Faculty of Economics and Business

The Influence of Organizational Culture in Construction Safety Performance: the Moderating Role of Workforce Skill

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The Influence of Organizational Culture in Construction Safety Performance The Moderating Role of Workforce Skill

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ABSTRACT

Construction projects continue to experience high accident rates despite the growing adoption of safety management systems, suggesting that technical measures alone are insufficient to ensure safe operations. A critical yet often underexplored issue lies in understanding how organizational culture (OC) shapes construction safety performance (CSP) and why similar safety systems produce different outcomes across organizations. Furthermore, existing studies have paid limited attention to the role of workforce skill (WS) in strengthening or weakening the influence of organizational culture on safety performance.

To address these gaps, this research develops a theoretical framework integrating seven dimensions of organizational culture-organizational values (OC1), management strategy (OC2), management/organizational style (OC3), organizational structure (OC4), managerial behaviour (OC5), employee participation (OC6), and team collaboration (OC7). Partial Least Squares Structural Equation Modelling (PLS-SEM) was employed to validate the hypothesized relationships.

The results demonstrate that all seven cultural dimensions exert significant positive effects on construction safety performance, with managerial behaviour (OC5) emerging as the strongest predictor due to its direct influence on on-site safety supervision and leadership. Team collaboration (OC7) further enhances safety coordination through efficient communication and shared responsibility, while organizational structure (OC4) provides essential institutional support. Organizational values (OC1) and management strategy (OC2), although showing relatively smaller direct impacts, form the cultural foundation that sustains long-term safety practices.

The analysis also reveals important moderating effects of workforce skill. High-skilled workers amplify the positive influence of key cultural dimensions-especially organizational values, managerial behaviour, and team collaboration-whereas the moderating effects on management strategy and organizational structure appear insignificant, likely due to their reliance on systemic processes rather than individual competencies.

Through path analysis, this research elucidates the multi-layered ways in which organizational culture influences construction safety performance. Behavioural guidance approaches directly shape employees' safety behaviours, with managerial behaviour and team collaboration enhancing safety awareness and accountability. Process optimization strategies, supported by management policies and organizational structure, improve the systemic efficiency and adaptability of safety management. Cultural shaping factors, driven by organizational values and employee participation, cultivate a safety-oriented organizational environment through long-term cultural transmission and proactive employee engagement.

By integrating multidimensional organizational culture with safety performance pathways and incorporating the moderating role of workforce skill, this research provides new empirical evidence and enriches theoretical understanding of how culture-driven mechanisms shape safety outcomes in construction organizations and also provides practical guidance for construction firms seeking to enhance safety performance through culture-driven management strategies.

Keywords: Organizational culture, construction safety performance, workforce skill, moderation effect, PLS-SEM

Pengaruh Budaya Organisasi terhadap Prestasi Keselamatan Pembinaan: Peranan Moderasi Tahap Kemahiran Tenaga Kerja

ABSTRAK

Projek pembinaan terus mengalami kadar kemalangan yang tinggi walaupun penggunaan sistem pengurusan keselamatan semakin meningkat, menunjukkan bahawa langkah teknikal sahaja tidak mencukupi untuk memastikan operasi yang selamat. Isu kritikal namun sering kurang diterokai terletak pada pemahaman bagaimana budaya organisasi (OC) membentuk prestasi keselamatan pembinaan (CSP) dan mengapa sistem keselamatan yang serupa menghasilkan hasil yang berbeza merentas organisasi. Tambahan pula, kajian sedia ada telah memberi perhatian terhad kepada peranan kemahiran tenaga kerja (WS) dalam mengukuhkan atau melemahkan pengaruh budaya organisasi terhadap prestasi keselamatan.

Untuk menangani jurang ini, penyelidikan ini membangunkan rangka kerja teori yang mengintegrasikan tujuh dimensi budaya organisasi-nilai organisasi (OC1), strategi pengurusan (OC2), gaya pengurusan/organisasi (OC3), struktur organisasi (OC4), tingkah laku pengurusan (OC5), penyertaan pekerja (OC6), dan kerjasama pasukan (OC7). Pemodelan Persamaan Struktur Kuasa Dua Terkecil Separa (PLS-SEM) telah digunakan untuk mengesahkan hubungan yang dihipotesiskan.

Keputusan menunjukkan bahawa kesemua tujuh dimensi budaya memberikan kesan positif yang ketara terhadap prestasi keselamatan pembinaan, dengan tingkah laku pengurusan (OC5) muncul sebagai peramal terkuat kerana pengaruh langsungnya terhadap penyeliaan dan kepimpinan keselamatan di tapak. Kerjasama pasukan (OC7) meningkatkan lagi penyelarasan keselamatan melalui komunikasi yang cekap dan tanggungjawab bersama,

manakala struktur organisasi (OC4) menyediakan sokongan institusi yang penting. Nilai organisasi (OC1) dan strategi pengurusan (OC2), walaupun menunjukkan kesan langsung yang agak kecil, membentuk asas budaya yang mengekalkan amalan keselamatan jangka panjang.

Analisis itu juga mendedahkan kesan penyederhanaan penting kemahiran tenaga kerja. Pekerja berkemahiran tinggi menguatkan pengaruh positif dimensi budaya utama-terutamanya nilai organisasi, tingkah laku pengurusan dan kerjasama pasukan-manakala kesan penyederhanaan terhadap strategi pengurusan dan struktur organisasi kelihatan tidak penting, mungkin disebabkan oleh pergantungan mereka pada proses sistemik dan bukannya kecekapan individu.

Melalui analisis laluan, penyelidikan ini menjelaskan cara berbilang lapisan di mana budaya organisasi mempengaruhi prestasi keselamatan pembinaan. Pendekatan bimbingan tingkah laku secara langsung membentuk tingkah laku keselamatan pekerja, dengan tingkah laku pengurusan dan kerjasama pasukan meningkatkan kesedaran dan akauntabiliti keselamatan. Strategi pengoptimuman proses, disokong oleh dasar pengurusan dan struktur organisasi, meningkatkan kecekapan sistemik dan kebolehsuaian pengurusan keselamatan. Faktor pembentuk budaya, didorong oleh nilai organisasi dan penyertaan pekerja, memupuk persekitaran organisasi yang berorientasikan keselamatan melalui penghantaran budaya jangka panjang dan penglibatan pekerja yang proaktif.

Dengan menyepadukan budaya organisasi multidimensi dengan laluan prestasi keselamatan dan menggabungkan peranan penyederhanaan kemahiran tenaga kerja, penyelidikan ini menyediakan bukti empirikal baharu dan memperkayakan pemahaman

teori tentang cara mekanisme dipacu budaya membentuk hasil keselamatan dalam organisasi pembinaan, dan juga menyediakan panduan praktikal untuk firma pembinaan yang ingin meningkatkan prestasi keselamatan melalui strategi pengurusan dipacu budaya.

Kata kunci: *Prestasi keselamatan pembinaan, tahap kemahiran tenaga kerja, kesan moderasi, PLS-SEM.*

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LIST OF ABBREVIATIONS

OC	Organizational Culture
WS	Workforce Skill
CSP	Construction Safety Performance
OC1	Organizational Values
OC2	Management Strategy
OC3	Management Style
OC4	Organizational Structure
OC5	Manager Behavior
OC6	Employee Participation
OC7	Team Collaboration

CHAPTER 1

INTRODUCTION

1.1 Introduction

The construction industry is one of the fundamental drivers of economic growth worldwide, contributing an estimated 13% of global GDP and employing more than 220 million workers (McKinsey Global Institute, 2017; ILO, 2023). Despite technological advancements and increased mechanization, construction remains highly labour-intensive and continues to experience disproportionately high accident rates compared with other industries (Zhou et al., 2015). In China, the construction sector occupies a particularly critical role in national economic development. According to the China Statistical Yearbook (2025), the industry's total output value has grown steadily over the past decade and has consistently accounted for around 7% of national GDP. In 2024, China's construction output reached 899.493 billion yuan, representing a 2.7% year-on-year increase and contributing 17.7% of the added value of the secondary industry. The historical trend of construction output value and its proportion of national GDP is presented in Figure 1.1.

Despite its economic significance, the construction industry remains one of the world's most hazardous sectors. The International Labour Organization (ILO) reports approximately 60,000 fatal construction accidents annually, equivalent to one death every ten minutes (Boakye et al., 2022). Globally, occupational accidents and diseases in the construction sector impose an economic burden estimated at 4% of global GDP, or approximately USD 3.02 trillion per year (Yap et al., 2024). In China, recurring safety incidents highlight persistent systemic challenges involving management practices, worker skills, and organizational behaviours. These concerns have led scholars to emphasize the need for more comprehensive and human-cantered approaches to safety management (Fang et al., 2015; Sunindijo, 2015).

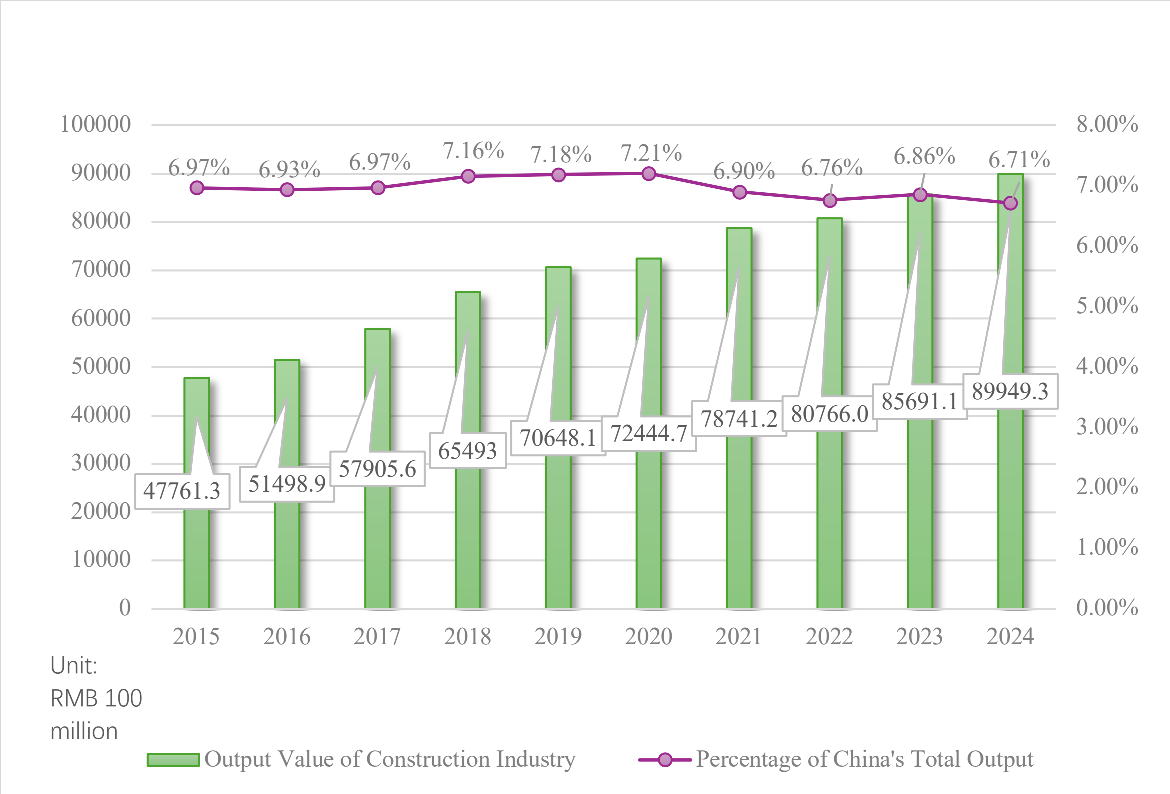

Figure 1.1: Construction Output Value & Proportion

Data source: China Annual Statistical Report (2025)

Organizational culture (OC) is widely recognized as a fundamental determinant of safety performance. Defined as the shared values, beliefs, norms, and behavioural expectations that shape organizational members' actions (Schein, 2010), Organizational culture (OC) influences how safety is perceived, prioritized, and implemented within an organization. Strong safety-oriented cultures foster open communication, high safety awareness, and consistent adherence to safety procedures (Choudhry et al., 2007; Cooper, 2000). Empirical studies have repeatedly shown that a positive organizational culture significantly reduces accident rates and improves workers' safety behaviours (Mearns & Yule, 2009; Xin et al., 2014). In the construction industry-where operations are temporary, dynamic, decentralized, and heavily dependent on human behaviour-the influence of organizational culture is even more pronounced. Aksorn and Hadikusumo (2008) found that cultural attributes such as leadership commitment, employee involvement, and effective communication are among the most critical success factors in construction safety programs. However, while the importance of culture is well acknowledged, the mechanisms through which culture influences construction safety performance (CSP) remain theoretically underdeveloped, particularly concerning its interaction with workforce characteristics.

The construction sector relies extensively on workers' technical expertise, operational proficiency, and situational judgment. Workforce skill (WS) refers to the knowledge, technical capabilities, experience, and competencies workers possess to perform construction tasks safely and efficiently (Lingard et al., 2019). Skilled workers are generally more capable of identifying hazards, interpreting safety instructions, and applying safety procedures correctly, thereby reducing operational errors and incident rates (Ismail et al., 2012). This study introduces workforce skill (WS) as a moderator based on Knowledge Management Theory (Nonaka & Takeuchi, 1995), which posits that organizational processes and outcomes are significantly shaped by how effectively individuals acquire, interpret, and utilize knowledge. From this perspective, workforce skill can be seen as a key enabler that allows organizational culture to translate into safe behaviour. For example, a strong safety culture may be more effective when workers possess adequate skills to interpret and internalize cultural expectations. Conversely, low-skilled workers may dilute the impacts of organizational culture due to limited capacity to understand procedures, communicate risks, or adopt safe behaviours.

Empirical evidence supports the idea that skill level moderates organizational influences. Hale et al. (2010) argued that workers' competence shapes how organizational safety policies are enacted onsite. Similarly, Fang et al. (2015) found that inexperienced or low-skilled workers tend to misinterpret safety signals or underestimate risks, weakening the impact of managerial interventions. Yet, despite this theoretical relevance, the interaction between organizational culture (OC) and workforce skill (WS) has been underexplored. Existing studies typically examine them as independent determinants of construction safety performance (CSP) leaving unclear the conditions under which culture-related interventions are most effective.

