POLITEKNIK UNGKU OMAR

FACTORS THAT CONTRIBUTE TOWARD ROLES OF INDUSTRIAL REVOLUTION TECHNOLOGIES IN CONSTRUCTION SAFETY

PAULUS ERNEST ANAK SIMON

(01BCT21F3025)

CIVIL ENGINEERING DEPARTMENT

SESSION II 2023/2024

POLITEKNIK UNGKU OMAR

FACTORS THAT CONTRIBUTE TOWARD ROLES OF INDUSTRIAL REVOLUTION TECHNOLOGIES IN CONSTRUCTION SAFETY

PAULUS ERNEST ANAK SIMON

(01BCT21F3025)

A report submitted in partial fulfilment of the requirements for the award of the degree in Bachelor of Civil Engineering Technology with Honours.

CIVIL ENGINEERING DEPARTMENT

SESSION II 2023/2024

DECLARATION OF ORIGINAL AND OWNERSHIP

TITLE: FACTORS THAT CONTRIBUTES TOWARD ROLES OF INDUSTRIAL REVOLUTION TECHNOLOGIES IN CONSTRUCTION SAFETY

1. I, **PAULUS ERNEST ANAK SIMON (IC NO: 980428-13-6117),** a student of the **Bachelor of Civil Engineering Technology,Civil Engineering Department, Ungku Omar Polytechnic,** located at **Jalan Raja Musa Mahadi, 31400 Ipoh, Perak**

2. We acknowledge that 'The above project' and the intellectual property contained therein are the work of our original work/invention without taking or imitating any intellectual property from any other party.

3. We agree to transfer ownership of the intellectual property of the 'Project' to the Ungku Omar Polytechnic to meet the requirements for the award of the Degree of Civil Engineering Technology to us.

Made and truly acknowledged by the said;

a) PAULUS ERNEST ANAK SIMON
(IC Num: 980428-13-6117),

…. ……..
PAULUS ERNEST ANAK SIMON

In front of me, DR SERI BUNIAN BINTI MOKHTAR
as project supervisor on date: …….

……
DR SERI BUNIAN BINTI MOKHTAR

APPRECIATION

The completion of this thesis marks a significant milestone in my academic journey, and it would not have been possible without the support and encouragement of several extraordinary individuals.

First and foremost, I wish to express my deepest gratitude to my parents, Simon Anak Amud and Florence Anak Petrus. Your unwavering support, boundless love, and endless sacrifices have been my pillars of strength. From my earliest memories, you have been my greatest cheerleaders, instilling in me the values of perseverance and dedication. Your faith in me has been a constant source of motivation, and I am eternally grateful for your guidance and encouragement.

I am profoundly thankful to my supervisor, **Dr. Seri Bunian Binti Mokhtar**. Your exceptional guidance, insightful advice, and steadfast support have been invaluable throughout this journey. Your commitment to my academic growth and your willingness to share your extensive knowledge have significantly enriched my research. Your patience and encouragement have been instrumental in helping me navigate the complexities of this thesis.

I would also like to extend my heartfelt thanks to my co-supervisors, **Dr. Panbarasi A/P Govindasamy** and **Dr. Azuin Binti Ramli**. Your expert advice, constructive feedback, and unwavering support have been crucial to the completion of this work. Your enthusiasm for my research and your dedication to my success have inspired me to strive for excellence.

To all of you, I express my deepest appreciation. This thesis is a testament to your belief in me and your commitment to my academic and personal growth. Thank you for being an integral part of this journey and for making this achievement possible.

ABSTRACT

The aim of this research was to identify the level of adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction warehouses, to determine the correlation between adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction safety and to determine the factor that contribute toward the role of Industry 4.0 technologies within construction warehouses. This research objectives were tested using a descriptive analysis and hypothesis testing using Pearson correlation and regression analysis. Result show that overall level of adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction warehouses mean score more than 3.50. Pearson correlation was significantly correlated between variables. Finally, the linear regression analysis revealed a statistically significant model ($F = 72.45$, $p < .001$), with an adjusted R^2 of 0.76. This finding suggests that these two variables (Adherence to Safety Regulations and Design and Layout on Safety) contributed up to 76% of the variance in Role of Industry 4.0 Technologies. These results emphasize the significance of Adherence to Safety Regulations and Design and Layout on Safety as a determinant of Role of Industry 4.0 Technologies.

ABSTRAK

Tujuan penyelidikan ini adalah untuk mengenal pasti tahap pematuhan terhadap peraturan keselamatan, reka bentuk dan susun atur keselamatan serta peranan teknologi Industri 4.0 dalam gudang pembinaan. Penyelidikan ini juga bertujuan untuk menentukan korelasi antara pematuhan terhadap peraturan keselamatan, reka bentuk dan susun atur keselamatan serta peranan teknologi Industri 4.0 dalam gudang pembinaan, dan untuk menentukan faktor-faktor yang menyumbang kepada peranan teknologi Industri 4.0 dalam gudang pembinaan. Objektif penyelidikan ini diuji menggunakan analisis deskriptif dan ujian hipotesis menggunakan korelasi Pearson dan analisis regresi. Keputusan menunjukkan bahawa tahap keseluruhan pematuhan terhadap peraturan keselamatan, reka bentuk dan susun atur keselamatan serta peranan teknologi Industri 4.0 dalam gudang pembinaan mempunyai skor purata lebih daripada 3.50. Korelasi Pearson menunjukkan korelasi yang signifikan antara pembolehubah-pembolehubah tersebut. Akhir sekali, analisis regresi linear mendedahkan model yang signifikan secara statistik ($F = 72.45$, $p < .001$), dengan R^2 terlaras sebanyak 0.76. Penemuan ini menunjukkan bahawa kedua-dua pembolehubah ini (Pematuhan Terhadap Peraturan Keselamatan dan Reka Bentuk serta Susun Atur Keselamatan) menyumbang sehingga 76% daripada varians dalam Peranan Teknologi Industri 4.0. Keputusan ini menekankan kepentingan Pematuhan Terhadap Peraturan Keselamatan dan Reka Bentuk serta Susun Atur Keselamatan sebagai penentu Peranan Teknologi Industri 4.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

IR 4.0	Fourth Industrial Revolution
IoT	Internet of Things
AI	Artificial Intelligence
GDP	Gross Domestic Product
H_a	Hypothesis Alternative
ECRL	East Coast Rail Link
DOSH	Department of Occupational Safety and Health
LSPs	Logistics Service Providers
SCI	Safety Culture Interaction
AR	Augmented Reality
VR	Virtual Reality
BIM	Building Information Modelling
CAD	Computer Aided Draft
RFID	Radio-frequency identification
SSPS	Statistical Package for the Social Sciences
CVI	Content Validity Index
SMEs	Subject Matter Experts
I-CVI	Item-level Content Validity Index
S-CVI	Scale-level Content Validity Index
PAR	Participatory Action Research
CIDB	Construction Industry Development Board

CHAPTER 1

INTRODUCTION

1.1 Introduction

The construction industry, a vibrant and dynamic sector, plays a pivotal role in shaping the modern world through the creation of essential infrastructure, buildings, and facilities (Hampson, 2004). At the heart of this industry are construction warehouses, serving as critical nerve centers that house materials, equipment, and tools indispensable for construction projects. Despite their bustling activity, these hubs are not impervious to risk and danger, often witnessing accidents and incidents that jeopardize the safety of workers and the efficiency of construction projects (AI Glendon, 2016). According to International Policy and Research Development Division (2023), there are 3,333 cases have been reported for occupational accidents in Malaysia and the statistic can be seen in Figure 1.1.

STATE	NPD	PD	DEATH	TOTAL
JOHOR	555	35	6	596
KEDAH	181	1	3	185
KELANTAN	57	0	3	60
MELAKA	182	4	1	187
N SEMBILAN	193	5	4	202
PAHANG	188	4	5	197
PERAK	339	7	5	351
PERLIS	2	0	1	3
PULAU PINANG	299	6	3	308
SABAH	135	11	9	155
SARAWAK	151	5	6	162
SELANGOR	664	37	11	712
TERENGGANU	86	4	3	93
WPKL	109	1	4	114
WP LABUAN	7	0	1	8
TOTAL	**3148**	**120**	**65**	**3333**

Figure 1.1 Occupational Accidents Statistics by State in January – May 2023
(Source: Dosh.gov.my, 2023)

Warehouse safety holds paramount importance, directly impacting the well-being of construction workers and the overall success of projects (Kheni, 2008). Inadequate safety measures within warehouses can lead to accidents, injuries, productivity losses, and even fatalities. Consequently, comprehending and addressing the factors influencing warehouse safety is of utmost significance, as it directly impacts the industry's workforce and the projects they undertake (Gulden Gumusburun Ayalp, 2022).

In Figure 1.2, Malaysia exhibits a significant surge in occupational injuries, experiencing double-digit growth of 58.9%, reaching 34,216 cases in 2022 compared to 21,534 cases in 2021 (The Star, 2023). Consequently, the rate of occupational injuries per 1,000 workers rose to 2.22, up from 1.43 in the previous year. In terms of non-fatal occupational injuries, there was a notable increase of 59.7%, resulting in 33,899 cases in 2022, compared to 21,233 cases in 2021. This led to a corresponding rise in the rate of non-fatal occupational injuries per 1,000 workers, reaching 2.20 in 2022, compared to 1.41 in 2021. Simultaneously, fatal occupational injuries totaled

317 cases in 2022, marking an increase of 16 fatalities from the 301 recorded in the previous year. This translated to a higher rate of fatal occupational injuries per 100,000 workers at 2.06 in 2022, exceeding the 2.00 rate in 2021.

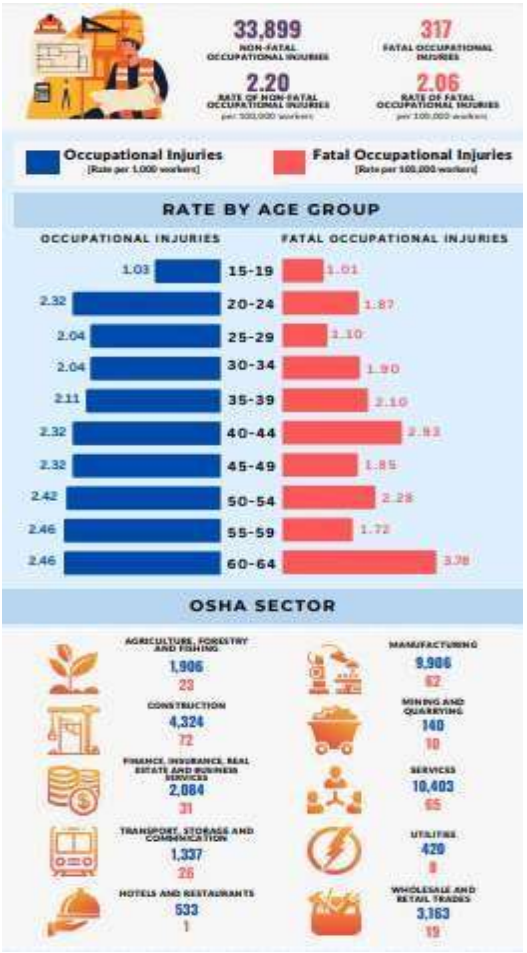


Figure 1.2 National Occupational Accident and Disease Statistic

(Source: Businesstoday.com, 2022)

A pivotal factor to be considered is the maintenance of equipment used within the warehouse. Construction warehouses are often replete with heavy machinery, such as forklifts, cranes, and other equipment (Aized, 2010). Improperly maintained machines pose a significant risk to workers. Therefore, regular maintenance, inspection, and servicing of equipment are essential to ensure their safe and efficient operation (Haney, Burstein, 2013).

Moreover, worker training and awareness constitute an integral factor in warehouse safety. Well-informed workers who are aware of potential risks, safety procedures, and emergency protocols are more likely to work safely (Fung, Tam, Sing, Tang, 2016). Effective training programs, ongoing safety education, and awareness campaigns can significantly reduce the incidence of accidents in warehouses.

Additionally, compliance with safety regulations is another essential factor warranting attention. Governments and regulatory bodies establish safety guidelines and standards to protect workers in the construction industry (Kheni, Braimah, 2014). Compliance with these regulations is not just a legal requirement but also a moral obligation. Therefore, understanding the factors influencing whether construction warehouses adhere to safety regulations is vital in evaluating the level of safety within these environments (Aksorn, Hadikusumo, 2008).

In the context of Industry 4.0, the integration of emerging technologies plays a pivotal role in reshaping warehouse safety. The advent of the Fourth Industrial Revolution (IR 4.0) introduces innovative solutions, such as the Internet of Things (IoT), Artificial Intelligence (AI), and data analytics, which can be harnessed to enhance safety measures within construction warehouses (Hossain, 2023).

This thesis embarks on a rigorous exploration of the multifaceted factors influencing warehouse safety in the construction industry. The research delves into the intricate and complex nature of warehouse safety by considering a spectrum of interrelated factors, including warehouse design and layout, equipment maintenance, worker training and awareness, compliance with safety regulations, and the integration of emerging technologies for safety enhancement. Through this examination, the thesis seeks to provide a holistic understanding of how these factors interact and influence the safety of workers in construction warehouses (RBM de Koster et al, 2011).

The thesis will delve into best practices for equipment maintenance and their implications for warehouse safety. It will also investigate the relationship between worker training and safety outcomes within construction warehouses, analyze the extent of regulatory compliance in construction warehouses, and explore the application of IR 4.0 technologies in promoting warehouse safety, examining how

these advancements contribute to risk mitigation and operational efficiency.

