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Evaluation of the Implementation of Occupational Health and Safety Management Systems in the Business World

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DECLARATION

I hereby declare that I am the sole author of this thesis. To the best of my knowledge, this thesis contains no material previously published or written by another person, except where due acknowledgment has been made in the text. The contents of this thesis are solely the result of the readings and research I have conducted. This work has not been submitted for any other degree or qualification at this or any other institution.

By Chung Tai Leung

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In recent years, I have assumed the overall responsibility for campus health and safety at Hong Kong Baptist University. This role has reinforced my commitment to introducing competent safety measures into campus management, ensuring the well-being of both students and employees. The challenges and experiences I have encountered have further enhanced my understanding of leadership dynamics and hierarchy design, particularly within the framework of safety and compliance.

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ABSTRACT

This thesis presents a comprehensive analysis of the evolution, current challenges, and future directions of occupational safety and health (OSH) in Hong Kong's construction industries, with a particular focus on the proactive management of near-miss incidents. Tracing the historical development from the hazardous conditions of the 1960s through successive legislative reforms, the study examines the impact of regulatory changes, advancements in training, and the adoption of safety management systems on reducing accident and fatality rates over recent decades. Despite marked improvements, the industry continues to face persistent obstacles—including complex subcontracting arrangements, fragmented accountability, economic pressures, and cultural inertia—especially within small-scale and traditional operations.

Through a mixed-methods approach incorporating accident statistics, court case analyses, and real-world incident investigations, the research identifies critical gaps in the implementation of safety measures across the 6M framework: Men (personnel), Machine (equipment), Material, Method, Milieu (environment), and Measurement. The findings reveal that while statutory regulations have become more stringent, their effectiveness is undermined by weak enforcement, procedural inefficiencies, and limited engagement at the grassroots level. Notably, near-miss incidents remain underreported and undervalued, representing missed opportunities for risk identification, learning, and system improvement.

The thesis advocates for the systematic integration of near-miss investigation into organizational safety culture as a cornerstone of proactive risk management. Key recommendations include: embedding safety education from early schooling through professional development; leveraging technology such as AI, wearables, and digital platforms for real-time monitoring and predictive analytics; strengthening material traceability and supply chain integrity; enforcing robust procedural compliance; and fostering open communication and non-punitive reporting environments. The study also proposes next-generation strategies—such as dynamic digital marketplaces for compliant materials, AI-driven emergency response systems, and continuous regulatory alignment—to further enhance workplace resilience and operational excellence.

In conclusion, the research underscores that a paradigm shifts from reactive to preventive safety management—anchored by thorough near-miss investigation and continuous improvement across the 6Ms—is essential for achieving sustained reductions in workplace incidents. By cultivating a culture of shared responsibility, leveraging technological innovation, and reinforcing leadership commitment, Hong Kong’s construction industry can move closer to the ideal of zero harm, setting a benchmark for safety excellence both locally and globally.

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CHAPTER ONE

INTRODUCTION AND AIM OF STUDY

1.1 Background of the Study

Occupational health and safety is a critical aspect of any industry, aiming to protect the well-being of personnel and minimize the risk of accidents. Despite stringent health and safety protocols and advanced technologies, high accident rates continue to be a pressing issue in many sectors. This study aims to investigate the underlying causes of these high accident and near-miss incident rates in Hong Kong, focusing on the interplay between failure management systems, personnel (men), equipment (machines), materials, methods, environment (milieu) and measurements. Enhanced statutory has been implemented, but the failure of effective control mechanisms still hampers the reduction of these incident rates.

1.2 Statement of the Problem

Before each accident, numerous signs such as near-miss incidents are often recorded. The breakthrough was caused by personnel's ignorance and lack of awareness regarding the proper handling of equipment and materials, adherence to methods and procedures, and the assessment of environmental hazards, which were hidden contributing factors. Frequent findings in the health and safety inspection report included inadequate training, improper equipment maintenance, insufficient procedural compliance, lack of proper material storage, and failure to identify and mitigate environmental risks. These kinds of problems are crucial to be eliminated even under an enhanced health and safety management system.

1.3 Research Objective

Implementing effective occupational health and safety measures require deep understanding of the organization's culture and the identification of any contradictions that may exist within it. Health and safety culture that genuinely prioritizes employee well-being essential for the successful adoption of effective protocols. To achieve this, it is crucial to conduct a thorough root cause analysis to uncover underlying issues that may hinder health and safety improvements. This research helps in identifying gaps between current practices and

desired health and safety standards. Addressing these gaps through targeted interventions and continuous monitoring ensures that health and safety measures are not only implemented but also sustained over time. By fostering a culture of health and safety and proactively addressing root causes of health and safety issues, organizations can significantly improve their overall health and safety performance and create healthier and safer working environment for all employees.

1.3.1 Specific Objectives

Health and Safety Management System

The research objective is to investigate the challenges associated with implementing Occupational Health and Safety (OH&S) Management System in accordance with ISO 45001, focusing primarily on the root cause of insufficient top management commitment and engagement. The study aims to identify and analyze the critical factors that influence top management's role in fostering health and safety culture, integrating health and safety into strategic objectives, and promoting health and safety practices throughout all organizational levels.

Men (Personnel)

This deficiency leads to a heightened risk of accidents and injuries due to insufficient oversight and enforcement of health and safety protocols, resulting in non-compliance with regulations and potential legal and financial repercussions. This research aims to identify the root causes that create this disconnect, with the goal of enhancing the alignment and engagement of health and safety management practices with the daily operations of front-line workers.

Machines (Equipment)

Regular equipment maintenance is essential to ensure optimal performance and employee health and safety. This involves conducting frequent inspections, adhering to a preventive maintenance schedule, and keeping detailed records of all activities. This research will investigate the competency of maintenance personnel who should be well-

trained, experienced, and engaged in continuous education to stay updated with the latest standards. It aims to identify and address deficiencies through corrective action plans and root cause analysis, thereby preventing accidents and ensuring a safe work environment.

Materials

Stringent quality control of materials is one of the health and safety measures that is costly, requiring investment in health and safety equipment, training, and thorough quality assurance processes. Additionally, managing stock expiration effectively to prevent waste and ensure timely usage adds another layer of complexity. This study will investigate possible ways to prioritize the quality of health and safety, ultimately leading to long-term savings by reducing accidents, liability, and waste, thereby enhancing overall efficiency and reliability in the supply chain.

Methods

Comprehensive health and safety procedures and conducting regular training sessions are essential to educate employees on health and safety protocols. It is a challenge to allocate sufficient time specifically for health and safety training, emphasizing the importance of adhering to health and safety measures to prevent accidents and injuries. This study will focus on discussing the continuous monitoring and updating of health and safety procedures, which are crucial to addressing new hazards and maintaining compliance with health and safety measures.

Milieu (Environment)

Cultivating a strong health and safety culture is essential, as it encourages employees to follow health and safety protocols diligently and report any hazards promptly. However, creating a health and safety working environment also involves considering local nature practices and the prevailing weather and climate conditions, which can significantly impact workplace morale and productivity. This study integrates these factors into health and safety and maintenance protocols, determining how organizations can better manage downtime and foster a more resilient and motivated workforce.

Measurements

Measurement in a health and safety management system involves inspection, evaluation, and other physical measures—whether conducted manually or automatically. It is crucial to remain vigilant about calibration errors and other measurement challenges, as these can lead to inconsistencies in safety data. Such inconsistencies may become a source of defects within the system, potentially contributing to incidents or near misses. Therefore, regular study of measurement effectiveness and its relationship to near miss incidents is essential for continuous improvement and risk reduction.

1.4 Research Questions

1. How effective are recent legislative amendments in Hong Kong, such as increased penalties under the Occupational Safety and Occupational Health Legislation (Miscellaneous Amendments) Bill 2022, in actually deterring workplace safety violations and holding employers accountable?
2. In Hong Kong's construction industry, how does the multilayered subcontracting practice impact the implementation and monitoring of workplace safety culture and protocols?
3. Why are near-miss incidents often underreported or overlooked, particularly among small-scale businesses and informal workgroups, and what statutory or practical interventions could improve the reporting and investigation of near misses?
4. Given the limitations of statutory regulation in reaching small companies and one-man operations, what role can active technical outreach, training, and support play in promoting safety compliance in these sectors, as opposed to a solely punitive approach?
5. How can the integration of advanced technologies—such as AI-enabled monitoring, wearables, digital reporting, and predictive analytics—transform the management and prevention of workplace accidents and near-miss events?
6. What were the key personnel, equipment, material, and procedural (6Ms) gaps identified in past major Hong Kong industrial incidents, and how could systematic application of the 6Ms framework in root cause analysis and continuous improvement reduce the recurrence of such events?

1.5 Significance of the Study

This study lies in its comprehensive exploration and critical evaluation of the development, challenges, and future directions of occupational safety and health (OSH) in Hong Kong within both global and local contexts. By examining the historical evolution of OSH systems in leading jurisdictions such as the United Kingdom, United States, and China, it draws important parallels and contrasts that help to benchmark Hong Kong's progress and identify effective practices. This study highlights how international principles, such as self-regulation and the employer's duty of care, have influenced Hong Kong's legislative framework, while also acknowledging the city's unique socioeconomic circumstances and the adaptive journey it has taken.

A key contribution of this study is its critical assessment of statutory regulation effectiveness. While legislative amendments in Hong Kong, such as increased penalties for OSH violations, demonstrate government commitment to safer workplaces, the research identifies significant limitations in enforcement, judicial proceedings, and real-world deterrence. This gap between legal intent and operational reality is compounded by economic pressures and traditional work practices, especially within small-scale businesses and subcontracting arrangements. The findings make clear that legislation alone cannot achieve meaningful change unless it is supported by robust systems of monitoring, technical outreach, and continuous improvement.

Moreover, this study illuminates persistent gaps in practical workplace safety—particularly among workers, equipment management, material sourcing, compliance with safe work methods, environmental conditions and measurements effectiveness. Through the structured application of root-cause methodologies like the 6Ms, alongside case studies of accidents and near misses, the research illustrates the multifaceted nature of safety failures and the need for holistic interventions. The analysis advocates for the development of a deep-rooted safety culture driven by leadership commitment, employee engagement, proactive reporting, and ongoing education, especially in sectors where safety culture is weakest. This cultural transformation is positioned as equally vital as regulatory compliance in reducing accidents and improving health outcomes.

Another significant aspect of this study is its focus on the role of near-miss incident management. By revealing how near-misses often go underreported and unaddressed, particularly in small or informal business settings, the research underscores an untapped

opportunity for accident prevention and continuous improvement. It advocates for statutory and practical interventions to promote near-miss reporting, learning, and investigation as core components of a resilient safety system.

Looking to the future, the study recognizes the transformative potential of advanced technologies—such as AI-driven monitoring, predictive analytics, wearables, and digital reporting platforms. These innovations promise to revolutionize how risks are detected, managed, and mitigated, making safety management more dynamic, data-driven, and inclusive. The proposed adoption of transparent, integrated digital platforms for material sourcing and compliance monitoring further illustrates the way forward for industry-wide risk reduction.

Ultimately, this study offers valuable guidance for policy-makers, industry leaders, educators, and practitioners by presenting a nuanced blueprint to strengthen workplace health and safety. It calls for an integrated approach—combining legislation, technical support, early education, proactive risk management, and collaborative platforms—to bridge existing gaps and build a culture where safety is prioritized, shared, and continuously improved. These studies’ significances therefore rest in their abilities to synthesize complex historical, legal, cultural, and technological dimensions into actionable insights for a safer, more resilient future for Hong Kong’s workforce and beyond.

1.6 Scope of the Study

The scope of this study encompasses an in-depth analysis of the existing occupational health and safety culture within the organization, with a focus on identifying and addressing any contradictions that may impede the effectiveness of health and safety measures. This involves conducting a comprehensive root cause analysis to uncover underlying issues and gaps between current health and safety practices and the desired standards. The study aims to develop targeted interventions to bridge these gaps and establish a continuous monitoring system to ensure the sustainability of health and safety improvements. Additionally, the research will explore strategies to foster a culture that genuinely prioritizes employee well-being, thereby enhancing the overall health and safety performance of the organization. The ultimate goal is to create a healthier and safer working environment for all employees through proactive and sustained health and safety practices.

1.7 Organization of the Study

1. To enhance local health and safety culture, this study starts by reviewing existing local health and safety legislation and comments from the Authorities to identify any contradictions or inconsistencies that may impact health and safety measures.
2. To prioritize employee well-being, studies focus on health and safety cultures genuinely which ensure leadership visibly supports and advocates for health and safety initiatives, and establish communication channels to regularly inform and involve employees in health and safety-related matters.
3. It conducts thorough root cause analyses using data-driven approaches to uncover gaps between current practices and desired health and safety standards, involving cross-functional teams for diverse perspectives.
4. It develops a protocol to address identified gaps in health and safety practices and implements targeted interventions to close these gaps, thereby improving overall health and safety.
5. It fosters a health and safety culture through ongoing training and development programs, recognizing and rewarding employees who contribute to maintaining a safe working environment, and encouraging open communication and reporting of health and safety concerns without fear of reprisal.
6. Finally, to sustain health and safety measures, this study integrates them into daily operations and long-term strategies, promote a proactive approach to address potential issues before they become significant problems, and maintain a commitment to continuous improvement and adaptability in health and safety practices.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of OSH development in Global

2.1.1 United Kingdom

The evolution of Occupational Safety and Health (OSH) practices and legislation in the United Kingdom reflects a significant transformation from the traditional master-servant relationship to the establishment of comprehensive employer duties under modern law. Historically, employers were not held liable for workplace accidents, as prevailing legal doctrines such as common employment and voluntary assumption of risk placed the burden on employees. However, a pivotal moment occurred with the 1938 *Wilsons & Clyde Coal Co. Ltd v English* case, which introduced the concept of employer liability as a non-delegable, personal duty of care. This case laid the foundation for the principle that employers must provide a safe workplace, competent staff, effective supervision, and suitable equipment, thereby setting the stage for the modern understanding of general duties in health and safety law. Despite these advancements, by the late 1960s, the UK's OSH legislative framework was recognized as fragmented, overly complex, and inadequately enforced, prompting a comprehensive review led by Lord Robens. The subsequent Robens Report of 1972 highlighted the inefficacy of prescriptive regulations and the prevalence of employer ignorance and worker apathy regarding safety responsibilities. It recommended a shift toward performance-based, self-regulatory legislation that would enshrine the employer's duty of care and promote proactive risk management. These recommendations culminated in the enactment of the Safety and health at Work Act (HASWA) in 1974, a landmark statute that not only redefined the legal obligations of employers but also influenced global standards in occupational health and safety management, including in jurisdictions such as Hong Kong. Thus, the development of OSH in the UK represents a paradigmatic shift from reactive, rule-based controls to a holistic, duty-oriented framework emphasizing prevention, accountability, and continuous improvement in workplace safety.

2.1.2 United States

The development of Occupational Safety and Health (OSH) regulation in the United States was fundamentally transformed with the enactment of the Occupational Safety and Health Act (OSHAct) of 1970, which established a comprehensive federal framework for the protection of workers' health and safety. As described by Levy and Wegman (1995), the creation of the Occupational Safety and Health Administration (OSHA) within the Department of Labor provided an enforcement arm responsible for workplace inspections and compliance with established standards, while the establishment of the National Institute for Occupational Safety and Health (NIOSH) under the Centers for Disease Control and Prevention (CDC) enabled focused research and health hazard evaluation. The Environmental Protection Agency (EPA) further complemented these efforts by administering the Toxic Substances Control Act (TSCA) and other regulations aimed at the control of hazardous substances. The OSHAct's broad coverage includes nearly all US workers, with notable exclusions of small enterprises (with ten or fewer employees, except in cases of reported violations) and federal agencies, which are mandated to maintain their own health and safety programs. One of OSHA's major initial undertakings was the adoption of permissible exposure limits (PELs) for hundreds of airborne contaminants, drawing from the threshold limit values (TLVs) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). While TLVs are regularly reviewed and updated, PELs are enshrined in regulation, making their amendment a complex and contentious process requiring substantial evidence of health impairment, particularly for substances with long latency periods or reproductive effects. A defining feature of the US approach is the "right to know" principle, which mandates transparency and the dissemination of information about toxic substances to workers, unions, and government agencies. This is operationalized through labelling, the provision of material safety data sheets (MSDSs), and other communication mechanisms, thereby empowering workers to understand and manage occupational risks. Collectively, these developments represent a shift towards a more systematic, evidence-based, and participatory model of occupational health and safety regulation in the United States.

2.1.3 China

The development of Occupational Safety and Health (OSH) in China has been profoundly shaped by the country's rapid economic transformation since its opening-up policies began in 1978. As China evolved into the "world's factory," unprecedented industrial expansion, especially within the special economic zones (SEZs) and major manufacturing hubs like the Pearl and Yangtze River Deltas, brought with it significant OSH challenges. The breakneck pace of industrialization exposed grave deficiencies in workplace safety, with frequent reports of accidents in mining and manufacturing sectors drawing international concern and cementing an image of China as lacking industrial safeguards. In response, the Chinese government established a comprehensive legal and regulatory framework to address these issues, spearheaded by the State Administration of Work Safety (SAWS) under the State Council. In 2001 and 2002, China's legislature, the National People's Congress approved the Occupational Disease Prevention Law and the Safe Production Law, the laws both went into effect in 2002. these two important laws respectively authorize the health administrative department and work safety administrative department to assume their duties and responsibilities and extend OSH obligations to all economic entities operating in China and codifying the responsibilities of government, management, and workers. Central to this framework is the principle of "safety production first," which mandates proactive prevention policies and places ultimate responsibility for safety on organizational leadership. The government also promotes safety knowledge and the adoption of advanced technological measures, supported by technical service centers. Supplementary regulations target specific hazards, such as the safe management of dangerous chemicals, labor protection against toxic substances, and radiation safety, reflecting an increasingly sophisticated and sector-specific approach to risk management. The regulatory regime is enforced through a hierarchical administrative structure, with SAWS and the State Administration of Coal Mine Safety overseeing compliance at both national and local levels. Overall, China's OSH development represents a transition from minimal oversight to a more structured, legally grounded system, though the effective implementation and enforcement of these standards remain ongoing challenges amid continued economic growth and industrial complexity.

2.2 Evaluation road of safety management system in Hong Kong

After World War II, Hong Kong entered a formative period for its manufacturing industry in the 1950s, experiencing a significant rise in the number of factories and workers. This transformation shifted Hong Kong from a transit port to a light industrial city, prompting the need for corresponding government policies. However, challenges such as an understaffed Factory Inspectorate and widespread corruption hindered effective law enforcement during this time.

In 1955, the Hong Kong Government took a significant step by introducing the Factories and Industrial Undertakings Ordinance (Cap. 59), which laid the most important foundation for industrial safety legislation in Hong Kong. This ordinance marked a critical milestone in regulating factory operations and ensuring worker safety, setting the stage for the development of modern industrial safety standards in the region.

The 1960s and 1970s were the golden decades of Hong Kong's manufacturing industry, with factories spread across various districts, transitioning from manual labor to mechanized production. The Hong Kong government enacted over a dozen regulations for high risk machinery, processes, and industries, such as the "Factories and Industrial Undertakings (Woodworking Machinery) Regulations" (1971), the "Factories and Industrial Undertakings (Electrolytic Chromium Process) Regulations" (1972), and the "Construction Sites (Safety) Regulations" (1978). These regulations required workplace owners to take appropriate measures to achieve recognized health and safety standards.

