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Implementation of Artificial Intelligence for Labour Controlling in the Construction Site

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Abstract

This research presents a survey on the implementation of artificial intelligence for labour control in construction sites. The construction industry is famously slow to accept new technologies, and this has been a persistent issue for years. The common problems of low-skilled labour participation in construction have been attributed to unfair wages, poor safety on construction sites, a lack of defined career paths, a decline in skilled labour training programs, and delays in the on-site work schedule. Therefore, this research was carried out to identify challenges, potential, and steps to improve the Artificial intelligence implementation for labour control in the construction site. To accomplish the objectives, the research was conducted with the quantitative approach by using questionnaires as the instrument to collect the primary data. There were 234 respondents among G7 contractors selected at Penang state for this research. For this research, 132 respondents have been successfully collected. Statistical Package for the Social Science (SPSS) software was utilized to analyse the collected data in descriptive methods to determine the frequency and mean score values. Besides, secondary data information was obtained through various references such as journals, articles, websites, or reports related to the implementation of artificial Intelligence for labour control in the construction site. Moreover, the result showed that the biggest challenges of AI implementation was higher cost for hiring AI expert, and the potential of AI implementation was providing critical information on threats to labour, as well as the improvement steps of AI implementation was providing an AI training program. In conclusion, this research provided a better understanding of the AI implementation for labour controlling at construction sites.

1. Introduction

1.1 Research Statement

Construction sites often employ unskilled people who do manual tasks, known as "manual labour" or "site labour" in the industry. A multitude of tasks, such as excavating, cleaning, catering, hauling, and lifting within its capabilities. Workers in this category often lack the necessary training and credentials and temporary workers,

subcontractors, or employees of the main contractor (Fateh *et al*., 2022). Artificial Intelligence (AI) refers to the capacity of computers to perform tasks requiring intelligence such as learning, planning, logical reasoning, critical thinking, and creatively solving routine problems when conducted by humans. A recent organizational push towards digitalization depends on AI for business market competitive advantage. AI is superior to humans in terms of processing information and making effective decisions in terms of both speed and volume, and it eliminates the possibility of judgmental bias (Nazir *et al*., 2023). AI is a potentially useful construction safety instrument. Using artificial intelligence, safety monitoring systems can filter through vast quantities of visual data to identify individuals and situations that violate safety standards. It is believed that the potential of AI could provide both immediate and long-term benefits (Razi *et al*., 2023). Therefore, this study seeks to investigate the implementation of artificial intelligence in labour control in construction sites. Artificial intelligence is making it easier for users to feel at ease while using the technology. Hence, we may deduce that it is an excellent technological advancement, but each method requires careful application to avoid unintended consequences.

1.2 Problem Statement

Construction is a high-risk industry that incorporates a wide range of construction, modification, and maintenance activities. Numerous activities performed by construction labour expose them to significant dangers, including falls from rooftops, unguarded machinery, collisions with heavy construction equipment, electrocution, silica pollution, and asbestos exposure. (OSHA, 2023). The construction industry is growing rapidly, which increases the need for workers, but locals aren't keeping up. The construction sector in Malaysia is severely hampered by the country's overreliance on a huge migrant worker workforce (Najib *et al*., 2019). The common problems of low-skilled labour participation in construction have been attributed to unfair wages, poor safety on construction sites, a lack of defined career paths, a decline in skilled labour training programs, and delays in the on-site work schedule (Fateh *et al*., 2022). As labour is the most essential resource in the construction industry, project performance is measured and evaluated based on the skills of the labour force during project execution (Hussain *et al*., 2020).

A construction labourer dies in Pasir Gudang after falling 70 meters. The victim, who had fallen from a height of 70 meters and sustained severe injuries, was pronounced deceased at the scene by medical personnel. Under the Occupational Safety and Health Act of 1994, those culpable will be held liable. Employers are solely responsible for ensuring that their workplaces are risk-free through risk control and assessment (The Star, 2023).

The Malaysian construction industry struggles to use and implement new technology, which is crucial to the government's ambitions to enhance performance and efficiency. The sector's low productivity is due to a lack of technology adoption. The industry's contractors' capacity to learn and apply new technologies and profit from them is not solved easily by the government's current techniques and processes, mediated through CIDB. Most difficulties develop during implementation, but the guidelines and ideas never reach the construction phase (Kamal *et al*., 2023). Artificial Intelligence is the simulation of human intelligence by computer systems and other machinery. Due to a lack of technology, the construction industry had low output, wasted time, bad product performance, and poor safety and security (Dinesh *et al*., 2023). According to (Abioye *et al*., 2021) Construction research has used AI technologies, but adoption of newer more powerful AI technologies has been delayed. The construction industry has considerable difficulties due to the resistance to adopting new approaches. Therefore, this study will investigate the challenges, potentials, and steps for implementation of Artificial Intelligence. Using technology to improve work quality or using AI for human management on building projects are important.

This research will explain the value of enhanced AI implementation for construction project management personnel. Artificial intelligence (AI) integration into labour control will make organizations better because these applications can analyze, predict, and diagnose to help HR teams make better decisions, according to research published in the International Research Journal of Engineering and Technology. This will benefit stakeholders in the construction industry and the quality of the built environment. Furthermore, this research can be utilized as a reference for those in the construction sector interested in better implementing artificial intelligence for human resource management on construction projects. The results of this research will help those involved in the construction industry better understand how to use AI in the handling of individuals on building sites. to acquire new abilities and establish a plan for maximizing profits in the construction industry.

