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DEVELOPMENT OF FRAMEWORK MODEL FOR CONSTRICTION SAFETY CULTURE TOWARDS ACCIDENT PREVENTION AND PERFORMING VALIDATION OF DEVELOPED MODEL

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ABSTRACT
The construction industry, often deemed high-risk due to complex tasks, heavy machinery, and hazardous work environments, faces persistent safety challenges. This research proposes a framework model to cultivate a robust construction safety culture aimed at accident prevention. The model integrates leadership commitment, employee involvement, and well-established safety policies to foster a safety-conscious environment. It emphasizes cultural elements, such as shared values and attitudes, to create a shift in safety perception throughout all project phases. Through an empirical research approach, the framework is validated by analysing real-world construction safety data. A key contribution of this study is the development of a modified Hazard Identification and Risk Assessment (HIRA) framework that incorporates risk multiplication factors (RMFs), ensuring a more comprehensive risk assessment process. The findings suggest that the new model not only enhances safety outcomes but also positively impacts overall project performance, reducing accident rates and improving worker morale. The study highlights the critical importance of leadership, policy, and resources in shaping safety culture, while also addressing the broader societal, financial, and legal implications of construction safety. Ultimately, the framework provides a structured approach to improving safety practices and outcomes across construction projects, contributing to industry-wide best practices for safety management.

Keywords:
Construction Safety, Safety Culture, Risk Assessment, Accident Prevention, Leadership, Safety Policy, Hazard Identification, Risk Multiplication Factors, Structural Equation Modelling, Safety Management.

I. Introduction
The construction industry, known for its high-risk environment, faces persistent challenges in ensuring the safety of workers. With complex tasks involving heavy machinery, precarious work environments, and tight project timelines, accidents remain a major concern [1]. A safety culture, which reflects the shared values, attitudes, and behaviours of an organization towards safety, is crucial in preventing these accidents. Despite the implementation of safety protocols, accidents continue to occur, pointing to the need for a more integrated, proactive approach to safety management. The development of a framework model for construction safety culture is aimed at embedding safety into every facet of project execution, with a focus on accident prevention [3].

The framework model being developed seeks to address the gaps identified in existing safety management systems by integrating cultural elements into safety practices. This model will combine leadership commitment, employee involvement, and the establishment of robust safety policies to foster a safety-conscious environment across all project phases. By focusing on the cultural and behavioural aspects of safety, the model aims to create a shift in how safety is perceived and acted

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upon within the industry. Furthermore, the framework will be validated through empirical research, ensuring its applicability and effectiveness in real-world construction settings [3]. The significance of this framework lies not only in improving safety outcomes but also in enhancing the overall performance of construction projects. A positive safety culture has been shown to reduce accident rates, improve worker morale, and increase productivity by creating an environment where safety is prioritized by all stakeholders. The proposed model will therefore play a vital role in reshaping the safety landscape of the construction industry, providing organizations with a structured approach to reduce accidents and foster a culture of continuous safety improvement. Through the validation of this model, this study aims to contribute to the establishment of industry-wide best practices that prioritize safety and ensure the well-being of workers across construction sites [4].

1.1 Importance of Construction Safety Culture

In the construction industry, safety is essential for both worker well-being and successful project execution. Given the inherent risks such as working at heights and operating heavy machinery a robust safety culture is crucial. This culture goes beyond compliance with regulations; it involves a shared mindset across all levels, from workers to executives [5].

A strong safety culture not only reduces accidents but also ensures timely and cost-effective project completion, fostering trust among stakeholders and enhancing the industry's reputation. Originating from the Chernobyl disaster, safety culture has become a key concept in organizational management, emphasizing shared values and attitudes towards health and safety. Over time, this concept has evolved to include psychological, behavioural, and corporate dimensions, highlighting its critical role in proactively addressing risks and preventing accidents [6].