Given these gaps, this research develops a conceptual framework to examine that how organizational culture influences construction safety performance, and whether workforce skill strengthens or weakens this relationship. By integrating organizational culture theory, safety culture theory, and knowledge management theory, the study contributes a multidimensional understanding of how cultural and human skill factors jointly shape safety outcomes. The findings offer theoretical insights and actionable guidance for construction companies on allocating resources, designing targeted interventions, and enhancing both cultural and competence-related safety mechanisms to achieve project success.

1.2 Background of the Research

Statistics indicate that the number of people employed in China's construction industry has exceeded 50 million for five consecutive years, representing 7.03% of the nation's total employment, as shown in Figure 1.2. In 2023, construction investment accounted for 27.3% of the China's fixed asset investment, driving the growth of 68 upstream and downstream related industries such as steel, cement and engineering services. In the 14th Five-Year Plan (2021-2025), the Chinese government has listed the intelligent and green transformation of the construction industry as a key task. Prefabricated buildings are expected to account for 40% of new urban buildings by 2025, marking the industry's transition to more sustainable and efficient ways of building.

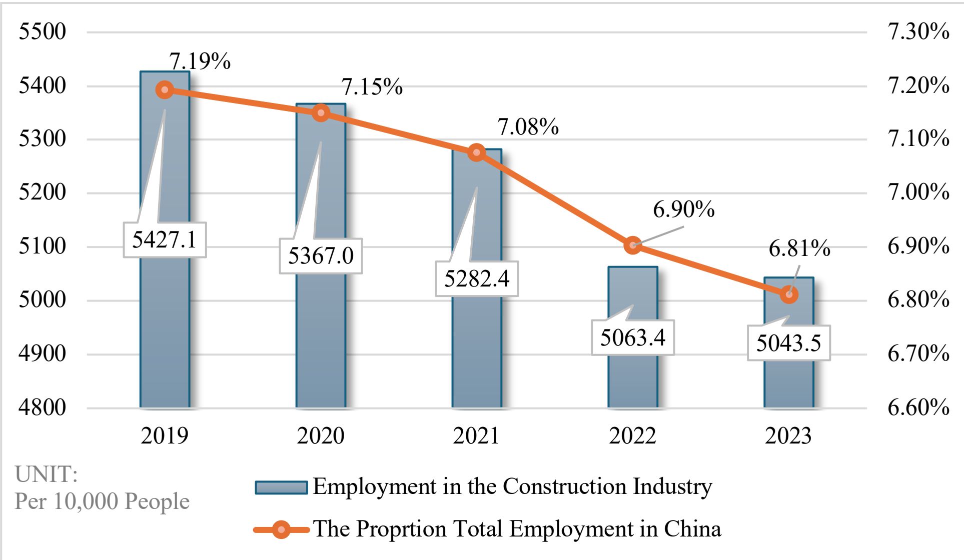

Figure1.2: Number and Proportion of Employees in Construction Industry

Data source: China Annual Statistical Report (2024)

However, for various reasons, this industry has long been plagued by high risks and accident rates (Fu et al., 2019; Shao et al., 2020; Szymczak-Graczyk et al., 2021). In recent years, despite increasing attention to construction safety (Alkaissy et al., 2023; W. Li et al., 2022; Luo, et al., 2022; Rokooei et al., 2023; Tian et al., 2023), accident and fatality rates remain alarmingly high (Abdul Halim et al., 2022; Kiral & Demirkesen, 2022; Musarat et al., 2022; Yap et al., 2023). This phenomenon has made the exploration of factors affecting

Construction Safety Performance (CSP) an urgent issue. From 2019 to 2023, statistics from the Public service Portal of the China Engineering Quality and Safety supervision information platform show that the number of safety accidents in housing and municipal engineering is accompanied by a high number of deaths, There have been an average of 700 accidents per year, accompanied by an average of more than 600 deaths per year. Despite increasing attention to construction safety, accident and fatality rates remain alarmingly high. The data is shown in Figure 1.3.

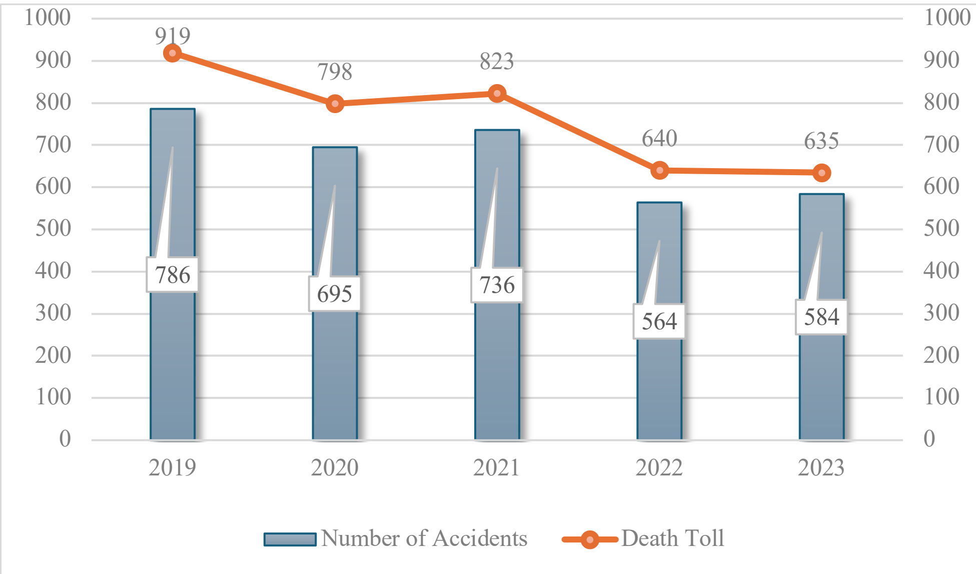

Figure1.3: Data on the Number of Construction Safety Accidents and Fatalities

Data source: Public Service Portal of the China Engineering Quality and Safety Supervision Information Platform (2024)

When comes to the research of scholars, some evidence also can be found to prove that construction safety is a problem that cannot be ignored. In WOS (Web of Science) core collection, Literature from 1991 to 2023 related to this theme was searched, resulting in 5,113 articles on the subject. The years from 2019 to 2023 can be considered as the "high-speed development period" for this field. The annual number of papers exceeded 399, reaching a peak of 710. The number and trend of the articles show that construction safety has received more and more attention by scholars. The large volume of research output during this stage indicates that “Construction Safety” has become a hot topic of research. The publication count is shown in figure 1.4.

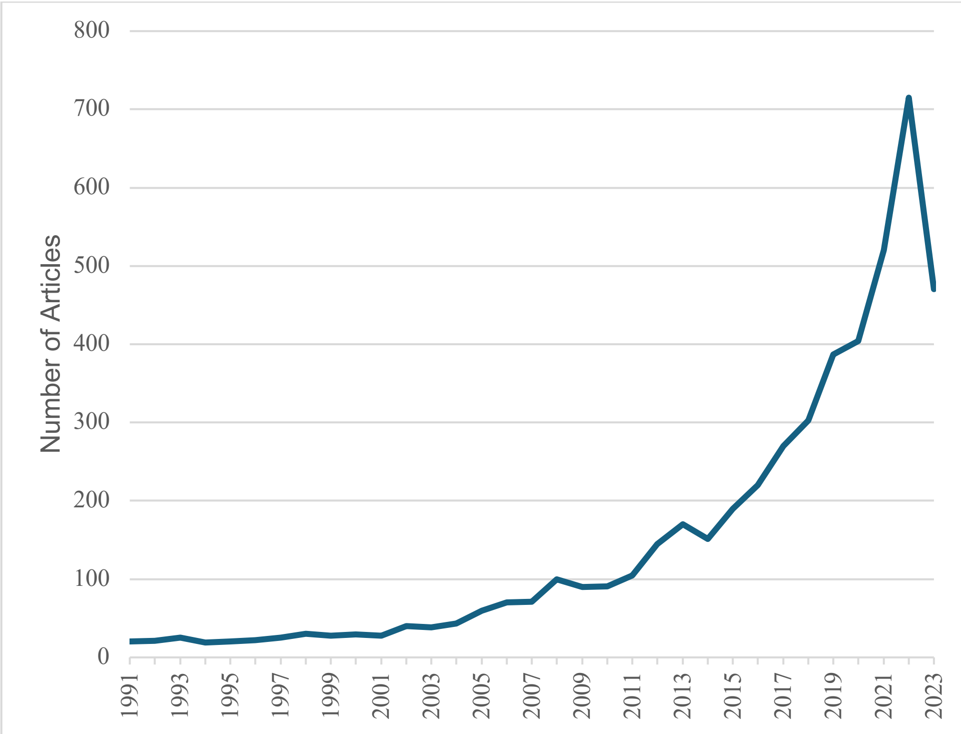

Figure 1.4: Publication Count

Data source: WOS (Web of Science) core collection, Literature from 1991 to 2023 related to this theme was searched, resulting in 5,113 articles on the subject

Traditionally, research has primarily focused on technical (Cheng & Teizer, 2013; Guo et al., 2017; Parsamehr et al., 2023; Zhang et al., 2022) and regulatory (Jin et al., 2021; Yuan et al., 2021)aspects, often overlooking the influence of soft factors such as organizational culture (OC) and workforce skills (WS). These soft factors not only affect employee behaviour and attitudes but may also impact an organization’s overall safety performance through various mechanisms. Organizational culture, as a difficult-to-quantify yet critical factor, is increasingly recognized as playing a key role in safety management. A positive organizational culture can enhance safety awareness, foster teamwork, and promote compliance with safety regulations. Workforce skills directly influence whether employees can correctly execute safety procedures and respond to emergencies, thereby affecting overall project safety performance.

Table 1.1: Top 10 Keywords by Frequency Ranking

Frequency	Centrality	Year	Keywords
610	0.09	1997	model
397	0.09	1994	construction
379	0.08	1991	design
56	0.08	1991	soil
451	0.07	2004	system
97	0.07	2009	tracking
57	0.07	2002	culture
394	0.06	2006	behavior
86	0.06	2002	injury
65	0.06	2004	cost

Based on Figure 1.5 and Table 1.1, which ranks the top 10 keywords by frequency, we can observe the multidimensional research focus and evolving trends in the field of "Construction Safety". These keywords not only cover multiple aspects ranging from "model" and "design" to "behaviour" and "culture", but also reflect the research importance of these themes across different time periods. However, It all adds up that traditional research has primarily focused on technical , management measures and norms aspects, and the impact of soft factors such as Organizational Culture (OC) is increasingly being recognized.

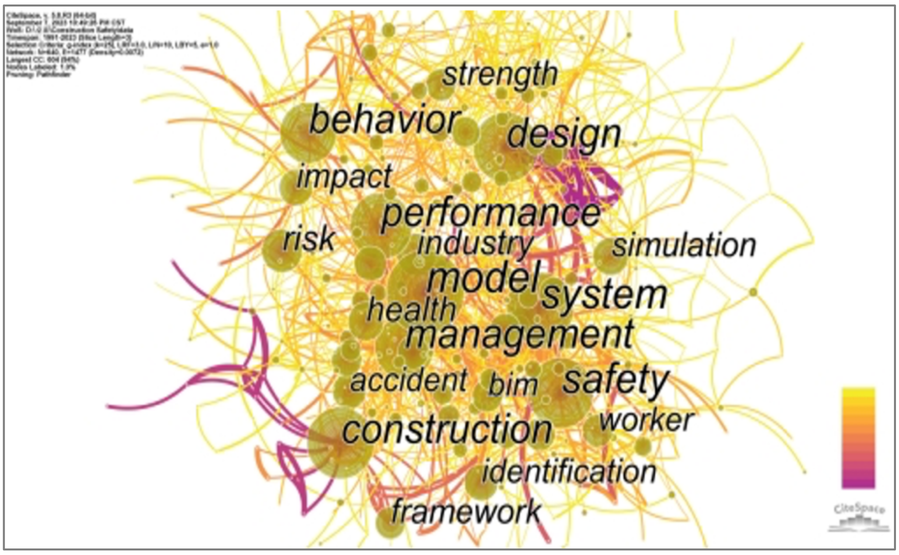

Figure 1.5: Knowledge Map of Key Words

Data source: WOS (Web of Science) core collection, Literature from 1991 to 2023 related to this theme was searched, resulting in 5,113 articles on the subject

To further explore the relationships between various topics and reveal the distribution of topic clusters, this research uses the LLR (Log Likelihood Ratio) algorithm for clustering. A total of 5 topics were identified with a Q value of 0.6077 and an S value of 0.7923, both falling within the range of reasonable clustering, as shown in Figure 1.6. It can be seen that in the field of construction safety management, existing literature mainly focuses on hard factors and technical aspects, such as simulation, equipment, and procedures.

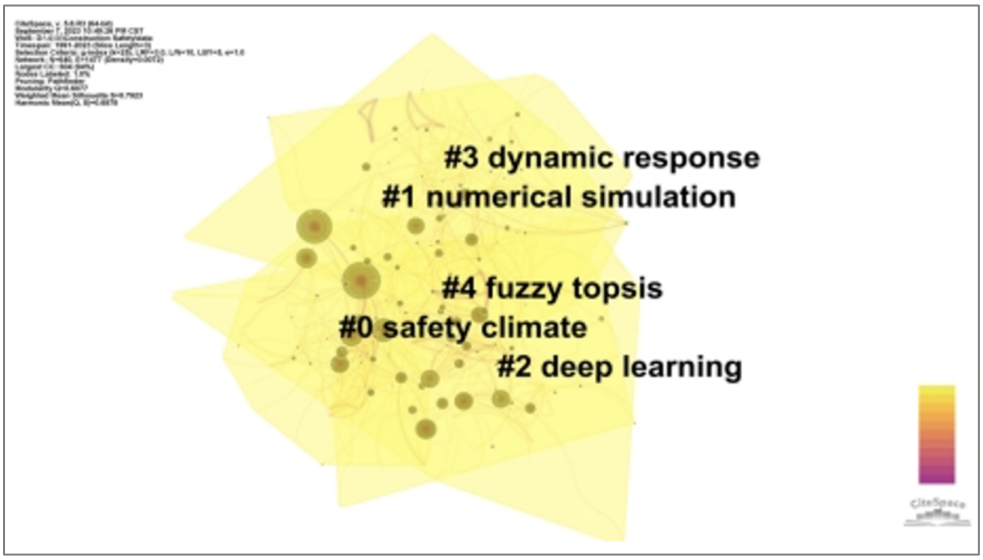

Figure 1.6: Visual Map of Keyword Cluster

Data source: WOS (Web of Science) core collection, Literature from 1991 to 2023 related to this theme was searched, resulting in 5,113 articles on the subject

There is relatively less research on soft factors such as organizational culture and workforce skills. The traditional studies tend to overlook the interactive effects of these soft factors and their comprehensive impact on construction safety performance. Moreover, most existing research focuses more on theory and model building, lacking direct guidance for actual engineering projects and policy formulation.