Besides that, this research is also important for academics, especially students who are interested in the construction industry. They might be able to use what they found in this study for future research. This research is aimed at artificial intelligence implementation for labour control in construction sites. The benefits of AI for human resource management, as well as the obstacles that must be overcome to effectively use AI technology in the construction industry. Thus, it is expected that this study's findings will be implemented as guidelines for human management using AI in construction projects.

2. Literature Review

2.1 Challenges of AI Implementation for Labour Controlling

2.1.1 High initial costs

The initial costs associated with investing in AI are quite high. These solutions' maintenance requirements must also be considered. This may be prohibitive for most subcontractors and minor 4 businesses, which constitute most of the construction industry (Abioye *et al*., 2021). There is a high initial cost associated with possessing and utilizing these AI technologies because they are not completely developed and require constant investment to keep up with technological advancement (Regona *et al.,*2022). The initial implementation costs of cutting-edge technology are always substantial. To circumvent months of training, training a model on a deep neural network requires computers with GPU processors that are extremely potent. But the initial cost of these tools is high, and hiring experts in deep learning can be very expensive (Akinosho *et al*., 2020). Incorporating AI technologies can impose significant costs on the construction industry, such as maintaining artificial intelligence that is incredibly costly and requires high maintenance costs. In addition, software programs must be routinely updated to meet the requirements of an environment that is continuously changing (Singh *et al*., 2023).

2.1.2 Cultural issues

The construction industry is one of the least digitalized and adopts new technologies slowly. In the construction industry, traditional methods are favoured over new, unproven technologies that promise substantial benefits. This indicates that the construction industry adopts innovative technologies slowly. In contrast to industries like manufacturing, construction sites are typically unique and diverse, necessitating AI that can rapidly learn and adapt to shifting environments (Abioye *et al*., 2021). The biggest barriers to technology adoption are the authority of project managers and the slow adoption of technologies among conventional partners. (Gholami, 2023). Slow adoption of new technologies and an ageing workforce can generate inefficiencies and impede productivity growth. Therefore, the slow adoption of new technologies tends to prolong the transformation required to optimize workplace safety, reduce hazards, and increase productivity on hazardous construction sites (Yap *et al*., 2022).

2.1.3 Computing Power and Internet Connectivity

Most construction sites lack electricity, telecommunications, and internet connectivity; as the number of connected devices increases, data generation and traffic will increase exponentially (Louis & Dunston, 2018). Wi-Fi is widely used to connect end devices to the internet, however, its application for construction sites may be restricted by its short range (30 m), high power needs, and large form factor (Abioye *et al*., 2021). AI applications will need greater connections for discussion, traditional AI techniques, such as artificial neural networks, have obvious shortcomings in terms of scalability and computational efficiency when applied to routing (Ahmad *et al*, 2022).

2.1.4 Talent Shortage

There is a global scarcity of AI technologists with the requisite abilities to lead significant industry developments (Mikalef and Gupta, 2021). The lack of knowledge about AI is believed to be significantly slowing down the rate of adoption of the technology. (Hradecky *et al*., 2022). In addition, construction specialists must collaborate with academicians and industry experts in the field of artificial intelligence (AI) to integrate ideas and create innovations that satisfy the requirements of the construction industry (Regona *et al*., 2022).

2.1.5 Fairness and Bias

In the realm of AI algorithms, bias and fairness are critical considerations that demand our attention, especially during the data training process. AI algorithms extensively rely on historical data to learn patterns and make informed decisions (Bankins *et al*., 2022). However, this historical data might carry societal biases and discriminatory practices, reflecting unfairness from the past. If left unaddressed, AI algorithms can inadvertently perpetuate these biases, leading to unjust outcomes in crucial areas like hiring, promotions, and performance evaluations. Ensuring fairness in AI algorithms requires a thoughtful and systematic approach to identify and mitigate biases at every stage of development (Akter *et al*., 2022). By prioritizing fairness and transparency, we can build AI systems that promote equitable outcomes and enhance trust in the technology's applications. Furthermore, ongoing monitoring and fine-tuning of AI systems is essential to continuously improve their

fairness and eliminate any unintended biases that may emerge over time (Robert *et al*., 2020). Table 1 shows a summary of the challenges of AI implementation for labour control.

