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Enhancing Safety Management Barriers in Railway Construction Towards Sustainable Construction Projects: A Preliminary Review

Yugeswaran Chinniah[1*], Norsyakilah Romeli[2]

[1,2]Faculty of Civil Engineering & Technology, UniMAP, Malaysia

ABSTRACT

Malaysia is one of the countries that have been influenced by the growth of the global railway network as a vital tactic for railway sustainable infrastructure by enhancing the country's internal transportation system and increasing economic competitiveness. Not knowing the safety management barriers lead to calamity of in sustainable e environment health and safety. Therefore, it is essential to identify the barriers in safety management practices in railroads for sustainable projects. This study was conducted in the objectives of to investigate safety management barriers for railway construction projects. Using the purposive samplings, 25 numbers of Scopus Indexed journal regarding Safety Culture and Railway Safety Management gathered and was finalized from year (2018 – 2024). The qualitative data analysis (Thematic Data Analysis) and quantitative data analysis (Frequency Analysis) has been implemented to dissect the main barriers in railway construction landscape. The results indicated that the most significant variables lack awareness of the benefits of IR 4.0 has the frequent mention in these studies, as the safety practices can be enhance using the IR 4.0 tools for example using the Unmanned Aerial Vehicle, Building Information Modelling and Terrestrial Laser Scanner. It is believed to improve on technological management can solve the problem on uneven transparency and safety project plan issues and leads to sustainable construction projects.

Keywords: Safety Management Barriers, Railway Construction, Sustainable Construction Project

1. INTRODUCTION

Malaysia is a developing country in Asia with a population of 32.7 million (Department of Statistics, 2020). Transportation has long been considered one of the main forces behind economic activity throughout civilizations. Transportation is the capacity to transfer people, things, and information transitorily between multiple places of origin and destinations via a single or multiple points of interchange via a network in space (CIDB, 2019).

Malaysia is a developing country; (Gheisari et al, 2019), thus it is still learning about sustainability. In managing projecting development versus demand, the Malaysian government is determined to comprehend the exponential growth of Klang Valley urbanite the center of Kuala Lumpur which is extending southward to mix with new townships and corridors, including rail infrastructure (Lin et. al, 2018). However, to gear up with the rapid large railway infrastructure development plan, the safety management practices often being the factor that jeopardies the wellbeing of railway construction management. Supported by the Department of Occupational Safety and Health (DOSH) reports that, as of November 2022, 6719 incidents had been documented across all industries. 148 of these occurrences are handled by the construction sector. Out of all industries with high-risk sectors, the construction sector had the largest number of fatalities with 59 overall (Du et. al, 2021).

* yugeswaran@studentmail.unimap.edu.my

2. LITERATURE REVIEW

Around 50% of capital stock investment in major developing countries is allocated to the construction sector. Creating job opportunities and generating new income sources are critical for societal progress, regardless of individuals' education levels (Al- Ashmori et. al, 2021). In Malaysia, construction projects are divided into two main sectors: public and private. The Public Works Department (PWD) oversees public-sector projects, while the Construction Industry Development Board (CIDB) regulates both public and private projects. Over the last two decades, the construction sector's contribution to GDP has grown to 3–5%, playing a vital role in national development (Horváth, 2019). Development efforts focus on improving living standards, conserving natural resources, and combating climate change. To promote social and economic progress, the Malaysian government has heavily invested in infrastructure development, allocating US$13 billion or 3.66% of GDP to infrastructure under the Malaysia Plans in 2019 (Davidson et. al, 2020).

Literature on sustainable infrastructure highlights a focus on developing tools for evaluating green infrastructure, such as indicators, criteria, sub-criteria, weighting, and certification processes. This area has received significant attention in recent research on Malaysia's sustainable infrastructure projects (Ahmad et. al, 2020). The implementation of resilient infrastructure throughout all stages of the project cycle has been identified as a key component of achieving economic, environmental, and social sustainability (Al-Ashmori et. al, 2020).