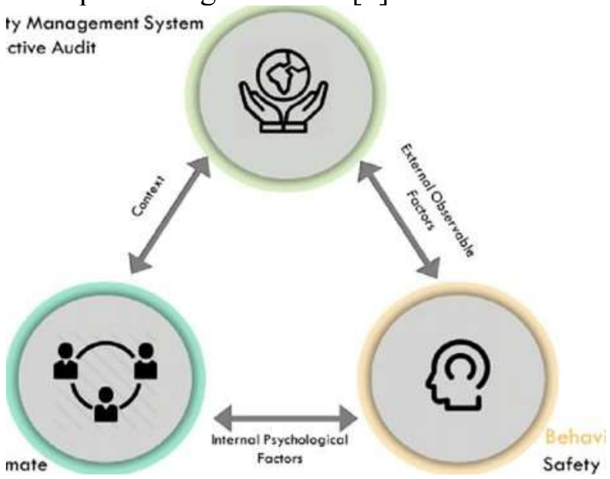

Fig 1. Construction Safety Culture Model

II. Literature

The construction industry, known for its inherent risks and complex operations, requires effective safety measures to prevent accidents and ensure worker well-being. Recent studies have focused on various safety-related aspects, including the development of decision aids, the role of safety climate, and the adoption of innovative technologies like exoskeletons and virtual reality. Researchers have explored factors influencing safety performance, such as leadership, worker empowerment, and hazard identification, offering valuable insights into improving safety practices. This collection of studies highlights the ongoing efforts to enhance safety culture, identify risks, and develop predictive models, ultimately aiming to reduce accidents and improve construction site safety management.

Sean M. Whitaker et al. (2002) developed SCAFPASS, a decision aid to improve scaffold safety. It identifies common issues like improper installations and poor supervision. By enhancing safety management, SCAFPASS aims to reduce scaffold-related injuries in construction projects. Gunjan Tripathi et al. (2014) surveyed 100 retail investors in India to understand their perceptions of derivative

trading. They found that income influences investment decisions, while other factors like gender and education do not significantly affect investor behaviour in derivatives. Tariq Umar et al. (2015) analysed safety climate factors in Omani construction. They identified leadership commitment, worker empowerment, and communication as key influences. The study recommends further validation of these factors across broader construction teams to improve safety practices and performance. Sunwook Kim et al. (2019) explored the use of exoskeletons to reduce musculoskeletal injuries in construction workers. They found potential benefits but also concerns regarding practical application. The study calls for further research to overcome obstacles to exoskeleton adoption in construction. M. Loosemore et al. (2019) evaluated the effectiveness of safety training in Australian construction. Their survey revealed that while training improved workers' understanding of safety hazards, it had little effect on altering their safety attitudes. More engaging training methods are recommended.
Ivan W. H. Fung et al. (2022) introduced the Stress-strain Model to enhance construction safety and risk management. It helps organizations identify hazard release points and manage risks effectively, aiming to improve safety performance in dynamic construction environments. Siddharth Bhandar et al. (2019) studied how emotions affect hazard identification, risk assessment, and safety decisions in construction. Using augmented reality, they found that emotions influenced risk assessments and safety decisions but did not significantly impact hazard identification processes. Sooyoung Choe et al. (2020) proposed a safety risk generation and control model for construction. The model examines factors like resources, temporal risks, and management control, aiming to enhance safety risk analysis and promote proactive safety management on construction sites. Tao Shen et al. (2019) developed a construction safety prediction model using an optimized BP neural network algorithm. The model accurately predicted safety risks and reduced casualties by providing proactive measures to manage risks before construction issues occurred.
Mohammad Tanvi Newaz et al. (2018) proposed a five-factor safety climate model for construction. Their systematic review highlighted factors like worker engagement and supervisor accountability as key to safety climate. The model aims to standardize safety climate evaluation across the industry. Feng Bin et al. (2019) developed a virtual realitybased safety training system for construction. The system enhances hazard awareness by immersing workers in realistic virtual environments, helping them respond to safety risks, thereby improving overall safety training effectiveness on construction sites. Tao Chen et al. (2020) analyzed the correlation between construction safety factors and non-fatal accidents in China using multiple regression. Their findings suggest that higher labor productivity decreases accidents, while increased profits and mortality rates contribute to higher non-fatal accidents. Saeed Reza Mohandes et al. (2019) developed the CHFORAM model to improve risk assessment for construction workers. The model enhances risk analysis accuracy by reducing uncertainties and proposing effective mitigation strategies, offering practical guidance for safety managers to improve worker safety. Murat Gunduz et al. (2018) created a fuzzy structural equation model to assess safety performance on construction sites. The model combines fuzzy set theory with structural equation modelling to evaluate safety indices, providing an effective tool for real -time safety assessments via a mobile app. Eiei Soewin et al. (2022) used system dynamics modelling to analyse construction performance indices. The study found that collaboration, management, and internal stakeholders impact safety and performance. It emphasizes the importance of integrating environmental policies into long-term performance improvement strategies.