Table 1 *Challenges of AI implementation for labour controlling*

No.	Challenges of AI implementation for labour controlling	Author
1	High initial cost	• Abioye *et al*. (2021) • Regona *et al*. (2022) • Akinosho *et al*. (2020) • Singh *et al*. (2023)
2	Cultural issues	• Abioye *et al*. (2021) • Gholami. (2023). • Yap *et al.* (2022)
3	Computing power and internet connectivity	• Louis & Dunston (2018) • Abioye *et al*. (2021) • Ahmad *et al. (*2022)
4	Talent Shortage	• Mikalef and Gupta (2021) • Hradecky *et al*. (2022) • Regona *et al*. (2022)
5	Fairness and Bias	• Bankins *et al*. (2022) • Akter *et al*. (2022) • Robert *et al*. (2020)

2.2 Potential of Artificial Intelligence for Controlling Labour

2.2.1 Control Safety

Technology for safety and health management is used in the construction site to monitor and enhance safety, health management and safety performance (Nnaji and Karakhan, 2020). AI algorithms can aid in the visual analysis of a construction site by supplying real-time data gathered from cameras and other sensors located throughout the site. This can provide vital information on prospective dangers, disaster likelihood, and other relevant factors to aid in labour safety planning (Baduge *et al.*, 2023). Through sensors or image recognition, it is possible to monitor more thoroughly the aspects that must be monitored, thereby enhancing the algorithms for the emergence of alerts and control of labour on the site for safety monitoring (Lee & Lee,2023). The work environment inspection system can help management personnel inspect the construction environment by using a video monitoring terminal based on image recognition and manual inspection at the same time and find hidden and difficult to check unsafe points, such as structural crack areas, forbidden fire source areas, protective fences, scaffolding, and other areas with inadequate protective facilities, to improve the efficiency and accuracy of labour safety in the construction site (Yi *et al*., 2020).

2.2.2 Enhance Productivity

AI innovation is a new source of productivity and may further expand the rising productivity as well as increase productivity by better aligning team formation with the team's objectives. Adoption of AI and supporting digital technologies can improve labour productivity, leading to a remuneration increase that will ensure that the productivity benefits of AI are realized by a greater number of companies and labourers (Pan & Zhang, 2021). AI has the potential to increase productivity through a variety of channels, including the reduction of uncertainty due to improved forecasting precision, the automated recombination of existing technologies, and, more generally, the origination of new innovations (Damioli *et al*., 2021). AI's potential impact on overall productivity, where AI can enhance the precision of a task, and where AI can make a task that was previously unthinkable feasible (Jones, 2023). AI increases the productivity of one set of activities almost always has a multiplier effect on the economic worth of the other activities (Deranty & Corbin, 2022).

2.2.3 Problem Solving

Artificial Intelligence (AI) may serve as the foundation for the innovative adjustments facing the industry. AI is a subfield of computer science that confers human-like capabilities, such as problem-solving and decision-making, on computers (Haefner *et al*., 2021). The effects of AI labour competence will likely vary according to the nature of the jobs and abilities being automated. The impact on human abilities will vary depending on the nature of the jobs being automated and the degree to which they can be automated. There are also the possibility that problem-solving and critical-thinking abilities may become in demand as AI develops (Morandini *et al*., 2023).

2.2.4 Workforce Planning and Optimization

The technology enables a consistent and systematic approach, eliminating human bias and error, generating more equitable planning schedules, and decreasing the managerial bandwidth needed to supervise the scheduling process (Rodgers *et al*., 2022). With AI-enhanced feedback mechanisms, organizations can encourage the retention of valuable employees using analytics to devise employee incentives (Rozman *et al.,* 2022).

2.2.5 Reduce Bias

The potential for using AI to detect biases and lessen their effects (Varsha, 2023). When artificial intelligence (AI) is used to make judgements, whether humans are involved in the process, it is crucial that the decisions made are ethical and that the information utilized to create them is free of bias (Rhem, 2020). AI can reduce human subjectivity in data interpretation because machine learning algorithms learn to consider only the variables that increase their predictive accuracy based on training data. In addition, there is evidence that algorithms can enhance decision making, thereby making it more equitable (Mahmud *et al*., 2022). Table 2 shows a summary of the potential of AI implementation for labour controlling.

Table 2 *Potential of AI implementation for labour controlling*

No.	Potential of AI Implementation for labour controlling	Author
1	Control Safety	• Nnaji and Karakhan. (2020) • Baduge *et al*. (2023) • Lee & Lee *(*2023) • Yi *et al*. (2020)
2	Enhance Productivity	• Pan & Zhang, (2021) • Damioli *et al*. (2021) • Jone, (2023) • Deranty & Corbin, (2022)
3	Problem Solving	• Haefner et al., (2021) • Morandini *et al,* (2023)
4	Workforce Planning and Optimization	• Rodgers *et al*. (2022) • Rozman *et al*. (2022)
5	Reduce Bias	• Varsha (2023) • Rhem (2020) • Mahmud *et al*. (2022)

2.3 Improvement Step of Artificial Intelligence for Controlling Labour

2.3.1 Promote AI

To promote AI, organizations must foster an inclusive working environment and advocate diversity of opinion at every stage of AI implementation (Ryan & Stahl, 2020). AI technology must be promoted, and the practical implementation of AI technology has been enhanced throughout human society. With the progression of time and technology, constant innovation has been undertaken to satisfy the requirements of contemporary humans (Lu, 2022).

2.3.2 Financial Resources

Financial resources are the most important factor in the implementation of AI; consequently, financial pressure will determine whether the AI technology is successful or not (Reim *et al*., 2020). The use of AI techniques may be restricted to larger financial advisors or large investors who have the resources and capacity to invest in such

technologies. Although clients are the primary source of financing, in some countries, contractors can acquire bank loans from special institutions designed to facilitate the financing of construction projects and investments in the construction industry. Supplier credit, direct financing from commercial banks, and the establishment of companies that lease and employ equipment are additional types of financial aid that can assist contractors in launching heavy construction projects (Pheng & Hou, 2019). Implementing AI effectively and efficiently requires significant infrastructure resources, including financial resources, hardware devices, software, and technical support (Chen *et al.*, 2022).