Rail transportation, which uses wheeled vehicles on tracks to transport passengers and goods, has become the most significant and efficient mode of public transportation worldwide (DOSH, 2018). To achieve complete sustainability in Malaysia's construction sector, three core elements of environmental, social, and economic development which are essential (Misiurek et. al, 2017). While sustainability has long been a focus of Malaysia's construction industry, many skilled workers, despite their understanding of sustainable practices, often neglect these approaches due to factors such as higher initial costs, increased labor demands, resistance to adopting non-traditional methods, and a lack of strict legislation (Fei, 2020).

In Malaysia, many construction projects are in hazardous environments, which significantly elevate the risk of accidents. Factors such as the unique nature of the construction industry, human behavior, unfavorable site conditions, unsafe work practices, machinery, and procedures which are often influenced by inadequate safety management are commonly identified as contributors to accidents within the sector (Horváth, 2019). Typically, construction site accidents stem from a lack of expertise or experience, insufficient management commitment to safety and health, and limited safety awareness (Kim et. al, 2019). More specifically, incompetence, inexperience, poor top-level supervision, or individual negligence are frequent causes of such incidents. A key underlying issue is the absence of a strong safety culture, as reflected in unsafe behaviors (Lingard et. al, 2017).

Assumptions on safety barriers is always on poor equipment maintenance and a lack of ability to understanding of the job are common causes of accidents. Even though most incidents go unreported, a labourer may be given first aid or other medical care if needed. Most of the time, advanced medical care or perks are not accessible. However, the real barriers are vague and staff members concede that accidents are a part of their job and claim that they are unavoidable due to their own incompetence. Nonetheless, because there is a chance of monetary damages and legal action, serious workplace accidents that cause a worker's death can be reported (Sanni-Anibire et. al, 2020). Selections at the top of the hierarchy of practice ought to be given priority. However, the only realistic option for reducing the risk is frequently to alter and or establish routines and

procedures. As a result, it can be said that an organization's safety barriers must be identifies first, then the procedures must be consistent for safety to be successful generally.

3. RESEARCH METHODOLOGY

This research is primarily derived on a concept on a review of the literature. Additionally, it aids in the establishment of the safety barriers in the railway engineering sector, which guides the avoidance of accidents and supports Malaysia's sustainable construction industry. Using the purposive samplings, 25 numbers (N=25) of Scopus Indexed journal regarding Safety Culture and Railway Safety Management gathered and was finalized from year (2018 – 2024). The research observed the most main element selected by the authors used by assessing 6 local journal and 19 international journals. Later, using the qualitative data analysis (Thematic Data Analysis) has been implemented to dissect the main barriers in railway construction landscape. The themes then have undergone the process of quantitative data analysis (Frequency Analysis) toward the safety barriers involved. The results and discussion were further discussed at the next chapter.

4. RESULTS AND DISCUSSION

Table 1 shown the Safety Barriers in Railway Construction. The major safety barrier in construction is lack of awareness of the benefits of IR 4.0. Most businesses are concerned about whether the facilities and technology are appropriate at this early point in IR 4.0 [26]. In the era of digital transformation, IR 4.0 is progressively changing the construction sector [31]. It is projected that IR 4.0 will significantly impact the construction market and industry, improve operational processes, impact the entire product lifecycle, and increase a company's competitiveness. The benefits of Industry 4.0 for the construction sector can be divided into four major categories: (1) worker participation, (2) hazard prevention and control, (3) management, and (4) education and training. There are also concerned with the cost-benefit analysis, effectiveness, and efficiency of the facilities and technologies. Another challenge in IR 4.0 is managing and analyzing huge amounts of data and transforming that data into meaningful knowledge. One issue that hasn't been fixed throughout IR 4.0 deployment is transforming the useful data that comes from multiple smart devices into a common format (Kim et. al, 2019). For safety to progressively become an essential component of construction project operations, it should start with the establishment of an appropriate structure of governance at the national level to support the implementation of safety programmed. An essential component of this governance structure is the creation of OSH laws and their effective enforcement.