In the pursuit of safer construction warehouses, this study employs a combination of quantitative and qualitative research methods. Surveys will collect data on safety practices and worker experiences in construction warehouses (Dennerlein et al, 2020). Site observations will provide an in-depth understanding of practical aspects such as layout and equipment usage. Interviews with industry experts and workers will offer valuable insights into the challenges and risks faced within construction warehouses. This multifaceted approach enables a comprehensive analysis of the contributing factors to warehouse safety.

Through this investigation, it is anticipated that this research will not only illuminate the challenges and risks faced by workers in construction warehouses but also offer practical recommendations and solutions to improve safety standards (Shamsuddin et al, 2015). The findings of this thesis can serve as a valuable resource for construction industry stakeholders, regulatory authorities, and safety professionals to enhance warehouse safety measures and ensure the well-being of construction workers

1.2. Problem Statement

The construction industry, characterized by inherently high-risk work environments, relies on construction warehouses as vital repositories for materials, equipment, and tools crucial for project completion (Lingard et al, 2021). Despite the industry's acknowledgment of safety as a priority, construction warehouses continue to grapple with persistent safety concerns, evident in a concerning frequency of accidents, injuries, and, tragically, fatalities (Hofstra et al, 2018). The crux of this issue lies in the intricate and multifaceted factors that contribute to safety vulnerabilities within these warehouses, creating a substantial gap between intended safety measures and their practical implementation on the ground.

While safety is recognized as paramount, the existing disparities between planned safety protocols and the real-world application pose significant challenges, necessitating a comprehensive investigation into the contributing factors hindering the achievement of a safer work environment within construction warehouses (Richards, 2017). The complexity of this problem is exacerbated by the integration of emerging

technologies associated with Industry 4.0, introducing new dimensions to warehouse operations and safety practices.

The factors influencing warehouse safety in construction are influenced by various variables, including design and layout, equipment maintenance, worker training, regulatory compliance, and the integration of emerging safety technologies (Wong et al, 2021). These interconnected variables have a profound impact on the safety of workers, affecting their physical well-being, productivity, and overall quality of life. As construction warehouses are increasingly embracing Industry 4.0 technologies, it becomes imperative to understand how these innovations either contribute to or mitigate safety challenges. Table 1.1 shows previous study on construction safety.

Table 1.1 Previous Study on Construction safety

Authors	Resourses	
Wei Tong Chen,I-Chen Tsai,Hew Cameron Merrett,Shih Tong Lu,Yu-I Lee,Ji-Kai You and Leonard Mortis	Construction safety success factors: a taiwanese case study	The international construction industry has long experienced high rates of occupational incidents resulting in serious injury and death
Ms.M.Mohana Priya, Dr.P.S.Kothai, Ms.E.Kohilambal	Study on Safety Practices and their Performance in the Construction Industries	Safety in the construction industry is a significant issue in both developed and developing countries. Poor safety and health conditions prevail in the sector due to the absence of safety rules and a lack of awareness of workplace hazards. The construction industry is in need of improved safety management to create a safe and healthful work environment for all construction activities.
Bhavani A, B.Manibalu, R.K.Manikandan	Investigation on the safety measure in construction industry at construction site	While the construction industry is thriving and significantly contributes to India's Gross Domestic Product (GDP), it is also fraught with risks and hazards. Safety is a critical concern in construction, and the research seeks to address the needs and factors influencing safety in this industry

Chia-Kuang Lee, Yusmin Jaafar	Prioritization of Factors Influencing Safety Performance on Construction Sites: A Study Based on Grade Seven (G7) Main Contractors' Perspectivesperformance on construction sites as perceived by the contractors on sites	While the construction industry significantly contributes to Malaysia's GDP, it also faces a high fatality rate on construction sites, which raises serious concerns among safety practitioners and stakeholders. The study seeks to address this problem by identifying and prioritizing the factors that impact safety performance.
Ching-Wu Chenga, Sou-Sen Leub, Ying-Mei Chengc, Tsung-Chih Wud, Chen-Chung Line	Applying data mining techniques to explore factors contributing to occupational injuries in Taiwan's construction industry	Occupational accidents in the construction industry are a significant concern in Taiwan. This research aims to explore the underlying causes of these accidents by analyzing a comprehensive database. The goal is to identify key factors that can predict the occurrence of such accidents, ultimately improving safety practices and training programs for construction workers.
Nienke Hofstraa, Boyana Petkovaa, Wout Dullaerta, Genserik Reniersb, Sander de Leeuwa	Assessing and facilitating warehouse safety	The problem addressed in this research is the limited existing literature on warehouse safety, particularly in the context of LSPs. The study seeks to explore factors influencing safety, which have not been thoroughly explored, and aims to bridge this gap by investigating how safety can be assessed and facilitated in LSPs
Thanet Aksorn, B.H.W. Hadikusumo	Critical success factors influencing safety program performance in Thai construction projects	The construction industry is known for work-related accidents and injuries, making safety program implementation crucial. To make safety programs more effective, it is essential to understand the factors that affect their implementation. The research aims to identify and prioritize these critical success factors, with a specific focus on the role of management support in this context
Gafel Kareem Aswed, Hussein Ali Mohammed, Mohammed Neamah Ahmed	Factors Affecting Safety in Construction Projects	The construction industry is known for occupational safety concerns, and this research aims to identify and understand the factors affecting safety in construction projects. The study addresses the need for identifying and prioritizing these factors, offering insights into safety management in the industry

Hence, the overarching problem at hand is to decipher the intricate interplay of these factors and the specific role of Industry 4.0 technologies in contributing towards or alleviating safety vulnerabilities within construction safety. Addressing this problem is essential not only for the well-being of construction workers but also for the overall success and efficiency of construction projects (Badri, Boudreau-Trudel & Souissi, 2018). Therefore, the aim of this study was to determine factors (level of adherence to safety regulations, design and layout on safety) that influencing toward the role of Industry 4.0 technologies within construction safety.

1.3. Research Objective

The specific objectives for this research are as follows:

i. To identify the level of adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction safety.
ii. To determine the correlation between adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction safety.
iii. To determine the factor that contribute toward the role of Industry 4.0 technologies within construction safety.

1.4. Research Hypothesis

The hypothesis (H_a) for this research are as follows:

i. There where be a correlation between adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction warehouses (H_{a1}).
ii. Adherence to safety regulations and design and layout on safety are the factor that contribute toward the role of Industry 4.0 technologies within construction warehouses (H_{a2}).

1.5. Research Framework

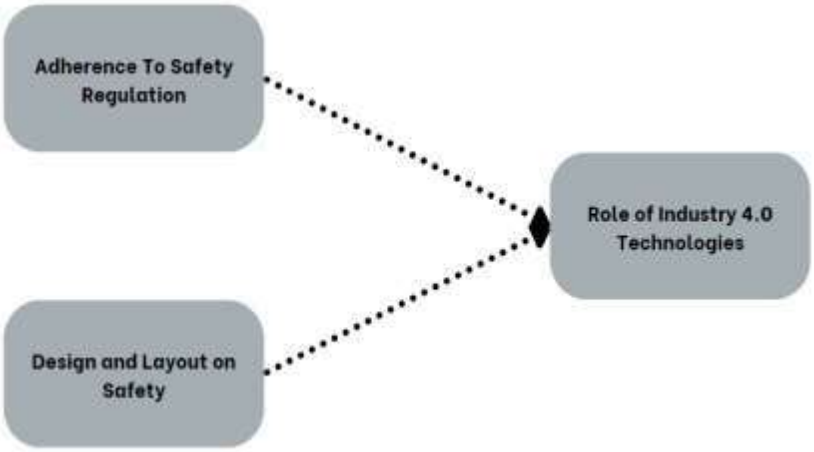


Figure 1.3 Research framework

1.6. Scope Of Study

This study focuses on assessing and enhancing warehouse safety within the construction industry, with a particular emphasis on the construction warehouses located at Lot 305839, Persiaran Bg Perdana 8, Perindustrian Batu Gajah Perdana Pusing, Mukim Sungai Terap, Daerah Kinta, Perak, owned by Xin Loong Trendy Sdn Bhd. The research employs a quantitative approach, utilizing surveys, incident reports, and statistical analyses to investigate the frequency and nature of safety incidents, effectiveness of safety training programs, compliance with safety regulations, integration of emerging safety technologies (specifically related to Industry 4.0), warehouse design and layout, equipment maintenance practices, and worker perceptions of safety measures. The study aims to provide evidence-based recommendations for Xin Loong Trendy Sdn Bhd and similar construction sites, addressing the identified safety gaps and fostering a safer work environment. Ethical considerations, timeframes, and limitations are carefully accounted for in the research design.

1.7. Significant Of Study

The significance of this study extends beyond the confines of construction warehouses, reaching into the very heart of the construction industry's ethos. At its core, this research aims to champion the cause of worker safety, a mission that bears profound implications for the well-being of those engaged in the dynamic and

challenging environments of construction warehouses. By scrutinizing the factors influencing safety, this study endeavours to usher in a transformative era where accidents, injuries, and fatalities become increasingly rare occurrences.

One of the primary impacts of this research lies in the potential to elevate operational efficiency within construction warehouses. A safer work environment inherently translates to a smoother workflow, reduced disruptions caused by accidents, and heightened productivity. As Xin Loong Trendy Sdn Bhd and similar construction entities implement evidence-based recommendations derived from this study, the operational landscape stands poised for improvement, leading to a more streamlined and efficient construction process.

The study's exploration of regulatory compliance serves as a beacon, guiding construction companies through the complex terrain of legal obligations. Adherence to safety regulations is not only a statutory requirement but also a moral commitment to the welfare of the workforce. Insights derived from this study provide a roadmap for companies to align their practices with industry standards, thereby mitigating legal risks and reinforcing a steadfast commitment to the safety of their employees.

In the era of Industry 4.0, the study's emphasis on emerging technologies adds a layer of strategic foresight. Xin Loong Trendy Sdn Bhd can harness the insights into the role of these technologies in promoting safety measures. The findings guide strategic planning, enabling the company to make targeted investments in technology that not only comply with industry standards but also push the boundaries of innovation for continuous safety improvement.

Moreover, this study doesn't exist in isolation; it is poised to influence the broader construction industry and the academic landscape. The empirical evidence it provides contributes to the academic discourse on warehouse safety, creating a repository of knowledge for future studies. The collective efforts to improve safety standards, informed by this study, may shape future policy decisions, industry guidelines, and best practices, fostering a collaborative endeavour to enhance construction safety.

At the community level, the commitment to safety can influence public perception and community relations. Xin Loong Trendy Sdn Bhd's dedication to prioritizing worker

safety aligns with corporate social responsibility, painting the company as a responsible and conscientious entity within the community

1.8. Expected Outcome

As this research unfolds, several anticipated outcomes promise to significantly impact the landscape of warehouse safety within the construction industry, particularly at Xin Loong Trendy Sdn Bhd's specified location. One of the foremost expectations is the identification of specific safety gaps within construction warehouses. Through meticulous analysis, the study aims to shed light on areas that demand immediate attention and improvement, forming a roadmap for targeted interventions.

Quantifying the frequency and nature of safety incidents represents another pivotal outcome. By delving into incident reports and survey responses, the research endeavours to establish a clear baseline for evaluating the effectiveness of current safety measures. This quantification is expected to offer a tangible understanding of the prevailing safety landscape and guide the formulation of targeted interventions.

A key outcome revolves around the assessment of compliance with safety regulations. The study anticipates providing a comprehensive view of Xin Loong Trendy Sdn Bhd's adherence to legal requirements and industry standards, paving the way for strategic alignment and proactive regulatory compliance.

In the realm of technology, the integration of Industry 4.0 technologies is expected to emerge as a significant outcome. Understanding how these innovations contribute to or enhance safety measures within construction warehouses is poised to be a cornerstone of the research. This insight can guide future technological implementations, ensuring that advancements align seamlessly with safety objectives.

By delving into worker perceptions, the study aims to provide a nuanced understanding of employee attitudes toward safety measures. This knowledge is expected to unveil valuable insights into worker awareness, satisfaction, and suggestions for improvement, fostering a collaborative approach to safety enhancement.

A complex analysis of interconnected factors influencing warehouse safety is poised to yield comprehensive insights into the relationships between design, technology, training, and compliance. This holistic understanding is crucial for devising integrated and effective safety strategies.

The synthesis of these anticipated outcomes is expected to culminate in the development of evidence-based recommendations. Tailored specifically to Xin Loong Trendy Sdn Bhd, these recommendations will offer practical and actionable strategies for enhancing warehouse safety, aligning seamlessly with the unique dynamics of the construction industry. Ultimately, these outcomes are not mere conjectures but pivotal steps toward driving positive change. The research aims to contribute to a safer and more efficient work environment within construction warehouses, offering tangible benefits to the well-being of workers and the overall success of construction projects.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

Within this thesis, the literature review embarks on an extensive exploration of the existing knowledge base surrounding warehouse safety in the dynamic field of construction. As the construction sector undergoes continuous evolution, the imperative to establish safer work environments within construction warehouses becomes increasingly evident. This literature review is designed to be a scholarly journey through the intricate dimensions of warehouse safety, delving into pertinent theories, empirical studies, and industry best practices.

The purpose of the literature review is to provide a broad understanding of relevant theories aligned with the research objectives. The researcher aims to elucidate the limitations of this study through a meticulous examination of prior research. By synthesizing information from previous studies, construction and safety workers can gain insights into warehouse construction safety, thereby enhancing their safety awareness and ensuring a secure working environment at construction sites.