III. Methodology

The methodology involves identifying key factors influencing construction safety culture through literature review and expert consultation. Variables like leadership, communication, and safety policies are highlighted. Data is organized in Excel using HIRA, ensuring clarity and consistency by defining columns for each variable to support structured analysis and informed decision-making in accident prevention efforts.

3.1. Conceptual Model Development

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The study developed a structural equation model of construction safety culture, focusing on six key enablers leadership, policy, people, partnerships, processes, and goals. It hypothesized relationships between these latent constructs and their attributes to improve safety outcomes, emphasizing leadership's pivotal role in fostering a positive safety culture.

Enablers Goals

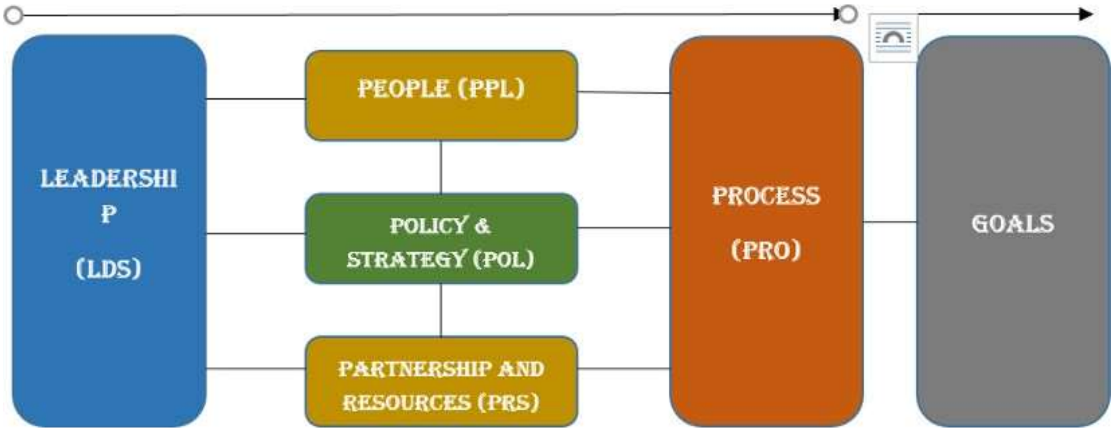

Fig 2. Proposed Conceptual Model of Construction Safety Culture

The diagram represents a strategic model where Leadership (LDS) drives enablers like People (PPL), Policy & Strategy (POL), and Partnerships & Resources (PRS). These elements influence Processes (PRO), which collectively contribute to achieving organizational Goals. It highlights the interconnected role of leadership, planning, and resources in delivering results.

3.2. Data Collection

Data were collected using a structured questionnaire survey designed to assess construction safety culture. Respondents rated statements on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The survey also captured demographic and organizational data, enabling analysis of safety performance, policies, reporting systems, and resource allocation across different construction organizations.

3.3. Data Analysis

The collected data were first analysed using exploratory factor analysis (EFA) to identify underlying factors and validate the grouping of attributes in the conceptual model. Subsequently, structural equation modelling (SEM) was applied to examine the relationships among the enablers, revealing complex interactions within the construction safety culture.

Exploratory Factor Analysis (EFA) identifies the underlying structure of variables by grouping them into factors based on their correlations. It helps uncover latent constructs by finding the smallest number of factors explaining maximum variance. Researchers interpret factors by examining variable loadings and their theoretical context, enabling a better understanding of complex data patterns.