2.3.3 Government Policies and Initiatives

To implement technology, the most important factors were perceived financial costs, organizational creativity, government pressure, government rewards, and regulatory backing (Lee *et al*, 2022). Policy will influence the rate of AI advancement, the rate of technology diffusion, and the nature of AI (Agrawal *et al*., 2019).

2.3.4 Training and Skill Development

Training and skill development play a crucial role in the implementation of artificial intelligence (AI). By investing in training for employees and management, they gain a comprehensive understanding of the capabilities and limitations of AI. This includes knowledge about AI system workings, data privacy protection, algorithm accuracy, and interpretability, among others (Jarrahi *et al.*, 2022). Armed with this knowledge, employees can effectively utilize AI tools, make informed decisions, and fully leverage AI's advantages (Arslan *et al.*, 2021). Additionally, training fosters awareness among employees and management about the potential risks and unintended consequences of AI, reducing the likelihood of misuse or improper use. Through comprehensive training and skill development, organizations ensure the proper and responsible use of AI, fostering innovation and competitiveness while maximizing the potential of AI in labour control (Lane *et al.*, 2023).

2.3.5 Fairness and Bias Evaluation

Fairness and bias evaluation are crucial in AI implementation for labor control to ensure unbiased and equitable treatment of workers. This process involves analyzing the AI model's outcomes across different demographic groups to detect disparities and unfair treatment (Rajkomar *et al*., 2018). By addressing biases, organizations can create a more inclusive work environment. Techniques like adversarial training and data reweighting help mitigate biases in decision-making (Pagano *et al*., 2023) Ongoing monitoring and involving diverse stakeholders ensure a comprehensive assessment of fairness and bias, leading to a more transparent and ethical AI system that fosters employee satisfaction and productivity (Roselli *et al*.,2019). Table 3 shows the summary of the improvement step of AI implementation for labour controlling.

Table 3 *Improvement step of AI implementation for labour controlling*

No.	Improvement step of AI implementation for Labour Controlling	Author
1	Promote AI	• Ryan & Stahl, (2020) • Lu. (2022)
2	Financial Resources	• Reim *et al*. (2020) • Pheng & Hou (2019) • Chen *et al.* (2022)
3	Government Policies and Initiatives	• Lee *et al.* (2022) • Agrawal *et al*. (2019)
4	Training and skill development	• Jarrahi *et al*. (2022) • Arslan *et al*. (2021) • Lane *et al*. (2023)
5	Fairness and bias evaluation	• Pagano *et al*. (2023) • Rajkomar *et al*. (2018) • Roselli *et al*. (2019)

3. Research Methodology

3.1 Research Design

A quantitative method has been utilized for this research. Utilizing and analyzing numerical data with specific statistical methods to answer questions through quantitative research requires quantifying and analysing variables to produce results (Apuke, 2017). This study employs a cross-sectional design as a sort of observational study design and most conducted using some form of questionnaire. Google Forms was used to construct this study's survey questionnaire. To achieve the objectives of this study, the collected results, and data from respondents, as well as the literature review, are analysed and examined. Table 4 shows the research design method.

Table 4 *Research design method*

No.	Research Objectives	Method
1	To investigate the critical challenges of managing labour in construction sites.	Literature Review
2	To identify the potential of artificial intelligence for labour control on the construction site.	Quantitative (Questionnaires)
3	To suggest the steps to improve artificial intelligence implementation for labour control in the construction site.	

3.2 Data Collection

In the research, five phases outline the complete process and activities from beginning to end. The research process consists of the research background, problem statement, research questions, research objectives, research scope, research significance, and research methodology. Fig. 1 shows the research process flow chart.