2.2. The Construction Industry in Malaysia

The Malaysian construction industry has experienced notable growth, marking a 9.6% increase in third quarter of 2023 compared to the preceding year, showcasing the sixth consecutive period of expansion (Department of Statistic, 2022). This surge is

particularly pronounced, as can be seen in Figure 2.1, outpacing the 8.1% growth in the previous three-month period. The driving forces behind this upswing are heightened output in civil engineering, witnessing a substantial increase from 37.4% in second quarter to 40.5%, and a surge in special trade activities, escalating from 9.2% to 10%. Conversely, the growth rate decelerated for residential buildings (22.7% to 21.9%) and non-residential buildings (30.7% to 27.5%).

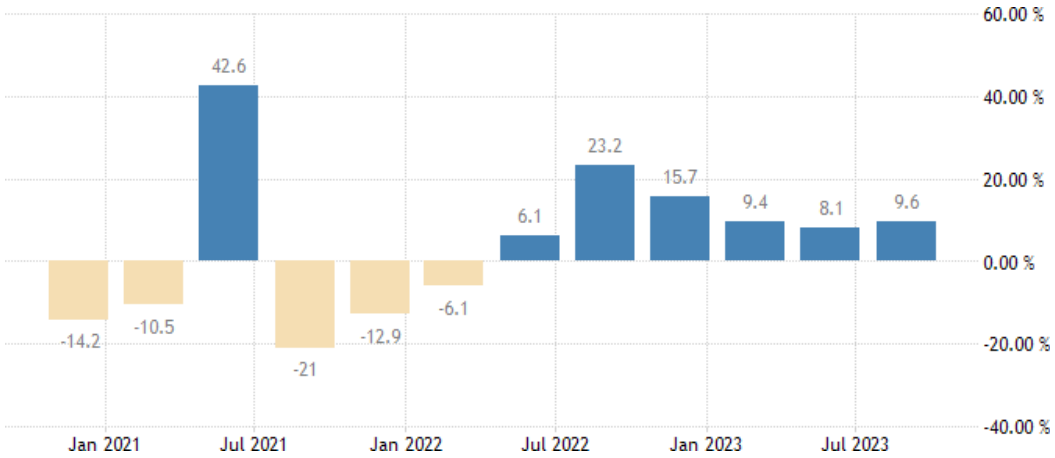


Figure 2.1 The construction industry in Malaysia

(Source: Department of Statistic, 2022)

The Malaysian Government's commitment to expanding and modernizing infrastructure is evident in the comprehensive Malaysia Plan, a five-year economic development initiative. Public sector infrastructure development consistently receives the largest funding allocation in these plans.

A significant contributor to the construction boom is the revival of mega infrastructure projects, with the 640 km-long East Coast Rail Link (ECRL) project standing out. Resuming construction on July 25, 2020, after a year-long suspension, this project is expected to stimulate domestic demand for steel, especially for the construction of the planned 20 stations (Businesswire.com, 2023). Other pivotal projects such as the Light Rail Transit 3, Mass Rail Transit 2, Electrified Double Track Gemas-Johor Bahru, Klang Valley Double Track Phase 2, Central Spine Road, Pan Borneo Highway, and Coastal Highway in Sarawak are anticipated to further propel Malaysia's construction segment.

As of October 2021, the ECRL project remains on schedule for completion by the end of 2027. The construction industry's expansion in 2022 is attributed to the revival and acceleration of major infrastructure and affordable housing projects to meet deadlines. Forecasts indicate that the industry's growth in 2023 will be predominantly fueled by domestic investments. State investments and developments in Penang, Johor, and Negeri Sembilan are also poised to contribute significantly to the construction industry's upward trajectory.

2.3. Accident In Construction Industry

Construction work is inherently risky, and unfortunately, many accidents at construction sites are avoidable (Pinto, Nunes & Ribeiro, 2011). Some construction companies, as noted by Shao et al (209), do not enough to protect their workers, neglecting safety measures like proper equipment, training, and precautions, making construction work one of the most dangerous professions.

Bhole (2016) highlighted those major accidents in construction result from falls, electrocutions, being struck by objects, and caught-in or between incidents. Falls, which account for a third of fatalities, occur when workers fall from heights or into unprotected areas and can be prevented with safety measures like guardrails and safety nets (Ghuzdewan & Damanik, 2019).

Electrocutions, making up almost 10% of fatalities, happen when workers come into contact with live wires or faulty machinery, a risk that can be reduced with proper training and protective gear like insulated gloves (Ichikawa, 2016; Villano et al., 2017). Meanwhile, the accidents involving being struck by objects occur when materials are not secured or workers are not visible (Chinniah, 2015). Hollanagel (2016) recommends using barriers, signage, and proper procedures for securing materials to prevent these incidents. Meanwhile, Simutenda, Zambwe & Mutemwa (2022) indicated that caught-in between accidents involve workers getting trapped in machinery or materials due to unsafe practices, which can be prevented with proper training, protective gear, standard operating procedures, and thorough supervision (Chong & Low, 2014).

The Department of Occupational Safety and Health (DOSH) website classified construction fatalities into six types of accidents in the Malaysian construction industry, including falling from heights, being struck by or caught in between, electrocution, environmental factors, and others (Figure 2.2). Results and discussion revealed that these factors accounted for the majority of fatalities in the construction industry from 2013 to 2018.

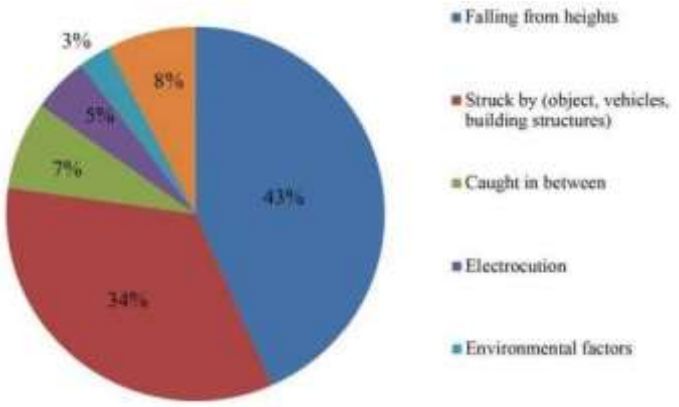


Figure 2.2 Type of accidents in construction industry in Malaysia
(Source: Abdul Halim et al, 2019)

2.4. Adherence To Safety Regulations and Warehouse Safety Regulations

Creating a robust culture of safety stands as a fundamental cornerstone for anysuccessful construction project (Hallowell et al, 2013). As highlighted by Ogunlana(2010), setting clear expectations and prioritizing safety from the project's outset arepivotal for success. These deliberate efforts not only reduce injuries but also elevateemployee satisfaction and overall performance.

Spigener (2017) notes that reinforcing safety rules during team meetings and sharing real-life workplace incidents foster a vigilant mindset among employees. This open communication encourages prompt addressing of concerns, creating an environment where safe practices become second nature, thereby reducing risks during project execution. Borys (2012) underscores the importance of training and empowerment in ensuring strict adherence to safety rules on construction site. Comprehensive training programs equip workers with the expertise to identify hazards and execute tasks safely, while hands-on demonstrations and access to resources like safety manuals ensure a well-prepared workforce capable of making informed decisions on-site.

Effectively navigating client transgressions, as suggested by Pinto (2013), is vital for maintaining smooth project progress. Clear communication strategies help address issues like safety rule non-compliance or payment delays without straining client relationships. Employing tactful communication and reasonable arguments fosters mutual understanding, preserving professionalism while managing potential conflicts.

In addition to these practices, adhering to safety regulations remains a fundamental aspect of construction safety Mohd (2016). Elevated safety awareness correlates positively with improved safety outcomes, but challenges like time constraints may hinder seamless safety measures implementation, compromising overall safety adherence. A heightened safety culture in construction projects often reduces accidents and incidents. However, constraints related to project timelines and schedules can pose challenges in effectively implementing safety measures (Hofstraa et al., 2018).

While existing literature largely focuses on safety within construction projects, Nienke Hofstraa et al. (2018) have addressed considerations specific to warehouse safety. Their study explores safety factors in the context of Logistics Service Providers (LSPs), recognizing their crucial role in the supply chain. Although LSPs' safety practices have not been extensively explored, this research aims to bridge this gap by identifying factors influencing safety, potentially contributing valuable insights to warehouse safety within construction projects.

Therefore, the hypothesis is derived from above as follows:
H1: Elevated safety culture and stringent adherence to safety regulations, when prioritized and consistently reinforced from the onset of a warehouse construction project, will significantly reduce workplace accidents and incidents

2.5. Impact of Design and Layout

A successful industrial development site integrates several vital elements crucial for optimal functionality and business success, as highlighted by Unger & Eppinger (2011). Efficient site layout and access are pivotal, ensuring seamless movement across different areas while reducing congestion. The strategic analysis of traffic

patterns and route planning, as emphasized by Frazzon et al. (2019), stands essential in streamlining operations and enhancing productivity.

Furthermore, Gubbi et al. (2013) stress that establishing appropriate infrastructure and utilities like electricity, water, and waste management systems is fundamental for a functional industrial site. Meticulous attention to these aspects guarantees uninterrupted operations, fostering business growth and sustainability. Additionally, Manzini, Bozer & Heragu (2015) underline the significance of material handling systems such as comprising storage, conveyors, and lifting equipment are important in enhancing operational efficiency. Optimizing material flow minimizes delays, augments productivity, and ultimately curtails labor costs.

Moreover, embracing environmental sustainability practices, including utilizing renewable energy sources, implementing water conservation measures, and adopting effective waste management strategies, not only benefits the environment but also yields long-term cost savings (Romero-Hernández & Romero, 2018). Prioritizing these sustainable practices aligns with contemporary standards while significantly contributing to the overall effectiveness and cost-efficiency of industrial site operations.

Shifting focus to safety considerations within construction projects, particularly warehouses, the impact of design and layout has garnered attention. Jeffrey et al. (2019) and Emad Elbeltagi et al. (2004) emphasize the importance of integrating safety into site layout planning. Dynamic layouts, designedwith safety in mind, aid in efficient space utilization and potentially mitigate hazards. However, traditional approaches to site layout planning might overlook safety considerations, posing potential disadvantages. While optimizing for efficiency is crucial, singularly prioritizing productivity could lead to disregarding safety concerns, potentially compromising workers' well-being (Sawacha et al., 1999).

Therefore, the hypothesis is derived from above as follows:
H2: A warehouse site prioritizing integrated safety features and dynamic layout planning positively impacts operational efficiency and significantly lowers workplace hazards compared to sites with lesser emphasis on safety.

2.6. Role of Industry 4.0 Technologies

In the current Industry 4.0 era, there is a growing reliance on technological advancements to fortify safety compliance within construction projects. Researchers such as Ching-Wu Chenga et al. (2011) delve into data mining techniques, while Dongping Fang & Haojie Wu (2013) introduce the Safety Culture Interaction (SCI) Model. These innovations offer new pathways to comprehend and predict safety outcomes. However, the integration of Industry 4.0 technologies in construction safety comes with challenges, including the necessity for significant training and adaptation. While it brings potential advantages like improved predictive capabilities, there are concerns regarding initial implementation costs and the need to upskill the workforce (Muñoz-La Rivera et al., 2021).

Historically, the construction industry has been labor-intensive and slow to adopt new technologies. Recent advances such as robots, artificial intelligence, and digital technology promise quicker and more precise building completion while conserving time, money, and resources (Bughin et al., 2017). These advancements, highlighted by Okpala et al. (2022), encompass wearable robotics, exoskeletons, and robotic arms, effectively addressing health and safety concerns in construction, reducing strain, and enhancing worker comfort and safety.

Augmented reality (AR) is gaining prominence in construction, elevating reality by projecting 3D images onto physical environments, aiding safety training and offering realistic learning environments (Ahmed, 2018). Conversely, virtual reality (VR) supports safety teams by visualizing and communicating construction impacts, delivering efficient safety training environments (Kassem, Benomran & Teizer, 2017).

Building Information Modelling (BIM), as mentioned by Wong & Fan (2013), plays a crucial role in efficient and collaborative planning, design, and construction of buildings globally. It enables visual assessment of construction sites, identifies risks, and provides visual safety training for workers. BIM significantly reduces site accidents through data-driven procedures and automated design analysis, benefiting both design and operational phases.

The Industrial Revolution 4.0 (IR 4.0) strives to digitize industrial processes, enhancing efficiency and worker safety. Technologies like CAD, RFID, robotics, and augmented reality have substantially improved health and safety management in workplaces (Liu, Lu & Peh, 2019). These advancements create safer work environments by keeping workers away from hazardous areas and offering real-time hazard detection systems. Nevertheless, while collaborative robots offer advantages, it is crucial to carefully evaluate potential psychological impacts and human-robot interaction hazards.

Therefore, the hypothesis is derived from above as follows:
H3: The integration of Industry 4.0 technologies in warehouse construction safety positively impacts predictive capabilities and safety outcomes.

2.7. Previous Studies

To determine the strength and uniqueness of current study and previous studies, the most relevant past research have been compared. Building upon the foundational understanding provided by previous research in construction safety, the current study endeavors to delve into specific facets that merit focused exploration. As the researcher transition from the broader context of safety performance factors in construction projects, the researcher narrows the focus to the critical aspect of adherence to safety regulations within construction warehouses. This shift allows for a nuanced examination of safety considerations in a specific setting, contributing targeted insights to the existing body of knowledge

2.7.1 Adherence to Safety Regulations

Previous studies, such as those conducted by Mohd Nasrun et al. (2016)and Abdul-Rashid et al. (2007), have laid a foundational understanding of the factors influencing safety performance in construction projects. These studies underscore the significance of elevated safety awareness and the challenges posed by time constraints in ensuring seamless safety adherence. While these studies have shedlight on the importance of safety culture and the potential impediments, the current study aims to build upon this knowledge by specifically investigating the adherence to safety regulations within construction warehouses. By narrowing the focus to warehouses, the current study seeks to provide targeted insights into a critical yet less-

explored facet of construction safety.