In the late 1970s, Hong Kong's economic structure gradually shifted from manufacturing to services. However, industrial accidents did not decrease as a result. Industries such as construction, textiles, plastics, shipbuilding and repair, metal products, and electronics were among those with higher rates of industrial accidents at the time. To address this issue, Hong Kong implemented a series of measures in occupational health and safety, achieving significant progress.

After a comprehensive process involving extensive planning, stakeholder engagement, and legal review over a decade. The progress in enhancing occupational health and safety in Hong Kong has been marked by significant milestones and legislative advancements with the establishment of the Occupational Safety and Health Council (OSHC) in 1988 which was established under the Occupational Safety and Health Council Ordinance (Cap.398). OSHC

aimed to promote safer working environments through education, training, and awareness campaigns. The council plays a leading role in promoting health and safety at work and sustaining the valuable workforce of Hong Kong until now.

The construction of the new Hong Kong airport at Chek Lap Kok officially commenced in 1992. This infrastructure project was of an unprecedented scale, and the associated safety issues drew significant attention from the authorities. To facilitate the development of the Tsing Ma Bridge, the Kap Shui Mun Bridge, and other key components collectively known as the Ten Core Projects for the new airport, the government acknowledged the necessity of implementing a more comprehensive safety management system for the construction works. The Airport Core Programme (ACP) from 1991 to 1996 underscored the importance of improved safety measures in these large-scale construction projects, leading to the creation of the ACP Construction Safety Manual in 1992 and the introduction of Safety Management Systems (SMS) in public works contracts in 1993. These initiatives were further boosted by the Pay for Safety Scheme (PFSS) and the Independent Safety Audit Scheme (ISAS) in 1996, incentivizing contractors to enhance safety performance.

In 1996, Construction Industry Training Authority (CITA) (currently Construction Industry Council (CIC)), launched a one-day "Construction Workers Safety Training Course" (commonly known as the Construction Industry Safety Card Course). Once employees participated in this course and passed the relevant examination, the Labour Department would consider that the employer had fulfilled their general responsibility for providing basic safety training to their employees. At the same time, this ensures competent basic health and safety training provided to every workers of Construction Industry, all defined as factorial undertaking works (refer to Cap.59).

The Occupational Safety and Health Ordinance (OSHO) (Cap.509) established a comprehensive legal framework for ensuring employee health and safety across industries in 1997. Safety management system comprising 14 elements, which was incorporated into the Factories and Industrial Undertakings (Safety Management) Regulation (Cap.59AF) was introduced by the Authority and passed in November 1999, known as the "Safety Management Regulation". Under the "Safety Management Regulation", classified industrial undertaking owners or contractors are required to develop, implement, and maintain a management system that includes various safety elements, and to regularly audit or review the system. The safety

management elements are closely linked to the safety work system, providing clear guidance for enterprises to practice safety management.

The year of 2003 was a deeply memorable year for Hong Kong people, as they will never forget the lessons and pain brought by the Severe Acute Respiratory Syndrome (SARS) outbreak. The SARS crisis resulted in significant loss of life and economic damage, but it also heightened awareness of health and safety, particularly in raising standards for personal and environmental hygiene. Starting from 2004, research was conducted to explore safety behavior patterns, examining the basic attitudes of workers across various industries and their awareness and understanding of health and safety. Importantly, the concept of a Safety Culture was introduced, aligning with advanced global systems and promoting ideas such as occupational rehabilitation and corporate responsibility, driving occupational health and safety development to a higher level. Aligning with international standards such as ISO 45001 helped improve safety performance and facilitate international cooperation. Technological integration, including the use of Building Information Modeling (BIM), assisted in identifying and mitigating risks during the design phase of construction projects.

The 2020s brought new challenges, including the COVID-19 pandemic, which necessitated new safety measures such as social distancing, remote work arrangements, and enhanced hygiene protocols, highlighting the need for flexibility and adaptability in safety management systems. There was also a growing focus on mental health, with organizations integrating psychological safety into their safety management systems to address workplace stress and promote work-life balance. Sophisticated emergency response planning, including regular drills and simulations, along with improved collaboration between government, emergency services, and the private sector, further enhanced overall preparedness.

Occupational Safety and Occupational Health Legislation (Miscellaneous Amendments) Bill 2022 marks a critical legislative effort to address the persistent issue of industrial accidents in Hong Kong. Despite years of reviews and the implementation of various safety measures, tragic workplace incidents continue to occur, highlighting the need for stronger deterrents and accountability. The bill, passed in 2023, amends the Factories and Industrial Undertakings Ordinance (Cap.59) and the Occupational Safety and Health Ordinance (Cap.509), significantly increasing the maximum penalties for occupational safety and health (OSH) offences. Key amendments include treating extremely serious OSH violations as indictable offences, with

maximum fines of HKD \$10 million and imprisonment terms of up to two years. Additionally, the bill introduces a tiered penalty system for offences prosecuted summarily, with fines adjusted according to the severity of employer-related and employee-related violations. While these changes represent a substantial step forward in enhancing deterrence, their effectiveness will depend on robust enforcement, increased awareness, and a sustained commitment to a Safety Culture across industries. The amendments underscore the urgency of reducing workplace accidents and protecting workers' health and safety, but achieving meaningful progress will still require a comprehensive approach that combines legislative measures with practical on-the-ground improvements.

2.3 Safety culture in working environment

The introduction of a health and safety culture within an organization is an essential step towards fostering an environment where the well-being of employees is prioritized and integrated into a safety system of work. This culture is built on the foundation of several key principles that collectively ensure a comprehensive approach to health and safety.

Leadership commitment is the first and most important consideration, as it sets the tone for the entire organization, with leaders visibly prioritizing health and safety through their actions and strategic decisions. This commitment must permeate all levels, encouraging a sense of shared responsibility among employees. Engaging employees in safety initiatives is crucial for cultivating a sense of ownership and active participation. This can be achieved by involving them in safety committees and decision-making processes, thus ensuring their insights and experiences contribute to the development of effective safety practices.

Open and direct communication is necessary to ensure that health and safety policies, procedures, and expectations are consistently conveyed and understood throughout the organization, utilizing varied channels to reach every employee effectively. Training and education form the backbone of a health and safety culture, providing employees with the competent knowledge and skills to identify risks and implement safety measures. Regular training sessions, alongside onboarding programs for new staff and refresher courses for existing employees, are essential for maintaining high health and safety standards. Promoting risk awareness and proactive management encourages employees to identify and report hazards without hesitation, enabling effective risk assessment and mitigation. Accountability and

responsibility must be clearly defined, with individuals held accountable for adherence to safety protocols. Continuous improvement, driven by regular reviews and enhancements based on data from incidents and employee feedback, ensures that health and safety practices remain relevant and effective. Recognition and reward systems further reinforce positive behaviors and contributions to the safety culture. Ultimately, fostering a supportive environment where employees feel comfortable discussing health and safety concerns is crucial. By implementing these principles into the organizational fabric, a robust health and safety culture can be developed, leading to a safer, more engaged, and productive workforce.

Improving safety culture in an organization involves a comprehensive approach that touches on various aspects of leadership, strategy, communication, and accountability. Here's a summary of the key features essential to fostering a sound safety culture:

1. **Leadership and Commitment:** Granted with visible leadership from the top management which is the most crucial element. Leaders must demonstrate a commitment to safety that is clear and consistent.
2. **Long-Term Strategy:** Recognize that building a strong safety culture is a long-term ambition requiring ongoing effort and dedication.
3. **Policy and Standards:** Develop a policy statement that sets high expectations and conveys optimism about safety achievements. This should be supported by guidance, codes of practice and safety standards.
4. **Resource Allocation:** Treat health and safety with the same importance as other organization goals and ensure they are properly resourced.
5. **Line Management Responsibility:** Make health and safety a core responsibility of line management to ensure accountability.
6. **Workforce Involvement:** Encourage 'ownership' of health and safety at all levels. This involves engaging employees through involvement, training, and effective communication.
7. **Target Setting and Measurement:** Set realistic and achievable safety targets and consistently measure performance against them.
8. **Incident Investigation:** Thoroughly investigate all incidents to understand root causes and prevent recurrence.

9. Consistency and Auditing: Ensure consistent behavior aligned with agreed standards through regular audits. Make good safety behavior a condition of employment.
10. Prompt Remediation: Quickly address any deficiencies found during investigations or audits to prevent future issues.
11. Information and Assessment: Provide management with timely and accurate information to assess performance and make informed decisions.

Implementing these features requires a holistic approach, where each element supports and enhances the others, creating a robust safety culture that can significantly improve performance and reduce risks.

2.4 Awareness to near-miss investigation

The concept of near miss incidents has garnered significant attention in safety management literature due to their crucial role in accident prevention. A near miss is generally defined as an event that could have resulted in injury, damage, or business interruption but did not, highlighting potential hazards that need addressing. However, the literature reveals considerable debate over the definitions and scope of near miss incidents, contributing to confusion among safety professionals. For instance, standards such as ANSI/AIHA Z10-2005 offer a broad definition, encompassing any event where an injury or fatality could have occurred, which can lead to ambiguity and misclassification of incidents.

Numerous studies underscore the importance of near miss reporting as a proactive measure in enhancing workplace safety. By systematically analyzing these events, organizations can identify weaknesses in their safety protocols and implement changes to prevent future accidents. Theoretical frameworks like the Swiss Cheese Model, Heinrich's Law, and the Safety Pyramid provide valuable insights into the significance of near misses.

The Swiss Cheese Model, for example, illustrates how multiple layers of defence can prevent accidents, while Heinrich's Law suggests that addressing near misses can significantly reduce the occurrence of serious accidents. The Safety Pyramid further emphasizes the importance of learning from less severe incidents to avert major ones. Empirical research across various industries, such as healthcare, construction, manufacturing, and aviation, demonstrates the practical impact of near miss reporting on improving safety practices.

In healthcare, near miss reporting has been shown to prevent medical errors and enhance patient safety. In the construction industry, it aids in managing risks associated with hazardous work environments. Similarly, manufacturing and aviation sectors have long recognized the value of near miss reporting in upholding high safety standards. Over time, the evolution of near miss reporting has been shaped by key studies and historical events, emphasizing its pivotal role in comprehensive safety management systems. Regulatory developments and standards, such as those instituted by the American National Standards Institute, have formalized the process, highlighting its importance in proactive safety measures. This body of literature collectively underscores the necessity of near miss reporting as an integral component of effective accident prevention strategies, advocating for its widespread implementation across industries to foster safer work environments.

Despite their importance, near miss incidents are often underreported due to factors such as responsibilities concern, lack of awareness, and inadequate reporting systems. Challenges in data collection and analysis, including methodological issues and the reliability of self-reported data, further complicate the process. However, the benefits of near miss reporting are significant. Organizations that effectively utilize near miss data can enhance accident prevention and risk mitigation efforts. Moreover, fostering a culture that encourages near miss reporting can lead to broader organizational improvements in safety culture and employee engagement.

This research identifies several gaps in existing research, such as the need for sector-specific studies, methodological advancements, and exploration of emerging trends. Future research directions may include the use of technology in near miss reporting, cross-industry comparisons, and the long-term impact of interventions based on near miss data. It underscores the critical role of near miss incidents in safety management and accident prevention. By addressing identified gaps, near-miss investigation further enhances the understanding of near misses and contribute to the development of more effective safety strategies, which aims to build on existing knowledge and explore new avenues for improving safety outcomes through near miss reporting.

2.5 6Ms cause and effect consideration

Reviewing the effectiveness of a Safety Management System (SMS) within the framework of a Quality Management System (QMS) like ISO 9001 is valuable because both systems share core principles of process orientation, risk management, and continual improvement. By systematically evaluating the SMS through the lens of the 6Ms—Man, Machine, Materials, Method, Milieu, and Measurement—organizations can ensure comprehensive coverage of all factors impacting safety performance. This involves assessing the competence and awareness of people (Man), as well as the management of facilities, systems, tools, and equipment (Machine), which are often mismanaged or technically misaligned and thus may not deliver intended results. It includes scrutinizing raw materials, components, and consumables (Materials), recognizing issues such as incorrect specification, mislabeling, improper storage, or poor organization that can compromise safety. The review also encompasses work processes and procedures (Method), identifying unnecessary complexity or non-value-adding steps that could introduce risk. Environmental factors (Milieu), such as weather or natural disasters, are considered in terms of what can be managed and what remains beyond control. Finally, the reliability of inspections and physical measurements (Measurement) is evaluated, since inconsistent or incapable measurement systems undermine the ability to make informed, repeatable decisions. Integrating these aspects within the QMS structure not only promotes a holistic and consistent approach to safety but also drives efficiency, risk reduction, and continual improvement across the organization.

Investigating near miss incidents using the 6Ms framework—Man, Machine, Materials, Method, Milieu, and Measurement—ensures a thorough and systematic exploration of all possible contributing factors. By applying this structured approach, organizations can move beyond surface-level causes and gain a deeper understanding of the underlying issues that may lead to incidents. This comprehensive analysis not only improves the accuracy of root cause identification but also supports the development of more effective corrective and preventive actions. The following sections provide a detailed interpretation of how each element of the 6Ms can be utilized in near miss investigations to enhance safety management and reduce the likelihood of future occurrences.

CHAPTER THREE

DATA AND METHODOLOGY

3.1 Interpretation of Health and Safety Culture Development in the past decades



Figure 1. The accident rates given in term of number of accidents per 1,000 workers per year is based on the statistics of the Labour Department.

Before the starting of above data collection, in the 1960s, construction works in Hong Kong were fraught with danger, with frequent accidents and even fatalities resulting from machinery malfunctions and insufficient safety awareness among workers. Although reports of construction worker accidents appeared frequently in newspapers, they only represented the tip of the iceberg.

In response, the government made several legal amendments in the 1970s to enhance safety standards and regulations on construction sites. In 1973, the government passed the Factories and Industrial Undertakings (Amendment) Ordinance 1973, which provided clear regulations on accident prevention and rescue measures, inspection of machinery and tools,

issuance of relevant certificates, and safety standards for confined spaces, all aimed at ensuring site safety.

Before 1980s, safety training in Hong Kong's construction industry was primarily handled by the Labour Department. After three years of training, factory inspectors were equipped to enforce laws related to factory and site safety and knew how to investigate accident occurrences to review and prevent future incidents. At the time, there was a shortage of safety supervision personnel, and many factory inspectors would switch to private companies after completing their training. Unlike their roles in the Labour Department, safety officers in private companies were mainly responsible for raising employees' safety awareness and inspecting potential safety hazards to prevent accidents before they occurred.

The period from 1988 to 1995 was called Technical Improvement Stage. Due to the insufficient safety awareness among workers and the increasing emphasis on construction site safety, the 1988 implementation of the "Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations" was launched.

In the 1990s, the Hong Kong construction industry made efforts to reduce industrial accidents, leading to a significant increase in demand for site safety personnel. In response, the Construction Industry Training Authority increased the number of safety officer training course slots significantly in 1990 and introduced courses related to construction safety and ISO9000 quality assurance systems in 1992 to meet the industry's safety and quality assurance requirements. In 1993, the Authority continued to offer courses on ISO9000 quality systems in the construction industry and safety officer training.

In 1994, it launched short-term advanced courses for in-service construction safety officers to enhance their safety knowledge, and also introduced the "Refresher Course for Construction Safety Officers" for those who have already become safety officers but wish to refresh their knowledge and acquire new information. Additionally, an "Industrial First Aid Certificate Course" was offered to train more current construction industry personnel to become qualified first aiders.

In 1995, the government released the Consultation Paper on the Review of the Industrial Safety in Hong Kong which recommended the implementation of safety management systems in the construction industry, and increased the demand for formally trained safety personnel. In

response, the Authority increased the number of slots for the construction industry safety officer course and the assistant safety officer course respectively.

In 1996, the Authority organized the "Contractor Project Manager Safety Management Course" to impart safety management knowledge to senior site management personnel in construction companies. In 1998, to comply with the government's promulgated Supervision Plan, which required sites to have technical personnel from various levels to carry out site safety supervision tasks, the Authority launched a Temporary Certificate Course for Training Site Supervisors for Competent Technical Personnel. This course aimed to temporarily qualify in-service site supervisors who did not meet the academic requirements during the first phase of the implementation of the Supervision Plan, addressing the practical situation at the time.

The period from 1996 to 2002, referred to as the System Improvement Stage, was marked by significant advancements in the development of safety systems in compliance with the Occupational Safety and Health Ordinance, Cap. 509. This stage focused on enhancing safety standards and practices in the workplace, ensuring that systems were in place to protect workers' health and safety. Key milestones during this period likely included the implementation of comprehensive safety management systems, increased regulatory oversight, and the introduction of new safety protocols and training programs to ensure compliance with the ordinance.

Over the past two decades recently, the development of safety systems in compliance with the Occupational Safety and Health Ordinance, Cap. 509, has seen significant advancements. Technological progress has played a critical role, with the integration of automation, artificial intelligence, and data analytics enhancing safety monitoring and risk assessment capabilities, allowing organizations to adopt a more proactive approach to safety management. Regulatory updates have been made to address emerging risks and industries, ensuring that safety standards remain relevant and effective in protecting workers.

Additionally, there has been a growing focus on mental health and well-being in the workplace, with initiatives aimed at reducing stress, improving work-life balance, and supporting employee mental health. Cultivating a strong safety culture within organizations has become increasingly important, encouraging employee involvement and leadership commitment to safety. Continuous improvement in training and education programs ensures employees are well-equipped to handle new safety challenges and technologies. The adoption

of international safety standards, such as ISO 45001, has provided a framework for occupational health and safety management systems, promoting a global approach to workplace safety.

Furthermore, the integration of sustainability practices with safety measures highlights the interconnectedness of environmental and occupational health and safety. These developments reflect a comprehensive approach to workplace safety, aimed at reducing accidents and improving overall employee health and safety.