Table 1. Safety Barriers in Railway Construction

Theme	Barriers	References	Frequency
Worker Participation	Staff are lack of technical skill and knowledge.	(Lingard et. al, 2017), (Magaldi and Berler, 2019), (Misiurek, 2017)	3
	Lack of financial resources.	(Lingard et. al, 2017), (Magaldi and Berler, 2019), (Misiurek, 2017)	3
	Lack of manpower.	(Rohani. M, 2021)	1
	Compatibility issues of the current software with new technology.	(Magaldi and Berler, 2019), (Peñaloza, et. al, 2017), (Prause, 2019)	3
Hazard Prevention and Control	Difficulty in authorizing and monitoring of the quality and progress of construction.	(Magaldi and Berler, 2019),	1
	Fear of long payback period.	Qian et. al, 2017	1

	Impractical planning, inefficient project construction & business processes.	(Rae et. al, 2019)	1
	Lack of continuous training.		1
	Lack of support from top management.	(Sanni-Anibire et. al, 2020)	1
Management	Complex nature of construction projects.	(Ryan et. al, 2021)	1
	Complexity and higher requirement of new technology.	(Read, 2019), ((Kim et. al, 2019), (Ross et, al, 2020)	3
	n Lack of awareness of the benefits of IR 4.0	(Rohani et. al, 2021), (Kalem et. al, 2021), (Ryan et. al, 2021), (Sanni-Anibire et. al, 2020), (Davidson, 2020), (Du et. al, 2021)	6
Education and training	Lack of standard and references in implementation.	(Rohani et. al, 2021), (Kalem et. al, 2021), (Ryan et. al, 2021),	3
	Difficulty in control and maintenance if exposed the technology on the site.	(Ross et, al, 2020), (Ryan et. al, 2021)	2
	Lack of relevant industrial clusters where they could learn.	(Read, 2019), ((Kim et. al, 2019),	2
	High cost in training/ attending seminars	(Sanni-Anibire et. al, 2020), (Davidson, 2020), (Du et. al, 2021)	3

4.1 Worker Participation

A key barrier to effective worker participation in adopting new technologies is the lack of technical skills and knowledge among staff (Lingard et al., 2017; Magaldi & Berler, 2019; Misiurek, 2017). This is compounded by insufficient financial resources to support technological adoption and training. Furthermore, some construction projects face a shortage of manpower (Rohani, 2021), limiting the workforce's ability to engage in digital transformation initiatives. Compatibility issues between existing software and new technologies also hinder seamless integration and active participation (Magaldi & Berler, 2019; Peñaloza et al., 2017; Prause, 2019).

4.2 Hazard Prevention and Control

In this theme, several barriers affect the effective control and prevention of hazards in construction. These include the difficulty in authorizing and monitoring the quality and progress of construction (Magaldi & Berler, 2019), as well as fear of a long payback period for investment in new technologies (Qian et al., 2017). Additionally, impractical planning, inefficient project processes, and a lack of continuous training restrict the optimization of hazard prevention measures (Rae et al., 2019). Another critical challenge is the lack of support from top management (Sanni-Anibire et al., 2020), which often delays implementation efforts.

4.3 Management

Management-level barriers arise mainly from the complex nature of construction projects (Ryan et al., 2021) and the increased complexity and high requirements of new technologies (Read, 2019; Kim et al., 2019; Ross et al., 2020). One of the most frequently cited barriers is the lack of awareness regarding the benefits of Industry 4.0 (IR 4.0) among stakeholders (Rohani et al., 2021; Kalem et al., 2021; Ryan et al., 2021; Sanni-Anibire et al., 2020; Davidson, 2020; Du et al., 2021), which impedes decision-making and reduces motivation for digital transformation.

4. Education and Training

The education and training theme highlights barriers related to the lack of standardized guidelines and references for implementation (Rohani et al., 2021; Kalem et al., 2021; Ryan et al., 2021). The difficulty in controlling and maintaining technology on-site (Ross et al., 2020; Ryan et al., 2021) adds further challenges, as does the absence of relevant industrial clusters where companies can learn and share knowledge (Read, 2019; Kim et al., 2019). Lastly, the high cost of training and participation in seminars (Sanni-Anibire et al., 2020; Davidson, 2020; Du et al., 2021) often limits the workforce's opportunities to upskill.