Organizational culture is an important factor influencing construction safety performance (Abdul Halim et al., 2022; Chen et al., 2018; El-Nagar et al., 2015; Khalid et al., 2021). A positive organizational culture can enhance employee safety awareness, strengthen teamwork, and promote compliance with safety regulations (Cooper, 2015; Garrett & Teizer, 2009; Shahriari et al., 2023). However, organizational culture is a challenging factor to quantify, making it difficult to accurately assess its impact on construction safety performance (Al-Bayati, 2021). Additionally, organizational culture can be influenced by other factors such as organizational structure, leadership style, and employee attitudes, further complicating research efforts. Therefore, in-depth research into the impact of organizational culture on construction safety performance and how to improve it is currently an important direction of research.

Workforce skills are also a significant factor affecting construction safety performance (Durdyev et al., 2017; Manoharan et al., 2023). Employee skill levels directly influence their ability to correctly execute safety procedures and respond to emergencies (Zaira & Hadikusumo, 2017). An organization with high workforce skills can more effectively prevent accidents, thereby improving construction safety performance. However, workforce skills are influenced by multiple factors, including education levels, training experiences, and work history, making research more complex. Therefore, in-depth research into the impact of workforce skills on construction safety performance and how to enhance it is currently an important research direction.

In summary, organizational culture and workforce skills are all critical factors influencing construction safety performance. However, these factors are complex and influenced by multiple variables, making research into their impact on construction safety performance a challenging task. This research aims to provide theoretical foundations and practical guidance for improving construction safety performance by deeply analysing these soft factors and revealing their mechanisms of influence. A thorough exploration of the research background hopes to comprehensively and deeply present the core content and significance of this research, providing a solid foundation for future research.

1.3 Problem Statement

In the construction industry, ensuring both safety and efficiency remains a significant challenge due to complex project environments, dynamic workforce conditions, and varying levels of organizational commitment to safety culture. According to the World Economic Forum (WEF), the construction industry employs more than 100 million people worldwide and accounts for 6% of global GDP. Specifically, the value added of construction accounts for about 5% of GDP in developed countries and 8% of GDP in developing economies. Although the construction industry plays a crucial role in the global economy, its construction safety performance (CSP) directly affects the smooth progress of each construction project and the safety of every worker. However, this industry has long faced high risks and a high rate of accidents. The research by Damanik et al. (2023) emphasizes the significant impact of using a risk-based Work Breakdown Structure (WBS) during the design and construction phases on construction safety performance, revealing the importance of early risk identification and management to improve safety performance.

Many construction projects still struggle with high accident rates, insufficient workforce training, and inconsistent implementation of safety protocols. According to data from the Public Service Portal of the China Engineering Quality and Safety Supervision Information Platform, from 2019 to 2023, China’s housing and municipal engineering sector experienced an average of 700 safety accidents per year, resulting in an average annual death toll of over 600 people. Each accident represents a family tragedy, and this high accident rate and mortality rate is not merely a statistical issue, but also poses a significant potential risk to economic development and social stability - as mentioned in China's national strategic planning, continuous work safety accidents are a threat to sustainable economic growth and social harmony (State Council of the People's Republic of China, 2022).

The impacts are profound at both project and industry levels. Firstly, at the project level, each accident typically triggers an immediate suspension of work for investigation and remediation, causing direct project delays. These delays disrupt critical paths, lead to contractual penalties, and increase financing costs due to extended project durations. Secondly, the financial burden extends far beyond direct medical and compensation costs (Al-Naser & Al-Tabtabai, 2025). It encompasses equipment damage, site rectification, increased insurance premiums, and potential regulatory fines. Thirdly, recurring accidents severely damage the reputation of the responsible contractors, affecting their ability to secure future projects in an increasingly competitive and regulated market that prioritizes safety records.

Collectively, these project-level issues escalate into significant impediments to the overall progress of the construction industry in China. Chronic safety problems lead to more stringent and frequent regulatory inspections, which, while necessary, can slow down approval processes and increase compliance costs across the board. Furthermore, a poor safety record undermines investor confidence and can deter skilled workers from joining or remaining in the industry, exacerbating the existing skilled labour shortage (Newaz, Jefferies, & Ershadi, 2025). Therefore, the high incidence of safety accidents is not merely a statistical concern but a fundamental operational and strategic challenge that directly causes project delays, escalates costs, tarnishes industry reputation, and ultimately hinders the sustainable and efficient development of China's construction sector.

Additionally, the research by Wong and Soo (2019) identified key factors affecting safety performance in the construction industry, such as personal protective equipment and safety education, which are crucial for understanding and addressing the high risks and accident rates in the industry. The research by Mahmoud et al. (2020) provides a global perspective, especially in developing countries, on the safety performance issues of the construction industry, closely related to the role of the industry in the global economy and the challenges it faces. Meanwhile, the research by Anil and Jose (2021) offers in-depth insights into the safety performance of the construction industry by focusing on a specific construction project (pipeline sleeper construction), highlighting the importance of integrating worker protection in assessing sustainable construction (Athira & Vidya, 2022). These studies collectively reveal the significance of the construction industry in the global economy and the key role of safety performance, risk management, and accident prevention in ensuring the industry's sustainable development.

Organizational culture (OC) has been extensively acknowledged in management literature as a pivotal driver of overall project performance. Research across industries, including construction, substantiates that a strong, positive OC correlates with enhanced efficiency, quality, and goal attainment (Lingard et al., 2012). Within the high-risk construction sector, this relationship crystallizes into a direct and critical impact on safety outcomes. A significant body of empirical evidence identifies specific deficiencies in safety culture-a core subset of OC-as a root cause of poor safety performance. Studies consistently link weak safety culture, characterized by inadequate management commitment, poor communication, and low workforce involvement, to higher accident rates, non-compliance with procedures, and systemic failure in hazard control (Choudhry et al., 2007; Mohammadi et al., 2018). Therefore, the salient issue within construction safety management is not whether OC matters, but rather how its specific dimensions-such as those fostering employee commitment-can be systematically measured and harnessed to directly and positively influence Construction Safety Performance (CSP). This focus is crucial, as employee commitment, often nurtured through culture, is posited as a key mediating factor between organizational practices and safe behaviours (Jitwasinkul et al., 2016).

Differences exist between the theoretical findings and practical implementations in understanding the relationship between organizational culture (OC), workforce skills (WS), and construction safety performance (CSP). The theoretical foundations are well-established. Seminal theories, such as Reason's (1990) model of organizational accidents and Cooper's (2000) reciprocal safety culture model, posit that organizational factors are fundamental precursors to safe or unsafe behaviour. This foundational view has been consistently substantiated and refined by contemporary research. The recent studies have empirically validated and extended these models in the construction context, demonstrating how specific dimensions of safety culture, such as management commitment and worker involvement, directly predict safety performance outcomes (Lingard et al., 2019; Feng et al., 2023). Empirical research further supports these theories; for example, studies have validated the positive relationship between safety climate (a manifestation of organizational culture) and safety performance metrics like reduced incident rates (Zhou et al., 2015). However, this suggests that while theoretical findings robustly highlight the potential impact of organizational culture (OC) and workforce skills (WS) on construction safety performance (CSP), effectively applying these theories and measuring their specific impact in actual construction project management remains a significant challenge. Therefore, further exploration of how these factors individually and collectively affect construction safety performance (CSP), and the development of feasible management strategies, are crucial for helping the construction industry better face current and future challenges, ensuring its continuous success and development.

Currently, while there has been extensive research on the interaction between organizational culture (OC) and workforce skills (WS) with construction safety performance (CSP), the application of these theories in real-world construction projects to enhance safety and efficiency has not been fully explored. For instance, the research by Viterouli et al. (2022) emphasizes the role of employee self-directedness in training and work environments, reflecting the importance of workforce skills in enhancing employee engagement and organizational performance (Viterouli et al., 2022). However, this research does not delve into how these theories can be specifically applied to construction projects to improve safety and efficiency. Moreover, the research by Monye et al. (2023) discusses the impact of Industry 4.0 in the automotive industry, particularly in terms of workforce skill enhancement, providing insights into the application of technological adaptability in the construction industry (Monye et al., 2023). However, this research also does not provide specific practical examples of how these theories can be applied in construction projects. These studies suggest that while the interaction between OC and WS with CSP is theoretically considered key to improving the safety and efficiency of construction projects, how to effectively integrate these elements in practice remains a challenge to be addressed.

Based on the above analysis, it can be concluded that although existing research has explored the impact of variables such as Organizational Culture (OC) and Workforce skill (WS) on Construction Safety Performance (CSP), these studies have typically considered them in isolation. Thus, the comprehensive relationship between OC and WS with CSP has not been fully investigated. This research aims to fill this research gap by thoroughly analysing how these factors interact and their combined impact on CSP. Through this integrated perspective, we can not only better understand the individual effects of each factor on CSP but also gain insights into their collective influence. Such research is of significant importance for the development of effective construction safety strategies and the improvement of safety and efficiency in construction projects.

1.4 Research Questions

Based on literature analysis and research gaps, this reseach will answer the following specific questions:

i. Does organizational culture have an impact on construction safety performance?
ii. To what extent does organizational culture affect construction safety performance?
iii. Does workforce skill play a moderating role in the relationship between organizational culture and construction safety performance?

1.5 Research Objectives

This section describes in detail the general and specific objectives of this study.

1.5.1 General Objective

The general objective of this research is to examine the influence of organizational culture in construction safety performance using the workforce skill as moderating role.

1.5.2 Specific Objectives

The specific objective of this research as follows:

i. To investigate whether organizational culture has a significant impact on construction safety performance.
ii. To assess the extent of the impact that organizational culture has on construction safety performance.

iii. To explore how workforce skill moderates the relationship between organizational culture and construction safety performance, and to specify the concrete manifestation of its moderating effect.

1.6 Significance of the Research

This section elaborates the significance of this study from two aspects of theory and practice.

1.6.1 Theoretical Significance

This research delves into the intricate relationship between organizational culture, workforce skills, and construction safety performance, addressing a significant gap in existing literature. By refining the dimensions of organizational culture and workforce skills and analysing their impact mechanisms on construction safety, this research establishes a comprehensive theoretical framework. It enriches the theoretical system in the field of construction safety management and deepens the academic understanding of key influencing factors. Furthermore, the study provides a systematic theoretical foundation and empirical data to support future research. It also serves as a valuable reference for interdisciplinary fields such as organizational behaviour and occupational safety and health management, promoting further exploration of the relationship between organizational culture and construction safety performance in academia.

1.6.2 Practical Significance

For government and regulatory authorities, the findings of this research provide scientific data and theoretical support for the development of more effective construction safety policies and regulations. By examining the influence of organizational culture and workforce skills on construction safety performance, regulatory authorities can formulate targeted safety standards and training policies to enhance overall safety performance in the construction industry.

For industry enterprises, this research offers practical insights for construction companies and project managers to optimize their management strategies. Enterprises can adjust their organizational culture, improve employee incentive mechanisms, and develop tailored training and management measures for varying levels of workforce skills. These adjustments will help improve construction safety performance and enhance overall project efficiency.

For individuals, this research can provide practical safety management suggestions and training programs for front-line workers and project managers in construction sites. By enhancing individual awareness of organizational culture and improving safety skills, workers can strengthen their safety consciousness and operational competence, thereby reducing the risk of accidents on construction sites. This also contributes to a heightened sense of occupational safety and belonging among personnel.

In summary, the theoretical and practical significance of this research not only aids in improving safety performance across the construction industry, but also offers valuable insights and lessons that can be applied to other industries in enhancing safety management.

1.7 Scope of the Research

This section elaborates the scope of this study, including the theoretical, methodological scope and the geographical scope.

1.7.1 Theoretical and Methodological Scope

This research focuses on assessing the impact of organizational culture (OC) on construction safety performance (CSP) and how workforce skill (WS) acts as a moderating variable between the two. It delves into the direct influence of organizational culture on the safety performance within the construction industry and the moderating mechanisms of workforce skill on this relationship. The research primarily centres on the soft factors that are often overlooked in traditional studies and their critical role in shaping construction safety performance.

The aim is to comprehensively understand how organizational culture can enhance the safety of construction projects and how improvements in workforce skills can optimize the positive effects of organizational culture on safety performance. Additionally, the research plans to use the PLS-SEM analytical method to investigate the specific moderating role of workforce skill and how these factors collectively affect construction safety performance, providing theoretical and strategic guidance for safety management practices.

1.7.2 Geographical Scope

In this research, Jinan City of Shandong Province is selected as the research area. In 2024, the total output value of the construction industry in Shandong Province reached 1.99 trillion yuan, accounting for more than 6.7% of the China's GDP for 30 consecutive years, ranking firmly in the first echelon of the country's construction industry. Among the 12,483 construction enterprises in the province, the mixed ownership structure of state-owned holding 904 enterprises and private enterprises (78%) provides a typical sample for exploring the interaction effect of organizational culture (OC) and workforce skill (WS). The detailed date is shown in the figure1.7.