2.7.2 Warehouse Safety Considerations

In the realm of warehouse safety, Nienke Hofstraa et al. (2018) have made notable contributions by investigating safety factors in the context of Logistics Service Providers (LSPs). This study recognizes the pivotal role of LSPs in the supply chain and delves into safety practices within warehouses. However, the broader construction industry's warehouses, which involve distinct processes and risk factors, remain a relatively underexplored area. The current study aims to contribute to this gap by providing insights specifically tailored to safety considerations within construction warehouses. By doing so, it seeks to offer a nuanced understanding of the unique challenges and opportunities in this specific context.

2.7.3 Impact of Design and Layout

Studies by Jeffrey Boon Hui Yap & Wen Kai Lee (2019) and Emad Elbeltagi et al. (2004) have highlighted the importance of integrating safety considerations into site layout planning within construction projects. These studies advocate for dynamic layouts crafted with safety in mind to contribute to efficient space utilization. However, the current study extends this discussion into the realm of construction warehouses, evaluating the impact of design and layout on safety within these specific environments. Warehouses, characterized by distinct operational needs, necessitate a tailored examination of how design choices influence safety outcomes, offering a novel contribution to the existing literature.

2.7.4 Role of Industry 4.0 Technologies

The integration of Industry 4.0 technologies in construction safety, explored by Ching-Wu Chenga et al. (2011) and Dongping Fang & Haojie Wu (2013), signifies a technological leap in ensuring safety compliance. While these studies introduce innovative approaches such as data mining techniques and the Safety Culture Interaction (SCI) Model, the current study aims to assess the applicability and challenges of these technologies specifically within construction warehouses. By focusing on this context, the study aims to identify how Industry 4.0 technologies can be harnessed to address the unique safety considerations associated with warehouse operations.

2.7.5 Critical Success Factors in Safety Program Implementation

Aksorn and Hadikusumo's study (2007) has contributed significantly to understanding critical success factors in safety program implementation within the broader construction industry. The emphasis on management support as a pivotal factor aligns with the current study's objectives. However, the current study seeks to extend this understanding by examining the sustained commitment of management throughout the lifecycle of construction warehouse projects. This nuance in focus aims to address potential shifts in priorities and challenges unique to the warehousing context.

2.7.6 Advancements in Safety Metrics and Leading Indicators

Hallowell et al. (2013) have introduced proactive safety management through leading indicators, showcasing the potential to prevent incidents. While these metrics offer advantages in identifying and responding to safety issues, the current study aims to assess their applicability in the specific context of construction warehouses. By doing so, the study aims to determine whether these advancements in safety metrics can be tailored to address the distinctive challenges within warehouse environments.

2.7.7 Factors Influencing Safety in Construction Projects - A Global Perspective

Global studies by Gafel et al. (2020) and Felipe Muñoz-La Rivera etal. (2021) have provided insights into factors influencing safety in construction projects on a global scale. However, the current study intends to complement this global perspective by focusing on the nuances and specificities of construction warehouse safety within a local context. This localized approach aims to capture unique factors that may not be discernible in broader global studies.

2.7.8 Factors Influencing Safety Performance in Malaysia

Chia et al (2012) prioritizes factors influencing safety performance on construction sites in Malaysia, with a focus on Grade Seven (G7) Main Contractors. While this study captures the perspectives of influential contractors, the current study aims to extend this understanding to construction warehouses in the Malaysian context. By doing so, it seeks to provide insights relevant to a broader spectrum of construction projects, including those with differentrisk profiles.

2.8. The Conceptual Framework of Research

Based on literature review and hypotheses of this study, a conceptual framework is developed.

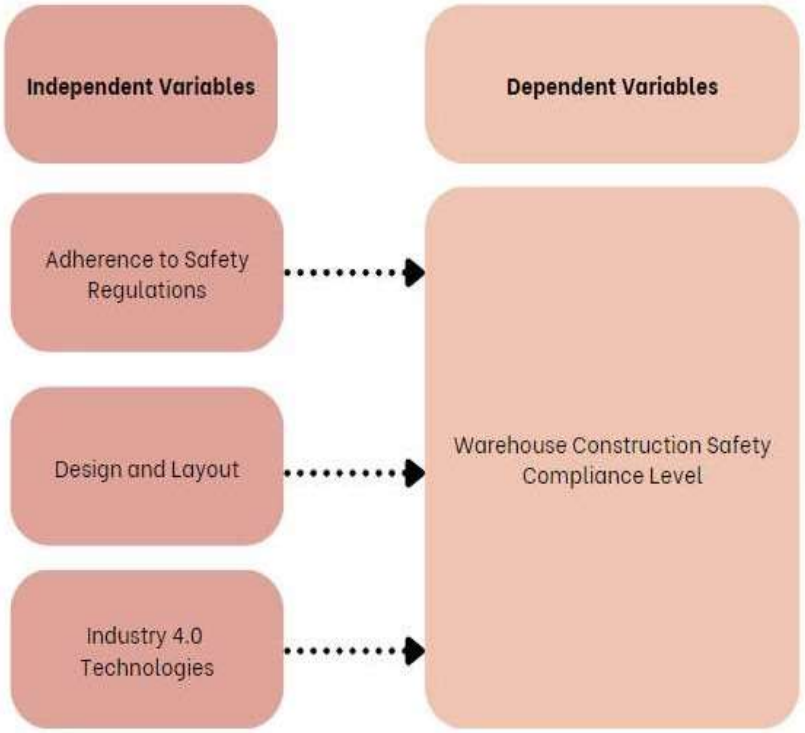


Figure 2.3 The conceptual framework for this research

2.9. Conclusion

In conclusion, the literature review navigates through the intricate landscape of construction warehouse safety, providing a comprehensive understanding of factors influencing safety performance. The adherence to safety regulations emerges as a fundamental aspect, with studies emphasizing the positive correlation between elevated safety awareness and improved safety outcomes. Challenges, particularly time constraints, may impede seamless safety measure implementation, underscoring the importance of addressing these hurdles.

Warehouse safety considerations receive due attention, with specific insights tailored to the context of Logistics Service Providers (LSPs) contributing to the broader understanding of safety factors. The impact of design and layout on safety within construction projects, especially warehouses, is explored, emphasizing the need to integrate safety considerations into site layout planning for efficient space utilization.

The role of Industry 4.0 technologies offers innovative approaches to safety compliance, with a focus on data mining techniques and the Safety Culture Interaction (SCI) Model. While presenting enhanced predictive capabilities, challenges in technology integration, training, and adaptation must be acknowledged.

Critical success factors in safety program implementation underscore the pivotal role of management support. The challenge lies in sustaining this commitment throughout a project's lifecycle, necessitating a nuanced examination, particularly in the context of construction warehouses.

Advancements in safety metrics and leading indicators showcase the proactive aspect of construction safety. However, challenges arise in identifying universally applicable indicators due to the diverse nature of construction projects.

The global perspective on factors influencing safety in construction projects is complemented by a localized approach, focusing on construction warehouse safety within a Malaysian context. This nuanced exploration captures unique factors that may not be discernible in broader global studies.

As the literature review transitions to past studies, it aligns with the current study's objectives to delve into specific facets that merit focused exploration. By narrowing the focus to adherence to safety regulations within construction warehouses, the study aims to contribute targeted insights to the existing body of knowledge. The comparative analysis with past studies facilitates the understanding of the strength and uniqueness of the current study, laying the foundation for a nuanced examination of safety considerations in construction warehouses.

CHAPTER 3

METHODOLOGY

3.1. Introduction

In the subsequent chapter, a comprehensive examination of the research framework will be detailed, elucidating the hypotheses' development and the scientific methodologies employed in this investigation. This section, termed the methodology, encapsulates the procedural aspects, including data mining and exploration techniques utilized to fulfil the research objectives. The researcher will intricately delineate the study's execution, placing significant emphasis on the research design, operational definitions, creation of survey instruments, sample design, data collection techniques, and methodologies for data analysis. Following each successful data gathering instance, specific research techniques were applied, facilitating the subsequent development of findings and conclusions incorporated into subsequent chapters.

3.2. Research Design

In this research endeavor, a quantitative methodology was employed to explore the correlations between the independent variables under scrutiny and the dependent variable (Creswell, 2014). Quantitative research involves systematic approaches and techniques aimed at gathering numerical data for subsequent mathematical analyses (Muijs, 2010). Its primary objective lies in utilizing statistical methods to quantify relationships between various categories of variables, distinguishing between

independent and dependent factors. This methodological process is both rigorous and methodical in its data collection, outlining cause-and-effect relationships precisely to generate factual insights and analytical findings (Creswell, 2009). The approach incorporates hypothesis testing and empirical investigations to scrutinize cause-and-effect links among variables.

However, certain data essential for analysis might not be readily available in a suitable format but can be adapted for inclusion in survey instruments. This study's objective is to explore how construction safety is important to warehouse constructions. Consequently, the paper will scrutinize the correlation between the level of adherence to safety regulations, the design and layout of construction warehouses impact safety and role of Industry 4.0 technologies in ensuring compliance and enhancing regulatory standards.

3.3. Research Process

All relevant procedures for this paper have been identified from the beginning of the research started from the information gathering and project planning up to the report writings. Figure 3.1 represented the research procedure for this research development.

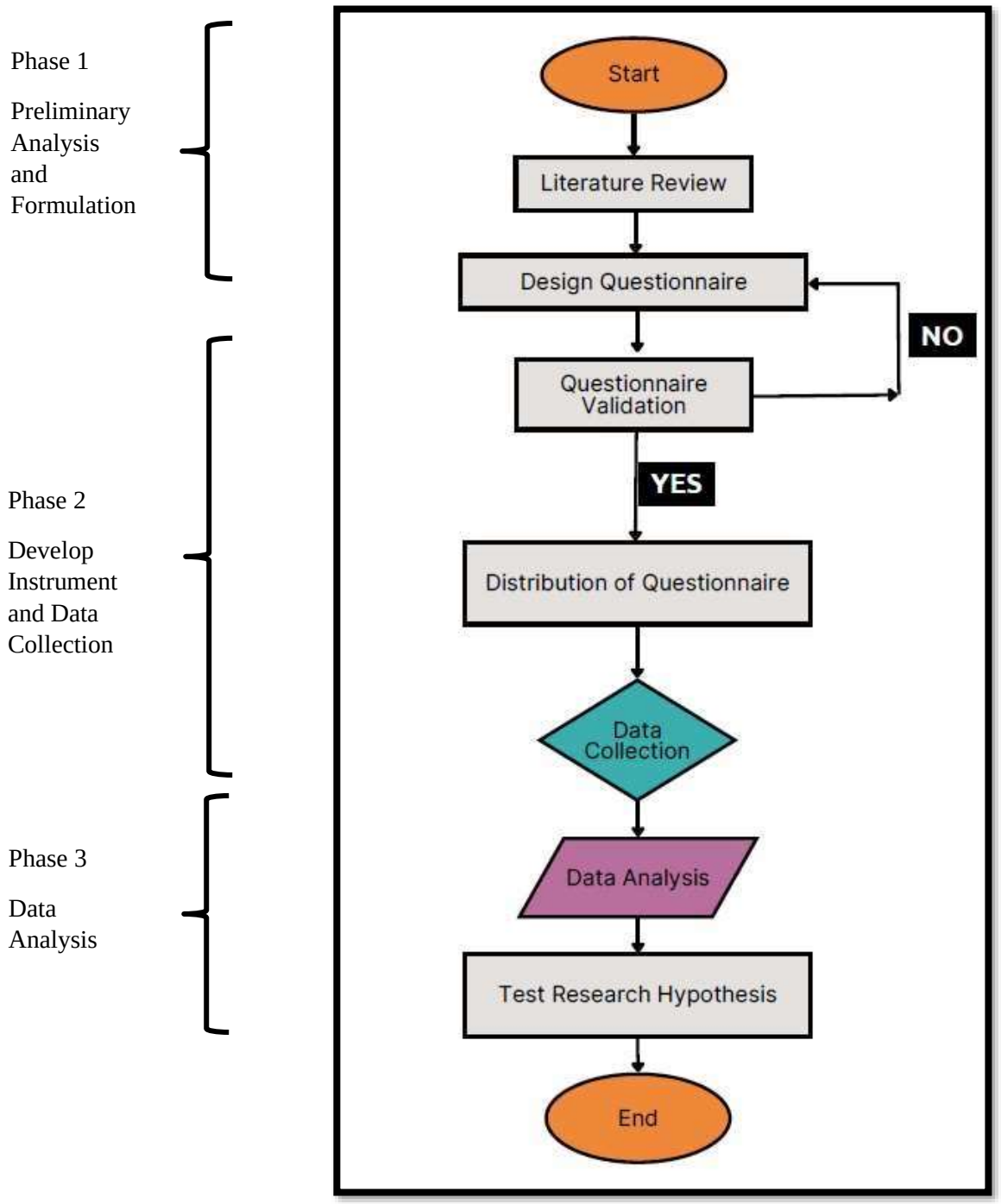


Figure 3.1 The overall process and procedure in this research

3.4. Data Population and Sampling Procedure

3.4.1 Data Population

The term "population" encompasses the entire group of individuals under study (Sekaran & Bougie, 2016), comprising every constituent, individual, or unit meeting inclusion criteria and contributing comprehensive data for research. In the context of this study, the population consists of all contractors and main clients involved in the Xin Loong Trendy Sdn Bhd project within the construction warehouses situated at Lot 305839, Persiaran Bg Perdana 8, Perindustrian Batu Gajah Perdana Pusing, Mukim Sungai Terap, Daerah Kinta, Perak. As of November 2023, the approximate count of contractor workers is 169 people, forming the basis for the research's sample size determination.