3.2 Accident Rate and Fatality Rate in recent decade

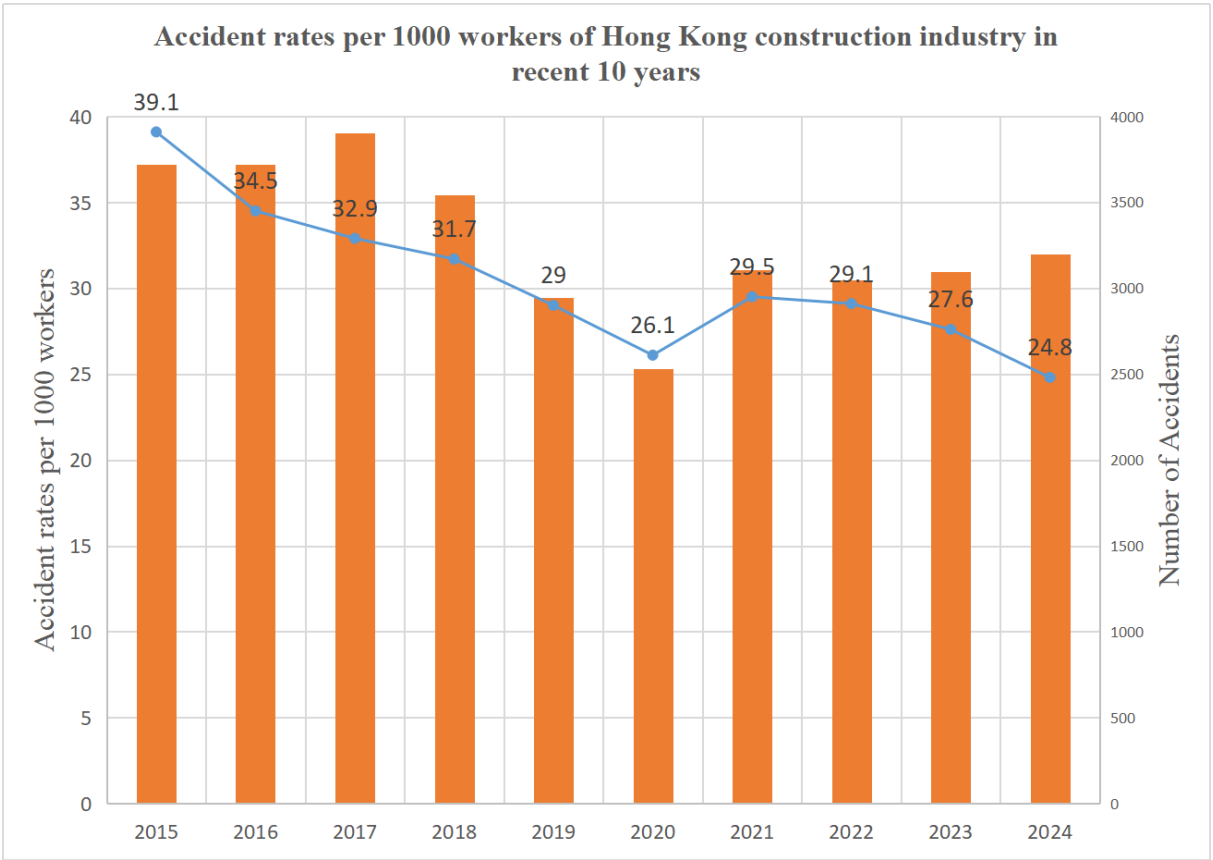


Figure 2. The accident rates given in term of number of accidents per 1,000 workers per year is based on the statistics of the Labour Department.

The data reflecting accident rates and numbers from 2015 to 2024 can be interpreted within the context of the construction industry, where safety is a critical concern. Over this period, both the accident rate and the number of accidents have shown a general decline, suggesting improvements in safety measures within the industry. The accident rate decreased from 39.1% in 2014 to 24.8% in 2024 (in Figure 2), while the number of accidents fluctuated but ultimately

decreased from 3723 to 3199. This correlation indicates that safety initiatives are likely effective.

In the construction industry, several factors could contribute to these positive trends. The implementation of advanced safety technologies, such as wearable sensors and automated equipment, might have helped reduce incidents by providing real-time monitoring and alerts. Enhanced regulatory standards and stricter enforcement of safety protocols could have led to safer work environments and practices. Furthermore, increased emphasis on safety training and awareness campaigns might have educated workers on the importance of adhering to safety guidelines, fostering a culture of safety.

Investment in better infrastructure, such as improved scaffolding and fall protection systems, may have also contributed to the reduction in accidents. Examining the data from the last five years (2020 to 2024) reveals some contradictory trends between the accident rate and the number of accidents within the construction industry. Despite fluctuations, there is a slight decrease in the accident rate from 26.1 in 2020 to 24.8 in 2024. However, the number of accidents shows a more complex pattern, initially decreasing from 2532 in 2020 to 3109 in 2021, then slightly fluctuating through to 3199 in 2024.

This contradiction suggests several possible interpretations. First, while safety measures may have effectively reduced the relative rate of accidents, factors such as increased construction activity or workforce expansion could have led to an overall rise in the number of incidents. As the industry recovered and ramped up operations post-COVID-19, the increased volume of projects and workers might have contributed to more accidents, even if the rate per unit of activity decreased.

Secondly, the implementation of new safety technologies and protocols might have initially improved safety conditions but required time for full integration and effectiveness, leading to temporary fluctuations in accident numbers. Alternatively, the data might reflect improvements in reporting and tracking accidents, leading to more accurate records of incidents but not necessarily an increase in actual safety breaches.

Ultimately, these contradictions highlight the complex interplay between industry dynamics and safety measures. Continued focus on integrating safety technologies, enhancing training, and maintaining rigorous oversight will be crucial in aligning both metrics towards consistent improvement. Further analysis could focus on specific factors influencing these

trends, such as changes in workforce size, project complexity, or regulatory adjustments, to better understand and address the underlying causes.

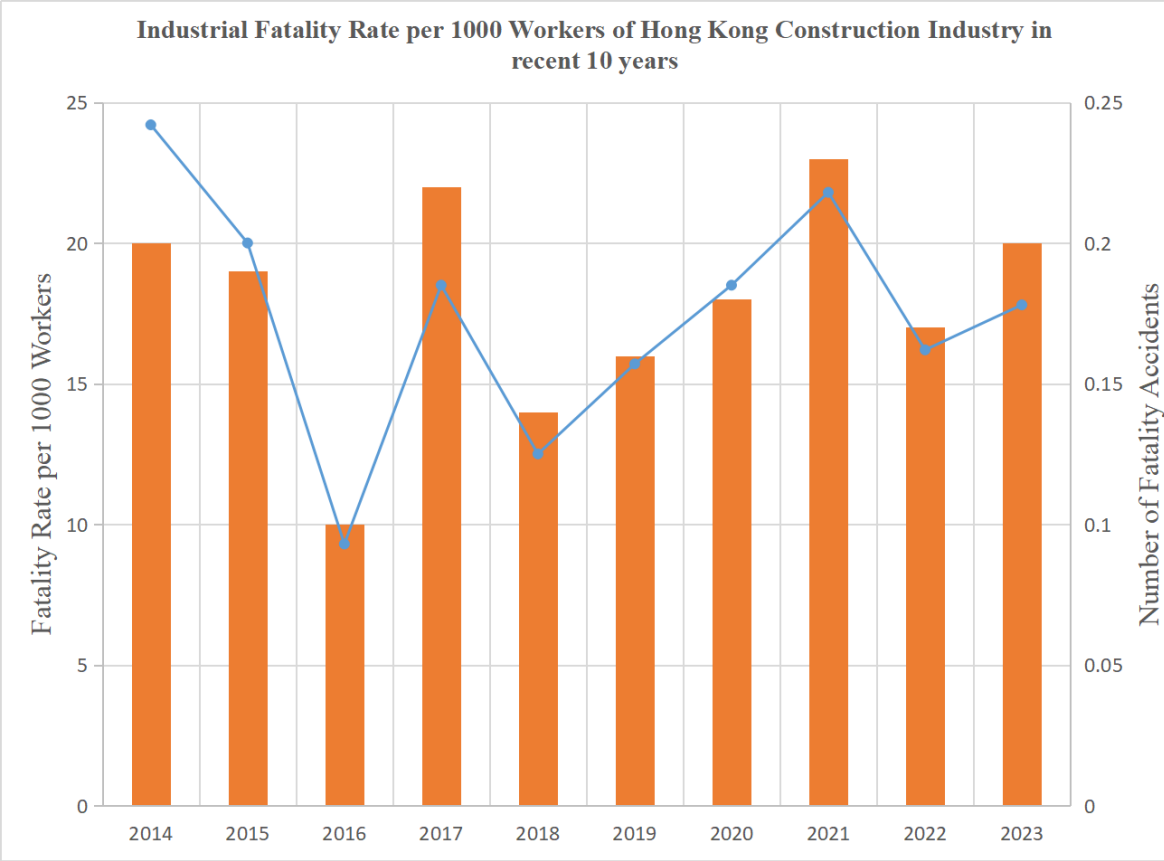


Figure 3. The fatality rates given in term of number of fatal accidents per 1,000 workers per year is based on the statistics of the Labour Department.

When cross-referencing the industrial fatality rate data with the accident rate data from 2014 to 2023 (in Figure 3), several significant observations emerge. Initially, from 2014 to 2016, there is a noticeable decline in both fatality and accident rates, suggesting an overall improvement in workplace safety measures and compliance. However, from 2017 onwards, the patterns between the two datasets start to diverge.

In 2017, while the accident rate continued to decrease, the fatality rate spiked, indicating that although fewer accidents occurred, they were more severe or not adequately mitigated, resulting in more fatalities. This trend suggests potential gaps in safety measures that specifically address the severity of incidents rather than just the frequency.

From 2018 to 2020, both rates climbed up, reflecting a period where improvements in safety protocols might have been overlooked, addressing both the frequency and severity of industrial incidents. In 2021, there is a noticeable increase in both accident and fatality rates, which could imply a temporary lapse in safety compliance or external factors affecting workplace safety.

The years 2022 and 2023 show a stabilization in the accident rate and a slight decrease in the fatality rate, indicating some recovery in safety measure effectiveness. Looking forward to the following 2 years until now, the data suggests a continued decrease in both rates, reflecting potential improvements or adaptations in safety strategies that are beginning to show positive outcomes.

Overall, the divergence and convergence patterns between fatality and accident rates highlight the complexity of industrial safety. It emphasizes the need for targeted safety measures that not only reduce the occurrence of accidents but also mitigate their severity to prevent fatalities.

CHAPTER FOUR

CONTENTS AND RESULTS

4.1 Interpretation of recent Safety Environment in Hong Kong

Over the past 20 years, the construction industry's safety performance in Hong Kong has shown improvements but has reached a plateau, largely due to challenges in effectively implementing safety measures across multiple subcontracting levels. The prevalent practice of tendering out construction projects and delegating work to various subcontractors creates a complex network of responsibilities. This complexity often results in diluted accountability for safety, as each subcontractor might prioritize cost-saving over comprehensive safety practices.

Subcontractors operating on tight budgets may struggle to invest in robust safety systems, training, and technology. As a result, safety measures may be inadequately implemented or inconsistently enforced, particularly at lower subcontracting tiers where profit margins are slimmer. This fragmented approach can lead to gaps in safety protocols and oversight, increasing the risk of accidents and near misses.

To address these challenges and improve safety performance, it is important to establish clearer accountability and responsibility across all levels of subcontracting. This could involve mandating comprehensive safety standards that apply to all contractors and subcontractors, ensuring that safety is not compromised at any stage of the project. Additionally, implementing a unified safety management system that includes regular audits and inspections can help maintain consistent safety practices across the board.

Encouraging collaboration between main contractors and subcontractors to share safety resources and knowledge can also foster a more integrated approach to safety. Providing incentives for subcontractors to prioritize safety, such as bonuses for maintaining accident-free records, could motivate them to invest more in safety measures.

4.2 Short circuit in the implementation of safety measures

In Hong Kong's construction industry, the tendency to overlook minor incidents and near misses poses a significant challenge to safety. These occurrences, though seemingly insignificant, can foreshadow more serious accidents. Traditional attitudes often dismiss these

warnings, treating them as unavoidable rather than opportunities for prevention. This mindset is especially prevalent in smaller-scale operations, such as one-man businesses, family-run projects, or informal work groups, where resources and capacity to implement comprehensive safety measures are limited. To address these challenges, several strategies can be employed to promote a culture of safety across all levels, including smaller operations.

Education and awareness should be prioritized through targeted safety training programs that emphasize the importance of recognizing and addressing near misses. These programs need to be accessible and tailored to the unique needs of small-scale operations, helping workers understand the potential consequences of ignored warnings.

Community-led initiatives can encourage collaboration among smaller contractors and workers to form safety networks, facilitating the sharing of resources, knowledge, and best practices without incurring significant costs. Simplifying safety protocols can also make it more feasible for these groups to integrate safety practices into their daily routines.

Additionally, introducing incentives for small contractors and workers who consistently follow safety protocols and demonstrate improvements in safety performance can motivate adherence to safety standards. Support from government and industry bodies, in the form of subsidies, grants, or low-cost access to safety training and equipment, can alleviate the financial burden of implementing safety measures.

Finally, promoting a cultural shift towards valuing safety as a priority, regardless of the size of the project, can help embed safety practices into the fabric of all construction activities. By implementing these strategies, Hong Kong's construction industry can create a more inclusive and comprehensive approach to safety, ensuring that all workers, regardless of the scale of their operations, have the necessary tools and support to maintain a safe working environment.

4.3 Road to eliminate the Gap-Distance

In conducting a gap analysis within Hong Kong's construction industry, the objective is to identify and bridge the gaps necessary for cultivating a robust safety culture. This analysis focuses on key areas such as personnel, equipment, materials, methods, environment, measurements, and the overall safety management system. An essential aspect of this research

is enhancing awareness of near miss incidents, recognizing them as early indicators of potential serious accidents.

By evaluating personnel practices, we can identify training deficiencies that may prevent workers from recognizing and responding to near misses effectively. Improving education and training programs can empower workers to take proactive measures, transforming near misses into learning opportunities that prevent future incidents.

Assessing equipment and material usage can highlight inadequacies in maintenance or suitability, ensuring that all tools and materials meet safety standards and are used correctly to minimize risks.

Methodological analysis involves examining work processes to identify unsafe practices and streamline procedures to enhance safety. Environmental evaluations focus on identifying hazards in the work setting, such as poor lighting or inadequate signage, that may contribute to accidents.

By addressing these environmental factors, we can create safer workspaces that reduce the likelihood of incidents. Finally, reviewing the safety management system as a whole allows us to pinpoint systemic weaknesses, such as lapses in communication or oversight, that hinder effective safety implementation.

Measurement analysis is crucial for understanding not only what incidents occur, but also how safety performance is tracked and improved over time. By evaluating the effectiveness of safety metrics, incident reporting systems, and key performance indicators, we can identify gaps in how near misses and accidents are recorded, analyzed, and acted upon. Accurate and consistent measurement ensures that safety initiatives are data-driven, enabling targeted interventions and continuous improvement.

By strengthening these systems, we can ensure that safety protocols are consistently followed and that near misses are reported and analyzed. Ultimately, this gap analysis underscores the importance of addressing near misses as crucial warnings that can prevent serious accidents. By fostering a culture that prioritizes safety and encourages workers at all levels to recognize and act upon these early signs, the construction industry can move towards a safer and more secure future.

CHAPTER FIVE

DISCUSSION

5.1 Health and Safety Management System

5.1.1 Fundamental legislation for OSH in Hong Kong

The evolution of Occupational Safety and Health (OSH) legislation in Hong Kong mirrors international developments, particularly the influential Robens Report in the UK, but has followed a distinct trajectory shaped by local industrial growth and socio-political readiness. Initially governed by the Factories and Industrial Undertakings Ordinance (F&IUO) of 1955, modeled after the UK Factories Act 1961, Hong Kong's approach to workplace safety was largely prescriptive and limited in scope, focusing primarily on the burgeoning industrial workforce. The 1970s and 1980s, however, saw increasing recognition of the need for reform, inspired by the UK's Health and Safety at Work Act (HASWA) of 1974 and the Robens principle of self-regulation, general duties, and shared responsibility among employers, employees, and other stakeholders. Nevertheless, Hong Kong's transition to this modern regulatory paradigm was gradual, hampered by limited expertise and a lack of awareness among both government officials and industry leaders.

To facilitate attitudinal and structural change, the government undertook foundational work such as legislative reviews, hazard identification, stakeholder engagement, and the establishment of training centers—culminating in key amendments to the F&IUO in 1989. These reforms introduced general duties for employers and employees, mandatory safety training, and a shift of responsibility from government alone to a more collaborative model involving industry commitment and tripartite structures. Subsequent regulations, including those mandating safety officers and supervisors, and the creation of the Occupational Safety and Health Council (OSHC), reinforced the self-regulatory ethos and enhanced coordination among stakeholders.

The 2002 F&IU (Safety Management) Regulations and the proliferation of subsidiary regulations under Cap. 59 further entrenched the principle of self-regulation and performance-based management, requiring top management to proactively establish and implement safety policies. The scope of OSH legislation was significantly expanded with the enactment of the Occupational Safety and Health Ordinance (OSHO) in 1997, which, along with its subsidiary

regulations, extended protection beyond traditional industrial settings to encompass all workplaces, including offices, schools, and hospitals. The OSHO established a framework of general duties for employers, employees, and occupiers, emphasizing accident prevention, workplace hygiene, fire precautions, manual handling, and the obligation to conduct risk assessments and communicate results to workers.

In response to persistent industrial accidents, the Occupational Safety and Occupational Health Legislation (Miscellaneous Amendments) Bill 2022, enacted in 2023, introduced more stringent penalties for OSH violations, treating the most serious offences as indictable crimes with substantial fines and potential imprisonment, thereby strengthening deterrence and accountability. Overall, Hong Kong's OSH regime reflects a progressive shift from rigid, prescriptive regulation to a dynamic, risk-based system underpinned by the Robens philosophy of shared responsibility, continuous improvement, and proactive prevention, though effective enforcement and sustained cultural change remain ongoing challenges.

5.1.2 Challenges in implementation

The implementation of a safe system of work (SSOW) within various industries is fraught with numerous practical challenges, despite the existence of well-established legal frameworks and theoretical guidelines. This thesis critically examines these challenges, focusing on three principal domains: the management of plant and equipment, the assurance of worker competency, and the complexities inherent in the practical application of legal and procedural requirements.

Firstly, the management of plant and equipment constitutes a significant obstacle in the realization of an effective SSOW. While contractors may not be the legal owners of all equipment utilized on site, statutory obligations unequivocally designate the main contractor as responsible for the safety of any equipment present on the worksite. This legal stipulation necessitates rigorous verification processes to ensure that all equipment is free from defects, adequately maintained, and compliant with prevailing safety standards. Compounding this challenge is the potential for inherent design or manufacturing defects, which may not be immediately apparent yet can contribute to workplace accidents and complicate the determination of liability. The necessity of obtaining maintenance documentation, maintaining comprehensive records, and arranging periodic technical audits further intensifies the

administrative and operational burden on contractors. Moreover, the selection of appropriate equipment requires specialized knowledge to evaluate factors such as lifecycle status, maintenance history, safety standards, and ergonomic design. Nevertheless, the provision of safe equipment alone does not suffice; an effective SSOW must encompass a holistic approach that integrates these considerations within a broader safety management framework.

Secondly, ensuring the competency of workers presents another formidable challenge. The human element introduces a level of complexity that surpasses purely technical or engineering concerns. Human error, whether unintentional or deliberate, remains a persistent risk factor, influenced by variables such as worker attitudes, levels of experience, morale, psychological and physical fitness, and risk perception. The heterogeneity and intricacy of tasks performed on construction works demand a workforce with diverse and advanced skill sets. Furthermore, workers must possess an acute awareness of how their actions may affect the safety of others on site. Maintaining high standards of competency necessitates ongoing assessment, targeted training initiatives, and, where appropriate, the replacement of workers who fail to meet requisite standards. The cultivation of a positive safety culture is equally critical, as the most robust systems and equipment can be undermined by a workforce that does not prioritize safety.

Finally, the translation of legal mandates and theoretical principles into practical, site-level actions represents a pervasive challenge in the construction industry. While familiarity with statutory provisions such as Section 6A and Section 13 in Cap 59 and pertinent case law is essential, the primary difficulty lies in operationalizing these requirements within the daily realities of construction work. This process demands the seamless integration of safe equipment, competent personnel, effective supervision, continuous risk assessment, and thorough documentation. The inherently dynamic nature of construction works, characterized by constantly evolving risks and operational scenarios, further complicates the maintenance of a consistently safe working environment. Contractors are also burdened with substantial legal accountability, often for circumstances beyond their direct control, such as the performance of subcontractors or the condition of equipment supplied by third parties. The maintenance of comprehensive documentation, which is vital for legal defense in the event of an incident, imposes an additional administrative challenge.