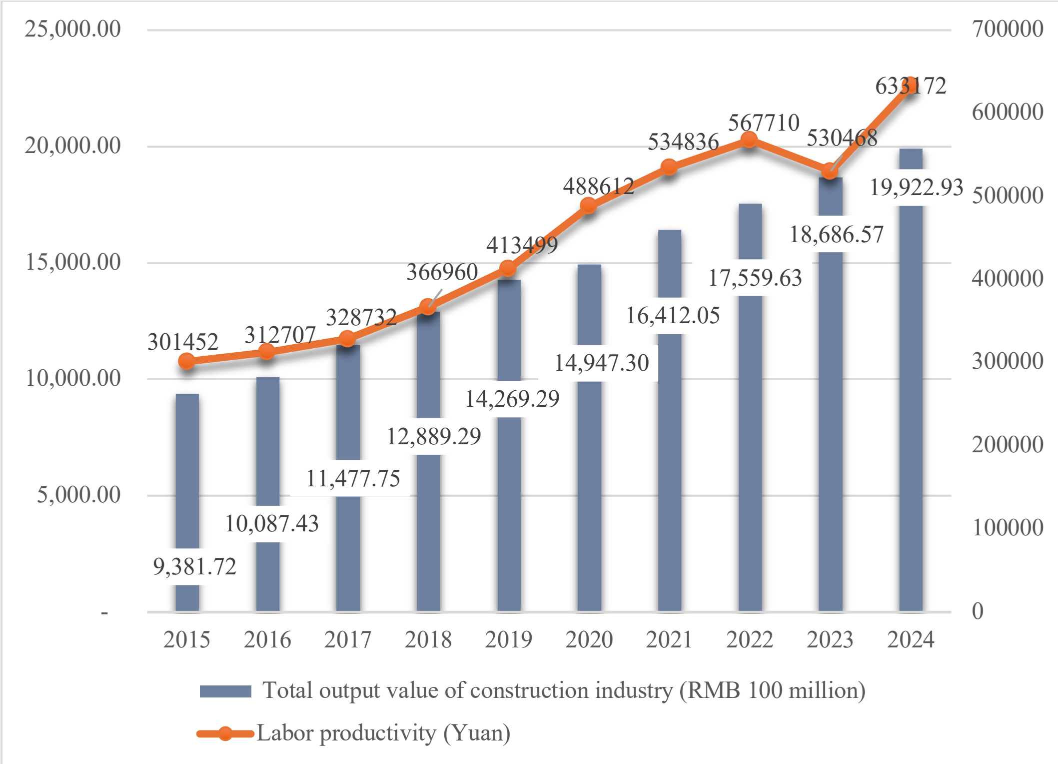

Figure1.7: Total Output Value and Labor Rate of Construction Industry in Shandong Province, 2015-2024

Data source: China Annual Statistical Report (2025); Statistical Bulletin of Shandong Province National Economic and Social Development in 2024

As the provincial capital of Jinan, there are 1,519 construction enterprises, accounting for 18% of the province, and 638,306 construction employees, accounting for 12% of the province, concentrating 23% of the province's super qualified enterprises. Its large infrastructure projects led by state-owned enterprises (such as rail transit) coexist with active residential development projects of private enterprises, perfectly mapping the industry ecology of “multi-subject collaboration” in Shandong Province. At the same time, Jinan is comprehensively promoting the application of BIM technology and smart site management, providing a dynamic window for observing the moderating role of WS in digital transformation (such as how digital skills strengthen the execution of safety culture). In addition, the significant contrast between labour productivity and accident rate in Jinan construction industry further highlights the urgency of organizational culture (OC)-workforce skill (WS) collaborative optimization. Based on the above economic representation and data accessibility, this study chooses Jinan City as the research scope, and its conclusions have strong spillover value for China's project safety management in the Yellow River basin and even along the "Belt and Road".

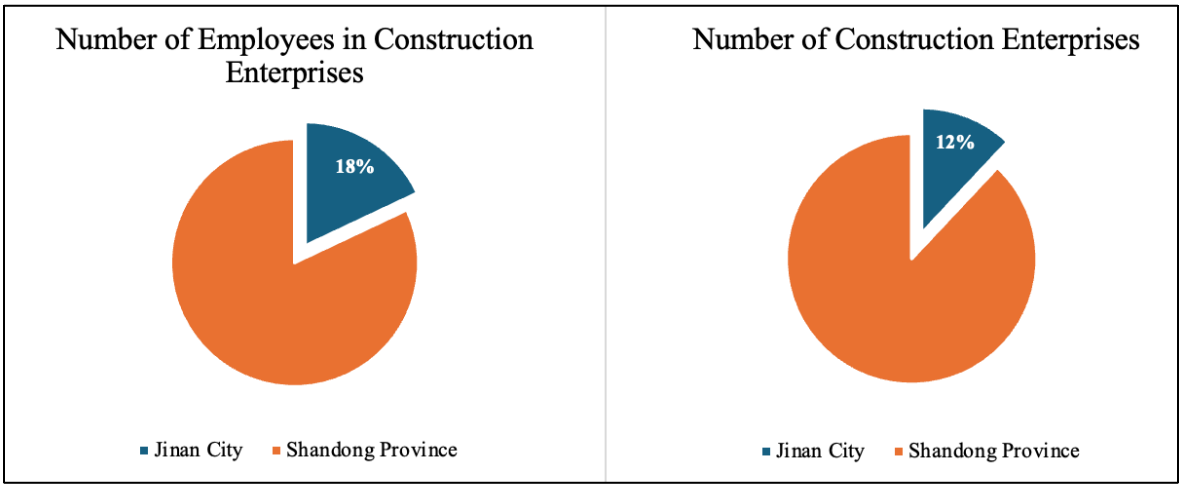

Figure 1.8: Number of Construction Enterprises and Employees in Jinan City

Data source: Statistical Yearbook of Shandong Province (2024)

The scope of this research also includes providing practical and actionable recommendations for policymakers, industry professionals and companies based on research findings. The objective is to assist them in developing and implementing strategies and policies that effectively enhance construction safety performance. The outcomes of this research are expected to have significant practical implications for a wide range of stakeholders, including government agencies, industry organizations, project managers, on-site workers, academia, and society at large.

1.8 Organization of the Research

This research is organized into five chapters.

Chapter One primarily focuses on the research background, problem statement, research questions and objectives, significance of the research, scope of the research, and the organization of the research.

Chapter Two is the literature review, which provides an in-depth exposition of the concepts and theories related to this research and proposes the theoretical framework and research hypotheses.

Chapter Three details the research methodology, covering aspects such as questionnaire design, survey subjects, survey areas, survey execution, data processing, and model evaluation.

Chapter Four presents the research results and discussions in detail.

Chapter Five concentrates on summarizing the influencing factors, conclusions, and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The construction industry is characterized by its complexity, multidisciplinary collaboration, and high-risk working environments. Within this sector, organizational culture (OC) plays a pivotal role in shaping project outcomes, influencing safety performance, efficiency, and overall sustainability. In China, where large-scale infrastructure projects and rapid urbanization are driving industry growth, the significance of organizational culture is even more pronounced.

Organizational culture in the construction industry encompasses shared values, norms, and behavioural expectations that guide interactions among stakeholders, including contractors, subcontractors, suppliers, and regulatory bodies. A strong safety-oriented culture has been widely recognized as a key factor in reducing workplace accidents and improving overall construction safety performance (CSP). However, achieving a robust safety culture remains a challenge in China due to factors such as fragmented project management, subcontracting practices, and varying levels of safety awareness among workers.

Moreover, the hierarchical nature of Chinese construction firms often impacts decision-making processes and communication efficiency. Traditional top-down management approaches may hinder the development of an open and proactive safety culture, where workers feel empowered to report risks and suggest improvements. Studies have shown that fostering a participatory organizational culture-where employees at all levels are encouraged to contribute to safety initiatives-can significantly enhance project safety and operational efficiency.

In addition to safety performance, organizational culture influences workforce skill development, technological adaptability, and overall project execution. As China continues to embrace digital transformation and smart construction technologies under the Industry 4.0 paradigm, the integration of innovative work practices requires a cultural shift toward continuous learning and adaptability. Without an organizational culture that supports knowledge sharing, skill development, and innovation adoption, the potential benefits of emerging technologies in construction may not be fully realized.

This chapter reviews existing literature on the interaction between organizational culture and construction safety performance, with a particular focus on its implications in the Chinese construction industry. It explores key theoretical frameworks, empirical studies, and case analyses to provide a comprehensive understanding of how organizational culture shapes safety practices, workforce behaviour, and project efficiency in China's evolving construction landscape.

2.1.1 Organizational Culture (OC)

Organizational Culture (OC) is a multifaceted concept defined from various perspectives in the literature. Osman et al. (2023) defines organizational culture as an intangible force within an organization that shapes its values, beliefs, and behavioural norms by influencing the attitudes and behaviours of employees. Organizational culture is regarded as a critical factor affecting safety in the construction industry because it can impact employees' compliance with safety regulations and their execution of safety behaviours. Primorac and Domljan (2022) defines organizational culture as a set of values, beliefs, and behavioural norms within an organization that influence the behaviours of employees and the way the organization operates. Organizational culture is considered a key factor influencing the performance of construction projects. Arditi et al. (2017) views organizational culture as a set of values, beliefs, norms, and behaviour patterns within an organization that influence the behaviour of its members and the decision-making processes of the organization.

It can be observed that organizational culture is a collective, shared set of values, beliefs, and behaviour patterns that influence and shape the thinking and actions of organizational members, thereby impacting the operation and performance of the organization. In the context of the construction industry, organizational culture plays a crucial role in driving safety awareness, promoting technological innovation, and enhancing project performance.

In this research, organizational culture is defined as an intangible social force that shapes and influences the values, beliefs, behaviours, and attitudes of organizational members. Organizational culture is a multidimensional construct that encompasses a range of values, beliefs, behaviour norms, and practices collectively manifested within an organization. These factors collectively shape the internal functioning and external manifestations of the organization. In the construction industry, organizational culture indirectly shapes the safety performance of construction sites and overall business outcomes by influencing aspects such as leadership styles, teamwork, goal alignment, risk tolerance, organizational heritage, market positioning, decision-making processes, problem-solving abilities, organizational values, and beliefs. A strong organizational culture not only facilitates efficient decision-making and problem-solving but also enhances employees' safety awareness and sense of responsibility, thereby ensuring the survival and success of the organization in a competitive market environment.

Given that organizational culture is a multidimensional and complex construct, it must be operationalized into a series of observable and measurable latent variables for empirical measurement and analysis of its specific impact pathways on Construction Safety Performance (CSP) within the field of construction safety. Through a systematic literature review, this study identified and selected seven key dimensions based on the following three core principles.

i. High Relevance to the Construction Industry: The dimensions must have a direct and significant connection to the management characteristics, risk attributes, and safety outcomes of construction projects.

ii. Theoretical and Empirical Support: The dimensions must be supported by mainstream organizational culture or safety culture theoretical models and repeatedly validated in existing construction safety literature.

iii. Actionability in Management Practice: The dimensions should correspond to specific management practices and intervention measures, providing a clear entry point for enhancing safety performance.

Based on the aforementioned principles, this study proposes and justifies the following seven latent variables of organizational culture, which are shown in the Table 2.1.

Table 2.1: The Latent Variables of Organizational Culture

No.	Measurement Items	References
OC1	Organizational Values	Newaz et al. (2019) Karanikas et al. (2018)
OC2	Management Strategy	Parsamehr et al. (2023) Yiu et al. (2019) Dewlaney and Hallowell (2012)
OC3	Management Style	Wang et al. (2023) Senthamizh and Anandh (2024)
OC4	Organizational Structure	Forteza et al. (2022) Cheung and Zhang (2020)
OC5	Manager Behavior	Heydari et al. (2024) Grill and Nielsen (2019) Zhang et al. (2019)
OC6	Employee Participation	Umar, (2020); Pandit et al. (2019)
OC7	Team Collaboration	Syed-Yahya et al. (2022) Liu et al. (2021)

OC1: Organizational Values

This constitutes the core of organizational culture, referring to the fundamental beliefs and principles upheld and championed by an organization. Within a safety context, it is concretely manifested in the priority accorded to "safety" by the organization-whether it supersedes cost and schedule or is compromised by them. Strong safety values can be internalized as employees' personal beliefs, guiding their voluntary adoption of safe behaviours (Newaz et al., 2019; Karanikas et al., 2018).

OC2: Management Strategy

This refers to the long-term plans and resource allocation schemes formulated by an organization to achieve its objectives, including safety goals. A strategy that explicitly integrates safety into the core business strategy and allocates sufficient resources such as time, budget, and personnel demonstrates substantive management commitment to safety, serving as the blueprint for translating safety culture into practice (Parsamehr et al., 2023; Yiu et al., 2019; Dewlaney & Hallowell, 2012).

OC3: Management Style

This refers to the habitual modes demonstrated by management in leadership, communication, and decision-making. A participatory, supportive, and leading-by-example management style, compared to an authoritarian or neglectful one, is more conducive to fostering open safety communication, willingness among employees to report hazards, and enhancing the perceived legitimacy of safety rules (Wang et al., 2023; Senthamizh & Anandh, 2024).

OC4: Organizational Structure

This refers to the allocation of authority and responsibilities, reporting relationships, and coordination mechanisms within an organization. A flat structure with clearly defined safety roles and authorities facilitates the swift upward and downward flow of safety information, ensures the effective execution of safety policies, and avoids management failures due to redundant hierarchies or unclear responsibilities (Forteza et al., 2022; Cheung & Zhang, 2020).

OC5: Manager Behaviour

This refers to the observable, safety-related specific actions exhibited by managers at all levels in their daily work. It is the most intuitive manifestation of management commitment, encompassing activities such as conducting site safety inspections, actively participating in safety meetings, promptly correcting unsafe behaviours, and recognizing safety role models. The consistency between managers' words and actions exerts a powerful demonstrative and suggestive influence on employees (Heydari et al., 2024; Grill & Nielsen, 2019; Zhang et al., 2019).

OC6: Employee Participation

This refers to the extent to which an organization grants employees a voice, involves them in decision-making, and empowers them with self-management regarding safety matters. Encouraging employee participation in risk assessments, safety improvement suggestions, and accident investigations not only leverages their frontline knowledge to identify hazards but also strengthens their sense of "ownership" and responsibility for safety (Umar, 2020; Pandit et al., 2019).