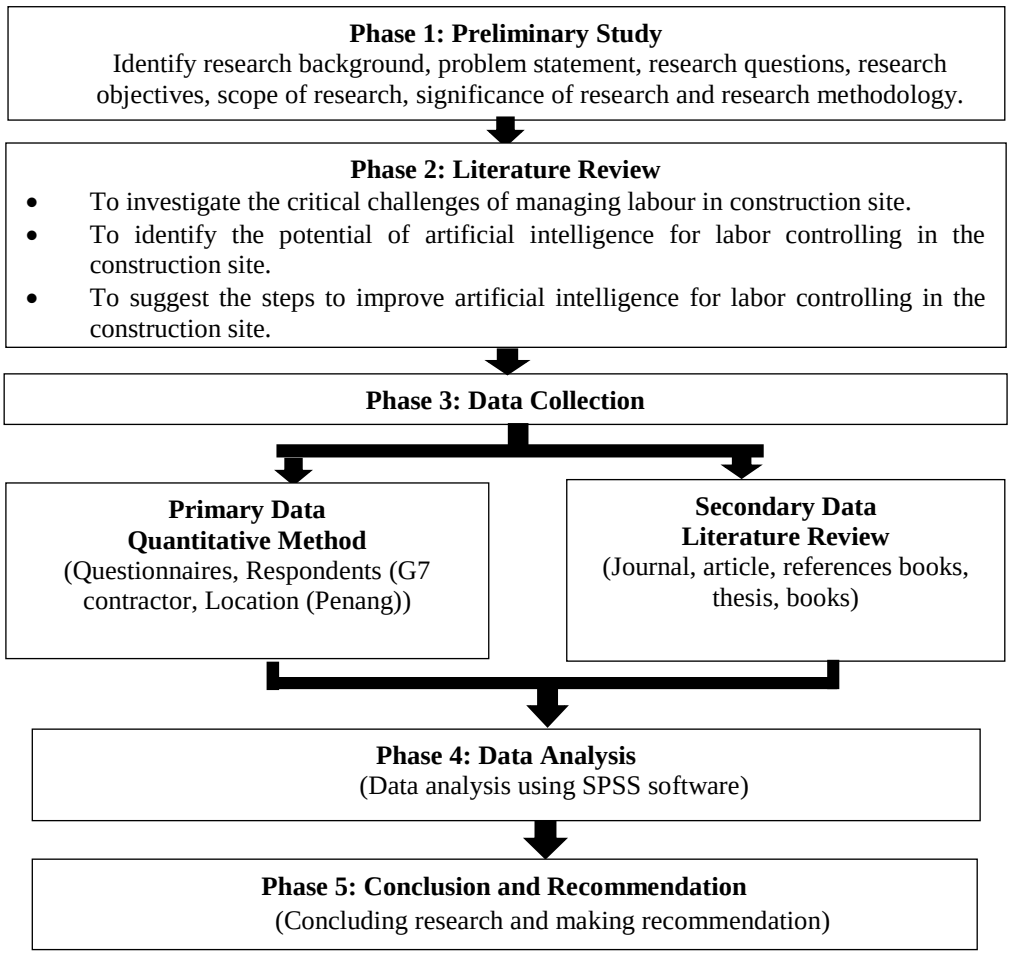

Fig. 1 *Research process flow chart*

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Data collection as a significant phase of research can obfuscate the quality of the results obtained by reducing the number of potential errors that can occur during research initiatives (Taherdoost,2022). Data collection is the process of gathering and measuring information about factors of interest in an organised way that makes it possible to answer stated research questions, try theories, and analyse results (Kabir, 2016). Primary and secondary data were collected for this study. Primary and secondary sources will be used for gathering the whole set of data. As a result, we'll study data collecting in depth.

3.3 Research Population and Sampling

This investigation focuses on G7 contractors in the construction industry located in Penang as its target population. According to the CIDB (2023), there are around 575 G7 contractors based out of Penang. Since Penang is one of the contributors to the nation's GDP and various of mega construction projects like the Penang Transport Master Plan (PTMP), Light Rail Transit (LRT) system, and Penang International Airport Expansion, it makes a good study population. However, the sheer size of the population means that sophisticated sampling methods are necessary to avoid wasting too much time and resources. In this study, 575 G7 contractors in Penang will serve as respondents to the questionnaire, and random sampling techniques will be used to select respondents from the G7 contractors in the construction industry. The sample size of 234 was consequently determined using the Krejcie and Morgan sampling table method. Respondents in this study included positions such as project manager, contractor, and site supervisor.

3.4 Research Instrument

In this study, a questionnaire will be used to get information from the intended respondents and achieve the study's goals. So, the dependability and validity of any research project rely a lot on how relevant the instruments are. This means that the instrument (refer to Table 5) must first be evaluated seriously to see how likely it is to produce the desired results.

Table 5 *Questionnaire content*

Section	Measured Construct	Measurement Technique
A	The question will ask the respondents about the demographic which consists of race, age, working experience, education level and occupational.	Frequency
B	This section is to know the respondent knowledge of Artificial Intelligence	Frequency
C	This section concerns the desire to reach the first objective of the critical challenges of managing labour in construction sites.	Likert Scale
D	This section concerns the desire to reach the second objective of the potential of artificial intelligence for labour control in the construction site.	Likert Scale
E	This section concerns the desire to reach the third objective of the step to improve artificial intelligence implementation for labour control in the construction site	Likert Scale

3.5 Data Analysis

Data analysis is the process of gathering, modelling, and evaluating data using different scientific and reasoning methods and techniques. Analytics methods and tools are used by businesses to get insights that help them make strategic and daily decisions. The most important aspect of an analysis is its validity or quality. The validity of an analysis is determined by whether it measures what it was designed to measure. In general, an analysis is considered profitable if the scores it generates enable individuals to reach accurate conclusions about a particular

intrinsic characteristic, trait, or attribute. After determining the purpose of the analysis, the next stage is to acquire the data that will be analyzed (Bathia, 2017). SPSS was used to analyze the results of the questionnaires after they were received. The analysis was carried out to generate the mean and median score values that would be shown in the next chapter's charts, tables, and graphs. Therefore, it aids the researcher in classifying, summarizing, and methodically making sense of findings (Ashirwadam, 2014).

4. Result and Discussion

4.1 Response Rate

A total of 132 out of 234 respondents were collected through the distributed questionnaire. The percentage of questionnaires collected from the respondents is 56.4 % out of 100%. Table 6 shows the rate of the questionnaire distributed, received, and not received with its percentages respectively.