In conclusion, the implementation of a safe system of work in various industries is a complex and ongoing endeavor that extends beyond mere compliance with legal and technical standards. It requires the continuous integration of safe equipment, competent workers, effective procedures, and a strong safety culture within a proactive and adaptable management system. The unpredictable and ever-changing environment of construction work, production plant, maintenance site etc, coupled with significant legal responsibilities, underscores the necessity for a dynamic and evidence-based approach to safety management. For a safe system of work to be truly effective, it must be actively managed, regularly reviewed, and continuously improved to address both statutory obligations and the practical exigencies of the works.

5.1.3 Court cases study of limited liability with common law and statutory law defenses

HKSAR v Shun Tak Properties Limited [2009] 3 HKLRD 299 (HCMA 1014/2006)

In this case, Shun Tak Properties Limited, the owner of a commercial building, faced prosecution after a serious accident in which two workers were injured when a suspended working platform (gondola) malfunctioned. The prosecution was brought under the Factories and Industrial Undertakings (Suspended Working Platforms) Regulation, which imposes a duty on owners to "ensure" that such equipment is properly maintained. Shun Tak argued that it had engaged qualified contractors to maintain the equipment and had relied on their expertise. However, the magistrate held that the statutory duty to "ensure" safety is strict and non-delegable. The court concluded that an owner cannot discharge this duty simply by relying on third-party contractors. Both the Magistrate and the appellate court found that "ensure" implies an active, robust duty to make certain the equipment is properly maintained. Simply relying on a maintenance contractor to report any defects, without taking further proactive steps, was deemed insufficient to fulfill this statutory responsibility. The court emphasized that the owner must take positive and energetic measures to guarantee maintenance, not just passively depend on others.

HKSAR v Hin Lin Yee and Another [2010] 2 HKLRD 826

The issue of available defenses was further examined in this case. Here, the defendants were prosecuted for failing to comply with statutory safety requirements. The central legal

question was whether, in the absence of explicit statutory defenses, defendants could rely on common law defenses such as an honest and reasonable belief that they had complied with the law. The Court of Final Appeal delivered a justification, "Neither the reasons of the Magistrate nor those of the appeal judge can be supported. The reasoning of the majority in *HKSAR v Shun Tak Properties Ltd* [2009] 3 HKLRD 299 is wrong and that of *Stock JA* in that case is right." stated by Justice Bokhary. Justice Stock discussed the concept of a "common law defence"—sometimes called a "halfway house"—in certain statutory contexts. This defence allows an accused person to avoid liability if they can prove, on the balance of probabilities, that they honestly (even if mistakenly) believed in circumstances which, if true, would have provided a legal defence. However, Justice Stock clarified that where the statute uses the word "ensure"—such as in safety legislation—the duty imposed is non-delegable, meaning the responsibility cannot be passed on to someone else. In the case of the gondola owner, this meant their liability was limited and they could not rely on the common law defence. The owner was required to personally ensure safety, regardless of their beliefs or actions of others.

As a result, the majority opinion in the High Court and the Magistrate, who had supported applying the common law defence, was found to be incorrect. This led Justice Bokhary, in the subsequent *Hin Lin Yee* case, to state and affirm that the so-called common law defence does not apply to safety legislation. In other words, for statutory duties involving safety (where terms like "ensure" are used), the law does not allow the accused to escape liability simply by showing they honestly believed they were complying—the duty is strict and non-delegable.

In conclusion, through this sequence of cases, the Hong Kong courts have established that statutory safety duties—especially those requiring an employer or equipment owner to "ensure" safety—impose strict and non-delegable liability. Employers and equipment owners cannot rely on common law defenses such as honest and reasonable belief in compliance unless the statute expressly allows it. Their only recourse is to rely on statutory defenses, if any exist. This legal development sets a high standard for safety compliance and underscores the courts' commitment to upholding public and worker safety through strict statutory interpretation.

5.2 Personnel competency

5.2.1 Safety Training Schemes

In Hong Kong, the Labour Department and the Occupational Safety and Health Council (OSHC) work together to promote workplace health and safety and enhance the well-being of the workforce. The Labour Department plays a crucial role in enforcing laws and regulations related to workplace safety, conducting inspections, and ensuring compliance with established standards. It also engages in educating employers and employees through workshops, seminars, and information dissemination, fostering good employment practices and resolving disputes to create a harmonious and safe work environment.

Additionally, the Labour Department is involved in policy development to safeguard employees' rights and benefits. On the other hand, the OSHC focuses on promoting occupational health and safety through community campaigns and initiatives. It provides education and training programs to improve the safety skills and knowledge of the workforce, offers consultancy services to help organizations enhance their safety practices, and conducts research to support evidence-based strategies for workplace safety improvement. The council also acts as a central hub for sharing information and facilitating communication between government bodies, employers, employees, and professionals.

Together, the Labour Department and OSHC collaborate on initiatives that leverage their strengths in regulation, education, and community engagement. They design comprehensive programs that not only teach safety practices but also promote a culture of safety within organizations. By engaging various stakeholders—such as employers, employees, and industry professionals—they foster a community-wide commitment to health and safety. This collaborative effort effectively raises workplace health and safety standards, contributing significantly to the overall well-being of the workforce.

In case of construction industry, it is supported by several specialized training bodies that focus on developing a skilled and knowledgeable workforce. The Hong Kong Institute of Construction (HKIC) is a prominent organization dedicated to providing vocational training and education tailored specifically to the needs of the construction sector. It offers a range of programs in areas such as civil engineering, electrical and mechanical services, and occupational safety, aiming to equip individuals with both practical skills and theoretical knowledge.

Additionally, the Vocational Training Council (VTC) in Hong Kong plays a significant role in offering diverse courses related to construction and engineering. These programs are designed to meet industry demands and cover various aspects, from basic trade skills to advanced management techniques. The VTC collaborates with industry stakeholders to ensure its curricula are aligned with current trends and technologies. These training bodies not only focus on skill development but also promote safety awareness and sustainable practices, aligning with Hong Kong's commitment to building a safe, efficient, and environmentally responsible construction industry. By fostering innovation and a culture of excellence, they contribute significantly to maintaining Hong Kong's position as a leading hub for construction expertise in the region.

5.2.2 Trigger to be trained

The effectiveness of training is closely tied to the motivation of participants, even when a competent training program is in place. Motivation plays a crucial role in determining how deeply employees engage with the training content and how effectively they apply what they learn. Intrinsically motivated employees, driven by a genuine interest in personal and professional growth, are more likely to benefit from training.

When participation is voluntary rather than mandated by statutory enforcement, employees often show greater commitment, leading to better retention and application of new skills. The relevance of the training to employees' roles and career aspirations further enhances motivation, as they can see the direct benefits to their personal and professional development.

Moreover, a supportive organizational culture that values and encourages learning can significantly boost motivation. When employees feel backed by their leaders and peers, and see the positive outcomes of training in others, they are more inclined to engage actively. Recognition and rewards for completing training and applying new skills can also enhance motivation, whether through simple acknowledgments or more formal incentives like certifications or career advancement opportunities.

In essence, while the quality of a training program is important, its true effectiveness is largely dependent on creating an environment that fosters and supports the intrinsic motivation of its participants.

5.2.3 Court case sharing for the importance of competent safety training

Court Case, HCMA 219/2012, HKSAR with Yau Hop Scaffolding Engineering Company Limited

The appellant company faced charges under the Factories and Industrial Undertakings Ordinance (FUIO) due to inadequate safety training following an incident where an employee was injured. The Court highlighted that the safety training provided was insufficient, as it was delivered by a peer rather than a higher-ranking authority figure, underscoring the necessity for training to be conducted by individuals with recognized expertise. Furthermore, the absence of evidence to assess the training's effectiveness contributed to the ruling against the company, emphasizing the importance of not only implementing but also evaluating training programs. The Court also noted that distributing safety pamphlets, although not mandatory, is a straightforward and effective way to enhance safety education, particularly for workers who may be illiterate, through the use of visual aids like cartoons or pictures. This case serves as a reminder for safety practitioners to ensure that safety training is comprehensive, authoritative, and supplemented with accessible materials, reflecting the Authority's emphasis on the significance of proper safety education.

5.2.4 Gap analysis for where personnel concerned

The objective of this focus is to minimize the risk of accidents and injuries by improving oversight and enforcement of health and safety protocols, ensuring compliance with regulations, and avoiding legal and financial repercussions. Research aims to identify the root causes of disconnects between safety management and front-line operations, aiming to enhance alignment and engagement. By addressing these factors, organizations can create an environment where safety measures are embraced, ensuring their effectiveness and prioritizing the well-being of all personnel.

In discussing the integration of safety motivation into a safety management system, it's essential to consider the cultural and personnel factors that may influence its success. Enthusiasm plays a vital role in motivating individuals to adhere to safety practices, as it fosters a positive and energetic environment conducive to learning and engagement. Avoiding arguments is crucial, as counterwork can create resistance and hinder open communication. It's important never to tell another person they are wrong, as this approach can lead to defensiveness

and reduce cooperation. Instead, if you are wrong, admit it promptly, demonstrating humility and a willingness to learn, which can encourage others to do the same. Beginning interactions in a friendly manner sets a positive tone and opens the door for effective communication. Utilizing two-way communication ensures that all parties feel heard and valued, facilitating better understanding and collaboration. Rather than aggressively selling safety, allowing individuals to buy into the concept encourages personal investment and commitment to safety measures. Confidence in the implementation of safety practices inspires trust and respect among team members. Furthermore, recognizing and rewarding safe practices through commendations and compliments reinforces positive behavior and motivates continued adherence to safety protocols. Lastly, setting the example by consistently demonstrating safe practices is perhaps the most powerful motivator, as it shows commitment to safety and inspires others to follow suit. The success of any safety management system is deeply intertwined with the culture within which it operates. A culture that values open communication, mutual respect, and continuous improvement is more likely to successfully implement safety measures.

However, personnel factors such as individual attitudes, varying levels of risk perception, and resistance to change can often be overlooked. Addressing these factors through training, support, and engagement is crucial for fostering a culture that prioritizes safety and ensures the effectiveness of safety measures. Personnel factors play a critical role in the effectiveness of safety measure implementation within any organization. Individual attitudes towards safety can significantly influence how safety protocols are perceived and followed. For instance, if employees view safety measures as cumbersome or unnecessary, they may be less inclined to adhere to them consistently, thereby undermining their effectiveness. Additionally, varying levels of risk perception can lead to inconsistent application of safety practices, as individuals who perceive less risk may not engage fully with safety measures. Resistance to change is another formidable challenge; entrenched habits and routines can make it difficult for new safety protocols to be adopted smoothly. This resistance can stem from a lack of understanding, fear of the unknown, or simply discomfort with altering established procedures. Addressing these personnel factors requires a comprehensive approach that includes targeted training to enhance understanding and awareness, ongoing support to facilitate transitions, and active engagement to foster buy-in and commitment to safety culture. By prioritizing these elements, organizations can create an environment where safety measures are not only implemented but

embraced, thus ensuring their effectiveness and fostering a culture that prioritizes the well-being of all personnel.

5.2.5 Personnel factors inducing near miss incident

Personnel factors play a significant role in contributing to near miss incidents within the workplace, often sourcing from human-related issues that can compromise safety. One primary factor is human error, which can occur due to loss in attention, fatigue, or misinterpretation of procedures, leading to potential hazards. Inadequate training always does a main issue, as employees who are not fully equipped with the necessary knowledge and skills may inadvertently mishandle equipment or overlook critical safety protocols.

Additionally, underestimation can set in over time, with workers becoming too comfortable or overconfident, thus miss the right moment to adequately assess risks. Poor communication further complicates matters, as misunderstandings or lack of clear instructions can result in errors and unsafe actions. Stress and fatigue also impair cognitive functions, reducing an individual's ability to make sound judgments and react promptly to emerging risks. Inexperience, particularly among new or temporary staff, may not be sensitive to near misses due to unfamiliarity with procedures and potential hazards.

Furthermore, making unsafe behavior, such as bypassing safety measures or engaging in risky practices, directly elevates the likelihood of incidents. Lastly, distractions, whether from personal issues or environmental factors, can divert attention away from critical tasks, leading to errors. Addressing these personnel factors through comprehensive training, fostering a culture of safety, and improving communication and support systems is essential in mitigating the risk of near miss incidents.

5.2.6 Suggestions to mitigate near miss incident

To effectively mitigate personnel factors that contribute to near miss incidents, organizations must adopt a comprehensive education, culture, and proactive management. Enhancing training programs is important, as all-rounded and ongoing education ensures that employees are well-versed in safety protocols and equipment operation, reducing the likelihood of human error.

Establishing a safety-first culture is equally important; this involves leadership consistently modeling safe behavior and rewarding adherence to safety standards, thereby develop safety as a core organizational value. Improved communication channels are essential to ensure all team members are informed about safety procedures, changes, and potential risks, with regular meetings or briefings facilitating alignment and awareness. Addressing stress and fatigue through policies that promote work-life balance and offer resources for stress management can maintain employee well-being, thus enhancing focus and decision-making. Increasing supervision and mentoring, particularly for less experienced or new staff, helps reinforce adherence to safety protocols through guidance from senior colleague. Encouraging an open environment for reporting near misses and providing feedback allows employees to identify and address potential hazards proactively.

Regular safety audits serve as a critical tool for identifying hidden defects in procedures or equipment handling, with findings used to continuously refine safety practices and training. Finally, implementing safety incentives can motivate employees to maintain high safety standards, fostering a workplace where safe behavior is recognized and rewarded.

By integrating these strategies, organizations can effectively reduce personnel-related factors leading to near miss incidents, thereby enhancing overall workplace safety and efficiency.

5.3 Equipment performance

5.3.1 Control of safe working condition

Regular equipment maintenance is important for ensuring optimal performance and safeguarding employee health and safety. This involves conducting frequent inspections to identify wear and tear, adhering to a preventive maintenance schedule that includes routine tasks such as lubrication, calibration, and parts replacement, and maintaining detailed records of all maintenance activities. Such records are crucial for tracking equipment performance metrics over time and informing future maintenance planning.

The competency of maintenance personnel is equally important; they must be well-trained, experienced, and engaged in continuous education to stay updated with the latest industry standards and technologies. Providing workshops, seminars, and participation in professional

organizations can enhance their skills and knowledge, ensuring they are prepared to handle the complexities of modern equipment.

Furthermore, comprehensive training programs for equipment operators should be developed, comprising both hands-on sessions and theoretical education, supported by clear and accessible user manuals. Equipment must be clearly labeled with specifications such as working capacity, loading limits, operational constraints, and potential hazards to ensure safe use.

Regular safety audits, risk assessments, and root cause analyses of accidents and near-misses should be conducted to identify deficiencies and develop corrective action plans. By integrating these strategies, organizations can minimize risks, enhance operational efficiency, and maintain a safe work environment.

5.3.2 Accident case sharing for the importance of competent equipment

In July 2022, during a concert by the popular boy band MIRROR at the Hong Kong Coliseum, a serious accident occurred when a giant LED screen fell from a height onto the stage. This incident resulted in injuries to two dancers, Mo Lee Kai-yin and Cheung Tsz-fung, with Mo Lee facing severe risks of paralysis initially. The accident was attributed to significant lapses in safety measures and equipment management by the companies involved, prompting legal actions and fines for failing to adhere to occupational safety standards. The event highlighted the critical need for stringent safety protocols in the entertainment industry to prevent such occurrences.

This incident underscores the critical importance of equipment safety assurance in the event management industry. The failure to ensure the safety of the equipment, particularly the giant LED screen that fell and caused injuries, highlights the severe consequences of inadequate safety measures. Engineering Impact Limited's negligence in maintaining equipment safety and accurately reporting equipment specifications demonstrates a significant lapse in responsibility. Proper equipment safety assurance is essential to prevent accidents and protect both performers and crew. It involves rigorous inspection, maintenance, and accurate documentation of all equipment used in events.

This case emphasizes that equipment safety isn't just a technical requirement; it's a fundamental obligation that directly impacts human lives. Companies must prioritize thorough

safety checks and transparent reporting to avoid tragic outcomes. The fines and legal actions taken against the companies involved serve as a stark reminder of the repercussions of neglecting equipment safety. Ultimately, ensuring equipment safety is not only about compliance with laws but also about safeguarding the health and well-being of everyone involved in events. It is a critical component of risk management that must be upheld to prevent future incidents and ensure safe and successful event execution.

5.3.3 Gap analysis for where equipment concerned

In small-scale projects where budget constraints are significant, ensuring the safety and maintenance of equipment poses a considerable challenge. The limited cost often makes it difficult to have competent equipment or implement comprehensive safety measures. This is particularly problematic when the project involves work-above-ground, such as using ladder platforms. Ideally, ladders should be utilized solely for access and egress purposes rather than as platforms for prolonged work, due to the inherent falling hazards involved. However, in projects with only one or two personnel, there is often less rigorous monitoring of equipment maintenance status, which can lead to safety oversights. The short time frames typically allocated for these projects further worsen the issue, as they render frequent inspections of portable tools impractical.

To address equipment-related safety issues in small-scale projects, enhancing training and awareness among personnel is critical. This involves providing targeted education on safe equipment use and the importance of regular maintenance, supported by easy-to-understand guidelines, particularly for ladder use. Implementing regular inspections, even within tight project timelines, ensures compliance with safety standards. This can be facilitated through streamlined checklists to maintain carefulness. Restricting ladders to access and egress purposes, while investing in alternative platforms for work-above-ground, optimizes equipment usage.

Additionally, establishing simplified maintenance schedules and prioritizing budget allocation for essential equipment upkeep can mitigate risks. Leveraging technology, such as mobile apps or software, for real-time monitoring and alerts on equipment conditions further enhances safety protocols. Increasing monitoring and accountability by designating specific personnel for equipment oversight fosters a proactive safety culture, encouraging workers to

report issues promptly. These consolidated measures aim to improve equipment safety effectively within the constraints of small-scale projects.

5.3.4 Equipment factors inducing near miss incident

In any operational environment, the integrity and functionality of equipment play an essential role in ensuring safety and preventing incidents. A near miss incident, often regarded as a close call, is an event that could have resulted in injury, damage, or loss but did not, often due to a combination of accidental circumstances and responsive interventions.

Equipment-related factors contributing to near miss incidents may include inadequate maintenance, which can lead to equipment failure or malfunction; outdated technology that may not meet current safety standards; or improper usage due to lack of training or oversight. Additionally, design faults or manufacturing defects can compromise the reliability of equipment, increasing the likelihood of operational errors. These factors underscore the importance of rigorous equipment management protocols, regular inspections, and adherence to safety standards.

By understanding and addressing these equipment-related issues, organizations can significantly reduce the occurrence of near miss incidents, thereby enhancing overall safety and operational efficiency.

5.3.5 Suggestion to mitigate near miss incident

To effectively mitigate equipment-related factors that could lead to near miss incidents, organizations must have a plan for proactive maintenance and safety strategies. First, implementing a rigorous schedule for regular maintenance and inspections is a must to every responsible parties. This ensures that equipment is consistently monitored and kept in optimal working condition, allowing potential issues to be identified and addressed before they develop to safety hazards. Upgrading and modernizing equipment to incorporate the latest technology and safety features can further enhance performance and reduce the likelihood of malfunctions.