OC7: Team Collaboration

This refers to the degree of mutual support, communication, and coordination within teams and across teams to achieve safety objectives. In complex construction projects, effective team collaboration is crucial for disseminating safety information, coordinating risks associated with interdependent tasks, and forming a mutually vigilant safety network (Syed-Yahya et al., 2022; Liu et al., 2021).

The rationale for selecting these seven dimensions lies in the fact that they collectively form a complete chain from "philosophy" (Values) to "planning" (Strategy), then to "execution" (Structure, Style, Behaviour), and ultimately relying on "human factors" (Employee Participation, Team Collaboration). This framework encompasses the strategic, institutional, and behavioural layers of organizational culture, reflecting both high-level commitment and on-the-ground practices. It is thus capable of systematically capturing the multiple pathways through which organizational culture influences construction safety performance. Although other dimensions may exist in the literature, these seven dimensions enjoy high consensus within the construction safety research field, possess relatively mature measurement tools, and, when acting in concert, can provide the most direct and comprehensive explanatory power for safety outcomes. Therefore, this study adopts this seven-dimensional framework as the operationalized basis for analysing the impact of organizational culture on construction safety performance.

2.1.2 Workforce Skill (WS)

"Workforce Skill" is generally defined by scholars as the comprehensive demonstration of skills and abilities in specific occupational fields. This includes soft skills like communication, teamwork, and problem-solving, technical expertise in specific domains, and vocational skills for performing professional tasks. These competencies not only impact an individual's career development and performance but also play a crucial role in their employability and success within the construction industry. Improving workforce skills in construction is often achieved through education and training programs like Technical and Vocational Education and Training (TVET) and Work-Based Learning (WBL). These initiatives aim to enhance individual competitiveness, boost productivity, encourage entrepreneurship, and drive industry and economic growth (Chia et al., 2022; Hosseini et al., 2023; Jiang et al., 2023; Olabiyi & Olafare, 2022).

In this research, "Workforce Skill (WS)" is defined as the comprehensive abilities of employees in areas such as professional skills, safety awareness, adaptability, communication skills, teamwork, technical training, professional development, task completion, problem-solving, and self-drive. These capabilities not only reflect the personal qualities and professional competence of employees but also directly impact the overall performance of the organization and the success rate of projects. In the construction industry, the high skill level of employees is a key factor in ensuring that projects are completed on time, efficiently, and safely. It is also an important resource for enhancing the organization's competitiveness and adapting to the constantly changing market demands.

2.1.3 Construction Safety Performance (CSP)

The concept of "Construction Safety Performance (CSP)" has been thoroughly explored and defined in various research studies. CSP primarily pertains to the safety conditions within construction projects and extends beyond the measurement of accident and injury rates.

Selleck et al. (2022) highlight the importance of safety performance indicators like safety observations and hazard reports, which are precursors to safety events. Lagging indicators such as incident frequency and employee satisfaction indirectly measure safety performance by assessing the "absence of safety" (Selleck et al., 2022). Sinaga and Vioito (2022) stress the role of individual risk perception and organizational collectivism in construction personnel's safety status, advocating proactive approaches and strategies for safety improvement (Sinaga & Sinaga, 2022). Meng and Chan (2022) argue that safety performance depends on factors like safety awareness, behaviour, and attitudes, emphasizing the need for diverse measurement methods covering individual, organizational, and environmental aspects (Meng & Chan, 2022). Awolusi et al. (2022) describe construction safety performance as dynamic and multidimensional, suggesting various methods and strategies, including technology adoption, training, and cultural improvements, for practical safety enhancement (Awolusi et al., 2022).

In conclusion, construction safety performance is a complex, multidimensional concept involving factors and variables at multiple levels. To better understand and enhance construction safety performance, it is necessary to conduct research and analysis from multiple perspectives and employ comprehensive approaches to improve safety conditions within construction projects.

Therefore, this research defines Construction Safety Performance (CSP) as a critical indicator for assessing the effectiveness of safety management in construction projects. It encompasses various aspects, including accident rates, employee satisfaction, safety awareness, safety behaviour, safety attitudes, safety training, safety strategies, safety resources, safety leadership, and safety culture. These indicators not only reflect the achievements of construction projects in accident prevention, risk reduction, and the creation of a safe working environment but also demonstrate the organization's commitment and execution in safety training, resource allocation, leadership demonstration, and the cultivation of a positive safety culture. In the highly competitive construction industry, outstanding safety performance not only contributes to protecting employee well-being and reducing economic losses but also enhances corporate reputation and market competitiveness.

2.2 Underpinning Theories

This section establishes the theoretical bedrock of the study by synthesizing three theories: Organizational Culture Theory (OCT), Knowledge Management Theory (KMT), and Safety Culture Theory (SCT). Rooted in Schein's (1985) hierarchical model of cultural dynamics, OCT provides the lens to dissect how shared norms and values permeate safety practices. KMT, developed by O 'Dell & Grayson elucidates the mechanisms through which safety knowledge is codified, transferred, and operationalized within complex project ecosystems. Complementing these, SCT, advanced by Zohar's (2010) multilevel safety climate framework-anchors the analysis of how cultural priorities translate into measurable safety outcomes. Together, these theories form an interconnected triad: OCT defines "why" cultural norms matter, KMT explains "how" knowledge bridges norms to actions, and SCT establishes "what" constitutes effective safety performance. Their synergy underpins the conceptual model in section 2.3, where workforce skill emerges as the critical moderator navigating these theoretical intersections.

2.2.1 Organizational Culture Theory（OCT）

Organizational culture Theory was founded in 1985 by Edgar Schein, whose model divides organizational culture into three interrelated levels, artifacts, espoused values and basic assumptions. Artifacts are defined as observable surface cultural elements, such as the physical environment (open office layouts), rituals (safe morning meetings), and dress codes (hard hat colours identify ranks). The application in engineering, such as the density of safety signs posted in construction sites, reflects the importance enterprises attach to safety. At the same time, espoused values are defined as the values that the organization publicly declares, such as the slogan "safety first", but may be deviated from the actual behaviour. Some studies have found that 63% of construction enterprises emphasize the priority of safety in their policies, but the actual decision-making is still dominated by schedule compression(Schein, 2010). In addition, basic assumptions include six dimensions: truth, time, space, human nature, organizational environment, and interpersonal relationship(Schein, 2010), such as the implicit assumption that a "male-dominated culture" prevails in the construction industry, influences safe communication patterns.

The core content of Organizational Culture Theory revolves around the formation and impact of internal values, beliefs, and behavioural norms within an organization (Schein, 1985). This theory assumes that organizational culture is a key determinant in influencing employee behaviour and organizational performance. The importance of Organizational Culture Theory has been validated through studies examining the relationship between safety culture and employee safety behaviour in the construction industry. For example, research by Kim et al. (2025) in the service industry (including construction) demonstrated how safety leadership influences organizational safety culture and safety behaviour, strengthening the link between organizational culture and safety outcomes(Mi Moon et al., 2025). Almuntasheri and Almandeel (2022) explored the impact of leadership behaviour on safety culture in the healthcare industry, providing insights into how leadership within an organization shapes safety culture and performance, a concept that is also applicable in the construction industry(Almuntasheri & Almandeel). Damayanti et al. (2022) analysed the impact of employee identity on the safety behaviour of construction workers, highlighting the influence of organizational factors on safety practices (Damayanti et al., 2022). Bhagwat and Delhi (2021) investigated the multi-level safety culture in India’s construction industry, emphasizing the role of different levels of organizational culture in ensuring safety compliance (Bhagwat & Delhi, 2022). These studies collectively reinforce the application of Organizational Culture Theory in this context, as they help understand and improve the key cultural factors affecting construction safety performance. They demonstrate how organizational culture, shaped and influenced by various organizational factors and leadership, plays a key role in enhancing safety behaviour and performance in the construction industry. Based on these studies, Organizational Culture Theory is applicable to this research, as it aids in understanding and improving the key cultural factors that influence construction safety performance.

2.2.2 Knowledge Management Theory (KMT)

Knowledge Management Theory originated from the SECI model (socialization, externalization, combination, internalization) proposed by Nonaka & Takeuchi (1995), and was later developed by O 'Dell & Grayson (1998). Knowledge Management Theory focuses on how organizations effectively manage and utilize their knowledge resources to enhance organizational performance and innovation capacity. This theory emphasizes that systematically collecting, sharing, using, and enhancing knowledge within and outside the organization can significantly improve its competitive advantage and efficiency (O'Dell et al., 1998). In the construction industry, knowledge management is particularly critical due to the complexity and variability of projects, which involve a wide range of technical and managerial knowledge.

The skill level of the workforce directly impacts how employees apply this knowledge to enhance their work safety. Employees with high skill levels can more effectively identify and manage potential safety risks and better contribute to and utilize the organization's knowledge base (Argote & Ingram, 2000). Therefore, improving employees' skill levels is a key component of implementing effective knowledge management strategies.

In the construction industry, the application of knowledge management extends beyond technical and operational knowledge to include understanding and applying safety standards, best practices, and accident prevention strategies. Research indicates that through knowledge management practices, such as regular training, experience sharing sessions, and cross-departmental collaboration, construction firms can significantly improve their safety management outcomes (Sousa et al., 2014).

Knowledge Management Theory provides a robust framework for understanding and improving safety performance in the construction industry. By strengthening organizational culture and enhancing employees' skill levels, construction firms can more effectively manage and utilize their safety knowledge resources to improve workplace safety and production efficiency.

2.2.3 Safety Culture Theory (SCT)

Safety culture theory evolved from the "Swiss cheese model" proposed by Reason (2016) and was refined into the framework of multi-level safety culture by Zohar (2010). The theory has three classical dimensions: psychology, behaviour and system. Among them, the psychological dimension focuses on the degree of internalization of employees' safety beliefs, such as operating with injuries is shameful. The behavioural dimension focuses on the initiative of safety participation, such as voluntary reporting of hazards. The system dimension focuses on management resource input and institutional response speed. Safety Culture Theory emphasizes the important role of safety values, behaviours, and beliefs in shaping the safety behaviours of organizational members. This theory contends that there is a close link between the degree of emphasis on safety within organizational culture and the safety behaviours of employees, directly related to research on how organizational culture affects construction safety performance(Wiegmann et al., 2007). Safety Culture Theory provides a framework for examining how organizational culture enhances Construction Safety Performance (CSP) by influencing employees' behaviours and attitudes (Zohar, 2010).

Organizational culture plays a vital role in promoting the sharing and application of safety knowledge. A positive organizational culture can facilitate the flow of knowledge, making employees more willing to share and apply safe practices and experiences (Crossan, 1996). Such a cultural environment encourages learning and innovation, thereby improving workplace safety performance. A strong safety culture is characterized by safety beliefs and values shared among all members, prioritizing safety over operational efficiency or cost-cutting measures. This culture impacts all levels of an organization, including the commitment of senior management to safety, allocation of resources for safety training and equipment, and the daily actions and decision-making processes of front-line workers (Guldenmund, 2000). In such a culture, safety is considered an intrinsic part of the organizational identity and operations, rather than an additional compliance requirement.

Moreover, Safety Culture Theory also underscores the importance of promoting safety communication, collaboration, and continuous learning within an organization (Lingard et al., 2019; Jitwasinkul & Hadikusumo, 2016). It advocates for creating an environment where employees feel empowered and responsible for their safety and the safety of others. In this context, reporting errors and unsafe conditions is encouraged rather than penalized, thus fostering a proactive approach to risk management and mitigation.

In the construction industry, where projects often entail high risks and are subject to various external conditions, a strong safety culture can significantly reduce the incidence of accidents and improve CSP. Through the lens of Safety Culture Theory, organizations can identify areas for improvement in their cultural practices and policies to better support safety initiatives.

2.3 Conceptual Framework

This section analyses the theoretical foundation and key concepts underpinning this research, focusing on the relationships among organizational culture, workforce skills, and construction safety performance, which form the basis for constructing the conceptual framework.

It begins by discussing the research foundation, analysing the relationship between organizational culture and construction safety performance, followed by an exploration of the impact of workforce skills on construction safety. Subsequently, the comprehensive impact of these "soft factors" and their joint influence on construction safety performance are elaborated. Finally, the rationale for considering workforce skills as a moderating variable is explained in detail, clarifying its role within the conceptual framework.

This framework serves as a foundation for formulating the research hypotheses and guiding subsequent data collection and analysis.

2.3.1 Research Foundation

In the construction industry, safety performance has always been a critical issue, especially in rapidly developing economies. While traditional safety management methods tend to focus on technical and regulatory aspects, in recent years, researchers and practitioners have increasingly recognized the importance of non-technical factors such as organizational culture and workforce skills in construction safety performance (CSP). These factors not only influence the behaviour and attitudes of employees but may also impact the overall safety performance of organizations through various mechanisms. This research aims to delve into how these factors individually and collectively affect CSP, with a particular focus on developing countries like China.

While constructing our research framework, a few studies are found to be that tested similar variables or hypotheses. For instance, Asamani's (2020) research revealed that safety culture is a significant predictor of safety behaviour and safety performance. Safety behaviour partially mediates the relationship between safety culture and safety performance, but safety culture is a more effective predictor of safety performance than safety behaviour. Furthermore, the work of Choudhry et al. (2007) and Guldenmund (2000) also emphasized the influence of organizational culture on safety attitudes, safety behaviour, and safety outcomes. These studies not only provide a benchmark for testing our hypotheses but also help establish the academic precedence of our research framework.

2.3.1.1 Organizational Culture and Construction Safety Performance

Organizational culture plays a crucial role in the safety performance of the construction industry. A positive safety culture is considered key to reducing accident rates and improving safety performance levels. Zohar’s (1980) research was among the first to link organizational culture with workplace safety, highlighting the importance of management commitment to safety performance. Subsequently, many studies have focused on exploring how organizational culture influences safety outcomes through various mechanisms. Key elements in shaping a positive safety culture include management commitment, mutual concern among colleagues, and employee compliance with safety regulations (Choudhry et al., 2007; Guldenmund, 2000). Additionally, Zohar’s (2010) research indicated a positive correlation between the strength of safety culture and employee safety behaviour, underscoring the role of leadership in shaping a positive safety culture. In Fernández-Muñiz et al.’s (2007) research, it was highlighted that safety culture is a multi-dimensional concept encompassing employee attitudes, beliefs, perceptions, and behaviours. These factors collectively determine the extent to which employees embrace safety policies and practices, thus affecting safety performance. Moreover, the research emphasized the importance of management commitment, employee involvement, training and education, and continuous improvement.