Figure 1 shows the Variable of Barriers in Rail Safety Management. In general, individual carelessness or a lack of top-level supervision are frequently responsible for accidents on construction sites. According to (Ross et. al, 2020), unsafe conduct indicates that the primary cause of occurrences on building sites is a decrease in cultural security activity.

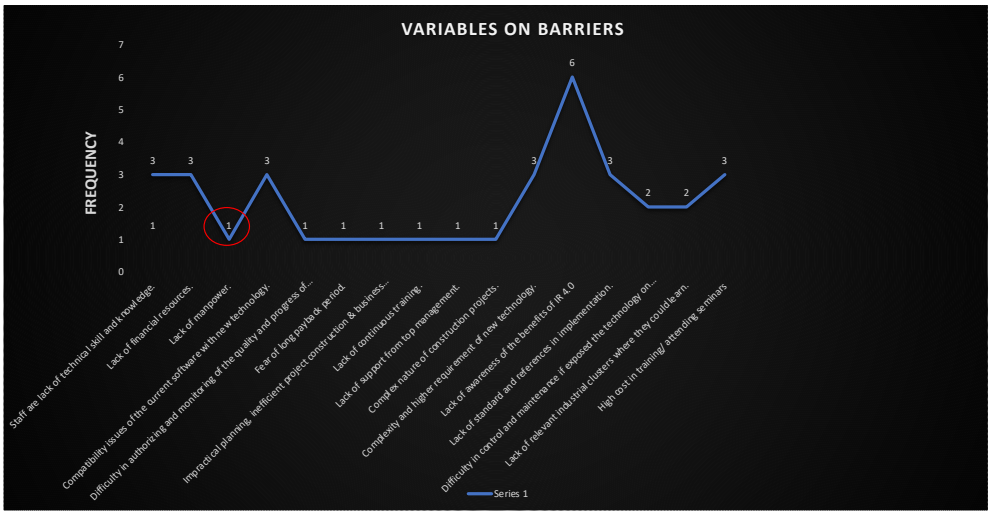

Figure 1. Variables of Barriers in Rail Safety Management

The construction industry's lax standards contributed to the rise in peasant employment. One factor that increases risks and hazards at work is a need for more understanding of safety. Site personnel should receive sufficient training and information to improve their comprehension of the safety issue (Lingard et. al, 2017). Challenges in safety practice encompass some aspects, including individual and work team, workplace, material, and organization. Most workers and members of the work team lack proper training, education, and experience.

The fast-changing workforce and employment practices on building sites are contributing to an increase in workplaces. Because an organized and well-designed (plan) would continue to give the best level of safe performance, the safety and risk management cultures in the sector should be improved. In the meanwhile, it results in narrow spaces, fatalities from site restrictions, or challenging access to complete a task. Site limitations result from insufficient local assessments and planning. Finally, organization, risk mitigation can be implemented by alternate building

methods or design. The development design and construction processes are intertwined, with the design team's concept and decisions driving the process. Due to ingrained habits and attitudes, a lack of safety education and training, and other factors, many designers continue to be blind to their impact on the safety of the construction process (Hasanzadeh, 2017).

The safety practice assessment discussion above can be correlated with the findings and perspectives of other researchers. The commitment of construction managers, communicating safety expectations, involving resident safety managers and safety committees, planned hazard identification, risk assessment and hazard elimination control, and extensive inspection procedures are all essential components of construction companies' safety practices [9]. Furthermore, jobsite features, owner participation in project safety, safety staffing, safety planning, training, and education are examples of recognized safety practices (Choe et. al, 2016).

Inadequate project management and planning give rise to problems with uneven transparency and difficulties in contractor collaboration. The project plan might also have issues because of this (Read et. al, 2019). Issues with a project include things like overlaps in trades, crowded work areas, diminished attention to detail, and schedule constraints. The two most crucial on-site activities to improve site security are toolbox discussions and management engagement. Planning, organizing, implementing safety measures, and working procedures are all part of the successful safety management programmed that management oversees (Misiurek et. al, 2017).