Additionally, comprehensive training programs for personnel are essential, equipping them with the knowledge to use equipment correctly and recognize signs of wear or malfunction. Developing standardized operating procedures provides clear guidelines for equipment usage

and maintenance, ensuring consistency and safety across operations. Regular risk assessments and management strategies help identify potential equipment hazards and allow for the implementation of effective mitigation measures. Establishing feedback and reporting systems encourages employees to report equipment issues or near misses, facilitating continuous improvement through the identification of trends and areas needing attention.

Finally, conducting safety audits and compliance checks ensures adherence to industry standards and regulations, addressing any non-compliance issues promptly. By integrating these strategies, organizations can significantly reduce the risk of equipment-related near miss incidents, fostering a safer and more efficient working environment.

5.4 Material quality

5.4.1 Quality control of working materials

Material quality control is integral to safety control measures, ensuring the structural integrity and reliability of engineering projects. By implementing competent testing and certification processes, quality control prevents the use of incompetent materials that could lead to structural failures, thereby significantly reducing the risk of accidents. This is particularly important in detecting contamination, whether accidental or deliberated, which can adversely affect material properties such as strength and durability.

Adherence to quality control not only ensures compliance with regulatory standards but also mitigates legal liabilities and penalties, thus maintaining confidence with the users. Although the costs of certified material may be high, the long-term benefits include cost savings from avoiding repairs and replacements, as well as contributing to the sustainability and duration of structures.

Additionally, consistent applying quality control measures enhances a company's reputation for reliability and safety, fostering trust and securing production quality. Therefore, material quality control is indispensable for ensuring safety, compliance, and sustainability in engineering projects.

In the world of manufacturing and production, ensuring the safety and quality of materials is a fundamental concern. Engineering works often rely on materials like chemicals, metal raw materials, cement, and other construction elements, which need to meet specific quality standards to support effective production processes. Collaborating with suppliers who adhere

to ISO 9001 standards can be a significant step toward achieving this goal. ISO 9001 certification indicates that a supplier has a sound quality management system in place, ensuring that their materials and production policies meet established quality benchmarks.

Moreover, the involvement of end-users in the supply chain is critical. It's important for end-users to focus on sourcing materials that prioritize quality and safety, even when cost is an essential factor in their business decisions. While managing expenses is critical, it should not come at the expense of the safety and reliability of the materials used. By emphasizing these priorities, end-users help ensure that the materials contribute positively to the overall quality and safety of the production process.

Ultimately, finding a balance between cost, quality, and safety is key to fostering responsible and sustainable business practices, particularly in industries that depend heavily on specific materials for their operations.

5.4.2 Incident case sharing for the importance of competent material

The 2015 Hong Kong water supply lead contamination incident, officially referred to as the "Lead in Drinking Water Incident," began in July 2015 when it was discovered that drinking water in certain public housing estates, Home Ownership Scheme flats, private residential estates, hospitals, and educational institutions in Hong Kong contained excessive levels of heavy metals. Following the incident, the construction company China State Construction, along with the government and relevant organizations, investigated the construction process and materials used, finding that the cause was the use of lead-containing solder by welders.

The Task Force of the Authority conducted a thorough investigation by dismantling over 100 components of pipes and fittings from three water supply chains in Kai Ching Estate and Kwai Luen Estate Phase 2, and performed testing on them. They concluded that the excess lead in the drinking water at these locations was primarily caused by the use of leaded solder materials in the solder joints. Additionally, the Task Force discovered discrepancies between the brands and models of some valves and taps among the dismantled pipes and fittings and those submitted to the Water Supply Department (WSD) before the commencement of construction of the inside service. Although these were listed in the WA's directory of approved pipes and fittings, some copper alloy valves and taps did not meet the British Standard requirements for lead content. However, the leaching test results for these copper alloy valves

and taps were comparable to those that complied with the requirements, indicating they would not lead to excess lead in drinking water. Based on these findings, the Task Force concluded that the primary cause of excess lead in drinking water was the leaded solder joints.

5.4.3 Gap analysis for where material concerned

The improper behavior leading to excess lead in drinking water incidents primarily involved the use of leaded solder materials and non-conforming pipe fittings, both of which are unsuitable for potable water systems due to their potential to leach harmful substances. A significant gap exists in regulatory compliance, as evidenced by the use of materials that do not meet established standards, highlighting the need for stronger enforcement and penalties for non-compliance.

The inspection and testing processes have also been inadequate, failing to detect and prevent the use of improper materials. Additionally, decentralized procurement processes have led to inconsistencies and the use of unapproved materials, necessitating a shift towards centralized procurement to ensure accountability and compliance.

Furthermore, insufficient training and awareness among industry stakeholders about the risks and regulations associated with leaded materials underscore the need for enhanced education and training programs. These programs should focus on regulatory compliance and the health impacts of lead exposure.

Finally, the legislative framework may not be robust enough to support effective enforcement of standards, indicating a need for review and updates to legislation to address these gaps and ensure that it supports comprehensive compliance measures.

5.4.4 Suggestion to mitigate the incident of improper material selection

With respect to the incident of excessive lead content in drinking water, the Task Force of the Authority identified that the incidents of excess lead in drinking water were largely due to a lack of awareness among stakeholders in the construction industry regarding the use of leaded solder materials and their impact on water quality.

To address this issue and prevent similar occurrences in the future, the Task Force proposed several recommendations. Firstly, to prevent the use of leaded solder materials and

non-conforming pipe fittings, it is essential to enhance the site inspection and testing system for plumbing works. This can be achieved by engaging qualified professionals, such as Building Services Engineers or Inspectors, to conduct regular field inspections.

Additionally, systematic non-destructive testing of solder pipe joints during construction should be implemented, using methods such as quick lead tests or portable x-ray fluorescence analyzers. Random sampling and testing of materials delivered to the site are also recommended.

Furthermore, testing for four additional heavy metals—lead, chromium, cadmium, and nickel—in drinking water samples, as well as testing for lead content in solder pipe joints in newly installed inside services, should be stipulated. Moreover, the Water Supply Department (WSD) is encouraged to explore the use of pipe materials that eliminate the risk of misuse of leaded solder joints in plumbing works. This includes considering the use of silver brazing or compression joints for copper pipes, and the adoption of stainless steel or crosslinked polyethylene pipes. The Housing Authority should also consider requiring main contractors to adopt central procurement for solder materials and other essential plumbing components, to clearly define material supply responsibilities and prevent the use of unapproved materials on site. Lastly, the WA should review relevant legislation to facilitate the implementation of these recommendations, ensuring a safer and more reliable water supply system.

Material competency plays an essential role in ensuring safety measures that can prevent similar near miss incidents, particularly through proper testing and quality control. Competency in selecting and using the right materials ensures that all components meet the necessary safety and performance standards, reducing the risk of failures that could lead to hazardous situations. Proper testing and quality control are integral parts of this competency, as they verify that materials conform to specifications and are free from defects. These processes help identify potential issues before they result in incidents, thereby acting as a proactive measure to safeguard against failures. By maintaining high standards of material competency, organizations can ensure that all materials used in construction and manufacturing are reliable and safe, significantly minimizing the likelihood of near misses. This proactive approach not only enhances safety but also builds trust and confidence in the integrity of the systems in place, ultimately contributing to a safer environment for all stakeholders involved.

To further mitigate incidents resulting from improper material selection, establishing a transparent material market within the construction industry is crucial. A transparent

marketplace would make detailed information about materials readily accessible, including quality specifications, independent test results, and certification records. By requiring suppliers to disclose this data, contractors and project managers can more confidently verify that the products they purchase meet regulatory and safety standards prior to procurement and installation. This level of openness helps minimize the risk of using unsuitable or unsafe materials.

Furthermore, incorporating information on manufacturers' production competency—such as their technical expertise, track record of compliance, and audit results—will aid stakeholders in evaluating the credibility of suppliers and the reliability of their products. Publicly available compliance ratings and regular audits can bolster industry accountability and help ensure that only qualified manufacturers are chosen for important construction projects.

Allowing purchasers and end-users to contribute comments and ratings on both materials and suppliers enriches the marketplace with real-world performance data and insights. These shared experiences can reveal strengths or highlight concerns that may not be evident from technical documentation alone, offering practical perspectives for future buyers. Moreover, integrating a system for after-sale feedback enables ongoing monitoring and quality improvement. Reports on issues such as durability, installation experience, or the emergence of defects serve as early warnings for industry-wide challenges, prompting suppliers to improve their products and respond to user concerns proactively.

Greater transparency and a wider range of available, compliant materials also promote fairer market conditions. By enabling buyers to compare multiple products based on trusted quality information and peer feedback, the risk of inadvertently selecting unsafe or non-compliant options is significantly reduced. This open access prevents monopolies, encourages competition, and ensures better choices for every stakeholder involved.

Ultimately, a transparent material market not only enhances safety but also builds confidence throughout the construction supply chain. Accessible, trustworthy information ensures that only thoroughly vetted, high-quality materials are used, dramatically reducing the likelihood of near misses or hazardous incidents linked to improper material selection. Additionally, such transparency supports regulatory oversight and cultivates a culture of continuous improvement.

To achieve this, the industry should collaborate with relevant authorities to develop an online platform that integrates independent testing results, compliance documentation, and user feedback in one easily accessible location. Regular updates and oversight will help maintain the integrity of this marketplace, driving higher standards and contributing to a safer and more equitable construction industry in Hong Kong.

5.5 Compliance of Method Statement

5.5.1 Assessment for safety procedural planning

The role of a Safety Manager extends beyond exclusive measures monitoring, implement a comprehensive and professional understanding of safety management as it pertains to project execution. This involves a detailed assessment of method statements, which are detailed documents outlining the procedures and safety measures to be followed during project activities.

Collaborating with the Project Manager, the Safety Manager ensures that these method statements are not only compliant with statutory requirements but are also effectively integrated into the site's operational framework. A deeper investigation into the importance of compliance reveals that method statements serve as a blueprint for maintaining consistency and safety across all project phases. They act as a safeguard against potential hazards by providing clear guidelines on how tasks should be performed.

The Safety Manager must therefore scrutinize these documents to identify any gaps or areas for improvement, ensuring that they are robust enough to address the dynamic and often unpredictable nature of construction and industrial environments. Furthermore, the Safety Manager's role in site management involves strategic planning and the arrangement of resources, which are critical to the implementation of safety measures. This includes not only physical resources such as equipment and materials but also human resources, ensuring that all personnel are adequately trained and aware of the safety protocols.

By fostering a culture of safety through education and communication, the Safety Manager underscores the importance of complying with site rules, which are designed to prevent accidents and ensure the well-being of everyone involved. The consequences of deviating from method statements can be severe, leading to operational disruptions, financial losses, and, most importantly, threats to human safety.

Thus, the methodology control becomes a pivotal element in safety management, providing a structured approach to risk assessment and mitigation. It offers a systematic way to identify potential hazards, evaluate their impact, and implement control measures that are both proactive and reactive.

In summary, the Safety Manager's duty involves a profound engagement with the principles of safety management, ensuring that every aspect of project execution is aligned with best practices and regulatory standards. This deep investigation emphasizes the critical nature of methodology control, advocating for a strategic approach that integrates safety into the very fabric of project planning and execution. Through this lens, safety becomes not just a requirement but a fundamental aspect of achieving operational excellence and safeguarding human life.

5.5.2 Case study for improper of procedure follower (Laboratory)

The incident occurred on December 6, 2022, in the University of Hong Kong. A doctoral student set up an experimental reaction apparatus and then left the laboratory. It is suspected that due to incorrect quantity and operation, a flask containing high concentration, strongly alkaline sodium hydride suddenly exploded, spraying chemicals two to three meters away. At the time, another doctoral student was in the laboratory and was injured when the chemicals sprayed onto her face.

This accident underscores several critical deviations from designated experimental procedures that could have contributed to the incident. Firstly, the suspected incorrect quantity of sodium hydride used suggests a failure to adhere to precise measurement and handling instructions, which is essential in preventing adverse reactions. Additionally, the explosion and chemical spray indicate that adequate safety precautions may not have been followed, such as proper containment measures and the use of appropriate protective equipment.

The fact that the first doctoral student left the experimental setup unattended highlights a lack of continuous monitoring, which is important when dealing with reactive chemicals to quickly address any unexpected reactions or equipment malfunctions. Furthermore, there might have been a lack of verification or double-checking of the setup prior to initiating the reaction, a critical step to ensure all components are correctly assembled and variables controlled. This incident may also reflect gaps in training or communication regarding the risks associated with

the chemicals and the necessary precautions. Lastly, there might have been an inadequate risk assessment or failure to implement appropriate risk mitigation strategies for experiments involving hazardous materials and pressure buildup.

Overall, this accident emphasizes the importance of strictly adhering to experimental protocols, maintaining vigilance during experiments, and ensuring comprehensive training and communication about laboratory safety procedures.

5.5.3 Case study for improper of procedure follower (Electrical Installation)

In Hong Kong, handling electrical work requires strict adherence to safety protocols due to the high voltage levels typically used, which are 220 volts for single-phase and 380 volts for three-phase systems. These voltages pose significant risks, including electric shock, burns, or even death if contact is made with live parts. A real-life incident highlights the importance of following safety procedures:

An electrician's helper was working on a lighting fixture in a dark room without first isolating the power supply. When someone else turned on the lights, the helper was exposed to live electrical wires, putting him in immediate danger. This situation could have been avoided by following proper lock-out and tag-out procedures, which involve isolating the electricity supply, locking the switch, and attaching clear caution notices to the equipment. These notices should include details such as the date, time, and the identity of the person who locked the switch. Additionally, screens or barriers should be used as needed to ensure safety. It's crucial to consult a supervisor if there is any uncertainty about the procedures.

This incident underscores the vital importance of taking all necessary precautions to ensure the safety of individuals working with electrical installations. It is classified as a near miss incident, serving as a reminder to reinforce the importance of safety measures and vigilance in preventing workplace accidents.

5.5.4 Gap analysis for the control of methodology

The incident and accident mentioned in previous sections highlight several key areas where procedural non-compliance may have occurred, leading to the undesired results. Firstly, there seems to be a gap in following the documented procedures for handling and measuring high risk activities. Safety protocols also appear to have been inadequately implemented, as

evidenced by the electrical shock, explosion and chemical spray that may cause injuries. The lack of continuous monitoring is another significant issue, as the experimental setup was left unattended, increasing the risk of uncontrolled reactions.

Additionally, it seems there was no verification process to ensure the correct assembly and operation of the setup before starting the works, which could have caught any errors. Training and competency may also have been lacking, as the personnel involved might not have been fully aware of the risks or procedures necessary for safely handling such dangerous works.

Lastly, it appears that risk assessment and management were insufficient, as potential hazards were not adequately anticipated or mitigated. Addressing these gaps through better documentation, training, monitoring, and risk management can help prevent similar accidents in the future.

5.5.5 Suggestion to mitigate the deviation from designated method statement

To keep workplaces safe, eliminate near-miss incidents and avoid accidents across different industries, starting with the discussion for laboratory and electrical work, it's important to follow detailed safety plans, known as method statements. These statements explain how to do specific tasks safely, including the steps to follow, tools to use, and precautions to take. In laboratory, they might cover how to handle chemicals correctly, while in electrical work, they focus on safely managing any part connecting with power supply. In other fields like manufacturing, construction, and healthcare, these plans guide everything from operating machines to caring for patients.

Sticking to these plans is essential because deviating from them can lead to serious dangers. For instance, mishandling experiment setup in a laboratory can cause explosion due to accidental pressure buildup, and not following electrical safety steps can result in shocks or fires. In other industries, ignoring these plans might lead to machine breakdowns, structural damage, or even harm to people. This is why it's essential for everyone to follow the method statements closely to keep the workplace safe.

In Hong Kong, ensuring compliance with workplace safety regulations involves a collaborative effort among various parties, including workers, employees, employers, safety specialists, and regulatory authorities. Each of these stakeholders plays a vital role in creating and maintaining a safe working environment.

Workers and employees are on the front lines, responsible for adhering to safety protocols and method statements in their daily tasks. Their commitment to following these guidelines is essential in preventing accidents and minimizing risks. Employers, on the other hand, are tasked with implementing comprehensive safety measures and ensuring that their workforce is adequately trained and informed about safety practices. They must provide the necessary resources and support to foster a culture of safety within their organizations.

Training programs should educate employees the importance of these safety plans and how to stick to them. Workers need to understand the risks of not following the plans and the importance of compliance. Regular practice drills help reinforce this knowledge and ensure everyone knows the safety protocols deep down to their mind. Monitoring the work environment continuously helps ensure these plans are being followed. Using checklists and automated systems can help spot any deviations early, so they can be fixed before becoming a problem.

Safety officers and industry specialists play a key role in making sure these safety plans are followed. They oversee the implementation of safety protocols, conduct inspections, and provide training. They also investigate any incidents to find out what went wrong and make improvements to prevent future issues. By following these strategies, organizations can greatly reduce the risk of accidents caused by not following safety plans, creating safer workplaces in all industries. This approach not only protects employees but also boosts efficiency and reliability, building a strong culture of safety and compliance. Safety specialists, often employed within companies or as external consultants, bring expertise in identifying potential hazards and developing strategies to mitigate them. They conduct risk assessments, design safety plans, and offer guidance on best practices, helping organizations comply with regulatory standards.

Regulatory authorities, such as Hong Kong's Labour Department and the Occupational Safety and Health Council, oversee the enforcement of safety regulations. They conduct inspections, provide guidance, and ensure that both employers and employees understand their legal responsibilities. These authorities also facilitate training and education programs to keep all parties updated on the latest safety standards and practices. Risk assessments are important to identify potential hazards and find ways to reduce them. Emergency response plans should be ready to deal with incidents efficiently and effectively, with easy access to safety equipment

and clear instructions for everyone. These plans should be reviewed and updated regularly to keep up with any changes or new risks. Encouraging open communication is key, allowing workers to share concerns or questions about the safety plans. This helps improve safety practices and empowers employees to point out any potential hazards or deviations.

Compliance is a collective responsibility that requires cooperation and communication among all involved parties. By working together, they can ensure that workplaces remain safe and compliant with legal standards, protecting workers and promoting a culture of safety and accountability across Hong Kong's industries.

5.6 Challenge from working environment

5.6.1 General condition in Hong Kong

Hong Kong's densely populated and rapidly developing landscape is home to several high-risk working environments that demand comprehensive safety measures. Construction site is one of most important field due to ongoing urban development, posing risks such as machinery accidents, falls from heights, and exposure to dust and noise, all induced by the limited space and close to residential areas. Transportation and logistics hubs, including the city's bustling ports, are high-risk due to the fast-paced movement of goods and vehicles, with potential accidents involving cranes, forklifts, and hazardous materials during loading and unloading processes. Shipyards and dockyards present dangers related to heavy lifting, welding, and working with large vessels, alongside exposure to adverse weather conditions. Chemical plants and laboratories in Hong Kong handle potentially volatile substances, requiring robust systems to manage leaks, spills, and toxic exposures, while food processing facilities face machinery-related risks and stringent hygiene demands to prevent contamination. High-rise building maintenance involves working at great heights, where falls, electrical hazards, and extreme weather exposure are significant concerns. Healthcare facilities must navigate risks associated with infectious diseases, hazardous waste, and chemical exposure from pharmaceuticals, necessitating rigorous hygiene protocols and waste management systems. Entertainment and event venues, such as theme parks and concert arenas, involve crowd management challenges and electrical safety concerns, requiring efficient emergency response systems and structural integrity checks. Lastly, underground utilities and tunneling work present dangers like cave-ins, flooding, and hazardous gas exposure, highlighting the need for comprehensive safety equipment and monitoring. Each of these environments requires specific safety strategies to

protect workers and ensure the smooth operation of Hong Kong's diverse and dynamic industries.