2.3.1.2 The Impact of Workforce skills on Construction Safety

The skill level of the workforce is a key determinant of the success of construction projects. Higher skill levels are associated with higher work quality, increased productivity, and lower accident rates. However, the construction industry faces challenges related to skill shortages, which can potentially threaten worker safety. The skill level of the workforce has a direct impact on construction safety performance. Studies by Lee et al. (2020) highlight that key factors influencing construction safety performance include management and organization, resources, site management, appearance, and labour force. Additionally, Lingard and Rowlinson (2013) found in their research that providing safety training and education can significantly improve employees' safety awareness and behaviour. Furthermore, they discovered that safety performance is related to the skills and knowledge levels of employees, indicating that enhancing workforce skills is crucial for improving safety performance.

Although considering each factor individually is important, they are often not isolated. In practice, these factors interact with each other, jointly influencing construction safety performance. For example, a strong safety culture can promote technological adaptability, as employees may be more willing to embrace new technologies that can enhance safety. Similarly, a highly skilled workforce is better equipped to understand and comply with safety regulations, thus reducing accidents. These interactions demonstrate how organizational culture and workforce skills, when combined, jointly shape safety performance (Choudhry et al., 2007; Zohar, 2010). Specifically, a positive organizational culture can facilitate technological innovation and adaptability, thereby improving safety performance (Choudhry et al., 2007; Zohar, 2010). Meanwhile, a highly skilled workforce can better adapt to new technologies and work processes, reducing accidents and enhancing productivity (Lee et al., 2020).

In summary, organizational culture and workforce skills are crucial soft factors influencing construction safety performance. These factors impact safety outcomes through various mechanisms and pathways, including employee behaviour, technology adoption, and risk management (Zohar, 2010). To improve construction safety performance, organizations need to consider these factors comprehensively and create a safety-supportive environment. This may involve nurturing a positive safety culture, enhancing employee skill levels, and promoting technological innovation. By doing so, construction companies can not only improve their safety records but also enhance work quality and employee satisfaction, ultimately achieving success in a competitive industry.

2.3.1.3 The Logical Basis for Workforce Skill as a Moderating Variable

In exploring the complex relationships between Organizational Culture (OC), Workforce skill (WS), and Construction Safety Performance (CSP), distinguishing the roles of mediating and moderating variables is crucial for understanding the essence of interactions among variables. In multivariate analysis, mediating variables (Mediating Variable) and moderating variables (Moderating Variable) play different roles, with mediating variables explaining why or how one variable affects another. Specifically, they act between the independent and dependent variables, transmitting or explaining the causal relationship between them. Recent studies further affirm the key role of mediating variables in elucidating the process by which independent variables affect dependent variables.

Mackinnon et al. (2007) emphasize the importance of mediating variables in transmitting the effect of an independent variable on a dependent variable, distinguishing the different functions of mediating variables from other variables, such as moderating variables (MacKinnon et al., 2007). Feingold et al. (2019), through their analysis of alcohol use disorders, demonstrate how mediating variables can reveal underlying mechanisms. Cheung (2022), through meta-analytic methods, synthesizes research on indirect effects in mediation models, further proving the applicability of mediation analysis in revealing complex relationships between variables. These studies collectively support the central position of mediating variables in elucidating causal relationships between variables, providing a solid theoretical and empirical foundation for understanding and applying mediating variables.

Conversely, moderating variables affect the strength or direction of the relationship between independent and dependent variables, altering the “degree” or “quality” of this causal relationship. In recent studies, the role of moderating variables has increasingly been recognized, especially in the exploration of complex relationships between independent and dependent variables. The research by Valter da Faia and Vieira (2019) delves into the concept of moderating effects and demonstrates through multiple regression analysis how moderating variables can affect the strength or direction of the relationship between independent and dependent variables. The work of Li and Tze (2019) further underscores the importance of moderating variables in lifespan developmental analyses, indicating that moderating variables can help researchers more comprehensively understand the IV-DV effect and its applicability to specific groups. Liu et al. (2021), by proposing new measures of effect sizes, explore mediated moderation models, highlighting the key role of moderating variables in revealing complex processes. These studies collectively support the central role of moderating variables in altering the “degree” or “quality” of the impact of independent variables on dependent variables, providing a solid theoretical and empirical foundation for understanding the interactions among variables.

This research argues that workforce skill should be conceptualized as a moderating variable, rather than a mediating variable, in the relationship between organizational culture and construction safety performance. A thorough analysis supporting this position follows. Firstly, in this research, if there exists a process or mechanism through which Organizational Culture directly affects Construction Safety Performance, then the carrier of this process or mechanism is a mediating variable.

Conversely, moderating variables change the strength or direction of the relationship between independent and dependent variables. In this research, the setting of Workforce skill as moderating variables is based on their ability to affect the degree of impact of Organizational Culture on Construction Safety Performance. This is not to say that Workforce skill directly mediates the relationship between Organizational Culture and Construction Safety Performance, but rather it may strengthen or weaken this impact, or change the direction of this impact under different conditions.

The logical basis for Workforce skill as a moderating variable lies in that employees with higher skill levels are more capable of understanding and implementing safety measures and are more likely to identify with and promote a positive safety culture. Therefore, the level of Workforce skill may moderate the impact of Organizational Culture on Construction Safety Performance, where groups of employees with higher skill levels may play a greater role in promoting and implementing safety measures, further enhancing the organization's safety performance. For example, the research by Bassam Ramadan et al. (2023) analyzed the impact of worker training on the personal performance records of construction workers and frontline supervisors (including safety, attendance, quality, productivity, and initiative), finding that training had a statistically significant effect on improving worker performance. Albert Chan et al. (2023) explored the moderating effects of educational level, individual learning ability, and resilient safety culture on the safety performance of construction workers, confirming that educational level has a positive impact on safety performance, and that individual learning ability and resilient safety culture have a positive moderating effect on this relationship. Sheng Xu et al. (2019) developed a learner model to assess the learning abilities of individual workers during safety training, revealing the heterogeneity of workers in terms of safety training motivation, existing knowledge, and emotional changes during the knowledge acquisition process, as well as their vulnerability to model effect and convenience effect during the knowledge application process. These studies collectively indicate that improving employees' skill levels, especially through education and training to enhance their professional skills, safety awareness, and adaptability, is crucial for enhancing safety performance in the construction industry. The enhancement of workforce skills not only directly impacts individuals' work efficiency and problem-solving abilities but also facilitates the promotion of a positive safety culture and effective safety communication, further improving the overall safety performance of organizations. Despite the challenges and barriers to implementing training, by adopting effective strategies and measures, these challenges can be overcome, making skill enhancement a key factor in improving safety performance in the construction industry.

Combining the above analysis, this research defines Workforce skill as moderating variables rather than mediating variables, based on their role in the relationship between Organizational Culture and Construction Safety Performance not being direct mediation, but affecting the strength and direction of this relationship. This definition helps deepen our understanding of the role of organizational behavior in construction safety management, providing theoretical and practical guidance for developing more effective safety management strategies and practices.

2.3.2 Critique of Literature

Current research on the relationship between organizational culture and construction safety performance is extensive and consistently highlights the pivotal role of organizational culture in enhancing safety outcomes. Al-Bayati's work delves into the significant impact of safety culture on individual safety behaviour and motivation, stressing the importance of nurturing a proactive safety culture within everyday safety practices (Al-Bayati, 2021). Trinh and Feng have developed a model for the maturity of resilient safety culture, providing a detailed framework for assessing and evolving organizational culture, highlighting its progressive and multilayered development (Trinh & Feng, 2022). Mokarami (2019) and others have demonstrated the statistical relationship between organizational culture and unsafe behaviours and accidents through structural equation modelling, laying a quantitative groundwork for cultural interventions (Mokarami et al., 2019). Nguyen and Watanabe's research, utilizing empirical data, indicates a direct correlation between project organizational culture and the performance of construction projects, underscoring the critical role of cultural construction in management practices (Nguyen & Watanabe, 2017). Abubakar's research explores the potential of a resilient safety culture in enhancing safety performance, especially within the developing market context of Nigeria (Abubakar et al., 2022).

When comparing these studies, it's clear that while they all acknowledge the contribution of organizational culture to safety performance, there is an inadequate exploration of the role of workforce skill. For instance, Abubakar et al. (2022)' research framework is as follows.

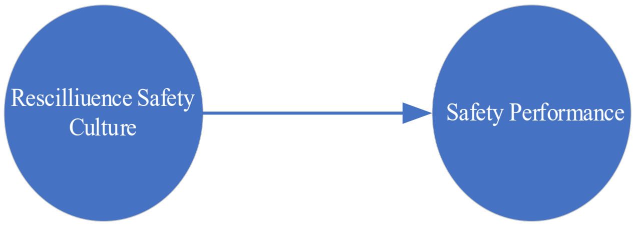

Figure 2.1: Referential Research Framework

The research centres on exploring the potential impact of a resilient safety culture on the safety performance of construction organizations, highlighting the significance of reinforcing such a culture to elevate safety management and reduce accidents in Nigeria's construction sector (Abubakar et al., 2022). However, the research does not account for the key variable of workforce skill. These factors are critical for implementing safety practices, adapting to new safety technologies, and enhancing overall safety performance amidst rapid technological growth in the construction industry. While the research offers valuable insights into resilient safety culture, future research should incorporate a more comprehensive consideration of technology and skill factors to deepen the understanding and improvement of construction safety performance.

In essence, the specific mechanisms of interaction between these variables and organizational culture, and how they jointly influence safety performance, have not been sufficiently studied. Yet, findings highlight the importance of management and staff awareness of occupational health and safety (Singh & Misra, 2021), as well as the improvement of safety performance and site productivity through enhanced participation and welfare. Additionally, the positive effects of emerging technologies like Building Information Modelling (BIM), Geographic Information Systems (GIS), Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI), and wearable devices on safety performance underscore their significance in safety planning, training, inspection, and monitoring (Dobrucali et al., 2022). Despite extensive research on the positive impact of organizational culture on safety performance, the direct effects of workforce skill require further exploration. With rapid technological progress and evolving workforce skills, these variables play a crucial role in construction safety management. Current literature has gaps in discussing how workforce skills interact with organizational culture to impact safety performance. Future research should probe into the interplay between workforce skills and organizational culture, and how they collectively shape safety performance in different organizational and cultural contexts. Such studies would not only augment the existing body of literature but also provide deeper and more comprehensive guidance for safety management practices in the construction industry.

This research framework is based on a comprehensive analysis of existing literature, reviewing research related to organizational culture and workforce skills, as well as how these factors influence construction safety performance. Our framework integrates findings from these studies to provide a holistic perspective on how these variables interact and jointly impact CSP. Overall, our research, informed by synthesizing existing literature, presents a unique framework that explains how organizational culture and workforce skills influence construction safety performance. Our framework is not only theoretically grounded but also supported by existing research, providing a solid foundation for further hypotheses testing and research. By gaining a deeper understanding of the roles of these soft factors, our research aims to offer practical insights and strategies for improving safety performance in the construction industry.

2.3.3 Justification of the Conceptual Model

i. Organizational Culture Theory (OCT): Revealing the Intrinsic Cultural Drivers of Safety Performance

Organizational Culture Theory (OCT), proposed by Schein (1985), conceptualizes culture as a multi-layered construct encompassing visible artifacts, espoused values, and underlying assumptions. Within construction project environments, these cultural layers significantly influence how employees internalize and enact safety norms. Management style (OC3), organizational structure (OC4), employee participation (OC6), and team collaboration (OC7) reflect both leadership's commitment to safety and the operationalization of cultural values into daily practices. Thus, the theoretical model in this study disaggregates organizational culture into seven core dimensions to comprehensively capture its multifaceted impact on construction safety performance (CSP), laying a robust theoretical foundation for subsequent hypothesis testing and structural modelling.

ii. Knowledge Management Theory (KMT): Explaining How Culture Transforms into Safety Behaviour through Knowledge Pathways

Knowledge Management Theory (KMT), evolving from the SECI model, emphasizes the systematic acquisition, dissemination, and application of knowledge as a critical driver of organizational performance. Culture serves as both the enabler and container of knowledge management processes, while workforce skill directly shapes knowledge absorption and enactment. In construction, the effectiveness of safety training, experience sharing, and knowledge institutionalization largely depends on the synergy between cultural encouragement and workforce capability. Skilled employees exhibit superior cognitive and behavioural capacity to internalize and operationalize safety-related knowledge. KMT thereby provides a critical theoretical link between cultural norms and safety outcomes, justifying the inclusion of workforce skill as a moderator in this model.

iii. Safety Culture Theory (SCT): Defining the Behavioural Pathways Linking Culture to Safety Outcomes

Safety Culture Theory (SCT), advanced by Zohar's multi-level framework, outlines how safety-related beliefs, behaviours, and institutional mechanisms interact to shape organizational safety performance. This theory underscores that the extent to which safety is prioritized within an organization's culture directly affects employees' risk perception, hazard reporting, and compliance behaviour. By focusing on psychological internalization, behavioural initiative, and systemic responsiveness, SCT offers a structured pathway from cultural values to tangible safety outcomes. It thus informs the conceptualization and measurement of CSP in this study and substantiates the inclusion of cultural dimensions as key predictors of safety performance.

iv. Workforce Skill as Moderator: A Key Intervening Construct Across Theoretical Intersections

Workforce skill emerges at the intersection of OCT, KMT, and SCT as a pivotal moderator that determines the intensity and effectiveness of culture-driven safety outcomes. High-skilled employees not only align more closely with safety-oriented cultural values (OCT) but also demonstrate enhanced capacity to absorb and apply safety knowledge (KMT), thereby engaging more proactively in safety behaviours (SCT). As such, workforce skill modulates the strength and direction of the relationship between each organizational culture dimension and CSP. This rationale underpins the formulation of the hypothesis of moderating variables, positioning workforce skill as a critical contextual factor that amplifies or attenuates cultural influences within construction safety management practices.

v. Identifying Knowledge Gaps and the Prospective Contribution

The integrated use of the three theories above helps to pinpoint two specific areas where understanding remains limited in construction safety research, which this study aims to address.