Table 6 *Response rate of questionnaire survey*

Questionnaire	N	Response Rate
Questionnaire Distributed	234	100%
Questionnaire Received	132	56.4%
Questionnaire Not Received	102	43.6%

4.2 Respondent's Background

This study evaluated the reliability of the variables by conducting a reliability test using Cronbach's Alpha. A total of 132 sets of questionnaires were used for this purpose. An alpha value that falls below 0.6 is deemed to be of poor quality. When the Alpha Coefficient falls between the range of 0.6 to 0.7, the level of dependability might be considered moderate. Conversely, when the Alpha Coefficient ranges from 0.7 to 0.8, it indicates a satisfactory level of dependability. In the context under consideration, alpha values ranging from 0.8 to 0.9 are regarded as very favourable. Finally, a coefficient alpha over 0.9 indicates a high level of dependability. Therefore, Table 7 depicted a total of 132 questions, including 15 items in Sections C, D and E about the respondents' backgrounds and the main study aims.

Table 7 *Reliability statistics*

Section	Number of Items (N)	Cronbach's Alpha	Respondent	Level of Reliability
C	15	0.976	132	Excellent
D	15	0.980	132	Excellent
E	15	0.984	132	Excellent

4.3 Respondent's Background

Table 8 below shows the summarization of the respondent's background, including gender, age, highest academic qualification, working experience, and level of AI usage in the construction industry. The frequency and percentage were summarized from the responses of 132 respondents. Based on Table 8 below, most of the gender in this survey is male at 59.1%, the age is 41-50 years old at 45.5%, and the highest academic qualification was a bachelor's degree 52.3% because the field of study was mainly in bachelor's degree. Moreover, the working experience is more than 10 years at 67.4% As a result, this demonstrated that the bachelor's degree was highly participative. Following that, the level of AI usage in the construction industry is low at 56.1%.

Table 8 *Respondent's background*

Item		Frequency	Percentage (%)
Gender	Male	78	59.1
	Female	54	40.9
Age	21 – 30 years old	20	15.2
	31 – 40 years old	33	25
	41 – 50 years old	60	45.5
	51 years old and above	19	14.4
Highest Academic	Bachelor's degree	69	52.3

Qualification	Diploma	8	6.1
	Master	38	28.8
	PhD	16	12.1
	Secondary school	1	0.8
Working experience	1-5 years	14	10.6
	6-10 years	24	18.2
	Less than 1 year	5	3.8
	More than 10 years	89	67.4
Level of AI usage in the construction industry	High	12	9.1
	Medium	41	31.1
	Low	74	56.1
	Not applicate	5	3.9

4.4 Knowledge about Artificial Intelligence

Referring to the data collected for the knowledge about Artificial Intelligence from the respondents as shown in Table 9 the frequency and percentage were summarized from the responses of 132 respondents, showing that most people in the construction industry are aware of and comfortable with AI. A huge 97.7% of those who answered said they had known about AI, while only 2.3% said they didn't. It's impressive that 94.7% of people agreed that AI used in the construction industry to be more convenient, and 88.6% agreed that AI would be good at controlling workers for safety and environmental issues. A large majority (89.4%) also agreed that AI plays a part in controlling workers to improve site performance and productivity. The poll also showed that most people (93.9%) agreed that AI could help make building projects more efficient. Interestingly, a large majority (94.7%) wanted businesses to use AI, and a similar number (94.7%) said they would use AI themselves in the future. All these results point to a good future for using AI in the building industry, with a strong tendency for both the whole industry and individuals to accept AI technologies.

Table 9 *Knowledge about artificial intelligence*

No	Questions	Responses	
		Yes	No
1	Do you know about the Artificial Intelligence (AI)?	129 (97.7%)	3 (2.3%)
2	Is AI used in the construction industry to be more convenient?	125 (94.7%)	7 (5.3%)
3	Does AI enable labour control in construction site safety and environmental conditions?	117 (88.6%)	15 (11.4%)
4	Can AI manage the labour in construction site performance and productivity?	118 (89.4%)	14 (10.6%)
5	Does AI play a role in construction sites to improve the efficiency of the construction project	124 (93.9%)	8 (6.1%)
6	Do you think that your company should apply Artificial Intelligence (AI)?	125 (94.7%)	7 (5.3%)
7	Would you like to use Artificial Intelligence (AI) in the future	125 (94.7%)	7 (5.3%)

4.5 The challenges of managing labour in construction projects

According to Table 10 below, the highest mean of the critical challenges of managing labour in construction projects was “higher cost for hiring AI experts” with 3.77, ranked 1 and the standard deviation was 1.210. The demand for artificial intelligence professionals has grown significantly, leading to the higher cost of hiring AI experts. The initial expenditures necessary to invest in such AI solutions, such as the maintenance requirements of such solutions, must also be addressed, and AI experts are typically expensive owing to the demand for AI (Alekseeva *et al*., 2021) Moreover, the lowest mean of the critical challenges of managing labour in construction projects was 3.11 ranked 15 which was “Lack of power supply at the construction site”, and the standard deviation was 1.357. In the construction industry, unreliable power supplies can present formidable obstacles to adherence to project schedules, operational effectiveness, and worker welfare. Providing illumination on the construction site and operating hefty machinery are both construction-related tasks that require electricity.