5.6.2 Case study for adverse working conditions

These three court cases from Hong Kong highlight different aspects of workplace safety regulations and the legal responsibilities of employers to ensure a safe working environment.

In *HKSAR v Hip Hing Construction Co. Ltd* (HCMA 376/2002), a formwork worker fell 2.71 meters due to a lack of safety measures to prevent falls. The investigation revealed that there were no barriers in place, and although the worker claimed he fainted, which suggested a possible health issue, the primary concern was the absence of fall prevention measures. The company was held strictly liable for not implementing safety protocols to prevent falls from heights of two meters or more, underscoring the employer's responsibility to ensure safety irrespective of other factors.

In *AG v Lee Yu Kee Ltd* (Criminal Appeal No. 325 of 1981), three workers died from gas exposure while working in an underground sewer. The investigation focused on the presence of hydrogen sulphide gas, commonly found in sewage. The court examined whether the gas levels were dangerously high at the time of the incident. The initial conviction was overturned because the prosecution failed to provide evidence that the gas levels were toxic enough to cause the deaths. This case highlights the importance of conducting detailed environmental assessments and providing conclusive evidence in proving safety violations.

In *HKSAR v Poon Wing Lam and Another* (HCMA 520/2006), the unsafe installation of temporary suspended working platforms was identified through photographs taken by an occupational safety officer. The investigation found that the platforms' supports were merely resting on a parapet wall without secure anchoring. While the defence argued that the system used was safe according to different standards, the appellants were acquitted of installation-related charges due to technicalities but admitted guilt for not providing safety belts and lifelines. This case emphasizes the need for compliance with specific safety codes and the provision of comprehensive safety equipment.

Together, these cases illustrate the critical role of thorough cause investigations in determining the adequacy of safety measures and highlight the legal obligations of employers

to maintain a safe working environment. They also demonstrate the importance of evidence and expert testimony in understanding the circumstances and causes of workplace incidents.

5.6.3 Gap analysis for safe working environment

The examination of these court cases concerning workplace safety reveals significant gaps between existing safety practices and ideal safety measures. The absence of fall prevention barriers highlights a significant gap in basic safety infrastructure. Despite the worker's health issue potentially contributing to the fall, the lack of physical barriers represents a fundamental oversight in safety planning. Proper safety measures should have included guardrails or netting to prevent falls, addressing foreseeable risks in construction environments.

In case of root cause investigation of gas accident, the gap is evident in the failure to conduct thorough environmental risk assessments and implement continuous monitoring systems. The inability to provide evidence of hazardous gas levels at the incident time reflects a shortfall in proactive safety measures, such as regular air quality checks and emergency response protocols. These measures are the first warning sign in confined spaces where gas accumulation is a known risk, pointing to a need for improved hazard identification and management strategies.

Lastly, the failure to properly secure temporary suspended working platforms and provide essential safety equipment like belts and lifelines indicates gaps in adherence to safety code of practices and regulations. The reliance on inadequate securing methods highlights a lack of compliance with established safety guidelines, while the absence of personal protective equipment further exposes workers to unnecessary risks.

Overall, these cases underscore the need for comprehensive safety strategies that encompass both preventative measures and compliance with regulatory standards. The gap analysis reveals deficiencies in safety protocols, risk assessments, and equipment provision, emphasizing the importance of rigorous safety planning, regular audits, and strict enforcement to ensure a safe working environment.

5.6.4 Suggestion to mitigate the deviation from adverse working environment

A comprehensive and adaptable mitigation plan to eliminate near-miss incidents should start with conducting thorough and regular risk assessments tailored to each working environment's specific needs. This ensures that all equipment, processes, and workspaces adhere to relevant safety requirements. By identifying potential hazards at an early stage, site management can implement targeted measures to address them, thereby minimizing the risk of accidents. Central to this plan is the provision of comprehensive training programs for all employees. These programs should be specifically designed to cover work-specific safety protocols and the proper use of equipment, empowering employees to perform their tasks safely and effectively respond to emergencies. Training should be ongoing, with regular updates to reflect new technologies and practices. Access to appropriate personal protective equipment (PPE) is essential across all working fields. Ensuring that employees have the necessary gear—such as helmets, gloves, masks, and safety harnesses—and are trained in its correct use can significantly reduce the risk of injury. Implementing a robust safety management system is also crucial. This involves conducting regular safety drills, maintaining clear documentation, and establishing straightforward processes for reporting hazards. Such systems help maintain a high level of safety awareness and ensure that employees are always prepared. Cultivating a strong safety culture is vital. Encouraging an environment where safety is prioritized and employees feel empowered to report concerns without fear of retaliation promotes open communication and facilitates the quick resolution of safety issues. Industries must stay informed about evolving regulations and standards, integrating these changes into their safety practices to ensure ongoing compliance and protection for workers. This involves continuous monitoring of industry developments and adapting safety protocols accordingly. Additionally, innovative technology can enhance safety measures. Management can implement advanced monitoring systems, automate hazardous tasks, and use data analytics to predict and prevent potential risks. By incorporating these strategies into a comprehensive mitigation plan, industries can significantly enhance workplace safety, reduce the likelihood of near-miss incidents, and promote the well-being of all employees. This proactive approach not only protects workers but also contributes to operational efficiency and sustainability.

5.7 Implementation for the role of measurement

5.7.1 Measurement for controlling and monitoring purposes

In the context of the 6M cause and effect analysis (Men, Machine, Material, Method, Milieu, Measurement), measurement is the systematic process of collecting, evaluating, and verifying data across all factors. It serves as the foundation for objective assessment, enabling organizations to quantify and validate human competency, machine performance, material quality, method reliability, and environmental conditions against established standards. Through accurate measurement, deviations can be detected, root causes identified, and informed decisions made for effective control and continuous improvement.

Measurement's pivotal role lies in its ability to provide the reliable data necessary to monitor and control all other parameters in the 6M framework. This objective evidence ensures that processes function as intended and comply with safety, quality, and structural requirements. However, in practice, challenges such as limited technical support and resources can hinder the collection of accurate data—especially for complex assessments like safety capacity or structural integrity. The absence of robust measurement tools and technical resources poses a significant obstacle to effective safety management, as it restricts an organization's ability to proactively identify, assess, and mitigate hazards based on objective evidence. There case studies for the importance of measurement in various parameters in the 6M framework in following sections.

5.7.2 Measurement with personal justification

Accurate measurement is critical for professionals who rely on precise data to make important decisions in their work. When measurement systems are flawed—whether due to uncalibrated instruments or poorly documented data—operators and technicians may be misled by incorrect information. For instance, if a technician uses a pressure gauge that gives inaccurate readings, they may believe a system is functioning safely when it is actually at risk. This mistaken belief can prompt actions that nearly result in hazardous incidents, with any narrowly avoided accidents owed more to luck or other safety controls than informed decision-making. In these situations, faulty measurement undermines human judgement and directly contributes to near misses and operational risks.

This point was illustrated by an incident in 2018 at a trendy eyewear shop in Mong Kok, Hong Kong, where questions arose about the proper measurement of eyeglass prescriptions for customers. Although the store sold glasses and contact lenses and had installed an optical measuring device to assess visitors' prescriptions, it did not employ a licensed optometrist. Store employees lacked the professional expertise required to operate the equipment appropriately.

Trouble surfaced when a reporter—posing as a customer—asked a store assistant to measure their eyeglasses' prescription. The assistant, who was untrained, placed the glasses in the machine incorrectly, with the lenses facing down and the temple arms pointed up—a reversal of the correct orientation. Nonetheless, the device produced prescription data, recording levels of nearsightedness, astigmatism, and an axis value labeled “A=163.”

To check the validity of these results, the reporter consulted a professional optometrist, sharing both the store's measurement method and the resulting data. The optometrist demonstrated the correct procedure—placing lenses up and temples down—and obtained similar readings for nearsightedness and astigmatism, but a drastically different and accurate axis value of “A=17.” The optometrist pointed out that selecting glasses based on the erroneous axis value would effectively mean wearing the lenses reversed, likely causing dizziness, blurred or distorted vision, poor spatial awareness, and potential loss of balance. Such errors would be especially dangerous while driving, increasing the risk of serious accidents or even fatalities.

Further investigation revealed that the store failed to measure other key factors, such as interpupillary distance, which is vital for ensuring that eyewear fits the wearer correctly. This incident exposed critical shortcomings in the use of proper measurement techniques, staff training, and comprehensive customer evaluation—ultimately compromising visual safety and professional standards within the store.

While human judgement in interpreting data is always important, relying solely on measurement results — especially when obtained through improper procedures or by inadequately trained personnel — can be misleading and dangerous. Personnel judgement should serve as a guide and be backed by accurate, professionally obtained data. Overconfidence in flawed measurement systems undermines safety and decision-making, and may lead to serious, sometimes catastrophic consequences. It is therefore essential for stores

and professionals to combine sound judgement with rigorously accurate measurement, ensuring that customer safety and product quality remain uncompromised.

5.7.3 Measurement for automatic driving

Advanced Driver Assistance Systems (ADAS) have become an essential component of modern vehicle safety, offering features such as lane keeping, autonomous emergency braking, and adaptive cruise control. These systems rely on a network of cameras and sensors distributed around the vehicle to monitor the road, detect hazards, and intervene when necessary to prevent accidents. However, the effectiveness of ADAS is entirely dependent on the precise calibration of these sensors. Even a minor collision, a simple repair, or something as routine as a tyre replacement can disrupt sensor alignment, compromising the system's ability to accurately interpret its surroundings. If ADAS is not properly recalibrated after such events, it may fail to activate critical safety features at the right moment or, worse, intervene inappropriately—leading to unexpected braking or swerving. This can transform otherwise avoidable incidents into dangerous near-misses or actual accidents. For instance, a misaligned sensor may not detect a pedestrian or another vehicle in time, or could trigger a false emergency response, startling the driver and other road users. By ensuring that ADAS calibration is performed by qualified technicians following manufacturer guidelines after any event that could affect sensor accuracy, repairers play a crucial role in maintaining vehicle safety. Proper calibration not only restores the intended function of safety systems but also significantly reduces the risk of near-miss accidents, protecting drivers, passengers, and everyone else on the road. In summary, correct ADAS calibration is not just a technical requirement—it is a vital safeguard against the real dangers of misinterpreted hazards and unexpected system failures, making it indispensable for preventing near-miss car accidents.

5.7.4 Measurement for the sign of material failure

Failure investigations are an essential process in industrial environments for identifying and mitigating the risks associated with material failures, aging, and degradation of components. Through systematic investigation, engineers and materials experts can detect and analyze the underlying mechanisms that lead to component breakdowns, providing essential insights that can help prevent near-miss incidents and catastrophic accidents. By employing techniques such

as the examination of fracture surfaces and cross-sectional analysis of damaged areas, investigators are able to pinpoint whether the failure was due to fatigue, ductile or brittle overload, corrosion, creep, or manufacturing defects. For instance, features such as beach marks, microvoids, and corrosion pits on the fracture surface can offer telltale signs of how a crack initiated and propagated, while microstructural analysis of polished sections can reveal secondary cracks, material inconsistencies, and service-induced degradation.

This detailed understanding allows for the implementation of targeted measurement and monitoring strategies. For example, if a failure mechanism is linked to creep due to elevated service temperatures, ongoing temperature monitoring and stress analysis can be initiated to prevent future occurrences. If cracks are found to originate from manufacturing defects, enhanced quality control and inspection regimes at the production stage can be established. Moreover, chemical analysis of corrosion products may trigger recommendations to adjust operational parameters or material selection to mitigate environmental attack. Such data-driven interventions not only optimize the planned preventative maintenance (PPM) programs, ensuring they address actual degradation threats but also enable regular condition monitoring based on known vulnerabilities identified during the failure investigation.

Ultimately, failure investigations serve as a measurement-based feedback loop, informing the continual improvement of asset reliability, operational safety, and maintenance strategies. By understanding and controlling known failure mechanisms, organizations are empowered to anticipate and address potential risks before they escalate into near-misses or serious accidents, thereby safeguarding plant availability, process safety, and public reputation. The collaboration between engineering, materials science, and operations in interpreting investigation findings forms the backbone of an effective preventative culture, making failure investigation a proactive tool for eliminating hazards connected to material failure and alleviating the risks associated with aging or overstressed components.

5.7.5 Measurement with misleading unit conversion

The Mars Climate Orbiter disaster is a cautionary tale about the critical importance of alignment in measurement methods, especially in complex, multi-organizational engineering projects. At the heart of the failure was a fundamental miscommunication: one team used the English system of measurement (pounds, inches, feet), while another operated under the metric

system (newtons, meters). This mismatch in measurement standards was not merely a trivial oversight, but a structural flaw that permeated both software and hardware processes. When crucial acceleration data generated in English units was mistakenly interpreted as metric by NASA's Jet Propulsion Laboratory, the cascade of errors ultimately resulted in the loss of a \$125 million mission. This underscores that even the most sophisticated technology and meticulous engineering can be completely undermined by a lack of standardization and clear communication in measurement systems.

Globally, the lack of a universally adopted calibration system presents similar risks across many industries, from aerospace to manufacturing and medicine. Different countries and companies may rely on varying standards for length, force, mass, temperature, and other critical parameters. If these differences are not diligently reconciled through documentation, routine checks, and cross-organization communication, the integrity and safety of a project or product can be severely compromised. Calibration systems exist to ensure that instruments and data sets are referenced against standardized units, yet discrepancies—such as those between the International System of Units (SI) and U.S. customary units—remain a perennial source of process incompatibility and potential failure.

The difference between these various calibration systems is not just in their units but also in their underlying methodologies and assumed reference points. For example, sensor outputs and control commands might be correctly calibrated within one system but will give entirely erroneous results when taken out of that context or misread by personnel from another calibration background. As seen in the Mars Climate Orbiter case, these errors are compounded when system engineering functions—tasked with integration and verification—are insufficiently robust or when operational teams are not fully versed in the design and calibration history of equipment.

Therefore, rigorous alignment and cross-checking of measurement methods are absolutely critical, particularly at transition points between organizations, teams, or operational phases. This alignment ensures that every engineer, technician, and software system involved speaks the same “measurement language,” eliminating the risk of fatal misinterpretation. In today's interconnected and globalized engineering environment, establishing clear conversion processes, shared standards, and strong systems engineering oversight not only prevents costly

errors but also builds the foundation for collaborative success and innovation well beyond planetary exploration.

5.7.6 Measurement for safe environment control

In sensitive and high-risk industries such as petrochemicals, stringent environmental control is vital for maintaining safe and effective operations. Minor deviations in physical conditions—including temperature, pressure, light, vibration, humidity, and noise—can quickly disrupt production processes, compromise product quality, and even undermine protective measures intended to safeguard personnel and equipment. Chemical factors, such as the composition of process gases and contaminant levels, are equally critical, as unanticipated changes can contribute to hazardous reactions, corrosion, or instrumentation failures. Biological hazards, including unchecked bacterial or mould growth, threaten not only production continuity but also the health of workers and the long-term integrity of facilities.

With the current trend toward refining and chemical integration, the global petrochemical industry is experiencing increased scale and complexity. This integration, while providing economic and process efficiencies, also significantly elevates the potential for diverse and compounded accident risks. The interconnected nature of integrated facilities means that minor uncontrolled environmental deviations within one unit can escalate rapidly across multiple process systems, magnifying the chances of equipment failure, chemical release, explosion, or fire. Moreover, innovative materials and advanced technologies used in large-scale petrochemical complexes often have tighter operational tolerances, making precise control of environmental parameters even more crucial.

Effective risk management in such environments depends on robust monitoring, rapid detection, and continuous adjustment of environmental factors. Advanced control systems must be employed to maintain process variables within safe ranges, detect anomalies, and prevent both acute and chronic hazards. Additionally, interdisciplinary collaboration is essential—integrating expertise from process engineering, safety management, chemical analysis, and occupational health—to ensure comprehensive oversight and response capability. As refining and chemical integration continues to drive the evolution of petrochemicals, proactive environmental control will remain a cornerstone of operational safety, preventing production failures and mitigating the likelihood of major accidents.

5.7.7 Gap analysis for measurement implementation

A comprehensive gap analysis of proper measurement compliance reveals several critical challenges and opportunities for improvement across safety management systems within industrial operations. Currently, organizations use various measurement tools and processes to monitor human competency, machine performance, material quality, method reliability, and environmental conditions. However, the efficacy of these efforts is often undermined by inconsistencies in data collection, calibration, and documentation. Technical resources may be insufficient or outdated, and not all staff involved in measurement possess the necessary qualifications or training, leading to risks of inaccurate data and compromised safety. Furthermore, discrepancies in the use of measurement units—such as the misalignment between metric and imperial systems—are a persistent source of error. In some sectors, such as retail eyewear or automotive repair, measurement responsibilities fall to underqualified individuals, diminishing the reliability of results and elevating the risk of near misses.

Ideally, organizations should strive for standardized, well-defined measurement systems that comply with recognized global standards and robust calibration protocols. All devices should be regularly maintained and checked for accuracy, and personnel undertaking measurements must be competent, certified, and frequently requalified. Data generated by measurement activities should be comprehensive, traceable, and properly documented to facilitate accurate decision-making and accountability. Importantly, measured results must be properly interpreted in context and supported by expert professional judgment. In the case of automated systems—such as Advanced Driver Assistance Systems (ADAS) in vehicles—timely recalibration by trained professionals after any relevant event is necessary to maintain safety functionality. Failure investigations should leverage detailed measurement analysis to pinpoint root causes and drive preventative action, while environmental conditions, especially in high-risk industries, require continuous and reliable monitoring enabled by advanced technology.

Key gaps identified in practice include a lack of access to modern, calibrated instruments and advanced monitoring equipment, as well as a shortage of technically proficient staff. Standardization is often lacking, with inconsistent approaches to unit selection, calibration systems, and measurement procedures seen across teams and organizations. Documentation gaps persist, with incomplete or poorly archived measurement data making traceability and post-incident analysis difficult. There is also a recurrent disconnect between measurement

findings and their integration into everyday operations, as well as challenges in maintaining robust environmental monitoring and fostering cross-disciplinary collaboration. Assurance and oversight, such as regular audits and peer reviews, may not be consistently enforced, and a unified measurement language or conversion protocol is frequently absent in multi-organizational or international projects.

To bridge these gaps, organizations must invest in state-of-the-art, regularly maintained measurement equipment and ensure that those responsible for measurement tasks receive thorough, ongoing training and professional certification. Universal adoption of international measurement standards—such as the SI system—is essential, alongside clear, organization-wide protocols for calibration, documentation, and interpretation of results. Documentation processes should be systematized to ensure that all measurement activities and findings are thoroughly recorded and easily retrievable. Measurement data should be consistently integrated into operational decision-making, supported by professional judgment, and regularly reviewed for ongoing relevance and accuracy. Automated safety systems ought to be recalibrated only by qualified technicians following any maintenance or potentially disruptive incident. Failure analysis protocols should explicitly require rigorous measurement to uncover root causes and to inform ongoing preventive efforts. Similarly, environmental monitoring systems must be technologically advanced and embedded within a broader interdisciplinary safety culture, with rapid intervention pathways for any detected anomalies. Regular audits, cross-checks, and standardized communication protocols—particularly around units and calibration in large-scale or international projects—are necessary for sustaining measurement reliability.