The first area concerns the details of organizational culture. While existing studies confirm that culture is important, they often measure it as a general concept. This makes it difficult to know which specific parts of culture, such as leadership actions or company structure, are most effective in improving safety. This study tackles this by breaking down organizational culture into seven clear, measurable parts to precisely analyse their individual and combined impact on safety outcomes. The second area involves the role of workforce skill. Although skill is recognized as important, its exact function is not fully clear. It is often studied separately from culture. This study proposes that skill is not just another influencing factor, but a key condition that can strengthen or weaken the effect of company culture on safety. Therefore, the research model specifically tests how workforce skill changes the relationship between each cultural aspect and safety performance. In summary, this study seeks to advance knowledge by providing a more detailed map of organizational culture and by rigorously testing how workforce skill acts as a crucial condition within that map.

Based on the above analysis, the research framework is shown in Figure 2.2.

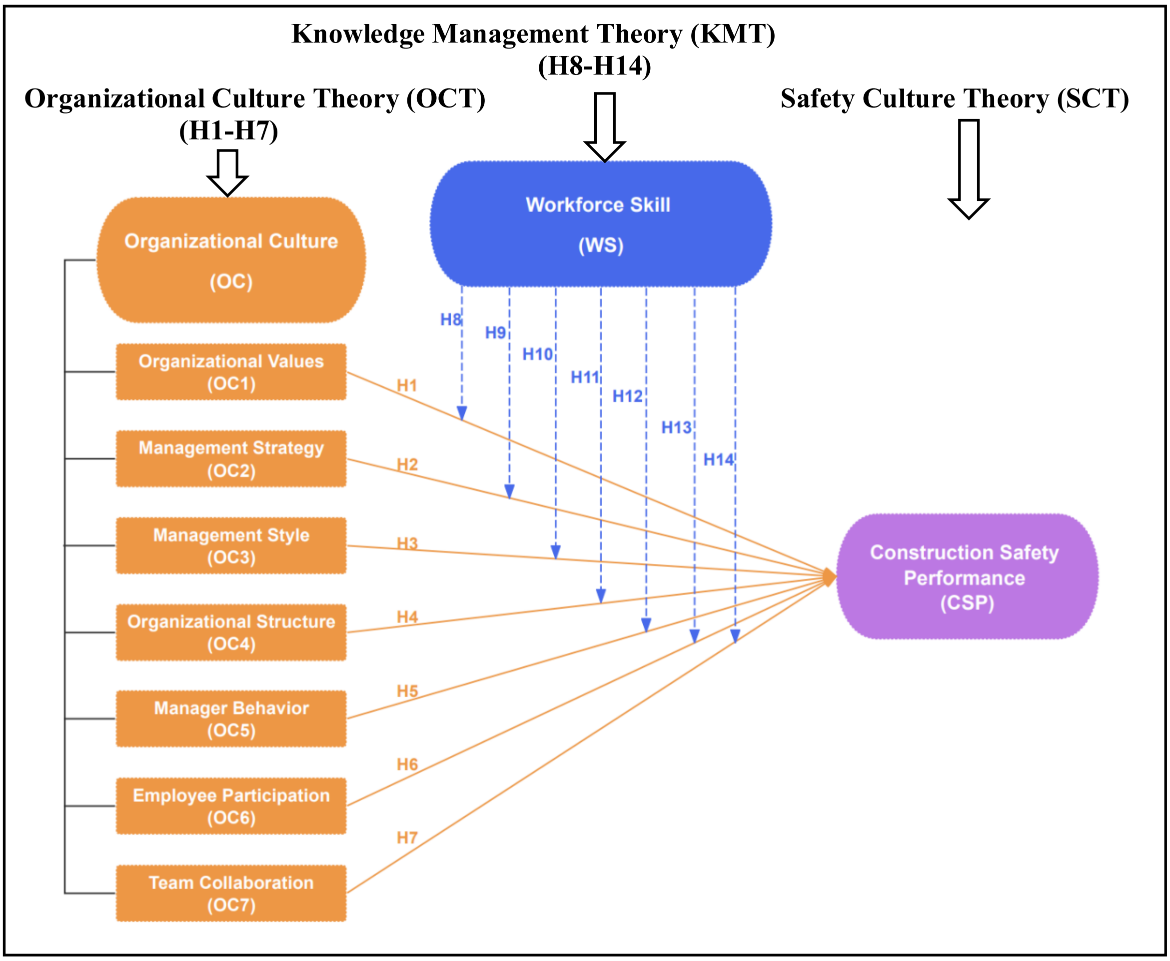

Figure 2.2: Research Conceptual Framework

2.4 Proposed Hypotheses

Following the review and integration of Organizational Culture Theory (OCT), Safety Culture Theory (SCT), and Knowledge Management Theory (KMT), this study establishes the following theoretical logic for hypothesizing: First, organizational culture, as a set of shared values, beliefs, and behavioral norms, is theoretically recognized as the fundamental driver that shapes the behaviors of organizational members (Schein, 1985). In the context of construction safety, this shaping function directly influences employee safety behaviors and organizational safety outcomes. Therefore, it is theoretically sound to position organizational culture and its multidimensional structure as the independent variable (IV) and construction safety performance as the dependent variable (DV), with the core relationship being the "driving" and "influencing" of performance by culture. Second, Knowledge Management Theory (KMT) posits that the effective application of knowledge depends on an individual's capacity to absorb and transform it. This implies that whether the safety culture promoted by an organization can be effectively received by employees and translated into actual practices hinges significantly on their skill level as "knowledge carriers." Consequently, workforce skill naturally emerges as a crucial moderating variable (MV), expected to alter the strength of the relationship between organizational culture and safety performance. Based on this rationale, the following two sets of hypotheses are proposed.

IV= Independent Variable

DV= Dependent Variable

MV= Moderating Variable

2.4.1 Organizational Culture (IV) Has a Significant Positive Impact on Construction Safety Performance (DV)

Organizational culture, understood as the shared values, beliefs, and behavioural patterns within an organization, plays a critical role in shaping members' attitudes and behaviours, particularly towards safety. In the construction industry, a robust and positive safety culture is widely recognized as a fundamental determinant of Construction Safety Performance (CSP), a key indicator for evaluating the effectiveness of safety management in projects (Newaz et al., 2019; Liu et al., 2021). Empirical research consistently supports this link; for example, Chen et al. (2018) found in the Taiwanese construction industry that a positive organizational culture promotes adherence to safety regulations and reduces accidents, thereby directly enhancing safety performance. Building upon this established relationship, recent scholarly work has refined the understanding by shifting focus from treating culture as a monolithic construct to examining its specific, actionable dimensions. Contemporary studies detail how distinct facets-such as management commitment (Feng et al., 2023), safety communication (Zou & Sunindijo, 2020), and worker involvement (Pandit et al., 2021)-independently and interactively contribute to reducing incidents and fostering proactive safety behaviours. These evolving viewpoints emphasize the necessity of studying specific cultures, including organizational culture, in promoting safety performance.

These studies collectively underscore the key role of a strong and positive organizational culture in raising safety awareness, promoting safety practices, and improving overall safety performance. Therefore, the following sections discuss each dimension and derive the corresponding research hypothesis.

Organizational Values (OC1) represent the core principles and priorities held by an organization. When safety is embedded as a fundamental value, it transcends being a procedural requirement and becomes a guiding principle for strategic and operational decisions. This prioritization directly influences resource allocation, management attention, and ultimately, the normative environment that shapes daily work practices. Research indicates that organizations with a strong safety ethos consistently demonstrate superior safety outcomes, as core values directly shape risk perception and behavioural choices (Karanikas et al., 2020; Pandit et al., 2021). Therefore, it is proposed that:

H1: Organizational Values (OC1) have a significant positive effect on Construction Safety Performance (CSP).

Management Strategy (OC2) refers to the formal integration of safety objectives into the organization's long-term plans and resource allocation frameworks. A strategy that explicitly prioritizes safety signals a substantive, organization-wide commitment, moving beyond rhetorical support to provide the necessary blueprint, budget, and benchmarks for safety improvement. This strategic alignment ensures that safety is not compromised by competing project goals like cost or schedule. Empirical work supports the role of strategic planning in institutionalizing safety and achieving measurable performance gains (Parsamehr et al., 2023; Yiu et al., 2019). Consequently, it is hypothesized that:

H2: Management Strategy (OC2) has a significant positive effect on Construction Safety Performance (CSP).

Management Style (OC3) encompasses the characteristic approach of leaders in communication, decision-making, and interaction with employees. A participative, supportive, and transformational style fosters an environment of psychological safety, where workers feel empowered to voice concerns, report hazards, and engage proactively with safety protocols without fear of reprisal. This open climate is crucial for early hazard identification and correction. Contemporary studies link such leadership styles to increased safety compliance and participation (Wang et al., 2023; Senthamizh and Anandh, 2024). Thus, the following hypothesis is formulated:

H3: Management Style (OC3) has a significant positive effect on Construction Safety Performance (CSP).

Organizational Structure (OC4) defines the framework of authority, responsibility, and communication channels within an organization. A clear and efficient structure with well-defined safety roles and accountabilities minimizes ambiguity, ensures timely flow of safety information, and enables swift response to emerging risks. It provides the formal "scaffolding" through which safety policies are executed and monitored. Research highlights that structural clarity is vital for effective safety management system operation (Forteza et al., 2022). Hence, it is proposed that:

H4: Organizational Structure (OC4) has a significant positive effect on Construction Safety Performance (CSP).

Manager Behaviour (OC5) constitutes the visible, day-to-day actions and demonstrations of commitment by supervisors and managers on-site. This dimension operationalizes leadership commitment through concrete actions such as conducting safety observations, providing constructive feedback, recognizing safe work, and actively participating in safety meetings. These behaviours serve as powerful, real-time signals that reinforce the importance of safety, directly influencing frontline worker behaviour through modelling and reinforcement (Zhang et al., 2019; Grill & Nielsen, 2019). Based on this, the hypothesis is:

H5: Manager Behaviour (OC5) has a significant positive effect on Construction Safety Performance (CSP).

Employee Participation (OC6) denotes the extent to which workers are involved in safety-related decisions, problem-solving, and the development of procedures. Active participation leverages valuable frontline expertise for hazard identification, fosters a sense of ownership and responsibility for safety, and increases commitment to implementing safety solutions. Studies consistently show that participative environments lead to more vigilant and proactive safety behaviours (Umar, 2020; Pandit et al., 2019). Therefore, the hypothesis is advanced:

H6: Employee Participation (OC6) has a significant positive effect on Construction Safety Performance (CSP).

Team Collaboration (OC7) involves the degree of cooperation, communication, and mutual support within and between work crews. In complex, interdependent construction tasks, effective collaboration is essential for coordinating activities safely, sharing critical risk information in real-time, and providing peer-to-peer oversight. A strong collaborative environment acts as a collective defence against errors and incidents (Syed-Yahya et al., 2022; Liu et al., 2021). Accordingly, the final hypothesis is:

H7: Team Collaboration (OC7) has a significant positive effect on Construction Safety Performance (CSP).

2.4.2 Workforce Skill (MV) Can Significantly Moderate the Relationship Between Organizational Culture and Construction Safety Performance (DV)

Employee skill levels, typically understood as a comprehensive reflection of employees' knowledge, skills, and abilities in specific areas, have been shown to play a crucial role in improving the effectiveness of safety management in construction projects. Building safety performance is a critical indicator for assessing the effectiveness of safety management in construction projects. Research by Durdyev (2017) and Mohamed et al. (2017) reveals that high levels of employee skills and expertise can significantly enhance safety performance, as reflected in promoting safety behaviours and reducing accident rates. The work of Trinh, M.T. and Feng, Y. (2020) also emphasizes the central role of employee skill levels in shaping safety behaviours and practices, stating that high-level employee skills are key to improving safety performance. Al-Bayati (2021) assesses a newly proposed framework for construction safety culture and climate, aimed at overcoming the ambiguity in the current definitions and measurements of construction safety culture and climate, highlighting the importance of employee skill levels in improving safety performance. Additionally, Saleem et al. (2022) reveal the roles of psychological capital and job engagement in enhancing the safety behaviours of construction workers, emphasizing the direct impact of high employee skill levels on safety performance. These studies collectively underscore the crucial role of high employee skill levels in enhancing safety awareness, promoting safety practices, and improving overall safety performance. Therefore, The logic for each moderating effect is discussed below, leading to the formulation of specific hypotheses.

Organizational Values (OC1) represent the core beliefs that determine the priority of safety. When safety is established as a fundamental value, it provides essential guidance for decision-making and behaviour across the organization (Karanikas et al., 2020). However, translating abstract values into consistent, concrete safe actions requires employees to possess the capability to interpret and enact them. A highly skilled workforce, with its deeper understanding of work processes and potential risks, can more accurately apply the "safety first" value to complex on-site situations, thereby making the driving effect of values on safety performance more direct and effective. Hence, it is proposed that:

H8: Workforce skill (WS) significantly moderates the relationship between Organizational Values (OC1) and construction safety performance (CSP).

Management Strategy (OC2) provides the blueprint and material foundation for safety performance by integrating safety objectives into long-term planning and resource allocation (Yiu et al., 2019). Nonetheless, the ultimate success of a strategy depends on employees' ability to effectively utilize the allocated resources, including advanced equipment and training systems, in executing the strategic intent. More skilled employees possess a greater capacity to understand the strategy's implications, fully leverage these resources, and adapt to new work procedures required by the strategy, thereby significantly enhancing the conversion efficiency from strategy to performance. Therefore, it is proposed that:

H9: Workforce skill (WS) significantly moderates the relationship between Management Strategy (OC2) and construction safety performance (CSP).