Structural Equation Modelling (SEM) tests and estimates complex relationships among observed and latent variables. It combines confirmatory factor analysis and path analysis to evaluate direct and indirect effects, assess model fit, and account for measurement error. SEM is widely used for modelling intricate variable relationships in social sciences and beyond.

3.4. Modified HIRA Framework for Dynamic Risk Assessment

Traditional Hazard Identification and Risk Assessment (HIRA) models are static in nature, primarily relying on the basic formula of Probability x Severity to evaluate risks. However, this approach often overlooks crucial contextual factors such as environmental conditions, organizational dynamics, and human factors. To address these limitations, a modified HIRA framework is proposed, integrating Risk Multiplication Factors (RMFs). This enhanced model aims to provide a more comprehensive and realistic assessment of risk by incorporating variables related to Environmental, Occupational Health and Safety (OH&S), and Operational aspects. The modified approach ensures that risk levels are more reflective of actual working conditions, thereby supporting more effective safety management and decision-making.

- Traditional Risk = Probability x Severity
- Modified Risk = (Probability x Severity) x Risk Multiplication Factors
- RMFs derived from 12 X 5 real-world influencing factors.

Table 2. Probability Rating

Probability/Likelihood of Rating Occurrence	Description
1. Very Unlikely (Improbable)	1 IN EVERY 10,000 OPERATIONS or 1 IN EVERY 10 YEARS OPERATION
2. Unlikely (Remote)	1 IN EVERY 1000 OPERATIONS or 1 IN EVERY 05 YEARS OPERATION
3. Likely (Possible)	1 IN EVERY 100 OPERATIONS or 1 IN EVERY YEAR OPERATION
4. Very Likely (Probable)	INCIDENT MOST LIKELY TO HAPPEN or 1 IN EVERY MONTH OPERATION

Table 3. Severity Rating

Severity Rating Occurrence	Description
1. Negligible	Minor injuries such as small cuts and bruise, back to work
2. Minor	Injury/ill health with short term effect, not reportable — away from work for less than two days
3. Severe	Major injury or permanent disability or ill health with long term effect reportable
4. Major	Fatality, disasters.

IV. Result and Discussion

The table presents a comprehensive framework for the development of a safety culture within the construction industry, aimed at accident prevention. It encompasses various aspects including risk assessment, societal engagement, financial assessment, design assessment, advisor evaluation, stakeholder perspective, contractor assessment, safety assessment, asset evaluation, workforce management, legal issues, and detrimental issues. Each aspect is evaluated based on multiple criteria, with checkboxes indicating the degree of adherence or risk level. For instance, under risk assessment, factors such as environmental impact, societal engagement, financial assessment, design assessment, advisor evaluation, stakeholder perspective, contractor assessment, safety assessment, asset evaluation, workforce management, legal issues, and detrimental issues are assessed. The checkboxes provide ranges or options for each criterion, allowing for a detailed evaluation.

Table 4: Framework of risk assessment model
(a) Environmental impact, social engagement, financial assessment and design assessment