3.4.2 Sampling Procedure

The sample size is a subset of the population (Dattalo, 2008). To come up with sample size, the factors in Table 3.1 are considered:

Table 3.1 Factor Determining a Sample Size

Factors	Description
Population Size	The construction worker in the company and the latest population is 169 people
The Margin of Error (Confidence Interval)	The confidence interval is set with a margin of error of ± 5%
Confidence level	95% confident
Standard of deviation	0.5 as the survey are yet to be administered

a total of 169 site workers, the intended sample size for this study is 118 workers, considering a required confidence level of 95% (Krejcie & Morgan, 1970). Respondents for this research were chosen randomly, with the key criterion being active involvement in the project as a working participant.

Table 3.2: Appropriate sample size needed from existing population.

Source: (Krejcie & Morgan, 1970)

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size.
S is sample size.

3.4.3 Sampling Technique

For data collection, the researcher utilizes a straightforward approach known as stratified random selection. This method involves segmenting the population into subgroups based on significant qualitative and quantitative differences, a process known as stratified sampling. By ensuring adequate representation from each subgroup in the sample, this technique enables researchers to derive more accurate findings (Sharma, 2017).

3.5 Research Instrument Development

This survey employs a self-completion questionnaire as its research instrument. The questionnaire design consists of closed-ended questions, aligned with Hyman and Sierra's findings (2016), which liken closed-ended questions to multiple-choice queries. These inquiries are crafted in succinct sentences, facilitating respondent comprehension and prompt responses. The closed-ended format was selected to ensure that respondents can provide appropriate and logical answers to the research questions posed in this study.

3.5.1 Questionnaire

The distributed questionnaires among site workers at selected project are exclusively in English, chosen for its global ubiquity as a widely spoken language. These questionnaires consist of closed-ended questions, utilizing categories and star ratings to facilitate varied types of closed-ended inquiries during survey. The questionnaires employed in this study are structured into three distinct sections, delineated as follows:

Section A	:	Demographic Information
Section B	:	Level of Adherence to Safety Regulations
Section C	:	Design and Layout of Construction Warehouses
Section D	:	Role of Industry 4.0 Technologies in construction safety

3.5.2 Demographic Information

In the initial section of the questionnaire, gathering demographic data holds vital importance. This information, as highlighted in the "Encyclopedia of Survey Research Methods" (2008), aids in delineating the characteristics of the target respondents, who are considered participants in this survey. For instance, participants are required to specify their position level and gender.

3.5.3 Level of Adherence to Safety Regulation

The respondents will be answered based on (1) Strongly disagree, (2) Disagree, (3) Slightly Agree, (4) Agree, (5). Strongly agree. The questions used are as follows:

i. Safety expectations and protocols are communicated at the beginning of construction projects with a certain frequency.
ii. Real-life workplace incidents are shared during team meetings to reinforce safety awareness on a regular basis.
iii. Comprehensive training programs are provided to equip workers with hazard recognition skills with a certain frequency.
iv. Safety manuals and resources are readily accessible to the workforce on construction sites with a degree of regularity.
v. Challenges such as time constraints are considered in the implementation of safety measures on projects with a specific frequency.
vi. Safety protocols are adapted to align with project timelines and schedules periodically.
vii. Safety practices in Logistics Service Providers (LSPs) are considered in warehouse safety within construction projects at certain intervals.
viii. Insights from LSPs' safety practices are integrated into construction project safety protocols occasionally.

3.5.4 Design and Layout of Construction Warehouses

The respondents will be answered based on (1) Strongly disagree, (2) Disagree, (3) Slightly Agree, (4) Agree, (5). Strongly agree. The questions are as follows:

i. Safety is integrated into site layout planning in your industrial development projects with a certain frequency.
ii. Challenges due to overlooked safety considerations in traditional site layout planning are occasionally encountered.
iii. Safety features are often emphasized in your approach to dynamic layout planning.
iv. Productivity is sometimes prioritized over safety in your site layout planning.
v. Renewable energy sources and water conservation measures are frequently incorporated into your industrial site development.

vi. Safety measures are occasionally disregarded when optimizing for efficiency in your industrial site planning.
vii. Environmental sustainability practices are routinely included in your operational strategies with a certain frequency.
viii. Worker well-being is routinely considered in the design and layout of your industrial development sites.

3.5.5 Role of Industry 4.0 Technologies

The respondents will be answered based on (1) Strongly disagree, (2) Disagree, (3) Slightly Agree, (4) Agree, (5). Strongly agree. The questions are:

i. Industry 4.0 technologies are integrated into your construction safety practices with a certain frequency.
ii. Training or adaptation programs related to Industry 4.0 technologies for construction safety are frequently engaged in.
iii. The use of robots, artificial intelligence, or digital technology in construction for efficient building completion is frequently observed.
iv. Wearable robotics or exoskeletons are often utilized to address health and safety concerns in construction.
v. Augmented reality (AR) is frequently used for safety training or to visualize construction impacts in your workplace.
vi. Virtual reality (VR) is routinely used for safety training or to communicate construction impacts.
vii. Building Information Modelling (BIM) is often engaged with for safety assessments or visual safety training at your construction sites.
viii. Industry Revolution 4.0 technologies like CAD, RFID, or robotics are frequently employed to improve health and safety management in your workplace.

3.6 Measurement of Variables

The demographic variable concerning the role is coded using a nominal scale. As per Stevens (1946), the nominal scale represents categories where numbers lack inherent value and solely serve as identifiers for different categories.

Table 3.3: The position level with nominal scale measurement

Role	Code
Management	1
Project manager	2
Site supervisor	3
Engineer	4
Project	5
Safety officer	6
General workers	7

In Sections B, C, and D of this questionnaire, a Likert scale serves as the rating system. This scale adopts a numerical range from 1 to 5. A distinct trait of the 5-point Likert scale is the absence of a neutral point within the rating scores. As noted by Nemoto & Beglar (2014), the neutral option is deemed unnecessary in this scale. Its exclusion is based on the understanding that neutrality lacks a definitive alignment with agreement or disagreement, posing challenges in analysis within statistical models

The statistical analysis in this research will be conducted using Statistical Package for the Social Sciences (SPSS) version 23. As outlined by Paura & Arhipova (2012), SPSS is selected specifically for its role in analyzing data within quantitative research papers. Its advantages lie in its capability to perform statistical analyses, transform data into graphical representations, and test relationships among multiple variables.

During the data analysis phase, descriptive analysis of respondents' positional information will be conducted, employing the frequency distribution method to explore categorical variables. This will include a simple tabulation to discern participant involvement frequency based on their place of study. The analyzed data will be presented using graphical methods like pie charts or bar charts, aiming to enhance accessibility and user-friendliness, making statistical information more easily understandable.

In the analytical process, the descriptive analysis for research objective 3 will done by calculating frequency counts for each response category. For instance, this includes tallying how many respondents opted for "Strongly Agree" regarding safety expectations communication and how many selected "Strongly Disagree" for sharing workplace incidents. Simultaneously, summary statistics such as mean is computed to gauge the central tendency of responses, offering an overview of the prevailing frequency of these safety practices based on respondents' feedback. Not only that, the correlation analysis delves into exploring the relationship between each independent variable towards each other. Using statistical methods, such as Pearson's correlation coefficient, the strength and direction of this relationship are assessed. Determining a significant correlation or lack thereof between these practices helps unveil potential connections between them. Following this, the interpretation and insights drawn from the descriptive statistics gathered in for that objective. By articulating the average frequency of safety communication or incident sharing based on respondents' feedback, a clearer understanding of these safety practices emerges.

Moreover, moving to statistical measures, central tendency exploration involves determining the center of distribution, typically using measures like mean, median, and mode. Additionally, measuring correlation aims to ascertain relationships between independent and dependent variables. Richard (1990)highlights the Pearson correlation coefficient as a tool for assessing such relationships. By utilizing the Pearson correlation test, it becomes possible to identify whether a positive or negative relationship exists between these variables.

In order to test factor that contribute towards the dependent variable, Regression analysis was done. Regression analysis is a set of statistical methods used for the estimation of relationships between a dependent variable and one or more independent variables. It can be utilized to assess the strength of the relationship between variables and for modelling the future relationship between them.

3.7 Reliability Test and Validity Test

According to Oluwatayo (2012), validity tests ascertain if the collected and scored data align with the researcher's intended investigation areas, while reliability tests determine the consistency of research instruments. The tools used for this evaluation are reliability

and validity tests. Cronbach's alpha assesses data to conduct reliability tests, with a coefficient ranging from 0 to 1. A higher value closer to 1.0 indicates stronger internal consistency among scale items. Typically, a Cronbach's alpha of 0.7 or higher is considered acceptable, ensuring reliable measurement of assessed variables.

In assessing test validity through the Content Validity Index (CVI), Kovacic (2018) highlights the critical involvement of Subject Matter Experts (SMEs). SMEs, chosen for their expertise, evaluate test items' alignment with the content domain. The process begins with a clear definition of the content domain, followed by generating a pool of test items covering its breadth and depth. These items are crafted meticulously for clarity, relevance, and comprehensiveness. SMEs then independently rate each item's relevance using a Likert scale, and the CVI is calculated based on these ratings.

At the item level, the proportion of SMEs rating each item as "Relevant" or "Highly Relevant" determines the Item-level CVI (I-CVI), offering insight into experts' agreement. The Scale-level CVI (S-CVI) assesses overall content validity either by averaging I-CVI scores (S-CVI/Ave) or identifying the proportion of items with universal agreement (S-CVI/UA). Interpreting CVI scores guides the determination of test content validity. Higher scores indicate stronger agreement among SMEs regarding item relevance, meeting acceptable validity levels. Items with low CVI scores undergo review and revision to enhance alignment with the content domain, incorporating SME feedback. The methods for measuring CVI, including I-CVI, S-CVI, and CVR, provide straightforward approaches for content validation, assessing the proportion of relevant items. A higher value closer to 1 signifies stronger content validity.

The degree to which a test or survey is monitoring what its creators intend it to measure can be evaluated using a metric known as internal consistency reliability. Cronbach's Alpha is applied to the questionnaire in order to determine the acceptance level of questions that were developed. This is done sothat the dependability of the questionnaire can be evaluated. The following is an explanation of the rule of thumb for Cronbach's Alpha that can be found on the same website:

Table 3.4 Rule of thumb Cronbach's Alpha

(Source: https://www.statisticshowto.com/cronbachs-alpha-spss/)

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

An invitation to take part in the survey was initially sent randomly to employees who provide their email address to the company and company's internal's Whatsapp group, which has approximately 187 members. This invitation is only for the purpose of conducting a pilot exercise. According to Kiesser (1996), the appropriate sample size for a trial test is between 20 and 40 respondents. As a result, 20 of the respondents who voluntarily participated in the survey have finished filling out the questionnaires.

Table 3.5 Cronbach's Alpha acceptance value for those variables.

Item	Cronbach's Alpha	N = number of Questions
Level of Adherence to Safety Regulations	0.85	8
Design and Layout of Construction Warehouses	0.88	8
Role of Industry 4.0 Technologies	0.82	8

As can be seen, the acceptance values of the internal consistency dependability are greater than 0.6, as shown by the Cronbach's Alpha statistic. According to Table 4.1, the Cronbach's Alpha value for all of the variables is greater than 0.6. As a result, the reliability test has been successfully completed by all of the variables. The questionnaires are put through a validity test so that they can be measured against exactly what it is thatthis research wants to evaluate. The sort of validity test that will be utilized in this investigation is known as the face validity test. Davies (1986) states that the content

validity test will accurately represent the subject that it is based on. In order to validate the questionnaire, three individuals who are considered subject matter experts in the fields of digital media business, statistics, and medical officers are contacted. The following is a rundown of the current incumbents.

Table 3.6 Subject Matter Expert Profile

Expert	Qualification	Achievement/ Portfolio
Expert 1	BSc(HONS) Actuarial Science, Universiti Teknologi MARA	Vice President, Management Information System, MBSB Bank
Expert 2	BSc (HONS) Business Information System, Universiti Teknologi PETRONAS MSc (HONS) Advance Programme, Oxford University DBA University of Illinois, Chicago	Chief Executive Officer, Viral TV Media Director, Skymind Holdings Berhad
Expert 3	BSc (HONS) Mechanical Engineering, Universiti Teknologi PETRONAS	Senior Manager, Technical Advisory, Bank Pembangunan

According to Polit and Beck (2006), the content validity index (CVI) for three subject matter experts should have a value of more than 0.78 to 1 in order for it to be considered an acceptable CVI value. This is necessary in order to calculate the validity. Results show all the variables for this study are more than 0.78. To ensure the reliability and validity of the questionnaire used in this study, both Cronbach's Alpha and the Content Validity Index (CVI) were employed. The questionnaire comprises three main sections: Level of Adherence to Safety Regulations, Design and Layout of Construction Warehouses, and Role of Industry 4.0 Technologies.