Ultimately, tightening measurement compliance in these ways delivers numerous benefits, including improved hazard detection, more accurate root cause analysis, better regulatory compliance, and a stronger overall safety culture. Consistent and accurate measurement practices minimize operational risks, prevent near misses and accidents, and reinforce public and stakeholder confidence. In environments defined by complexity and rapid change, the discipline of precise measurement, combined with effective assurance processes, is indispensable to both operational excellence and long-term safety. Therefore, addressing the identified gaps through targeted resource investment, training, standardization, and oversight will establish measurement as a foundational pillar of effective safety management and organizational success.

5.7.8 Meaning of measurement in safety management system

In all fields where safety, reliability, and performance are essential, the value of measurement effectiveness and assurance cannot be overstated. Accurate measurement provides the necessary foundation for operators, engineers, and decision-makers to correctly assess risks, maintain process control, and ensure the integrity of their products and systems. When measurement systems fail—whether due to poor calibration, inconsistent methods, or lack of qualified personnel—the hidden causes of near misses and actual incidents can go undetected, putting people and operations at risk.

Measurement effectiveness depends on using well-calibrated instruments, established procedures, and adequately trained staff who understand the importance of precision. Data must not only be gathered accurately but also correctly interpreted and applied. Assurance, meanwhile, requires that measurement standards are consistent throughout organizations and that conversions or changes in methods are carefully managed and communicated. Regular audits, cross-checks, and documentation practices build confidence that measurements are reliable, no matter the context.

By prioritizing effective measurement and robust assurance processes, organizations can detect and address issues before they escalate. This proactive approach minimizes the potential for errors that could slip through unnoticed and cause harm. In complex, rapidly changing environments, systematic measurement also supports coordination between teams, ensuring everyone is working with the same information and upholding the same standards.

Ultimately, the discipline and vigilance involved in maintaining effective measurement empower organizations to identify vulnerabilities early, react swiftly to anomalies, and enforce a preventative culture. This not only reduces the risk of near misses but also ensures long-term operational excellence, protecting both people and assets from the consequences of hidden and unmanaged hazards.

5.8 Hesitated areas in safety culture

5.8.1 Corner away from safety culture

The issue of safety in construction sites, particularly due to extensive subcontracting, is multifaceted and requires a comprehensive approach to ensure that all potential risks are adequately managed. The main contractor, often referred to as the tenderer of contract, has the

overarching responsibility for site management. However, when subcontractors are involved, especially if they are not well-integrated into the management framework and do not have sufficient resources, it becomes challenging for the main contractor to monitor their adherence to safety standards. This lack of monitoring can lead to significant safety oversights. Moreover, the practice of excessive subcontracting can dilute responsibility, leading to a fragmentation of accountability. As each layer of subcontracting is added, profit margins decrease, which can result in reduced investment in safety measures. This financial pressure is deteriorated by the industry's culture of rushing to meet deadlines, which can lead to safety protocols being neglected with speed and efficiency.

Furthermore, the division of responsibilities between safety officers, who focus on safety, and site managers, who concentrate on construction and progress, can create gaps in safety enforcement. In such an environment, the pressure to complete projects quickly can lead to risky behaviors and a disregard for safety measures. While upper management may allocate resources for worker training and safety initiatives, lower-tier subcontractors often operate on thin margins and may lack the financial capacity to invest in necessary safety training and equipment. This can lead to situations where workers are required to purchase their own personal protective equipment (PPE), further compromising safety.

To address these challenges, it is essential to strengthen oversight mechanisms and establish clear lines of communication and accountability across all levels of subcontracting. Main contractors should implement rigorous monitoring systems to ensure compliance with safety regulations by all subcontractors. Regular safety training should be mandated for all workers, and subcontractors should be provided with the necessary resources to conduct these trainings effectively. Risk assessments should be conducted frequently to identify and mitigate potential hazards proactively. Additionally, contracts should include clauses that hold subcontractors accountable for safety compliance, with incentives for maintaining high safety standards.

5.8.2 Safety awareness in traditional industries

The safety challenges in Hong Kong's small-scale businesses, particularly in industries like construction, are rooted in a complex interplay of economic, structural, and social factors. Economic pressures from the city's high cost of living force these businesses to prioritize

immediate financial survival over investing in safety measures, often resulting in inadequate equipment and training. This situation is compounded by the prevalence of informal labour arrangements, where temporary or casual employment without formal contracts leads to a lack of structured safety protocols. Without these formal arrangements, there is little incentive for employers to provide comprehensive safety training or equipment, leaving workers vulnerable. Furthermore, the absence of formal registration or regulatory oversight for small-scale operations means there is no systematic control or monitoring of safety practices, resulting in inconsistent safety standards across different projects and companies. When workers are required to purchase their own safety equipment, disparities in protection levels arise due to varying financial capabilities, leading to potential risks for those unable to afford adequate gear. Additionally, small groups working independently without a unified organization, such as a worker union, lack a collective voice to advocate for improved safety standards, making it difficult to implement and enforce safety measures effectively. Even with an ideal safety management system in place, its effectiveness is limited without proper implementation and enforcement at the grassroots level, resulting in a disconnect between policy and practice. Addressing these issues demands coordinated efforts to improve regulation, provide financial incentives for safety investments, and foster a culture of safety through education and collaboration across the industry.

The continued use of wooden A-frame ladders in general renovation works in Hong Kong, despite being explicitly prohibited by authorities, exemplifies the challenges in effectively promoting and implementing safety measures. This practice persists due to a combination of traditional habits, lack of enforcement, and economic considerations. Even though funding is available to small and medium-sized enterprises for purchasing safer, compliant ladder platforms, the transition to safer equipment is slow. This reluctance to change can be attributed to ingrained practices and the perceived adequacy of existing tools, despite their safety risks. The situation highlights the gap between policy intentions and actual on-the-ground practices, illustrating how safety promotions and measures often fail to penetrate deeply rooted traditional work methods. This example underscores the need for more robust enforcement, continuous education on safety benefits, and incentives to encourage the adoption of safer practices, ensuring that financial support translates into tangible safety improvements.

5.8.3 Where is near miss incident?

In traditional industries, where resources are often limited, near miss incidents are frequently overlooked because they do not result in immediate damage or injuries. However, these close calls are critical indicators of potential hazards and can highlight missing safety measures that need attention. For example, slips, trips, and falls are common occurrences, as seen when an employee nearly slips on a mopped floor lacking a wet floor sign or trips over boxes left in a walkway. These incidents suggest the need for better signage and housekeeping practices to prevent accidents. In the realm of machinery and equipment use, missing guards on machines, faulty electrical tools, and unexpected activations are near misses that underscore the importance of regular maintenance checks and safety protocols. Working at heights presents its own risks, with defective safety harnesses and unstable ladders pointing to the need for thorough equipment inspections and vigilance. Chemical handling and storage incidents, such as near mixes of incompatible chemicals and leaking gas cylinders, emphasize the necessity for stringent storage guidelines and proper labeling practices. Failures in signage and communication, like missing traffic flow signs leading to near collisions, reveal gaps in workplace communication and the importance of clear hazard warnings. Lastly, risky behaviors and horseplay, such as jumping from a truck tailgate or climbing shelving units, highlight the need for enforcing safe practices and educating employees on the risks of unsafe actions. Evaluating these near miss incidents allows organizations to proactively address these overlooked areas, ultimately enhancing workplace safety and preventing future accidents.

In small-scale or one-man businesses, the lack of formal reporting, follow-up, or corrective actions for near miss incidents can lead to significant risks remaining unaddressed.

Without proper reporting mechanisms, near miss incidents often go unnoticed or unrecorded. This invisibility means that workers, including the proprietor in a one-person operation, may not recognize the recurring hazards present in their daily operations. As these potential dangers are not documented, they fail to become part of the business's safety narrative, leaving them unaddressed and persistent.

When near misses are not followed up with discussions or evaluations, workers remain unaware of the risks associated with their tasks. This lack of awareness leads to complacency, as there is no perceived urgency to change behaviors or improve safety practices. Employees

may continue to engage in risky behaviors or operate in hazardous environments, thinking that past incidents were isolated events rather than indicators of systemic issues.

Without corrective actions, the conditions that led to near misses remain unchanged. For example, if a slippery floor is not addressed with appropriate signage or improved cleaning practices, the risk of slipping persists. Similarly, faulty tools or equipment, if not repaired or replaced, continue to pose a threat to safety. This absence of intervention allows hazards to accumulate, increasing the likelihood of an actual accident occurring.

The true extent of the problem often only becomes apparent when an accident occurs. By then, the opportunity to prevent the incident through proactive measures has been lost. This reactive approach can result in more severe consequences, including injuries, financial losses, and disruptions to business operations.

To combat these issues, small-scale businesses should prioritize creating simple yet effective systems for reporting near misses. Encouraging open communication about safety concerns and fostering a culture of vigilance can help identify risks early. Implementing regular reviews of operations to spot hazards and making incremental improvements can significantly enhance safety without the need for extensive resources.

To effectively enhance safety measures for near miss incidents in small-scale or one-man businesses, statutory regulations can serve as a pivotal tool. Simplified reporting systems should be mandated, providing easy-to-use templates or digital platforms that enable proprietors to log incidents swiftly without the burden of extensive paperwork. Furthermore, regulations should require basic safety training for all business owners and employees, irrespective of business size, with free or subsidized sessions focusing on hazard recognition and prevention strategies tailored to small-scale operations. Regular safety inspections should be implemented, utilizing local government resources to identify potential hazards and ensure compliance, or offering guidelines for self-assessment. Incentive programs can be established, providing tax breaks, grants, or recognition awards to businesses that actively engage in risk management and incident prevention. Access to safety resources should be guaranteed through centralized online hubs offering templates, checklists, and best practices for safety management. Encouraging community-based safety networks like worker union or working group would allow small business owners to share experiences and solutions, facilitated by regular meetings and collaborative initiatives. Enhanced communication channels, such as hotlines or online

platforms, should be established for immediate hazard reporting and guidance on corrective actions. By integrating these measures into statutory regulations, governments can empower small-scale businesses to adopt effective safety practices, ultimately improving workplace safety and supporting sustainable business growth by minimizing accident-related disruptions. However, effectiveness of statutory regulations is the next hesitated area in this analysis.

5.8.4 Effectiveness of statutory regulations

The effectiveness of statutory regulation for safety measures in Hong Kong appears limited, despite legislative amendments aimed at strengthening occupational health and safety standards. The Occupational Safety and Occupational Health Legislation (Miscellaneous Amendments) Ordinance 2023 now allows for higher maximum fines and imprisonment, yet the average fines imposed remain low, around \$9,000 per conviction, suggesting these penalties are insufficient to deter violations. Statistics reveal that after the amendments, over 3,500 industrial accidents were prosecuted, yet the average fine was only about \$8,311, a mere 4.6% increase compared to the average fine of \$7,942 before the ordinance's passage. Enforcement has increased, with more conviction summonses issued, but the judiciary's tendency to impose lenient penalties diminishes the impact of these efforts, highlighting a disconnect between legislative intent and judicial outcomes.

One case involved a fatal accident at a wood factory in Sha Ling, where a worker lost his life. The company responsible was found to have violated workplace safety regulations and was fined HK\$120,000. However, the driver of the machinery involved in the incident was not prosecuted, leading to disappointment and frustration among the victim's family and labor rights advocates.

Another incident occurred at the AIA Tower in Kwun Tong in April 2023, where a cleaner fell to his death down an elevator shaft. The individuals involved, the employer, and the property management company were all charged with failing to ensure workplace safety. Yet, the case was ultimately dropped due to insufficient evidence, which in turn resulted from prosecution witnesses refusing to accept subpoenas or testify in court. This meant the case never even reached trial, denying the victim's family any chance for justice. Judicial inaction is evident, as cases are often not prosecuted adequately due to "insufficient evidence," exacerbated by procedural issues like witnesses refusing subpoenas, leading to cases being dropped and

employers escaping accountability. The incident at the AIA Kowloon Tower in Kwun Tong, where a cleaning worker fell down an elevator shaft and died, illustrates challenges in the effectiveness of statutory regulation for workplace safety in Hong Kong. Although charges were filed against the parties involved for violations of the Occupational Safety and Health Ordinance, these charges were ultimately dropped due to insufficient evidence. This insufficiency was attributed to prosecution witnesses who declined subpoenas and did not appear in court, resulting in the case's termination without trial. This situation highlights difficulties in the judicial process related to occupational safety cases, where enforcement of regulations and accountability can be hindered by procedural obstacles. The broader context of Hong Kong's capitalist society, where legal equality is sometimes questioned, may further impact the rigorous application and enforcement of safety regulations, indicating areas where statutory regulation may be improved to better ensure workplace safety and justice.

These cases exemplify the recurring problem of workplace fatalities in Hong Kong, where even clear violations of safety laws often result in minimal punishment or no accountability at all, leaving families of victims without closure and undermining confidence in the legal system's ability to protect workers.

Systemic inefficiencies are apparent in the disparity in how different types of cases are handled, with industrial safety cases often taking longer or being less prioritized compared to other criminal cases, reflecting inefficiencies within the judicial system. The findings indicate a notable difference in the handling of occupational health and safety cases compared to other legal matters by the Department of Justice. While only a limited number of cases involving lenient penalties for workplace safety violations have been reviewed, many remain pending due to extended judicial procedures. In contrast, appeals in murdering cases are processed more swiftly, despite their complexity. This suggests that occupational safety cases, which are generally simpler, may not receive the same level of attention and urgency. The disparity in the efficiency of case handling raises questions about the prioritization of different types of legal matters. It highlights an opportunity for the Department of Justice to ensure more balanced and equitable attention to regulations that affect public safety and well-being. Social and economic influences, particularly the capitalist nature of Hong Kong's society, may further skew priorities towards economic interests over worker safety, affecting the rigorous application of safety regulations. This discrepancy between the law's intent and its real-world application signals a systemic failure to hold employers accountable for endangering workers' lives.

Enforcement is further hampered by judicial indifference and weak prosecutorial action. The courts continue to issue light penalties even in cases involving fatalities, and the Department of Justice rarely appeals against lenient sentences. In some cases, prosecutions collapse entirely due to procedural failures, such as witnesses refusing to testify or receive subpoenas, leaving victims' families without even the opportunity for a hearing. This not only denies justice to those affected but also signals to employers that the risk of serious consequences for safety violations is minimal.

The cases also draw attention to a troubling pattern of social inequality reflected in legal outcomes. Workers, often from the most vulnerable segments of society, see the value of their lives diminished in the justice system compared to affluent or high-profile defendants, whose cases are handled with greater care and urgency. The contrast exposes a gap between the ideal of equality before the law and the reality experienced by ordinary workers. The failure to impose substantial penalties or ensure rigorous prosecutions perpetuates a culture where workplace safety is neglected and employers feel emboldened to cut corners.

In summary, the legislative reforms aimed at improving workplace safety in Hong Kong have been undermined by weak enforcement, light sentencing, procedural inadequacies, and social bias. For the law to serve its intended purpose, there must be a commitment to imposing meaningful penalties, improving prosecutorial diligence, ensuring robust evidence collection, and upholding the principle that every life is of equal value. Without such changes, workplace fatalities will continue to be met with impunity, and the promise of legal protection for workers will remain unfulfilled. While statutory regulations exist, their effectiveness is compromised by enforcement and judicial challenges, as well as broader societal influences, resulting in insufficient protection for workers and inadequate accountability for employers. To improve effectiveness, there needs to be a concerted effort to better align judicial practices with legislative intent, enhance evidence collection processes, and ensure penalties are significant enough to deter violations.

5.9 Next steps in coming generations

5.9.1 Safety introduction prior to working

The development of safety personnel for future generations requires a shift from the traditional approach of introducing safety only at the onset of employment, such as through

orientation briefings or workplace policies. Historically, safety has been treated as a secondary concern in educational institutions, where technical and academic subjects take precedence and safety topics are often optional. This has led to a workforce that may lack a foundational understanding of safety principles, which only becomes relevant once they enter hazardous environments.

To foster a robust safety culture, it is essential to integrate safety principles into students' decision-making processes from an early age. By normalizing safety as a fundamental consideration in both academic and daily life, individuals will carry a safety-oriented mindset into their professional careers. This proactive approach is especially crucial in today's results-driven world, where the pressure to deliver outcomes can sometimes overshadow the importance of safe practices.

Introducing safety culture early can directly address personnel factors that contribute to near miss incidents in the workplace. Human error, inadequate training, complacency, poor communication, stress, inexperience, unsafe behaviors, and distractions are all significant contributors to such incidents. Early education in safety helps reduce human error and inexperience by instilling habits of caution and risk assessment. It also combats complacency and overconfidence, fostering continuous vigilance and respect for potential hazards. Improved communication and teamwork are natural outcomes of embedding safety in education, while training on recognizing personal limits can help individuals manage stress and fatigue. Moreover, when safety is normalized, unsafe behaviors become less socially acceptable, and individuals are better equipped to remain attentive in distracting environments.

Moving forward, the next step in safety personnel development should focus on integrating safety education into core curricula at all levels, from schools to universities. This includes practical exercises, case studies, and the use of technology such as simulations and e-learning platforms to make safety training engaging and relevant. Continuous reinforcement through workshops, competitions, and industry partnerships can sustain interest and ensure alignment with real-world expectations. Ultimately, by embedding safety culture early and consistently, future generations will be better prepared to recognize, assess, and manage risks, thereby reducing personnel factors that lead to near miss incidents and creating safer, more resilient workplaces.

Rather than viewing near miss incidents as mere strokes of luck or situations to be ignored, organizations and personnel should treat them as valuable opportunities for improvement. Workers must move beyond simply hoping for good fortune and instead heighten their awareness of abnormal performance, taking immediate action whenever there is a sense of potential risk. This means fostering a culture where individuals feel a strong responsibility to identify and report hazards, rather than adopting a passive “easy come, easy go” attitude that leaves dangers for others to deal with. Aggressive safety development should educate personnel not only to recognize near misses but also to actively participate in investigating such incidents, promptly identifying deficiencies, and implementing proactive action plans to prevent future occurrences. By shifting the perspective on near misses—from fortunate escapes to critical learning moments—organizations can drive continuous improvement, empower workers to take ownership of safety, and create a more resilient workplace where hazards are systematically addressed rather than overlooked.

5.9.2 Technique ready before incident happens

The next generation of safety culture for machines and equipment will be fundamentally transformed by the integration of artificial intelligence (AI) into monitoring and prediction processes. Currently, safety management relies heavily on setting physical limit values and utilizing centralized computer controls. Emergency action plans are triggered only when specific thresholds are exceeded. However, the effectiveness of these systems is often limited by static settings, which may become inaccurate over time due to equipment aging, malfunctions, false alarms, or human oversight. This reactive approach means that hazards are often addressed only after they have already posed a risk, and safety awareness is typically heightened only after incidents have occurred.

To move beyond these limitations, future safety systems should leverage AI for dynamic, predictive monitoring. AI can continuously analyze real-time data from machines—such as vibration, temperature, and pressure—to learn and adapt to the equipment’s normal operating patterns. Unlike static thresholds, AI models can adjust to the changing conditions of aging equipment and evolving environments, recognizing subtle deviations that may indicate developing hazards. By predicting unsafe conditions before they escalate into incidents, AI can provide contextual and highly relevant alerts, significantly reducing the occurrence of false alarms and ensuring that warnings are not ignored by operators.