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Framework of Risk Assessment											
Environmental Impact	Air Contamination	Aquatic Contamination	Sound Pollution	Ground-Related Concern.	Building Debris Generation.	Individual Risk Rating					Total RR
	<15%	<15%	<15%	<15%	<15%						
	Between 15% - 30%	Between 15% - 30%	Between 15% - 30%	Between 15% - 30%	Between 15% - 30%	2	1	3	2	2	10
	>30%	>30%	>30%	>30%	>30%						
Societal Engagement	Community Grievances	Public Movement Near Work Areas	Local Worker Inclusion	Public Complaints on Safety	Unauthorized Entry Incidents						
	No grievances reported	Fully restricted & controlled	>30% of workforce local	None	0 incidents						
	Upto 5%	Limited, but managed (barriers/TGs)	15%–30% local workforce	1–2/month	1–2/month	1	2	3	1	2	9
	>5% workforce affected	Unrestricted public movement	<15% local workforce	>2/month	>2/month						
Financial Assessment	Budget Allocation for Safety	Safety Equipment Investment	Safety Resource expenditure per worker	Safety Staff-to-Worker Ratio	Emergency Resource Readiness						
	>3% of total project cost	All PPE/tools are certified and modern	>₹1,000/month/worker	1:100 or better	100%						
	Between 1%–3%	Mostly compliant PPE with minor gaps	₹500–₹1,000/month	1:150–200	50-75%	3	2	2	2	1	10
	<1%	Inadequate/non-standard PPE	<₹500/month	>1:200	<50%						
Design Assessment	Design Complexity	Access & Egress Provisions	Height Work Consideration	Temporary Works Safety Design	Ergonomic Considerations						
	Simple/modular design	Multiple safe routes	Work <2m or full platform access	Full design integration & approvals	Clear space, minimal physical strain						
	Moderate complexity	Limited safe access	2m–6m with partial protection	Partial approvals, few checks	Acceptable clearances, minor risks	2	1	2	2	2	9
	Complex, congested design	Poor access or only one escape route	>6m with minimal edge/fall protection	No systematic safety design review	Tight, hazardous workspaces						

(b) Advisor evaluation, stakeholder's perspectives, contractor and safety assessment

Framework of Risk Assessment											
Advisor Evaluation	Safety Experience	Incident Investigation Skill	Regulatory Knowledge	Safety Communication	Training Contribution						
	>10 years in safety-critical projects	Proven expertise (≥95% root cause ID)	Fully updated	Highly effective across levels	Leads >90% sessions + effective review						
	5–10 years experience	Moderate (80–95% accuracy)	Moderate awareness	Average clarity	Participates in 50–90% sessions	2	1	1	1	1	6
	<5 years experience	Weak (<80% accuracy, superficial)	Poor awareness or outdated knowledge	Poor/unclear safety messaging	<50% involvement in safety trainings						
Stakeholder Perspective	Safety Commitment Priority	Workforce Safety Awareness	Budget Allocation to Safety	Stakeholder Engagement	Crisis Response Preparedness						
	Safety-Focused	>95% trained + active involvement	≥10% of project budget	Regular reviews & audits	Fully established plan + drills100%						
	Balanced (Safety + Progress)	85%–95% trained	5%–10% of project budget	Periodic feedback	Partial readiness	2	2	3	1	1	9
	Progress-Focused	<85% trained or passive involvement	<5% of project budget	Rare/no involvement	No plan or untested						
Contractor Assessment	Safety-Driven Priority	Training Proficiency Level	Economic Resilience	Workforce Deployment	Accident Frequency Rate (FR)						
	Strong safety-first approach	>95% trained workforce	Strong reserves, on-time pay	>90% deployment consistently	< 0.01%						
	Balanced (Safety & Progress)	75%–95% trained	Occasional delays, break-even status	80%–90% range	Between 0.01% - 0.1%	2	2	2	2	1	9
	Progress-focusedBoth	<75% trained	Unstable finances	<80%, irregular presence	> 0.1%						
Safety Assessment	Regulatory Compliance	Executing tasks as outlined in the HSE plan	Adequate staffing	Proficient and Seasoned Implementation Team	Stakeholder Focus						
	Complete Adherence	>95%	>90%	>90%	High						
	Partial adherence	Between 95% - 75%	Between 90% - 65%	Between 90% - 65%	Average	1	1	2	2	1	7
	No adherence	< 75%	< 65%	< 65%	Less						