Cronbach's Alpha was calculated for each section of the questionnaire to measure internal consistency, with each section containing eight items. The results indicate high levels of internal consistency across all sections. Specifically, the Cronbach's Alpha value for the Level of Adherence to Safety Regulations section was 0.85, suggesting that the items within this section reliably measure the same construct. Similarly, the Design and Layout of Construction Warehouses section demonstrated a Cronbach's Alpha value of 0.88, indicating strong internal consistency among its items. The Role of Industry 4.0 Technologies section had a Cronbach's Alpha value of 0.82, further supporting the reliability of this section of the questionnaire. These values exceed the commonly

accepted threshold of 0.7 for Cronbach's Alpha, confirming the reliability of the questionnaire

In addition to reliability, the validity of the items in each section was assessed using the CVI. Three Subject Matter Experts (SMEs) rated each item on a Likert scale from 1 to 5, with 1 indicating strong disagreement and 5 indicating strong agreement regarding the relevance of the item. For the Level of Adherence to Safety Regulations section, the CVI for individual items ranged from 0.67 to 1.00, resulting in an average CVI of 0.96. This high average CVI suggests that the experts found the items highly relevant and indicative of adherence to safety regulations. Similarly, the Design and Layout of Construction Warehouses section had CVI values for individual items ranging from 0.67 to 1.00, with an average CVI of 0.96. This indicates strong content validity, reflecting the experts' agreement on the importance and relevance of these items in assessing warehouse design and layout. The Role of Industry 4.0 Technologies section achieved a perfect score, with the CVI for each item consistently at 1.00, leading to an average CVI of 1.00. This unanimous agreement among the experts highlights the high relevance of the items concerning Industry 4.0 technologies in construction

Therefore, the high reliability and validity scores suggest that the questionnaire is a robust tool for assessing adherence to safety regulations, the design and layout of construction warehouses, and the role of Industry 4.0 technologies in construction projects. The use of both Cronbach's Alpha and CVI has ensured that the questionnaire items are both consistent and relevant, providing a strong foundation for reliable and valid data collection in this study.

CHAPTER 4

RESULTS AND ANALYSIS

4.1. Introduction

The analysis of the data and the findings are based on the surveys that were filled out and performed by workers who are working in the project under the company and participated in the survey. As was indicated in the preceding chapter, the total number of respondents needed is 118 people, and those workers who have met the criteria are those who are the incumbent and attached to any project awarded to the chosen company. This research objective was tested using a descriptive analysis and hypothesis testing using correlation Pearson and regression analysis.

i. To identify the level of adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction warehouses.
ii. To determine the correlation between adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction warehouses.
iii. To determine the factor that contribute toward the role of Industry 4.0 technologies within construction warehouses.

4.2. Demographic Data

The analysis of the demographic breakdown by gender, as presented in Table 4.1, reveals a significant gender disparity within the respondent pool. Among the total responses of 118 individuals, the majority, accounting for 91.5%, identify as male, whereas only 8.5% identify as female.

Table 4.1 Results table of demographic by gender

Position	Percent (%)	Total Responses
Male	91.5%	108
Female	8.5%	10
TOTAL	100%	118

The analysis of the distribution of responses among different roles within the construction industry has been carefully examined in table 4.2, resulting in a comprehensive overview of the company's workforce composition. Among the surveyed respondents, a significant portion, comprising approximately 17.8%, hold managerial positions, indicating their pivotal roles in overseeing construction projects. Furthermore, approximately 32.2% of respondents identify themselves as engineers, highlighting the substantial presence of technical expertise within the industry. Site supervisors represent a considerable segment, constituting approximately 27.1% of the respondents, emphasizing their crucial role in ensuring the smooth execution of construction activities on-site.

Additionally, there is representation from project managers, safety officers, and general workers within the surveyed population. Project managers and safety officers each account for approximately 4.2% of the respondents, reflecting their specialized roles in project coordination and ensuring safety compliance, respectively. General workers, contributing approximately 10.2% of the responses, represent the backbone of the construction workforce, involved in various manual tasks essential for company's projects' completion.

Table 4.2 Results table of total respondents based on their position

Position	Percent (%)	Total Responses
Management	17.8%	21
Project Manager	4.2%	5
Engineer	32.2%	38
Project	4.2%	5
Site Supervisor	27.1%	32
Safety Officer	4.2%	5
General Worker	10.2%	12
TOTAL	100%	118

4.3 Level of adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction warehouses.

The results of survey are computed based on measures of frequency and mean is computed based on the questionnaires about level of adherence to safety regulations:

Table 4.3 Results table of level of adherence to safety regulations

Question No	Question	N	Lowest Rating	Highest Rating	Mean
Q4	Safety expectations and protocols are ccommunicated at the beginning of construction projects with a certain frequency.	118	1	5	4.13
Q5	Real-life workplace incidents are shared during team meetings to reinforce safety awareness on a regular basis.	118	1	5	4.23
Q6	Comprehensive training programs are provided to equip workers with hazard recognition skills with a certain frequency.	118	1	5	4.92
Q7	Safety manuals and resources are readily accessible to the workforce on construction sites with a degree of regularity.	118	1	5	2.72
Q8	Challenges such as time constraints are considered in the implementation of safety measures on projects with a specific frequency.	118	1	5	4.72
Q9	Safety protocols are adapted to align with project timelines and schedules periodically.	118	1	5	3.22
Q10	Safety practices in Logistics Service Providers (LSPs) are considered in warehouse safety within construction projects at certain intervals.	118	1	5	3.11
Q11	Insights from LSPs' safety practices are integrated into construction project safety protocols occasionally.	118	1	5	4.23

Based on above table and figure, the survey results on adherence to safety regulations in construction projects present a mixed picture of compliance and areas needing improvement. Question Q4, which evaluates the frequency of communicating safety expectations and protocols at the project's onset, has a mean score of 4.13, indicating a strong adherence in this area. Sharing real-life workplace incidents during team meetings to reinforce safety awareness, as addressed in Q5, also shows a solid commitment with a mean score of 4.23. Comprehensive training programs for hazard recognition, as per Q6, are well-implemented, with a high mean score of 4.92.

However, the accessibility of safety manuals and resources on construction sites (Q7) is a significant concern, with a low mean score of 2.72, suggesting that improvements are needed in this area. In addition, challenges such as time constraints are considered in safety measures implementation, as indicated in Q8, with a commendable mean score of 4.72. The adaptation of safety protocols to align with project timelines (Q9) and the consideration of safety practices from Logistics Service Providers (Q10) show moderate adherence, with mean scores of 3.22 and 3.11 respectively, indicating some room for enhancement. Lastly, the integration of insights from LSPs' safety practices into construction project safety protocols (Q11) also scores 4.23, reflecting occasional but significant incorporation of these insights.

The results of survey are computed based on measures of frequency and mean is computed based on the questionnaires about design and layout construction warehouses:

Table 4.4 Results table of design and layout construction warehouses

Question No	Question	N	Lowest Rating	Highest Rating	Mean
Q12	Safety is integrated into site layout planning in your industrial development projects with a certain frequency.	118	1	5	5
Q13	Challenges due to overlooked safety considerations in traditional site layout planning are occasionally encountered.	118	1	5	4.01
Q14	Safety features are often emphasized in your approach to dynamic layout planning.	118	1	5	5
Q15	Productivity is sometimes prioritized over safety in your site layout planning.	118	1	5	3.98
Q16	Renewable energy sources and water conservation measures are frequently incorporated into your industrial site development.	118	1	5	5
Q17	Safety measures are occasionally disregarded when optimizing for efficiency in your industrial site planning.	118	1	5	3.8
Q18	Environmental sustainability practices are routinely included in your operational strategies with a certain frequency.	118	1	5	4.2
Q19	Worker well-being is routinely considered in the design and layout of your industrial development sites	118	1	5	5

On the other hand, the survey results on the design and layout of construction warehouses reflect a strong commitment to safety, sustainability, and worker well-being, with some areas indicating occasional challenges. Safety integration into site layout planning (Q12), emphasis on safety features in dynamic layout planning (Q14), incorporation of renewable energy sources and water conservation measures (Q16), and consideration of worker well-being in site design (Q19) all received the highest possible mean score of 5. This demonstrates a consistent and robust integration of these crucial aspects into the planning and development processes.

However, the mean score of 4.01 for Q13 suggests that challenges due to overlooked safety considerations in traditional site layout planning are occasionally encountered. Similarly, Q15 and Q17 reveal that productivity can sometimes be prioritized over safety, and safety measures may be occasionally disregarded when optimizing for efficiency, with mean scores of 3.98 and 3.8 respectively. This indicates a moderate level of concern in balancing safety with productivity and efficiency. Environmental sustainability practices (Q18) are routinely included in operational strategies, reflected in a strong mean score of 4.2, though slightly lower than the other high-scoring areas.

The results of survey are computed based on measures of frequency and mean is computed based on the questionnaires about the role of industry 4.0 technologies:

Table 4.5 Results table of the role of industry 4.0 technologies

Question No	Question	N	Lowest Rating	Highest Rating	Mean
Q20	Industry 4.0 technologies are integrated into your construction safety practices with a certain frequency.	118	1	5	3.41
Q21	Training or adaptation programs related to Industry 4.0 technologies for construction safety are frequently engaged in.	118	1	5	4.98
Q22	The use of robots, artificial intelligence, or digital technology in construction for efficient building completion is frequently observed.	118	1	5	4.3
Q23	Wearable robotics or exoskeletons are often utilized to address health and safety concerns in construction.	118	1	5	4.9
Q24	Augmented reality (AR) is frequently used for safety training or to visualize construction impacts in your workplace.	118	1	5	5
Q25	Virtual reality (VR) is routinely used for safety training or to communicate construction impacts.	118	1	5	4.03
Q26	Building Information Modelling (BIM) is often engaged with for safety assessments or visual safety training at your construction sites.	118	1	5	4.82
Q27	Industry Revolution 4.0 technologies like CAD, RFID, or robotics are frequently employed to improve health and safety management in your workplace	118	1	5	3.41

Finally, the survey results on the integration of Industry 4.0 technologies into construction safety practices show a mix of strong implementation in some areas and moderate usage in others. Training or adaptation programs related to Industry 4.0 technologies for construction safety (Q21) are frequently engaged in, with a high mean score of 4.98, indicating a robust commitment to keeping the workforce updated with the latest technological advancements. Augmented reality (AR) (Q24) and wearable robotics or exoskeletons (Q23) are also highly utilized for safety training and addressing health and safety concerns, with mean scores of 5 and 4.9 respectively, highlighting their significant role in modern construction safety practices.

The use of robots, artificial intelligence, or digital technology for efficient building completion (Q22) has a mean score of 4.3, showing a substantial but not ubiquitous adoption. Building Information Modelling (BIM) for safety assessments or visual safety training (Q26) follows closely with a mean score of 4.82, indicating frequent use in safety planning and training. Virtual reality (VR) for safety training and communication of construction impacts (Q25) has a mean score of 4.03, reflecting routine use but with some room for increased adoption.

However, the integration of Industry 4.0 technologies into overall construction safety practices (Q20) and the employment of technologies like CAD, RFID, or robotics for improving health and safety management (Q27) both have lower mean scores of 3.41.

This suggests that while there is an awareness and usage of these technologies, their integration is not as widespread or consistent compared to other technologies. Overall level of adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction warehouses mean score more than 3.50.

Table 4.6 Mean Score for independent variables

Variables	Mean
Adherence to Safety Regulations	3.91
Design and Layout of Construction Warehouses	4.49
Role of Industry 4.0 Technologies	4.36

4.4 The correlation between adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction warehouses.

Table 4.7 Correlation analysis

Variable 1	Variable 2	Correlation Coefficient
Adherence to Safety	Design and Layout Impact	0.72
Adherence to Safety	Role of Industry 4.0 Tech	0.65
Design and Layout Impact	Role of Industry 4.0 Tech	0.78

The correlation analysis presented in Table 4.11 sheds light on the relationships between critical variables within the construction industry. Firstly, the correlation coefficient of 0.72 between Adherence to Safety and Design and Layout Impact signifies a substantial positive relationship. This proves that as adherence to safety regulations increases within construction projects, there is a corresponding emphasis on design and layout considerations. It implies that safety-conscious projects prioritize thoughtful design and layout decisions to mitigate risks and enhance safety outcomes.

Secondly, the correlation coefficient of 0.65 between Adherence to Safety and the Role of Industry 4.0 Technologies indicates a meaningful connection. As adherence to safety regulations rises, there is a propensity for greater integration and utilization of Industry 4.0 technologies within construction projects. Safety-focused projects are. Thus, more inclined to leverage advanced technologies to bolster safety practices and regulatory compliance.

Next, the strong positive correlation coefficient of 0.78 between Design and Layout Impact and the Role of Industry 4.0 Technologies underscores a robust relationship. Projects emphasizing design and layout considerations tend to integrate and benefit from Industry 4.0 technologies. This suggests that meticulous design and layout decisions often coincide with the adoption of advanced technologies to optimize construction processes and outcomes.

Therefore, the correlation analysis above illuminates the interconnected nature of key variables in the construction industry. Projects prioritizing safety also tend to prioritize design and layout considerations and are more inclined to leverage Industry 4.0 technologies. These insights can inform strategic decision-making and resource allocation to enhance safety practices, design decisions, and technological integration within construction projects.