Therefore, the descriptive analysis determined the total average mean was 3.27 which is between 2.41 to 3.80 so it is considered moderate. According to findings, the main problems of AI frequently revolve around costly development expenses, such as hiring talent, data quality, infrastructure, and compliance. These financial barriers can limit widespread AI adoption.

Table 10 *Summary of challenges of managing labour in construction projects*

No.	Item	N	Mean	Standard Deviation	Ranking	
	Cost Implementation					
1	High Initial cost for AI implementation	132	3.70	1.283	3	
2	Higher maintenance cost of AI technology	132	3.73	1.412	2	1
3	Higher cost for hiring AI experts.	132	3.77	1.210	1	
	Average Mean			3.73		
	Cultural issues					
4	Traditional methods surpass new technology	132	3.49	1.156	9	
5	Slow adoption of new AI technology	132	3.61	1.221	6	3
6	AI requires one to rapidly learn and adapt	132	3.57	1.249	8	
	Average Mean			3.56		
	Computing power and internet					
7	Limited internet network at the construction site	132	3.16	1.295	14	
8	Lack of power supply at the construction site	132	3.11	1.357	15	5
9	AI applications require high speed internet connectivity.	132	3.39	1.335	12	
	Average Mean			3.22		
	Talent Shortage					
10	Shortage of skilled AI technologists	132	3.57	1.193	7	
11	Lack of the essential AI technical knowledge	132	3.63	1.298	5	2
12	Lack of skilled AI training	132	3.67	1.214	4	
	Average Mean			3.62		
	Fairness and bias					
13	Historical data might carry AI biases.	132	3.35	1.211	13	
14	Lack of labour detection and bias mitigation	132	3.42	1.248	11	4
15	Lack of fairness in AI data training	132	3.45	1.232	10	
	Average Mean			3.41		

4.6 The Potential of AI Implementation for Labour Controlling

According to Table 11 below, the highest mean of the potential of AI implementation for labour controlling was "Provides critical information on threats to labour" with 3.5, ranked 1 and the standard deviation was 1.316. Since the nature of the construction sector relies on labour, real-time safety information can be crucial in the construction industry, especially in high-risk industries. Safety information can help protect the labour at the construction site. However, the lowest mean potential of AI implementation for labour controlling was 2.98 ranked 15 which was "Reduce labour monitoring", and the standard deviation was 1.362. The implementation of AI by analyzing data from equipment sensors, AI can predict when a piece of equipment is likely to fail and enhance the safety at the construction site compared to the tasks that are monitoring by the labourers (Soori *et al.*, 2023). Thus, the descriptive analysis determined the total average mean was 3.354 which is between 2.41 to 3.8 so it is considered moderate. Based on the findings, respondents think that AI will provide important information on labour dangers by analysing enormous datasets, detecting trends, and predicting possible labour threats such as workplace hazards or safety difficulties. Its capacity to digest data quickly improves real-time danger detection and assists in proactive risk reduction for worker safety.

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Table 11 *The summary potential of AI implementation for labour controlling*

No.	Item	N	Mean	Standard Deviation	Ranking	
	Control safety					
1	Potential controlling labour on safety and health	132	3.44	1.286	5	
2	Provides critical information on threats to labour	132	3.50	1.316	1	**1**
3	Ensure labour work in a safe environment.	132	3.48	1.263	3	
	Average Mean			3.473		
	Enhance Productivity					
4	Connect labour enforce with goals to boost productivity.	132	3.44	1.180	6	
5	Improve forecasting on labour controlling	132	3.45	1.225	4	**2**
6	Strengthen and help workers perform difficult tasks.	132	3.49	1.175	2	
	Average Mean			3.46		
	Problem Solving					
7	Minimize Job related issues through automation	132	3.42	1.272	7	
8	Reduce human error in the nature jobs.	132	3.36	1.308	10	**3**
9	Provide problem-solving to control labour activity	132	3.40	1.301	8	
	Average Mean			3.39		
	Workforce planning and optimization					
10	Enhance labour control with improved scheduling	132	3.29	1.233	12	
11	Reduce labour monitoring	132	2.98	1.362	15	**5**
12	Reduce labour controlling time	132	3.08	1.264	14	
	Average Mean			3.116		
	Reduce bias					
13	Improve labour detection and bias mitigation	132	3.37	1.275	9	
14	Reduces data interpretation on labour controlling	132	3.33	1.317	11	**4**
15	Reduce optimism bias related to work risks of construction labour.	132	3.28	1.274	13	
	Average Mean			3.326		

4.7 The Improvement Step of AI Implementation for Labour Controlling

Based on Table 12 shown below, the highest mean of the improvement step of AI implementation for labour controlling was "Provide an AI training program" with 3.70, ranked 1, and the standard deviation was 1.229. Training is a strategic method used to augment the proficiency and competence of employees, enabling them to carry out their assigned duties with greater efficacy. The introduction of new technology, processes, or other innovative advancements to workers is a crucial procedure (McKee & Gauch, 2020). Next, the lowest mean of the improvement step of AI implementation for labour controlling was 3.39, ranked 13, which was "Mandatory AI utilization" and the standard deviation was 1.365. The robustness of AI solutions must include technological, legal, and ethical dimensions. It is important to include the community in the deliberation on AI objectives, and it is crucial to ensure transparency by providing public access to information about data use and technique unless there are compelling reasons to withhold such information due to overwhelming public interests (Dwivedi *et al*., 2023). Therefore, the descriptive analysis determined the total average mean was 3.55 which is between 2.41 to 3.8, so it is considered moderate. According to studies, the AI training programme is the most important phase in

AI deployment since training programmes entail providing the AI system with fresh data, allowing it to learn and adapt, enhancing its accuracy, and better aligning it with the desired objectives.