(c) Asset evaluation, workforce, legal issue and detrimental issue

Framework of Risk Assessment											
Asset Evaluation	Resource Accessibility	Resource Allocation	Resource Excellence	Stewardship of Resources	Fresh vs Aged Resources						
	>95%	>90%	Safety-required & compliant	100% well-maintained & tracked	>85% fresh and compliant stock						
	Between 95% - 85%	Between 90% - 65%	Average quality/condition	Between 99% - 65%	Between 85% - 55%	1	2	2	2	1	8
	< 85%	<65% allocated	Sub-standard or failing	<65%, poor tracking & upkeep	<55%, majority aged stock						
Workforce	Count	Resource Allocation	Tenure	Productive	Workforce Mobility						
	>95% readily accessible	>90% actively engaged	>95% long-tenured staff	>95% performing efficiently	<5% (very low churn, high retention)						
	Between 95% - 85%	Between 95% -65%	Between 95% -65%	Between 95% -65%	Between 5% -20%	2	1	3	2	3	11
	<85% workforce available	<65% allocated	<65% short-tenured workforce	<65% underperforming	20% (high turnover, safety risk)						
Legal Issue	Regulatory Framework	Administrative assurance	Consent from appropriate agency	Harmonious	Legal Proficiency						
	>95%	100	100	100	100						
	Between 95% - 85%	Between 99% - 95%	Between 99% - 95%	Between 99% - 95%	Between 99% - 85%	1	1	1	2	2	7
	< 85%	> 95%	> 95%	> 95%	> 85%						
Detrimental Issue	Budgetary	Safety concerns	Natural clarity	Occupational Emergencies	Quality concerns						
	No Issue	No Issue	No Issue	No Issue	No Issue						
	Tolerable	Intense	Tolerable	Upto 5%	Tolerable	2	2	2	2	2	10
	Intolerable	Substantial	Intolerable	> 5%	Intolerable	Risk Multiplication Factor					0.58

The framework aims to provide a holistic view of safety culture within construction projects, considering not only traditional safety metrics but also societal, financial, and legal aspects. This multifaceted approach recognizes that safety in construction is influenced by various factors beyond technical measures. To validate this framework, a risk multiplication factor of 0.52 is provided. This factor likely represents the overall risk level derived from the various assessed criteria. It suggests that despite efforts to mitigate risks, there remains a residual risk associated with construction projects, highlighting the importance of continuous improvement in safety practices. Performing validation of the developed model involves comparing the predicted risk multiplication factor with actual accident data from construction sites. If the predicted factor aligns closely with observed accident rates, it indicates the effectiveness of the framework in assessing and managing risks. Conversely, significant discrepancies may signal areas where the framework needs refinement or where additional safety measures are warranted. In conclusion, the table presents a structured framework for assessing and fostering a safety culture within the construction industry. It provides a systematic approach to identifying and managing risks, encompassing diverse aspects relevant to construction safety. Validation of this framework is crucial to ensuring its effectiveness in preventing accidents and promoting a safer working environment in construction projects.

V. Discussions

The proposed framework model for construction safety culture demonstrates a significant shift towards a more integrated approach to accident prevention. By embedding safety into organizational culture through leadership commitment, employee involvement, and comprehensive safety policies, the model aims to reduce the risks inherent in construction environments. Traditional safety protocols often fall short in addressing the behavioural and cultural factors that contribute to accidents. This study bridges that gap by emphasizing the psychological and organizational dimensions of safety. One key aspect of this research is the development and validation of the modified HIRA framework, which incorporates Risk Multiplication Factors (RMFs). This enhanced model allows for a more nuanced assessment of risks by considering contextual factors that traditional models overlook, such as environmental conditions and human factors. Through data analysis and validation, the framework's effectiveness in reducing accidents and improving safety performance is evident. The study also emphasizes the role of leadership and proactive safety measures in fostering a culture where safety is prioritized across all levels ofa construction project. The findings align with prior research, which suggests that a strong safety culture positively influences worker morale, reduces accident rates, and improves productivity. Therefore, the model presented here serves as a valuable tool for reshaping safety practices within the construction industry and ensuring the well-being of all stakeholders.