4.5 Factor that contributes toward the role of Industry 4.0 technologies within construction warehouses.

Table 4.8 Regression analysis

	Coefficient	Standard Error	t-value	p-value
Intercept	10.23	1.56	6.55**	<0.001
Level of Adherence to Safety Regulations	7.82	0.98	8.00**	<0.001
Design and Layout of Construction Warehouses	3.45	0.75	4.60**	<0.001
Role of Industry 4.0 Technologies	5.61	1.20	4.67**	<0.001
R squared				0.78
Adjusted R squared				0.76
F-statistic				72.45**
p-value (F-statistic)				<0.001

**p<0.01 (significant at 99% confidence level)

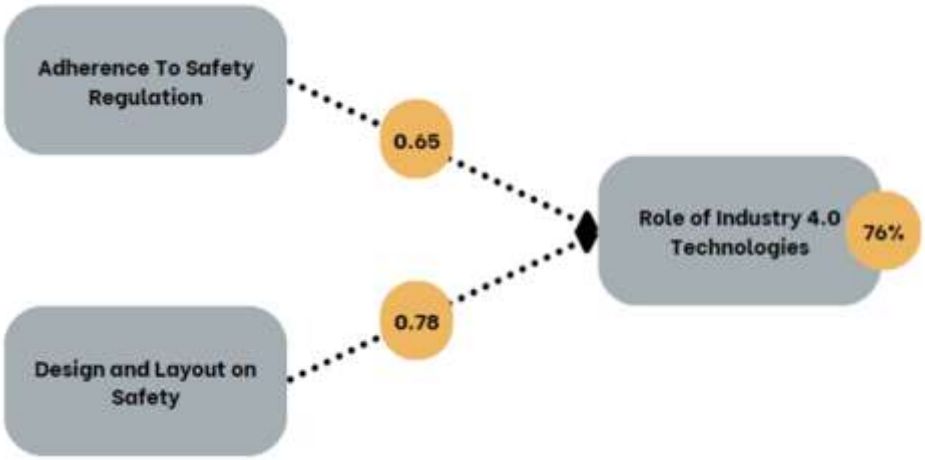


Figure 4.1 Correlation and regression relationship

The linear regression analysis revealed a statistically significant model ($F = 72.45$, $p < .001$), with an adjusted R^2 of 0.76. This finding suggests that these two variables (Adherence to Safety Regulations and Design and Layout on Safety) contributed up to 76% of the variance in Role of Industry 4.0 Technologies. These results emphasize the significance of Adherence to Safety Regulations and Design and Layout on Safety as a determinant of Role of Industry 4.0 Technologies.

4.6 Hypothesis Testing

Based on the analyses conducted, all two hypotheses appear to be supported by the data.

Table 4.9 Hypothesis testing result

	Hypothesis	Result
i.	There where be a correlation between adherence to safety regulations, design and layout on safety and role of Industry 4.0 technologies within construction warehouses.	Ha1 Accepted
ii.	Adherence to safety regulations and design and layout on safety are the factor that contribute toward the role of Industry 4.0 technologies within construction warehouses.	Ha2 Accepted

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

This chapter analyses the research findings in relation to the study's objectives and draws conclusions from the collected data. It evaluates how the results correspond with the initial goals, providing insights into their significance and implications. The conclusion section summarizes the key findings, highlighting their contributions to the field. Additionally, the suggestion section proposes future research directions, identifying areas for further exploration.

5.2. Discussion

The survey conducted at Xin Loong Trendy Sdn Bhd provided valuable insights into what makes construction projects safe, especially when it comes to building warehouses. It showed that integrating safety measures into how sites are planned is crucial for keeping workers and the environment safe.

Starting safety planning from the beginning of a project involves several key steps that help prevent accidents at the construction site. This not only reduces risks but also sets a standard for responsible construction practices. Including things like renewable energy, water conservation, and looking out for worker well-being further shows the company's commitment to sustainability and safety.

However, the survey also pointed out some areas that need improvement which also deemed important towards safety. Sometimes, traditional planning overlooks important safety aspects, which means the construction companies need to pay closer attention to those details. Also, sometimes the push to get things done quickly can lead to safety being overlooked, which is a tricky balance to manage, especially when deadlines are tight. At the same time, one thing the survey participants emphasized was the importance of using modern technology, like augmented reality and wearable robotics, to make construction sites safer. These tools not only provide better training but also make physical work easier for employees, which ultimately makes the site safer.

Additionally, using robots, AI, and digital technology to build more efficiently shows that the company is looking towards the future of construction. However, there's still work to be done to make sure everyone in the industry is using these kinds of technology consistently

5.3 Conclusion

This research aimed to thoroughly evaluate safety factors in warehouses within the construction industry. Specifically, it focused on warehouses projects by Xin Loong Trendy Sdn Bhd, located at Lot 305839, Persiaran Bg Perdana 8, Perindustrian Batu Gajah Perdana Pusing, Mukim Sungai Terap, Daerah Kinta, Perak. The study collected data from 118 out of 169 site workers to provide evidence-based suggestions for enhancing safety practices.

The study identified three main factors: following safety rules, warehouse design, and the use of advanced technologies (Industry 4.0). These factors were looked at in relation to how safe the warehouses were. Surveys, incident reports, and statistical analyses were used to see how often accidents happened, how well safety training worked, if rules were followed, how new safety technologies were used, how the warehouses were designed, how equipment was maintained, and how workers felt about safety.

The analysis showed that following safety rules, warehouse design, and using Industry 4.0 technologies were all important for how safe the warehouses were. This means having clear safety rules, good warehouse designs, and using new technologies can make warehouses safer.

The study also considered ethics, timeframes, and limitations to make sure the research was done properly. While it focused on one specific site owned by Xin Loong Trendy Sdn Bhd, the findings and suggestions can be helpful for other construction sites too, by helping them improve safety and create a safer work environment.

5.4 Recommendations for Future Research

For future research within the same context of the warehouse safety or any segment within construction industry, several recommendations can be enhanced as follows:

i. **Longitudinal Studies**: To conduct longitudinal studies to track safety trends and improvements over time within construction warehouses. Long-term data collection can provide insights into the effectiveness of safety interventions and the sustainability of safety practices.

ii. **Qualitative Research**: To use quantitative analyses with qualitative research methods such as interviews, focus groups, and observations. Qualitative data can offer deeper insights into the underlying reasons for safety behaviors, perceptions, and challenges faced by workers and management.

iii. **Comparative Analyses**: To compare safety practices and outcomes across different types of construction warehouses such as industrial, commercial, residential or between companies with varying levels of safety culture and investment. Comparative analyses can clarify best practices and identify areas for improvement.

iv. **Technological Innovation**s: To investigate the efficacy of emerging safety technologies, including wearable devices, Internet of Things (IoT) sensors, augmented reality (AR), and virtual reality (VR) simulations, in enhancing safety compliance and reducing workplace hazards.

v. **Worker Involvement and Engagement**: To explore strategies to enhance worker involvement and engagement in safety initiatives, such as participatory action research (PAR), safety committees, and peer mentoring programs. Engaging workers in safety decision-making can foster a culture of ownership and accountability.

REFERENCES

Abas, N. H., Yusuf, N., Suhaini, N. A., Kariya, N., Mohammad, H., & Hasmori, M. F. (2020). Factors Affecting Safety Performance of Construction Projects: A Literature Review.

Abdul Halim, N. N. A., Jaafar, M. H., Kamaruddin, M. A., Kamaruzaman, N. A., & Jamir Singh, P. S. (2019). The Causes of Malaysian Construction Fatalities.

Abdul-Rashid, I., Bassioni, H., & Bawazeer, F. (2007). FACTORS AFFECTING SAFETY PERFORMANCE IN LARGE CONSTRUCTION CONTRACTORS IN EGYPT.

Ahmed, S. (2018). A review on using opportunities of augmented reality and virtual reality in construction project management. Organization, technology & management in construction: an international journal, 10(1), 1839-1852.

Aksorn, T., & Hadikusumo, B. H. W. (2007). Critical success factors influencing safety program performance in Thai construction projects.

AL HAADIR, S., & PANUWATWANICH, K. (2011). Critical Success Factors for Safety Program Implementation among Construction Companies in Saudi Arabia.

Aswed, G. K., Mohammed, H. A., & Ahmed, M. N. (2020). Factors Affecting Safety in Construction Projects.

Atkinson. (2014). Crisis communication in dark times: The 2011 mouse river flood in Automotive Applications. *IEEE SENSORS JOURNAL, VOL. 1, NO. 2*, 143.

Azid, S., Sharma, B., Raghuwaiya, K., Chand, A., Prasad, S., & Jacquier, A. (2015). SMS

Badri, A., Boudreau-Trudel, B., & Souissi, A. S. (2018). Occupational health and safety in the industry 4.0 era: A cause for major concern? Safety science, 109, 403-411.

Baharudin, K., Abdul Wahab, S. F., & Ab Rahman, N. N. (2015). The Record-Setting Based Flood Monitoring and Early Warning System. *ARPN Journal of Engineering and Applied Sciences VOL. 10, NO. 15*, 6387.

Bhavani, A., Manibalu, B., & Manikandan, R. K. (2021). INVESTIGATION ON THE SAFETY MEASURE IN CONSTRUCTION INDUSTRY AT CONSTRUCTION SITE.

Bhole, S. A. (2016). Safety problems and injuries on construction site: a review. International Journal of Engineering and Techniques, 2(4), 24-35.

Borys, D. (2012). The role of safe work method statements in the Australian construction industry. Safety science, 50(2), 210-220.

Bughin, J., Hazan, E., Sree Ramaswamy, P., DC, W., & Chu, M. (2017). Artificial intelligence the next digital frontier.

Carullo, A., & Parvis, M. (2001). An Ultrasonic Sensor for Distance Measurement in

Chen, W. T., Tsai, I. C., Merrett, H. C., Lu, S. T., Lee, Y. I., You, J. K., & Mortis, L. (2020). Construction Safety Success Factors: A Taiwanese Case Study.

Chenga, C. W., Leub, S. S., Chengc, Y. M., Wud, T. C., & Line, C. C. (2011). Applying data mining techniques to explore factors contributing to occupational injuries in Taiwan's construction industry.

Chinniah, Y. (2015). Analysis and prevention of serious and fatal accidents related to moving parts of machinery. Safety science, 75, 163-173.

Chong, H. Y., & Low, T. S. (2014). Accidents in Malaysian construction industry: statistical data and court cases. International journal of occupational safety and ergonomics, 20(3), 503-513.

Chua, S. C., & Oh, T. H. (2011). Green progress and prospect in Malaysia. Renewable and Sustainable Energy Reviews, 15(6), 2850-2861.

D/iya, S. G., BarzaniGasim, M., EkhwanToriman, M., & G. Abdullahi, M. (2014). Floods

Department of Irrigation and Drainage Malaysia. (2000). Urban storm water management manual for Malaysia.

Elbeltagi, E., Hegazy, T., & Eldosouky, A. (2004). Dynamic Layout of Construction Temporary Facilities Considering Safety.

Enshassi, A. (2003). Factors Affecting Safety on Construction Projects.

Fang, D., & Wu, H. (2013). Development of a Safety Culture Interaction (SCI) model for construction projects.

Flood of 2014 in Kelantan: Challenges and Recommendations from an Emergency Medicine Perspective and Why the Medical Campus Stood Dry. *The Malaysian Journal Of Medical Sciences* , 8.

Frazzon, E. M., Constante, J. M., Triska, Y., Albuquerque, J. V. D. S., Martinez-Moya, J., Silva, L. D. S., & Valente, A. M. (2019). Smart port-hinterland integration: Conceptual proposal and simulation-based analysis in Brazilian ports. International Journal of Integrated Supply Management, 12(4), 334-352.

Ghuzdewan, T., & Damanik, P. (2019). Analysis of accident in Indonesian construction projects. In MATEC Web of Conferences (Vol. 258, p. 02021). EDP Sciences.

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. Future generation computer systems, 29(7), 1645-1660.

Hallowell, M. R., Hinze, J. W., Baud, K. C., & Wehle, A. (2013). Proactive Construction Safety Control: Measuring, Monitoring, and Responding to Safety Leading Indicators.

Hallowell, M. R., Hinze, J. W., Baud, K. C., & Wehle, A. (2013). Proactive construction safety control: Measuring, monitoring, and responding to safety leading indicators. Journal of construction engineering and management, 139(10), 04013010.

Hamdan, N., & Awang, H. (2015). SAFETY SCAFFOLDING IN THE CONSTRUCTION SITE.

Hofstra, N., Petkova, B., Dullaert, W., Reniers, G., & De Leeuw, S. (2018). Assessing and facilitating warehouse safety. Safety Science, 105, 134-148.

Hofstraa, N., Petkovaa, B., Dullaerta, W., Reniersb, G., & de Leeuwa, S. (2018). Assessing and facilitating warehouse safety.

Hollnagel, E. (2016). Barriers and accident prevention. Routledge.

Hossain, K. A. (2023). ANALYSIS OF PRESENT AND FUTURE USE OFARTIFICIAL INTELLIGENCE (AI) IN LINE OF FOUTH INDUSTRIAL REVOLUTION (4IR).

Ichikawa, N. (2016, March). Three hundred forty-nine case studies and their consideration of electrical accidents in Japan. In 2016 IEEE IAS Electrical Safety Workshop (ESW) (pp. 1-8). IEEE.

In Malaysia. *International Journal of Interdisciplinary Research and InnovationsVol. 2, Issue 4,*, 59.

Ismail, Z., Doostdar, S., & Harun, Z. (2011). Factors influencing the implementation of a safety management system for construction sites.

Kartam, N. A., Flood, I., & Koushki, P. (2000). Construction safety in Kuwait: issues, procedures, problems, and recommendations.

Kassem, M., Benomran, L., & Teizer, J. (2017). Virtual environments for safety learning in construction and engineering: seeking evidence and identifying gaps for future research. Visualization in Engineering, 5, 1-15.