Table 12 *Summary Steps of AI Implementation*

No.	Item	N	Mean	Standard Deviation	Ranking	
	Promote AI					
1	Promote AI technology to control labour safety.	132	3.61	1.215	6	
2	Improve AI technology capabilities for labour-controlling	132	3.69	1.211	2	1
3	Enhance the practical implementation of AI technology.	132	3.62	1.149	5	
	Average Mean			3.640		
	Financial Resource					
4	Financial support by the government	132	3.61	1.190	6	
5	Government provides loan initiatives.	132	3.67	1.317	3	2
6	Provide opinion and benefit to investors	132	3.63	1.256	4	
	Average Mean			3.636		
	Government policies and initiatives					
7	Government provides subsidies for AI training	132	3.52	1.207	9	
8	Government provide reward with AI implementation.	132	3.56	1.315	8	5
9	Mandatory AI utilization	132	3.08	1.365	13	
	Average Mean			3.387		
	Training and skill development					
10	Provide an AI training program	132	3.7	1.229	1	
11	Provide awareness program	132	3.61	1.209	6	3
12	Enrich worker's efficiency	132	3.58	1.223	7	
	Average Mean			3.630		
	Fairness and bias evaluation					
13	Create an inclusive work environment for AI applications.	132	3.39	1.215	12	
14	Provide monitoring assessed to detect bias	132	3.44	1.274	11	4
15	Enhance AI data reweighting and adversarial training biases	132	3.50	1.239	10	
	Average Mean			3.440		

5. Conclusion and Recommendations

In conclusion, all the research objectives were accomplished by the questionnaire distributed to G7 construction companies in Penang using the quantitative method. This research has demonstrated that the data analysis of the questionnaire using SPSS software has been successful in achieving all the study's objectives. The outcomes demonstrate that the contractor's problems are solvable. Due to most contractors believing that Penang's AI technology is still in its infancy, the factors that affect AI implementation have influenced the contractor's decision to deploy AI. The influencing factors of AI implementation are potential to reduce labour safety. The steps of AI implementation are to provide an AI training programme.

The researcher encountered a multitude of problems and limits during the process of data collecting. The influence of this phenomenon on data collection and processing is rather restricted. A few of the respondents who were specifically targeted for participation in the survey declined to provide responses to the questionnaire due to their excessive workload, resulting in incomplete survey data. Subsequently, the distribution of questionnaires to participants proved to be ineffective because of the presence of incorrect and inaccessible email addresses. Also, a few respondents expressed fear over the relationship because of con artists. Finally, a subset of participants

exhibits a lack of motivation in completing the questionnaire, while others have delays in resolving the matter. Hence, the researcher collected a cumulative dataset of 132 responses from a total of 243 participants.

This study makes a significant contribution to the construction industry by enhancing the comprehension of contractors and other stakeholders about the advantages of using artificial intelligence (AI) in construction. The technique has the potential to minimise mistakes in project activities, leading to the development of projects with superior quality. Furthermore, by enhancing comprehension of AI implementation, construction stakeholders will be equipped with a distinct trajectory for implementing new innovations to enhance the capabilities and retrain the current skilled workforce, thereby addressing the shortage of skilled labour within the building and construction industry. Therefore, this research study has the potential to provide sufficient data for contractors engaged in similar projects to make informed decisions on the implementation of artificial intelligence. This research has provided an academic contribution, particularly for students who are engaged in the construction industry. They could use this study as further information if they plan to continue working in the construction field. This study also examines the challenges that will be encountered during the implementation of technologies in the construction industry and the implementation of AI to enhance labour controlling. Thus, this research will be utilised to improve skilled workers through the implementation of AI in the construction industry for scholar reference related to the research.

Furthermore, the construction industry should implement AI since its benefits outweigh those of the traditional way. While AI technology is still in its infancy in the construction industry, its implementation can help to improve worker and project performance by reducing project errors, producing high-quality projects, optimizing construction processes, increasing workflow productivity, and reduce monitoring of some of the construction process. Furthermore, construction workers must be given a sufficient training programme for the use of new technologies on the job to increase their level of competence and expertise. Therefore, the implementation of AI can help the construction industry step forward.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Lim Ai Nee, Narimah Kasim;* ***data collection:*** *Lim Ai Nee;* ***analysis and interpretation of results:*** *Lim Ai Nee;* ***draft manuscript preparation:*** *Lim Ai Nee, Narimah Kasim, Sharifah Meryam Shareh Musa, Hamidun Mohd Noh. All authors reviewed the results and approved the final version of the manuscript.*

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