VI. Conclusion

In conclusion, the research offers a comprehensive framework for developing a safety culture within the construction industry, aiming to reduce accidents and enhance safety outcomes. The study's core contribution is the establishment of a safety culture model that incorporates leadership, communication, and policy integration into all stages of a construction project. This model seeks to address the gaps in existing safety systems by embedding cultural elements that emphasize the shared responsibility of all stakeholders in ensuring safety. The validation of this framework, using empirical data, underscores its applicability and effectiveness in real-world construction environments. The inclusion of a modified Hazard Identification and Risk Assessment (HIRA) model, which incorporates Risk Multiplication Factors (RMFs), offers a more holistic approach to risk assessment. By considering contextual and environmental factors, this enhanced framework provides a more accurate reflection of the actual risks in construction settings. The findings from the study suggest that a robust safety culture not only leads to a reduction in accidents but also improves worker morale, project timelines, and overall productivity. The framework offers a structured approach to creating a safety-conscious environment, which could ultimately shape industry-wide best practices. It contributes significantly to improving safety management strategies and underscores the importance of continuous safety culture development in construction projects.

References

[1] Kim, S.; Moore, A.; Srinivasan, D.; Akanmu, A.; Barr, A.; Harris-Adamson, C.; Rempel, D. M.; Nussbaum, M. A. Potential of Exoskeleton Technologies to Enhance Safety, Health, and Performance in Construction: Industry Perspectives and Future Research Directions. IISE

Transactions on Occupational Ergonomics and Human Factors. 2019, 7(3-4), 185-191. https://doi.org/10.1080/24725838.2018.1561557.
[2] Gunduz, M.; Talat Birgonul, M.; Ozdemir, M. Development of a safety performance index assessment tool by using a fuzzy structural equation model for construction sites. Automation in Construction, 2018, 85, 124—134. https://doi.org/10.1016/j.autcon.2017.10.012.
[3] Li, X.; Yi, W.; Chi, H.-L.;Wang, X.; Chan, A. P. A critical review of virtual and augmented Rea VR AR applications in construction safety. 2018.
[4] Bin, F.; Xi, Z.; Yi, C.; Ping, W. G. Construction safety education system based on virtual reality. IOP Conference Series: Materials Science and Engineering, 2019, 563(4).
[5] Chen, T.; Cao, Z. Construction safety an analysis of the cross-influence of economic, construction, and accident death factors. Environmental Science and Pollution Research, 2021, 28(46), 65243—65254. https://doi.org/10.1007/s11356-021-15231-4
[6] Newaz, M. T.; Davis, P. R.; Jefferies, M.; Pillay, M. Developing a safety climate factor model in construction research and practice: A systematic review identifying future directions for research. Engineering, Construction and Architectural Management, 2018, 25(6), 738—757. https://doi.org/10.1108/ECAM-02-2017-0038.
[7] Tripathi, G. An Empirical Investigation of Investors Perception towards. 2014, 6(2), 99—104.
[8] Loosemore, M.; Malouf, N. Safety training and positive safety attitude formation in the Australian construction industry. Safety Science, 2019, 113, 233—243. https://doi.org/l().1016/j.ssci.2()18.11.029.
[9] Mohandes, S. R.; Zhang, X. Towards the development of a comprehensive hybrid fuzzy-based occupational risk assessment model for construction workers. Safety Science, 2019, 115, 294—309. https://doi.org/10.1016/j.ssci.2019.02.018.
[10] Choe, S.; Leite, F. Transforming inherent safety risk in the construction Industry: A safety risk generation and control model. Safety Science, 2020, 124, 104594. https://doi.org/10.1016/j.ssci.2019.104594.
[11] Umar, T.; Egbu, C. Perceptions on safety climate: A case study in the Omani construction industry. Proceedings of Institution of Civil Engineers: Management, Procurement and Law, 2018, 171(6), 251—263. https://doi.org/10.1680/jmapl.18.00001.
[12] Whitaker, S. M.; Graves, R. J.; James, M.; McCann, P. Safety with access scaffolds: Development of a prototype decision aid based on accident analysis. Journal of Safety Research, 2003, 34(3), 249—261. https://doi.org/10.1016/S0022-4375(03)00025-2.
[13] Shen, T. ; Nagai, Y.;, Gao, C. Design of building construction safety prediction model based on optimized BP neural network algorithm. Soft Computing, 2020, 24(11), 7839—7850.
[14] Bhandari, S.; Hallowell, M. R.; Boven, L. van; Welker, K. M.; Golparvar-Fard, M.; Gruber, J. Using Augmented Virtuality to Examine How Emotions Influence Construction-Hazard Identification, Risk Assessment, and Safety Decisions. Journal of Construction Engineering and Management, 2020, 146(2), 1—12. https://doi.org/10.1061/(asce)co.1943-7862.0001755.
[15] Ismail, H. B.; Ghani, K. D. A. Potential Hazards at the Construction Workplace due to Temporary Structures. Procedia - Social and Behavioral Sciences, 2012, 49, 168—174. https://doi.org/l0.1016/j.sbspro.2012.7.15
[16] Malekitabar, H.; Ardeshir, A.; Sebt, M. H.; Stouffs, R. Construction safety risk drivers: A BIM approach. safety Science, 2016, 82, 445-455. https://doi.org/10.1016/j.ssci.2015.11.002
[17] Ning, X.; Qi, J.; Wu, C. A quantitative safety risk assessment model for construction site layout planning. Safety Science, 2018, 104, 246—259. https://doi.org/l0.1016/j.ssci.20.18.0l.16.
[18] Wu, H.; Zhao, J. An intelligent vision-based approach for helmet identification for work safety. Computers in Industry, 2018, 267-277. https://doi.orWIO.1016/j.compind.2018.03.037.
[19] Borkovskaya, V, Lyapuntsova, E., & Nogovitsyn, M. (2019). Risks and safety in construction by increasing efficiency of investments. E3S Web of Conferences, 97, 1—8. https://doi.org/l0.1051/e3sconf/20199706036