Moreover, AI can play a pivotal role in identifying and addressing near-miss events and hidden hazards. Using technologies such as digital twins, AI can simulate countless scenarios to anticipate possible failures or unsafe outcomes. By mining data from past incidents and near-misses—both within and across organizations—AI systems can extract valuable patterns and early warning signs, informing real-time monitoring and preventive actions. This creates a feedback loop where every anomaly, near-miss, or even false alarm helps refine the system's accuracy and predictive power.

Human-machine collaboration will also be redefined in this new safety culture. Operators will benefit from personalized safety education, receiving timely notifications and actionable suggestions tailored to their specific tasks and observed behaviors. Virtual safety coaches powered by AI can offer real-time guidance, prompting operators to consider potential hazards before they become critical. This proactive engagement enhances situational awareness and transforms operators into active participants in safety management, rather than passive responders to alarms.

In the future, emergency action plans will be revolutionized by the capabilities of AI-driven scenario analysis. Traditionally, organizations have relied on static, pre-defined procedures to respond to emergencies, which may not always account for the dynamic and unpredictable nature of real incidents. With advanced AI, these procedures can be replaced or supplemented by adaptive strategies that are continuously updated in real time as situations unfold. AI systems can assess the current state of the environment by analyzing data from a wide array of sensors and sources, allowing for rapid and accurate risk assessments that reflect the true context of the emergency.

When an emergency occurs, AI will consolidate and interpret all available physical parameters from the affected site. This could include monitoring temperature fluctuations, identifying heat sources, measuring electric current around utilities, detecting abnormal vibrations and sounds, and even tracking the heartbeats of personnel in the area. By integrating these diverse data points, the AI system can immediately estimate the severity and nature of the risk, enabling it to formulate the most effective and efficient rescue plan without delay. For example, if a fire breaks out in a factory, the AI could instantly pinpoint hotspots, assess smoke density, determine the safest routes for evacuation, and identify any personnel in distress based on biometric feedback.

Moreover, AI will empower emergency responders with cutting-edge tools and real-time support. Equipment such as virtual reality goggles could provide firemen or rescue teams with up-to-the-minute visualizations of the site, highlighting danger zones and safe passages. Integrated communication platforms would ensure seamless coordination among team members and command centers, while online instructors could guide personnel through complex procedures as they navigate the emergency. AI could also dynamically update escape routes, taking into account the evolving conditions, such as blocked exits or spreading hazards, and directing responders to the safest and quickest way out.

By leveraging these advanced technologies, emergency action plans will become not only more responsive and effective but also highly adaptable to the unique demands of each situation. This approach places the highest priority on the safety of personnel and the protection of equipment, ensuring that rescue operations are executed with maximum efficiency and minimal risk. Ultimately, the integration of AI into emergency response will set a new standard for workplace safety, transforming how organizations prepare for and respond to critical incidents.

Ultimately, the evolution of safety culture will shift from a focus on compliance and rule-following to a proactive, continuously learning system. By anticipating and preventing hazards before they occur, empowering workers with real-time insights, and systematically incorporating lessons from every experience, organizations can create a resilient and adaptive safety environment. This transformation will make safety a living, evolving practice—one that not only protects people and assets but also fosters a culture of shared responsibility and continuous improvement.

5.9.3 Coming techniques for incident prediction

Workplace safety is a critical concern for organizations across all industries, as even minor incidents can lead to serious accidents if not properly managed. Traditionally, safety management has focused on reacting to accidents after they occur, but recent advances in technology and data analytics are enabling a more proactive approach. Central to this shift is the effective management of "near miss" incidents—events that could have resulted in injury or damage but did not. By systematically capturing and analyzing near miss data, organizations can identify underlying risks and prevent future accidents before they happen. The development of a comprehensive Near Miss Incident Management System, highlighting key techniques such

as automated detection, natural language processing (NLP)-based reporting, wearable technology integration, and advanced predictive analytics inspired by the U.S. Coast Guard's MISLE database may explore state-of-art techniques for incident prediction. Through an examination of the principles, details, and real-world case studies for each technique, which will demonstrate how these tools can transform safety management from reactive to predictive, ultimately creating safer and more resilient workplaces.

- Automated Detection

Automated detection uses AI-enabled cameras and IoT sensors to continuously monitor the workplace for unsafe behaviors, hazardous conditions, or equipment misuse. The principle behind this technique is real-time, objective observation: algorithms trained on large datasets recognize patterns and anomalies that may indicate a near miss or imminent risk. For example, computer vision can spot workers entering restricted areas or failing to use protective equipment. A case study in manufacturing showed that automated detection systems reduced unreported near miss events by over 40%, as they captured incidents invisible to routine manual inspections. By automatically flagging these events and sending instant alerts to safety personnel, organizations can respond faster and gather more comprehensive data, laying the groundwork for a proactive safety culture.

- NLP-Based Reporting

Natural Language Processing (NLP) simplifies the reporting of near miss incidents by allowing workers to submit descriptions via speech or text, which AI then interprets and categorizes. The principle here is accessibility: lowering barriers to reporting ensures a larger and more accurate dataset. NLP algorithms parse free-form language, extracting relevant safety details and standardizing reports for analysis. In a logistics company case study, implementing an NLP-powered mobile app increased near miss reporting rates by 60%, as employees found it easier and less intimidating to share observations. By making reporting effortless and intuitive, organizations can capture a wider spectrum of near misses, enabling more effective risk assessment and intervention.

- Wearables Integration

Wearable technology, such as smart helmets, wristbands, or vests, continuously monitors worker movements, vital signs, and environmental exposures. The principle is continuous, personalized surveillance: wearables detect incidents like falls, fatigue, or close proximity to dangerous equipment, and transmit alerts in real-time. In the construction industry, a case study involving smart helmets showed a 25% reduction in serious incidents after near misses detected by wearables prompted timely interventions. By providing objective data and immediate feedback to both workers and safety teams, wearables help prevent minor incidents from escalating, improve situational awareness, and promote safer work habits.

- Predictive Analytics and the MISLE Database

Predictive analytics leverages historical and real-time incident data to forecast future risks, using AI/ML models like random forest decision trees. The principle is learning from patterns: analyzing near miss trends to anticipate where and when serious incidents are likely to occur. A notable case study is the U.S. Coast Guard's (USCG) use of the Marine Information for Safety and Law Enforcement (MISLE) database, which collects minor incident data from waterways. By applying machine learning, the USCG found that near miss counts could predict future casualties with high accuracy (92–99.9%). Monthly, R-based models were used to identify high-risk waterway-vessel combinations, enabling targeted preventive actions. This approach demonstrates how aggregating and analyzing near miss data transforms safety management from reactive to predictive, empowering organizations to intervene before accidents happen.

Each technique above brings unique strengths — objective monitoring, accessible reporting, personalized surveillance, and data-driven foresight — supported by real-world case studies that highlight their effectiveness. Together, these principles and technologies enable organizations to proactively manage risks, reduce workplace accidents, and foster a robust culture of safety.

5.9.4 Market for correct sourcing

The strategic development of a transparent digital market platform should begin with a centralized, exhaustive database that includes all material categories relevant to diverse

industries such as electronics, construction, manufacturing, and healthcare. This universal repository enables dynamic classification and precise categorization of materials by application, certification, regulatory standards, and risk profiles—ensuring that every item is clearly distinguished and easily accessible. Real-time integration with regulatory bodies and certification agencies keeps all listings and compliance data current, further supporting the accuracy and reliability of the platform.

Advanced verification processes are integral to this system, with AI-driven algorithms that automatically cross-check product specifications against regional and global standards, instantly flagging non-conforming items. Each material entry is accompanied by digital certificates, audit trails, and inspection records, which are readily accessible to all stakeholders. The platform's risk alert system proactively warns users about materials with known hazards or compliance issues, helping to prevent near-miss incidents and inadvertent supply chain contamination.

Accountability and traceability are enhanced through comprehensive supplier profiles displaying full product ranges, compliance records, and performance ratings. Blockchain technology can be leveraged to record every transaction and material movement, ensuring tamper-proof traceability from sourcing to installation. Feedback and rating systems allow clients, project managers, and inspectors to review and rate suppliers and materials, incentivizing ethical practices and continuous improvement throughout the market.

Decision support features empower buyers and project managers with advanced search, comparison, and recommendation tools, ensuring that their selections meet all technical, safety, and regulatory requirements. Lifecycle tracking capabilities monitor materials from initial sourcing through installation and maintenance, facilitating end-to-end quality assurance and compliance. Integrated incident reporting modules enable rapid resolution of compliance breaches or quality failures, supporting swift corrective action and reinforcing trust in the platform.

Globalization is a cornerstone of this ideal platform. By bridging international markets and harmonizing standards, stakeholders benefit from tools that allow for straightforward comparisons of products from different regions based on unified criteria. Multilingual and multi-currency support ensures accessibility for users worldwide, while collaboration with

international standardization bodies promotes the adoption of common safety and quality benchmarks across borders.

Continuous improvement is fostered through a centralized knowledge hub, providing access to training materials, regulatory updates, and best practices. Industry forums and collaboration spaces facilitate dialogue among manufacturers, suppliers, regulators, and clients, helping to address emerging risks and drive innovation. Data analytics tools aggregate platform usage data to identify trends, common risks, and areas for improvement, feeding insights back into industry standards and supplier development initiatives.

Proactive risk management is achieved through automated exclusion of non-compliant suppliers and materials, maintaining the integrity of the marketplace. Transparent performance metrics foster healthy competition, encouraging suppliers to uphold and exceed standards. The platform's verification mechanisms and transparency significantly reduce the risk of near-miss incidents and systemic failures, safeguarding projects and reputations.

The impact of such a platform is felt across all stakeholders. Manufacturers and builders can confidently source fully vetted, certified materials, minimizing the risk of mistakes or regulatory breaches. Suppliers are incentivized to maintain compliance and innovate, as their market reputation depends on verified performance and transparency. Project managers and service providers rely on the platform for real-time verification and documentation, streamlining quality assurance throughout the project lifecycle. Regulators benefit from consolidated, accessible data that enables efficient monitoring and enforcement, while clients and end-users enjoy safer, higher-quality products and services with clear provenance and compliance documentation.

In summary, a transparent, digital, and global marketing platform centered on quality, safety, and compliance redefines industry standards by empowering all stakeholders, minimizing risks, and fostering a self-improving ecosystem where only the best practices and products prevail. This approach streamlines procurement and project management, elevates trust and accountability, and enhances safety across the entire supply chain, making it a foundational element for modern, resilient industries.

5.9.5 Control of non-compliance safety implementation

To advance workplace safety and effectively eliminate near-miss incidents, industries must embrace a proactive, next-generation mitigation strategy that builds on foundational safety principles. Central to this approach is the adoption of intelligent risk assessment tools powered by artificial intelligence and predictive analytics. Through the integration of IoT sensors and big data evaluation, organizations can continuously monitor equipment, environments, and behaviors, enabling the early identification and mitigation of potential hazards. Training programs should evolve to become dynamic and highly personalized, leveraging adaptive e-learning platforms, immersive virtual reality simulations, and gamified micro-learning to keep safety education relevant, engaging, and tailored to specific job roles and risk profiles.

Equipping employees with advanced personal protective equipment is essential; the use of smart wearables that monitor vital signs and environmental conditions, coupled with automated compliance tracking, will ensure both optimal protection and accountability. Safety management systems should transition to digital, cloud-based solutions that automate documentation, facilitate instant mobile hazard reporting, and use AI to coordinate complex safety drills and evaluate readiness. Fostering a proactive safety culture is also key: empowering employees through peer-led committees, anonymous feedback channels, and incentive programs for exemplary safe behavior will encourage engagement and openness.

Continuous alignment with evolving regulations is crucial, achieved by subscribing to automated regulatory updates, participating in collaborative industry safety consortiums, and conducting regular audits to future-proof safety protocols. Harnessing robotics, automation, and drone surveillance for hazardous or repetitive tasks further minimizes exposure and enhances hazard identification, while integrating AI-powered incident prediction models into operational planning increases resilience. Finally, holistic well-being programs—including mental health support, work-life balance initiatives, and ergonomic resources—recognize the role of wellness in maintaining safe behavior and reducing error. By systematically integrating these advanced strategies, industries can significantly enhance workplace safety, reduce the likelihood of near-miss incidents, and build a foundation for long-term operational excellence and employee well-being.

5.9.6 Corner away from safety measures

Even with robust safety measures and proactive support, the possibility of incidents or accidents cannot be entirely eliminated. The dynamic and complex nature of construction environments — where men, machines, materials, methods, milieu (environment), and measurement interact — ensures that variables beyond complete control will always exist. This “black hole” of hidden risks persists despite our best efforts, as every worksite functions as a unique system with unpredictable points of failure. Human error, equipment malfunction, material flaws, rapid changes in environmental conditions, procedural gaps, and undetected risk factors in monitoring systems are all examples of how incidents may occur even when all safety protocols have, so far as is reasonably practicable, been executed.

While the goal is always to eliminate danger completely, the reality is that risks can only be reduced to the lowest practicable level. Achieving this requires a commitment to continuous improvement, meaning safety procedures and controls must be regularly updated to respond to new or evolving risks. Organizations should adopt a learning approach, treating near-misses and incidents as opportunities to strengthen safeguards. Encouraging open communication, where workers feel free to report hazards without fear of blame or penalty, is essential for surfacing risks that might otherwise remain hidden. Additionally, flexibility in planning and operations allows for the adaptation of methods and controls to fit changing circumstances, and integrating safety considerations into every aspect of work—rather than treating them as an afterthought—further embeds risk awareness across all levels.

Since the complete elimination of hazards is beyond reach, the industry’s priority must shift to building a proactive safety culture for both current and future generations. This begins with education and empowerment, ensuring that everyone involved is trained to recognize, assess, and respond to hazards — not merely to comply with rules, but to truly understand and engage with safety values. Active leadership is necessary, with those in authority modeling safe behavior and consistently prioritizing safety in decision-making. Continued investment in technological innovations — such as advanced monitoring tools and risk assessment systems — can further enhance the industry’s ability to detect and control hazards. Collaborative problem-solving, involving authorities, businesses, and workers, helps to ensure that no risks go unaddressed, and resilience planning prepares teams for emergencies or unexpected events.

In conclusion, while the “black hole” of risk can never be fully closed, its impact can be dramatically reduced through ongoing vigilance, education, and a culture of shared responsibility. As the construction industry evolves, its approach to safety must move beyond basic compliance toward continuous improvement, open communication, and a collective commitment to making workplaces as safe as they can feasibly be. Although perfect safety may always remain out of reach, steadfast dedication to these principles will help protect all workers and set a positive example for generations to come.

CHAPTER SIX

CONCLUSION

The evolution of occupational safety and health (OSH) within Hong Kong's construction industry has demonstrated remarkable progress through legislative reforms, enhanced training, and the adoption of systematic risk management strategies. These efforts have led to tangible reductions in accidents and fatalities, affirming the positive impact of sustained commitment to safety. Nonetheless, persistent challenges remain, particularly those rooted in complex subcontracting arrangements, fragmented accountability, resource limitations in smaller enterprises, and inconsistent implementation of safety protocols. Cultural resistance and inertia further hinder the effectiveness of even the most robust health and safety initiatives, underscoring the necessity for deeper organizational transformation.

A pivotal insight from this research is the transformative potential of near-miss incident investigation in fostering a proactive, resilient safety culture. Near-miss events, which are often underreported or inadequately analyzed, provide critical intelligence on latent hazards, procedural vulnerabilities, and the interplay of human and systemic factors. By systematically investigating and learning from near-misses, organizations can shift from a reactive posture to one of continuous improvement, embedding risk identification and organizational learning into everyday practice. This approach is most effective when supported by open communication, comprehensive root cause analysis, and timely remedial action, all within a culture that encourages reporting without fear of reprisal.

Technological innovation is poised to redefine the future of OSH management. The integration of artificial intelligence, predictive analytics, wearable technologies, and digital platforms will enable organizations to monitor environments more effectively, detect anomalies swiftly, and capture near-miss data in real time. These advancements will drive the transition from compliance-based models to dynamic, data-driven safety systems that anticipate hazards and support informed decision-making, further personalizing safety education and interventions.

Central to sustainable improvement is the rigorous application of the 6Ms framework—Men (Personnel), Machine (Equipment), Materials, Method, Milieu (Environment), and Measurement. This thesis highlights the need for comprehensive safety education and competency development across all career stages, rigorous inspection and predictive

monitoring of equipment, robust sourcing and traceability of materials, continual refinement of operational procedures, vigilant environmental risk assessment, and sophisticated measurement systems. Prioritizing near-miss analysis within each element of the 6Ms framework amplifies the potential for continuous improvement and risk reduction.

To move decisively towards eliminating near-miss incidents and entrenching a strong safety culture, organizations should reinforce their safety strategies through an enhanced application of the 6M framework:

- Men (Personnel):

Prioritize continuous safety education and competency development from early education through all career stages. Foster an environment where safety is internalized as a personal and shared value. Cultivate open communication and reporting, especially for near-miss events, through leadership modeling and peer-driven initiatives.

- Machine (Equipment):

Institute rigorous inspection, maintenance, and upgrading of all machinery and tools. Integrate predictive systems and AI to monitor equipment health, detect anomalies, and flag precursors to near-miss events before they escalate.

- Material:

Strengthen material sourcing, certification, and traceability through digital platforms and global standards. Regularly test incoming materials for compliance and foster collaboration with suppliers to uphold stringent safety and quality benchmarks.

- Method:

Ensure all operational procedures, method statements, and risk assessments are robust, updated, and strictly enforced. Integrate learnings from near-miss investigations into procedural updates and ongoing safety drills, allowing flexibility to adapt procedures in response to feedback and situational change.

- Milieu (Environment):

Conduct continual risk assessments of site and environmental factors, including confined spaces, weather, and evolving worksite dynamics. Deploy environmental sensors and

create rapid-response mechanisms for any identified deviation from safe working conditions.

- **Measurement:**

Develop sophisticated measurement and monitoring systems, with clear metrics for tracking not only accidents but also near-misses and leading safety indicators. Utilize big data analytics to identify trends, root causes, and predictive patterns, informing real-time decision-making and continuous system improvement.

Addressing the specific research objectives, this study has identified critical gaps between current OSH practices and desired standards, particularly in the alignment of top management commitment with front-line engagement, the competency of maintenance personnel, the prioritization of material quality, the allocation of time for effective training, the integration of environmental considerations, and the calibration of measurement systems. By conducting thorough root cause analyses and implementing targeted interventions, organizations can bridge these gaps, ensuring that health and safety measures are not only adopted but also sustained over time.

Looking ahead, the advancement of OSH in Hong Kong's construction industry—and beyond—depends on early integration of safety values into education, transparent digital systems for compliance, and adaptive regulatory frameworks that incentivize excellence while supporting vulnerable sectors. As human-machine collaboration deepens and safety becomes ingrained in policy and organizational culture, the paradigm will shift from reactive compliance to proactive risk anticipation and prevention.

Ultimately, the sustained enhancement of occupational safety and health relies on the collective commitment of policymakers, industry leaders, educators, and the workforce. Through a collaborative, holistic approach—grounded in education, empowered reporting, robust analysis, and continual adaptation—organizations can realize the ideal of a safe, resilient, and just working environment. By embedding near-miss investigation at the core of an enhanced 6M strategy, supported by technological innovation and empowered leadership, Hong Kong's construction industry is well-positioned to achieve operational excellence, minimize harm, and build enduring public trust for generations to come.

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