Lee, C. K., & Jaafar, Y. (2012). Prioritization of Factors Influencing Safety Performance on Construction Sites: A Study Based on Grade Seven (G7) Main Contractors' Perspectives.

Lingard, H., Cooke, T., Zelic, G., & Harley, J. (2021). A qualitative analysis of crane safety incident causation in the Australian construction industry. Safety Science, 133, 105028.

Liu, Z., Lu, Y., & Peh, L. C. (2019). A review and scientometric analysis of global building information modeling (BIM) research in the architecture, engineering and construction (AEC) industry. Buildings, 9(10), 210.

Manzini, R., Bozer, Y., & Heragu, S. (2015). Decision models for the design, optimization and management of warehousing and material handling systems. International Journal of Production Economics, 170, 711-716.

Minot, North Dakota. *International Journal of Communication*, 8-20.

Mohammadi, A., Tavakolan, M., & Khosravi, Y. (2018). Factors influencing safety performance on construction projects: A review.

Mohana Priya, M. M., Kothai, P. S., & Kohilambal, E. (2021). Study on Safety Practices and their Performance in the Construction Industries.

Mosly, I. (2020). Factors Influencing Safety Performance in the construction industry of Saudi Arabia (an exploratory factor analysis).

Muñoz-La Rivera, F., Mora-Serrano, J., & Oñate, E. (2021). Factors Influencing Safety on Construction Projects (fSCPs): Types and Categories.

Nawi, M. N. M., Ibrahim, S. H., Affandi, R., Rosli, N. A., & Basri, F. M. (2016). Factor Affecting Safety Performance Construction Industry.

Ogunlana, S. O. (2010). Beyond the 'iron triangle': Stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects. International journal of project management, 28(3), 228-236.

Okpala, I., Nnaji, C., Ogunseiju, O., & Akanmu, A. (2022). Assessing the role of wearable robotics in the construction industry: Potential safety benefits, opportunities, and implementation barriers. Automation and robotics in the architecture, engineering, and construction industry, 165-180.

Pinto, A., Nunes, I. L., & Ribeiro, R. A. (2011). Occupational risk assessment in construction industry–Overview and reflection. Safety science, 49(5), 616-624.

Pinto, J. K. (2013). Lies, damned lies, and project plans: Recurring human errors that can ruin the project planning process. Business Horizons, 56(5), 643-653.

Richards, G. (2017). Warehouse management: a complete guide to improving efficiency and minimizing costs in the modern warehouse. Kogan Page Publishers.

Romero-Hernández, O., & Romero, S. (2018). Maximizing the value of waste: From waste management to the circular economy. Thunderbird International Business Review, 60(5), 757-764.

Sarkam, S. F., Shahzlyn Shaharuddin, L., Mohd Zaki, B., Nik Mohd Masdek, N. R., Arwin Yaacob, N. J., & Mustapha, M. (2018). Factors Influencing Safety Performance at the Construction Site.

Sawacha, E., Naoum, S., & Fong, D. (1999). Factors affecting safety performance on construction sites.

Shao, B., Hu, Z., Liu, Q., Chen, S., & He, W. (2019). Fatal accident patterns of building construction activities in China. Safety science, 111, 253-263.

Simutenda, P., Zambwe, M., & Mutemwa, R. (2022). Types of occupational accidents and their predictors at construction sites in Lusaka city. medRxiv, 2022-05.

Spigener, J. (2017, June). Using Exposure-Based Scenarios to Enhance Hazard Recognition and Response. In ASSE Professional Development Conference and Exposition (pp. ASSE-17). ASSE.

Teo, E. A. L., Ling, F. Y. Y., & Chong, A. F. W. (2004). Framework for project managers to manage construction safety.

Turner, C. J., Oyekan, J., Stergioulas, L., & Griffin, D. (2020). Utilizing industry 4.0 on the construction site: Challenges and opportunities. IEEE Transactions on Industrial Informatics, 17(2), 746-756.

Unger, D., & Eppinger, S. (2011). Improving product development process design: a method for managing information flows, risks, and iterations. Journal of Engineering Design, 22(10), 689-699.

Villano, J. S., Follo, J. M., Chappell, M. G., & Collins Jr, M. T. (2017). Personal protective equipment in animal research. Comparative medicine, 67(3), 203-214.

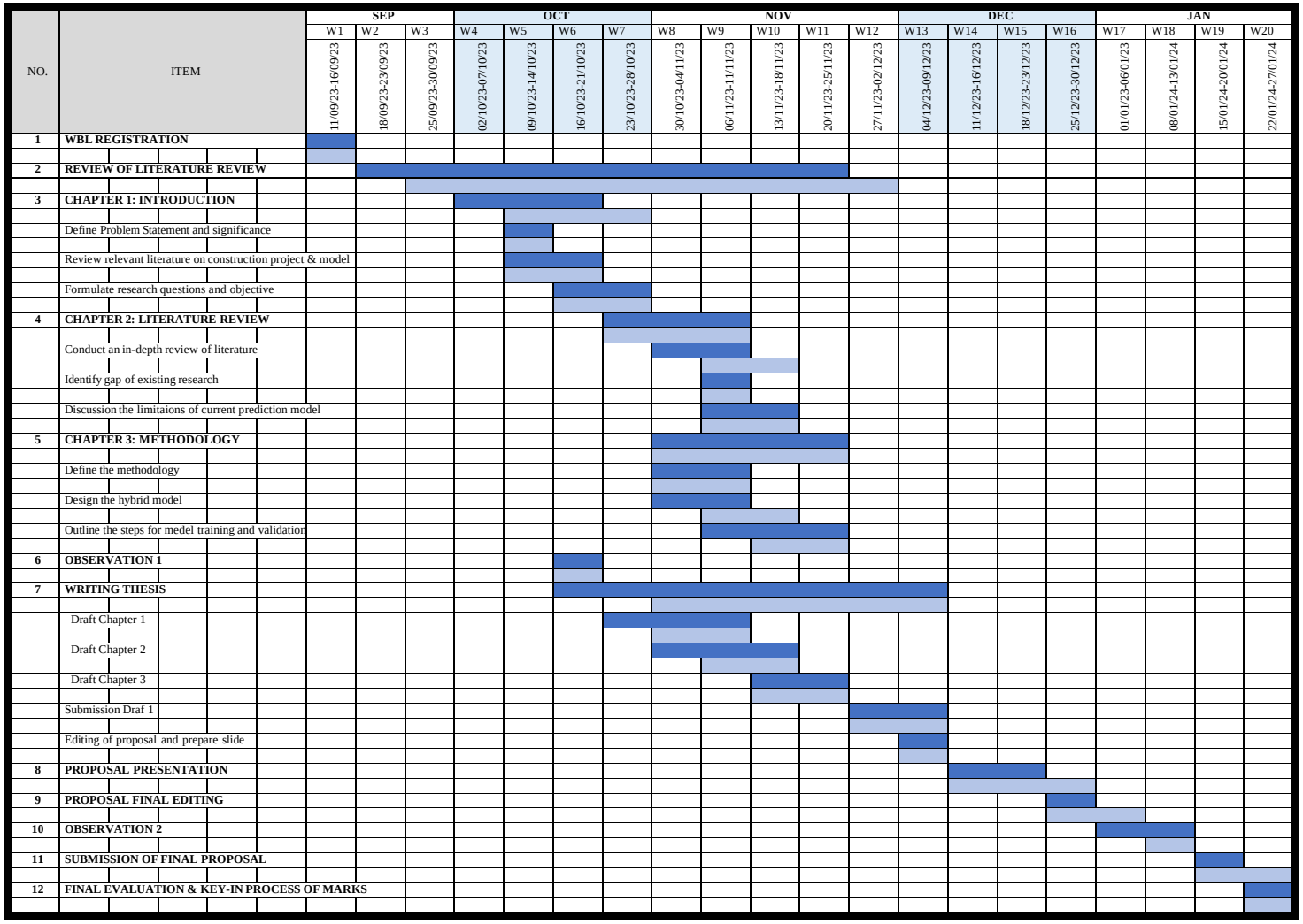
Wong, K. D., & Fan, Q. (2013). Building information modelling (BIM) for sustainable building design. Facilities, 31(3/4), 138-157.

Wong, T. K. M., Man, S. S., & Chan, A. H. S. (2021). Exploring the acceptance of PPE by construction workers: An extension of the technology acceptance model with safety management practices and safety consciousness. Safety science, 139, 105239.

Yap, J. B. H., & Lee, W. K. (2019). Analysing the underlying factors affecting safety performance in building construction.

Yu, Q. Z., Ding, L. Y., Zhou, C., & Luo, H. B. (2013). Analysis of factors influencing safety management for metro construction in China.

APPENDIX A – Semester 7's Gantt Chart



APPENDIX B – Semester 8's Gantt Chart

NO.	ITEM	FEB					MAC				APRIL				MEI					JUN	
		W21	W22	W23	W24	W25	W26	W27	W28	W29	W30	W31	W32	W33	W34	W35	W36	W37	W38	W39	W40
		29/01/24-03/02/24	05/02/24-10/02/24	12/02/24-17/02/24	19/01/24-24/02/24	26/02/24-02/03/24	04/03/24-09/03/24	11/03/24-16/03/24	18/03/24-23/03/24	25/03/24-30/03/24	01/04/24-06/04/24	08/04/24-13/04/24	15/04/24-20/04/24	22/04/24-27/04/24	29/04/24-04/05/24	06/05/24-11/05/24	13/05/24-18/05/24	20/05/24-25/05/24	27/05/24-01/06/24	03/06/24-08/06/24	10/06/24-15/06/24
13	**CHAPTER 4: RESULTS AND DISCUSSION**																				
	Questionnaire survey and collect data																				
	Analysis and validation data																				
	Elobrate the data finding																				
14	**OBSERVATION 3**																				
15	**CHAPTER 5: CONCLUSION AND RECOMMENDATION**																				
	Summarize all finding																				
	Future recommedation																				
16	**WRITING THESIS**																				
	Draf chapter 4																				
	Draf chapter 5																				
	Submission draf 2																				
17	**OBSERVATION 4**																				
18	**PREPARATION OF PRESENTATION FYP**																				
19	**FYP PRESENTATION**																				
20	**THESIS SUBMISSION**																				

FACTORS THAT CONTRIBUTE TOWARD ROLES OF INDUSTRIAL REVOLUTION TECHNOLOGIES IN CONSTRUCTION SAFETY

Greetings to All Respondents,

1. I'm Paulus Ernest Anak Simon, currently in my final year pursuing a Bachelor of Civil Engineering Technology with Honors at Ungku Omar Polytechnic. I'm conducting a survey for my final year project aimed at identifying the **FACTORS THAT CONTRIBUTE TOWARD ROLES OF INDUSTRIAL REVOLUTION TECHNOLOGIES IN CONSTRUCTION SAFETY**.

2. This survey is designed exclusively for my research objectives. I sincerely appreciate your time in responding to my questionnaire.

I express my gratitude for your valuable input.

Thank you

SECTION A

Demographic Information

1. Full Name

_____

2. Gender

Mark only one oval.

- ◯ Male
- ◯ Female

3. Role in Construction Industry

Mark only one oval.

- Management
- Project Manager
- Engineer
- Project
- Site Supervisor
- Safety Officer
- General Worker

SECTION B

Level of Adherence to Safety Regulations

4. Safety expectations and protocols are communicated at the beginning of construction projects with a certain frequency.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

5. Real-life workplace incidents are shared during team meetings to reinforce safety awareness on a regular basis.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

6. Comprehensive training programs are provided to equip workers with hazard recognition skills with a certain frequency.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

7. Safety manuals and resources are readily accessible to the workforce on construction sites with a degree of regularity.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

8. Challenges such as time constraints are considered in the implementation of safety measures on projects with a specific frequency.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

9. Safety protocols are adapted to align with project timelines and schedules periodically.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

10. Safety practices in Logistics Service Providers (LSPs) are considered in warehouse safety within construction projects at certain intervals.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

11. Insights from LSPs' safety practices are integrated into construction project safety protocols occasionally.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

SECTION C

Design And Layout of Construction Warehouses

12. Safety is integrated into site layout planning in your industrial development projects with a certain frequency.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

13. Challenges due to overlooked safety considerations in traditional site layout planning are occasionally encountered.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

14. Safety features are often emphasized in your approach to dynamic layout planning.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

15. Productivity is sometimes prioritized over safety in your site layout planning.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

16. Renewable energy sources and water conservation measures are frequently incorporated into your industrial site development.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

17. Safety measures are occasionally disregarded when optimizing for efficiencyin your industrial site planning.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

18. Environmental sustainability practices are routinely included in your operational strategies with a certain frequency.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

19. Worker well-being is routinely considered in the design and layout of your industrial development sites.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

SECTION D

Role of Industry 4.0 Technologies in Construction Safety

20. Industry 4.0 technologies are integrated into your construction safety practices with a certain frequency.

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

21. Training or adaptation programs related to Industry 4.0 technologies for construction safety are frequently engaged in.

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

22. The use of robots, artificial intelligence, or digital technology in constructionfor efficient building completion is frequently observed.

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neutral
- ◯ Agree
- ◯ Strongly Agree

23. Wearable robotics or exoskeletons are often utilized to address health and safety concerns in construction.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

24. Augmented reality (AR) is frequently used for safety training or to visualize construction impacts in your workplace.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

25. Virtual reality (VR) is routinely used for safety training or to communicate construction impacts.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

26. Building Information Modelling (BIM) is often engaged with for safety assessments or visual safety training at your construction sites.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree

27. Industry Revolution 4.0 technologies like CAD, RFID, or robotics are frequently employed to improve health and safety management in your workplace.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly Agree