[20] Jin, R.; Zou, P. X. W.; Piroozfar, P.; Wood, H.; Yang, Y.; Yan, L.; Han, Y. A science mapping approach based review of construction safety research. Safety Science, 2019, 285—297. https://doi.org/l O. 1016/j .ssci.2018.12.006
[21] Hamdan, N.; Awang, H. Jurnal Teknologi Full Paper SAFETY SCAFFOLDING IN THE CONSTRUCTION SITE. 2015, 75(5), 2180-3722. www.jurnalteknologi.utm.my.
[22] Demirkesen, S. Measuring impact of Lean implementation on construction safety performance: a structural equation model. Production Planning and Control, 2020, 31 (5), 412—433. https://doi.org/10.1080/09537287.2019.1675914.
[23] Soewin, E.; Chinda, T. Development of a construction performance index in the construction industry: system dynamics modelling approach. International Journal of Construction Management, 2022, 22(10), 1806—1817. https://doi.org/l O. 1080/15623599.2020.1742633.
[24] Fung, I. W. H.; Tam, V. W. Y.; Chu, J. O. C.; Le, K. N. A Stress-Strain Model for resilience engineering for construction safety and risk management. International Journal of Construction Management, 2022, 22(12), 2308— 2324. https•.//doi.org/l O. 1080/15623599.2020.1783602
[25] Joreskog, K. G. KARL G. JORESKOG AND DAG SORBOM* Recent Developments in Structural Equation formulated a general model, the LISREL model, for systems of structural equations. Journal of Marketing Research, 1973, 404—420.
[26] Quintana, S. M.; Maxwell, S. E. Implications of Recent Developments in Structural Equation Modeling for Counseling Psychology. The Counseling Psychologist, 1999, 27(4), 485-527. https://doi.org/10.1177/0011000099274002.
[27] Tarka, P. An overview of structural equation modeling: its beginnings, historical development, usefulness and controversies in the social sciences. Quality and Quantity, 2018, 52(1), 313—354. https://doi.org/10.1007/s11135017-0469-8.
[28] Ko, D. W.; Stewart, W. P. A structural equation model of residents' attitudes for tourism development. Tourism Management, 2002, 23(5), 521-530. https://doi.org/10.1016/S0261-5177(02)00006-7.
[29] Tan, K. C. A Structural Equation Model of New Product Design and Development. Decision Sciences, 2001, 32(2), 195-226, https://doi.org/10.1111/j.1540-5915.2001.tb00958.