5. CONCLUSION

The findings highlight that the adoption of new technologies and Industry 4.0 practices in the construction industry is hindered by a combination of human, organizational, and technical barriers. Worker participation is constrained by limited skills, financial resources, manpower, and software compatibility issues, which collectively slow down technology adoption on-site. Barriers under hazard prevention and control, such as insufficient managerial support, long payback concerns, and gaps in training, further restrict the consistent application of safety and quality measures. From a management perspective, the inherent complexity of construction projects, coupled with limited awareness of the tangible benefits of IR 4.0, weakens leadership commitment to digital transformation. Meanwhile, deficiencies in education and training, including the absence of standardized guidelines, lack of collaborative learning networks, and the high cost of training, limit workforce readiness for new technologies.

Overall, these challenges demonstrate that successful digital transformation in construction requires a holistic approach, focusing on capacity building for workers, consistent managerial support, financial and technical investment, and the development of accessible training frameworks. Addressing these barriers collectively will enable the construction sector to harness the full potential of Industry 4.0 innovations, improving productivity, safety, and long-term sustainability.

Malaysia is advancing its human capital development to become a more competitive and progressive nation by strengthening its infrastructure, fostering innovation, and embracing Industry 4.0. To achieve this vision, the country requires a highly skilled workforce, innovative strategies for job creation, and economic growth that aligns with social progress. Equally important are reliable and affordable transportation networks, as well as widespread access to high-speed internet. The nation’s future competitiveness hinges on its ability to control business costs, ensure consistent quality as industries expand, and compete effectively on the global stage. A pressing question remains: has Malaysia done enough to move away from its traditional reliance on low-cost imported labour? Integrating advanced technologies such as Unmanned

Aerial Vehicles (UAVs), Building Information Modelling (BIM), and Terrestrial Laser Scanners (TLS) offers promising solutions. These technologies can enhance technological management, address issues of uneven transparency and project safety, and ultimately support the development of more sustainable construction projects.

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REFERENCES

[1] Ahmad E. F, Nianti I., Zin M. & Alauddin K. (2020). Criteria of resilience infrastructure in flood-prone areas in Kelantan. Malaysian Journal of Sustainable Environment, 7(1), 173–190
[2] Al-Ashmori, Y. Y., Othman, I., Rahmawati, Y., Amran, Y. M., Sabah, S. A., Rafindadi, A. D., & Mikić, M. (2020). BIM benefits and its influence on the BIM implementation in Malaysia
[3] Arshad H., Thaheem M. J., Bakhtawar B. & Shrestha A. (2021). Evaluation of road infrastructure projects : A life cycle sustainability-based decision-making approach. Sustainability, 13(7), 3743.
[4] Choe, S., Yun, S., & Leite, F. (2016). Analysis of the effectiveness of the OSHA steel erection standarding the construction industry. Safety Science, 89, 190-200.
[5] Construction Industry Development Board Malaysia (CIDB) & Technical Committee of Safety and Health in Construction. (2019). Occupational Safety And Health – Specification.
[6] Davidson K., Nguyệt P. T. M., Gunawan N., & Boulle B. (2020). Green infrastructure investment opportunities Report 2020. Climate Bonds Initiative, Malaysia, pp. 1-52.
[7] Department of Occupational Safety and Health (DOSH). (2018). Occupational Accidents By Sector 2018 (Investigated). Official Website Department of Occupational Safety and Health.
[8] Du, Z., & Liu, Y. (2021). Causes of Work Safety Accidents in Railway Construction Engineering. *IOP* Conference Series: Earth and Environmental Science, 791(1), 012010.
[9] Durdyev, S., Mohamed, S., Lay, M. L., & Ismail, S. (2017). Key factors affecting construction safety performance in developing countries: Evidence from Cambodia. Construction Economics and Building, 17(4), 48
[10] Fei, J. (2020). Bridging Regions, Strengthening Ties: The East Coast Rail Line (ECRL) in Malaysia.
[11] Freitas, A. C., & Silva, S. A. (2017). Exploring OHS trainers' role in the transfer of training. Safety Science, 91, 310–319.
[12] Gheisari, M., & Esmaeili, B. (2019). Applications and requirements of unmanned aerial systems (UASs) for construction safety. Safety Science, 118, 230–240.
[13] Hamid, A. R. A., Noor Azmi, M. R. A., Aminudin, E., Jaya, R. P., Zakaria, R., Zawawi, A. M. M., Yahya, K., Haron, Z., Yunus, R., & Saar, C. C. (2019b). Causes of fatal construction accidents in Malaysia. IOP Conference Series: Earth and Environmental Science, 220, 012044.
[14] Hasanzadeh, S., Esmaeili, B., & Dodd, M. D. (2017). Measuring the Impacts of Safety Knowledge on Construction Workers' Attentional Allocation and Hazard Detection Using Remote Eye-Tracking Technology. Journal of Management in Engineering, 33(5), 04017024.
[15] Horváth D,. (2019). Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities? Technological Forecasting and Social Change, 146, 119–132
[16] Jamshed S. (2014). Qualitative research method-interviewing and observation. Journal of basic and clinical pharmacy, 5(4), 87–88.
[17] Kalem, A., Lindov, O., & ŠImić, E. (2021). Safety Culture in the Function of Optimization of Railway Safety Management System. New Technologies, Development and Application IV, 700–708.

