational research in engineering sciences: theory and applications*, *4*(1), 99-114. : https://doi.org/10.31181/oresta20401991

Lakhiar, M. T., Abdullah, A. H., & Sohu, S. (2021, May). Application of digital technologies for prevention of accidents in construction of high-rise building projects: A review. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1144, No. 1, p. 012009). IOP Publishing.

Li, Q., Wang, S., Zhang, Z., Qian, H., & Pei, J. (2020, March). AHP_FCE-based high-rise building construction risk assessment. In *IOP Conference Series: Materials Science and Engineering* (Vol. 780, No. 7, p. 072035). IOP Publishing.

Li, Y., Ning, Y., & Chen, W. T. (2018). Critical success factors for safety management of high-rise building construction projects in China. *Advances in Civil Engineering*, *2018*. https://doi.org/10.1155/2018/1516354

Lu, Y., Zhang, Z., Yan, H., Rui, B., & Liu, J. (2020). Effects of occupational hazards on job stress and mental health of factory workers and miners: a propensity score analysis. *BioMed research international*, *2020*. https://doi.org/10.1155/2020/1754897

Manzoor, B., Othman, I., & Waheed, A. (2022). Accidental safety factors and prevention techniques for high-rise building projects–A review. *Ain Shams Engineering Journal*, *13*(5), 101723. https://doi.org/10.1016/j.asej.2022.101723

Memon, M. H., Abas, N. H., & Sohu, S. (2023, June). Ranking the critical causes of accidents in construction projects of Sindh: Perspective of safety professionals. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1205, No. 1, p. 012035).

Mihić, M. (2020). Classification of construction hazards for a universal hazard identification methodology. *Journal of Civil Engineering and Management*, *26*(2), 147-159. https://doi.org/10.3846/jcem.2020.11932

Mishra, D., Mishra, A. K., Sah, D. P., Joshi, B. R., & Aryal, B. (2021). Assessment of Workers Safety and Health Status in High Rise Building: A Case Project of "Double Tree by Hilton Commercial Hotel at Naxal, Kathmandu". *Assessment*, *5*(2).

Mishra, K., & Aithal, P. S. (2021). Operational risk analysis of common activities of building construction projects. *Turkish Journal of Computer and Mathematics Education*, *12*(11), 6507-6524.

Mitropoulos, P., Abdelhamid, T. S., & Howell, G. A. (2005). Systems model of construction accident causation. *Journal of construction engineering and management*, *131*(7), 816-825. https://doi.org/10.1061/

Omar, M., Mahmoud, A., & Abdul Aziz, S. A. B. (2023). Critical factors affecting fire safety in high-rise buildings in the Emirate of Sharjah, UAE. *Fire*, *6*(2), 68. https://doi.org/10.3390/fire6020068

Patel, V., Chesmore, A., Legner, C. M., & Pandey, S. (2022). Trends in workplace wearable technologies and connected-worker solutions for next-generation occupational safety, health, and productivity. *Advanced Intelligent Systems*, *4*(1), 2100099. https://doi.org/10.1002/aisy.202100099

Peñaloza, G. A., Saurin, T. A., & Formoso, C. T. (2020). Monitoring complexity and resilience in construction projects: The contribution of safety performance measurement systems. *Applied ergonomics*, *82*, 102978. https://doi.org/10.1016/j.apergo.2019.102978

Purohit, D. P., Siddiqui, N. A., Nandan, A., & Yadav, B. P. (2018). Hazard identification and risk assessment in the construction industry. *International Journal of Applied Engineering Research*, *13*(10), 7639-7667.

Ratnaningsih, A., Dhokhikah, Y., & Fitria, A. (2018, June). Hazard identification, risk analysis, and risk assessment on high-rise building construction projects. In *AIP Conference Proceedings* (Vol. 1977, No. 1). https://doi.org/10.1063/1.5042870

Rimal, B., Baral, H., Stork, N. E., Paudyal, K., & Rijal, S. (2015). Growing city and rapid land use transition: Assessing multiple hazards and risks in the Pokhara Valley, Nepal. *Land*, *4*(4), 957-978. https://doi.org/10.3390/land4040957

Saidi, S. S., & Siew, N. M. (2019). Investigating the Validity and Reliability of Survey Attitude towards Statistics Instrument among Rural Secondary School Students. *International journal of educational methodology*, *5*(4), 651-661. https://doi.org/10.12973/ijem.5.4.651

Sakhare, M. V., & Chougule, M. B. (2019). Construction Equipment Monitoring: By Using Relative Important Indices (RII) Analysis.

Shaikh, A. Y., Osei-Kyei, R., & Hardie, M. (2021). A critical analysis of safety performance indicators in construction. *International Journal of Building Pathology and Adaptation*, *39*(3), 547-580. https://doi.org/10.1108/IJBPA-03-2020-0018