[18] Kim, K., Cho, Y., & Zhang, S. (2016). Integrating work sequences and temporary structures into safety planning: Automated scaffolding-related safety hazard identification and prevention in BIM. Automation in Construction, 70, 128–142.
[19] Kim, T., & Chi, S. (2019). Accident case retrieval and analyses: Using natural language processing in the construction industry. Journal of Construction Engineering and Management, 145(3), 04019004
[20] Lin, K. Y., Lee, W., Azari, R., & Migliaccio, G. C. (2018). Training of Low-Literacy and Low-English-Proficiency Hispanic Workers on Construction Fall Fatality. Journal of Management in Engineering, 34(2), 05017009.
[21] Lingard, H., Hallowell, M., Salas, R., & Pirzadeh, P. (2017). Leading or lagging? Temporal analysis of safety indicators on a large infrastructure construction project. Safety Science, 91, 206–220.
[22] Magaldi D. and Berler M. (2020) Semi-structured Interviews. In: Zeigler-Hill V., Shackelford T.K. (Eds.) Encyclopedia of Personality and Individual Differences. Springer, Cham.
[23] Misiurek, K., & Misiurek, B. (2017). Methodology of improving occupational safety in the construction industry on the basis of the TWI program. Safety Science, 92, 225–231.
[24] Mohd Rohani, J. B., & M.Y.A. (2021). Occupational Accidents and Prevention through Design in The Malaysian Construction Industry. Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management Singapore. Published.
[25] Peñaloza, G. A., Saurin, T. A., Formoso, C. T., & Herrera, I. A. (2020). A resilience engineering perspective of safety performance measurement systems: A systematic literature review. Safety Science, 130, 104864.
[26] Prause M. (2019). Challenges of Industry 4.0 Technology Adoption for SMEs: The Case of Japan. Sustainability, 11(20), 5807
[27] Qian F, Zhong W, Du W. (2017). Fundamental Theories and Key Technologies for Smart and Optimal Manufacturing in the Process Industry. Engineering, 3(2), 154–160
[28] Rae, A., & Provan, D. (2019). Safety work versus the safety of work. Safety Science, 111, 119–127.
[29] Read, G., Naweed, A., & Salmon, P. (2019). Complexity on the rails: A systems-based approach to understanding safety management in rail transport. Reliability Engineering & System Safety, 188, 352–365.
[30] Ross, T., May, A., & Cockbill, S. A. (2020). The personal and contextual factors that affect customer experience during rail service failures and the implications for service design. Applied Ergonomics, 86, 103096.
[31] Ryan, B., Golightly, D., Pickup, L., Reinartz, S., Atkinson, S., & Dadashi, N. (2021). Human functions in safety - developing a framework of goals, human functions, and safety relevant activities for railway socio-technical systems. Safety Science, 140, 105279.
[32] Sanni-Anibire, M. O., Mahmoud, A. S., Hassanain, M. A., & Salami, B. A. (2020). A risk assessment approach for enhancing construction safety performance. Safety Science, 121, 15-29