Management Style (OC3) refers to the characteristic approach leaders take in communication, decision-making, and interaction with employees. A participative, supportive, and transformational style fosters psychological safety, empowering employees to report hazards and actively engage with safety protocols, which is crucial for early risk identification (Wang et al., 2023). However, the safety benefits derived from this interaction depend significantly on the employees' capacity for meaningful participation. Employees with higher skills and greater knowledge can more accurately identify complex risks, communicate safety issues more clearly, and propose more viable solutions. Consequently, their engagement can more effectively translate the open climate fostered by leadership into concrete safety improvements. Therefore, it is proposed that:

H10: Workforce skill (WS) significantly moderates the relationship between Management Style (OC3) and construction safety performance (CSP).

Organizational Structure (OC4) defines the institutional framework of safety management by clarifying safety responsibilities, reporting relationships, and information flow (Forteza et al., 2022). For a clear structure to operate efficiently, a prerequisite is that employees can function correctly within it. Highly skilled employees can more accurately understand their roles, more adeptly follow communication channels, and more autonomously fulfill their assigned safety responsibilities, thus ensuring that the advantages of structural design are fully translated into on-site collaborative safety benefits. Therefore, it is proposed that:

H11: Workforce skill (WS) significantly moderates the relationship between Organizational Structure (OC4) and construction safety performance (CSP).

Manager Behavior (OC5) provides the most visible demonstration of safety standards through actions such as site walkthroughs and immediate feedback (Zhang et al., 2019). The effectiveness of this behavioral modeling depends on whether the employees possess sufficient knowledge and skill to identify, understand, and emulate these safe practices. Highly skilled employees, acting as more "professional" observers, can learn more from managers' behaviors and more effectively translate leadership demonstration into personal habits, thereby amplifying the driving effect of behavioral role models on overall safety performance. Therefore, it is proposed that:

H12: Workforce skill (WS) significantly moderates the relationship between Manager Behavior (OC5) and construction safety performance (CSP).

Employee Participation (OC6) relies directly on the quality of insights contributed by employees (Umar, 2020). The participation mechanism itself is merely a platform; its output value is determined by the capabilities of the participants. Highly skilled employees, as domain experts, can provide deeper risk insights, more actionable improvement suggestions, and participate more effectively in root cause analysis of incidents. Consequently, their participation can more substantially enhance the quality of safety decisions and measures, thereby amplifying the positive impact of a participatory culture on performance. Therefore, it is proposed that:

H13: Workforce skill (WS) significantly moderates the relationship between Employee Participation (OC6) and construction safety performance (CSP).

Team Collaboration (OC7) is crucial for ensuring safety in complex operations, relying on precise information sharing and tacit mutual support among members (Liu et al., 2021). High-level collaboration is not merely a matter of willingness but also of capability. Skilled team members can communicate using more precise professional terminology, more accurately anticipate teammates' actions and risks, and coordinate more efficiently in unexpected situations. Therefore, high skill levels make the collaborative "safety net" more robust, significantly enhancing the contribution of collaboration to safety performance. Therefore, it is proposed that:

H14: Workforce skill (WS) significantly moderates the relationship between Team Collaboration (OC7) and construction safety performance (CSP).

In response to the above seven hypotheses, if the T-value for the path is greater than 1.96, or the P-value is less than 0.05, then it represents that the hypothesis is true. Conversely, if the T-value for the path is less than 1.96, or the P-value is greater than 0.05, then it represents that the hypothesis is not true.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter delineates the methodological framework adopted to achieve the research objectives and test the hypotheses formulated in the literature review. The design integrates quantitative approaches with Partial Least Squares Structural Equation Modelling (PLS-SEM) to explore the complex relationships between organizational culture (OC), workforce skill (WS), and construction safety performance (CSP).

3.2 Research Paradigm

This study is within a post-positivist research paradigm, which posits the existence of objective realities while emphasizing their partial apprehension through contextual influences on human cognition and behavioral dynamics. The selection of Partial Least Squares Structural Equation Modelling (PLS-SEM) aligns methodologically with this paradigm through three key rationales. Firstly, PLS-SEM demonstrates robust capabilities in analyzing intricate causal relationships among unobserved theoretical entities, particularly when examining moderated effects such as the interplay between organizational culture and safety performance mediated by workplace conditions. Secondly, the methodology prioritizes predictive relevance over traditional model fit indices, a characteristic particularly suited to exploratory investigations in fluid operational environments like construction safety management. Thirdly, its capacity to integrate formative and reflective measurement approaches enables the nuanced operationalization of complex multidimensional constructs, including organizational culture as conceptualized in this study. This methodological pluralism ensures theoretical fidelity to the phenomenon's inherent complexity while maintaining epistemological consistency with post-positivist principles, as substantiated by contemporary methodological scholarship (Hair Jr et al., 2021). The tripartite alignment between philosophical orientation, theoretical framework, and analytical methodology establishes a rigorous foundation for advancing knowledge in organizational safety research.

3.3 Research Design

In this study, a quantitative design was used to test the hypothetical relationship between OC, WS and CSP. Population, sampling methods, analytical tools and data collection are key components.

3.3.1 Research Area and Research Object

This research was conducted in Jinan City, Shandong Province, China. Jinan City is the capital city of Shandong Province and serves as a political, economic, cultural, and educational centre. It is divided into several districts, including Lixia District, Shizhong District, Huaiyin District, Tianqiao District, and more, which encompass multiple urban areas, suburbs, and villages. Jinan is renowned as the "City of Springs" due to its abundant natural spring water.

Jinan City is a significant economic hub and transportation junction in northern China. It has experienced rapid development and growth during the era of economic reforms and opening up, becoming an influential city in the region. The city's economy primarily relies on industry, commerce, and services, and it boasts rich natural and cultural resources, attracting substantial investments and talent.

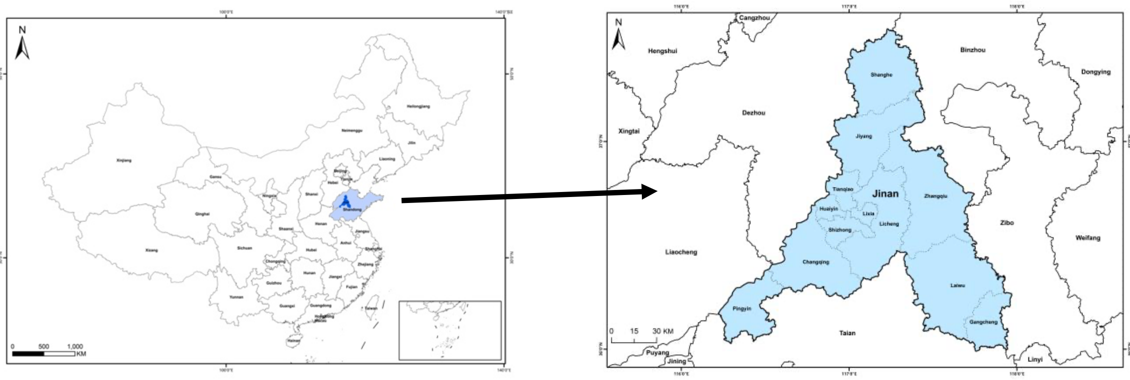

Figure 3.1: Map of Jinan City Shandong Region

Jinan’s geographical coordinates are located between approximately 36.40’ to 37.17’ north latitude and 116.58’ to 117.38’ east longitude, covering a total land area of 8,177 square kilometres. Its strategic location and excellent transportation connections make it a vital crossroads linking the eastern, western, southern, and northern regions of China. There are several reasons for selecting Jinan City as the research location:

Choosing Jinan City as the research sample is significantly rational and representative. Firstly, as the capital of Shandong Province, Jinan not only occupies an important position in terms of economic volume both provincially and nationally but also stands out in the field of construction. According to the *China Annual Statistical Report (2024)* and the *Statistical Yearbook of Shandong Province (2024)*, Jinan City plays a pivotal role in the provincial construction sector. By the end of 2023, the total employed population in the construction industry in Jinan City was 237,000, distributed across 1,519 construction enterprises. In 2023, the construction industry output value in Jinan reached 44.61 billion yuan, accounting for 25.4% of the provincial total (175.65 billion yuan). Concurrently, the number of construction enterprises registered in Jinan stood at 1,371, representing 12.88%

of all such enterprises in Shandong Province (10,643). In both output value and number of enterprises, Jinan ranks first among all cities in the province. This indicates that not only is the construction industry in Jinan City large in scale, but it also has a significant influence and representation in the construction sector both provincially and nationally. Additionally, the structure of the construction industry in Jinan City is rational, with both large and small enterprises developing together, complete with all necessary qualifications, reflecting the joint progress of various ownership structures, providing a rich and diverse sample and data source for the research.

Secondly, as a rapidly developing city, the prosperity of the construction industry in Jinan reflects the city's vitality and potential. The geographical location of Jinan, its economic development situation, and the scale of the construction industry provide a unique research background for researching the interaction between construction safety performance, organizational culture and workforce skill. More importantly, Jinan City's high emphasis on construction safety issues and its well-established construction safety management system provide an empirical basis for researching safety management practices in the construction industry. In summary, choosing Jinan City as the research area is not only due to its importance and representation in the construction industry but also because it provides authentic and effective data and a beneficial research environment.

The respondents in this study are primarily construction project managers, construction engineers, technicians, industry experts and consultants in Jinan City. The survey design and theoretical framework specifically targeted individuals in managerial, supervisory, or technical decision-making roles, as they are the primary carriers and implementers of organizational culture. To access this target population effectively, a multi-channel sampling strategy was implemented. Firstly, questionnaires were distributed online through industry-specific online communities, professional forums, and social media platforms (such as DingTalk and WeChat groups). Secondly, collaboration was established with the Shandong Provincial Construction Industry Association and selected large construction enterprises to disseminate questionnaires through their internal organizational networks. Finally, on-site distribution of questionnaires was conducted at relevant construction industry conferences and safety training sessions held in Jinan City. The underlying logic of this sampling design is elaborated as follows.

i. Focusing on Carriers and Transmitters of Organizational Culture

The primary rationale for selecting respondents in this study is grounded in the theoretical nature of organizational culture and its transmission mechanisms within construction projects. Organizational culture is not homogeneously distributed among all members but is constructed and disseminated through a hierarchical structure from design to implementation. Safety culture follows a top-down transmission model of strategy to institution to behavior. Within this chain, members in different roles fulfil distinct cultural functions. Senior and middle management establish safety values, set strategic priorities, and formulate core safety policies. Project managers, engineers, frontline supervisors, and technicians translate abstract cultural values into concrete operational procedures and on-site interventions. General workers primarily execute safety protocols under established systems and supervision.

Consequently, focusing the survey on individuals in managerial, supervisory, and technical decision-making roles is essential to trace how organizational culture is formed and subsequently influences safety performance. These individuals serve as the culture's carriers and implementation levers. Their decisions and behaviors directly manifest the operational logic of organizational culture. Surveying only general workers would capture terminal outcomes of cultural transmission without revealing its formative mechanisms and transmission pathways.

ii. Variable Measurement and Methodological Rigour

The respondent selection is further guided by the operational definitions of the study's core variables and the principles of research methodology.

a) Measurement of Organizational Culture

Organizational culture as an organizational-level construct is measured across institutional dimensions and leadership dimensions. These dimensions require evaluation by the designers and implementers of institutional policies, as they possess holistic insight into organizational-level consistency and strategic intent. Asking managers about safety innovation reflects policy direction, while asking workers yields responses constrained by localized experience. To ensure measurement validity, this study anchors its primary measurement of organizational culture to managerial respondents.

b) Defining Workforce Skill

Workforce skill is operationalized as the integration of safety management capabilities and technical application proficiencies. This definition aligns with project managers, engineers, and technical personnel whose skill levels determine their capacity to interpret and reinforce organizational safety culture. The core skills of general workers involve task execution proficiency. The pathway through which such skills interact with organizational-level cultural variables differs. To precisely test the moderating effect, this study focuses its primary skill measurement on frontline managerial and technical personnel.

c) Control for Methodological Considerations

The research design acknowledges that organizational culture operates at the organizational level while individual skills exist at the individual level. To address this, the study maintains clear separation between data from different respondent groups. Data from managerial respondents will be analyzed separately from any data collected from other roles. This approach prevents methodological issues that could arise from mixing different levels of analysis while allowing for appropriate comparative examination of perspectives across organizational roles.

To sum up, the respondents of this study is to give priority to management, construction engineers and technicians in construction enterprises in Jinan City, so as to investigate how organizational culture is formed, disseminated and implemented through these main carriers.

3.3.2 Sample Size Determination

The sample size for this study was determined through a priori statistical power analysis, following established methodological principles in behavioural science and considering the specific requirements of Partial Least Squares Structural Equation Modelling (PLS-SEM). This process ensures the research design is sufficiently sensitive to detect hypothesized effects while guaranteeing the stability and reliability of the parameter estimates.

i. A Priori Sample Size Calculation via Statistical Power Analysis

A priori power analysis was conducted using G*Power 3.1 software (Faul, Erdfelder, Buchner, & Lang, 2009) to determine the minimum sample size required. The parameter Settings are shown in Table 3.1. The specific reasons are as follows:

Statistical Power ($1 - \beta$): Set at 0.80, the conventional benchmark in behavioural sciences, indicating an 80% probability of correctly rejecting a false null hypothesis (Cohen, 1988).

Significance Level (α): Set at 0.05 for a two-tailed test.

Number of Predictors (k): Set at 15. This represents the maximum set of predictors requiring simultaneous estimation in the model, encompassing: the main effects of the seven organizational culture dimensions (OC1-OC7), the main effect of workforce skill (WS), and the seven interaction terms between workforce skill and each culture dimension (WS × OC1 to WS × OC7).

Expected Effect Size (f^2): Set at 0.02, defined by Cohen (1988) as the threshold for a small effect. This deliberately conservative criterion is justified by two key considerations:

Sensitivity for Detecting Moderation: In complex organizational models, the effect size of moderation (interaction) is typically much smaller than that of main effects (Aguinis, 1995). Adopting a small effect size standard ensures the research design is sufficiently sensitive to detect potentially weak yet theoretically meaningful moderating effects.

Realism in Multivariate Contexts: In complex models featuring multiple competing predictors-such as the seven distinct dimensions of organizational culture examined in this study-the unique variance attributable to any single predictor is often diluted, resulting in a reduced effect size magnitude. (Hair et al., 2022). Planning based on a small effect safeguards the reliability of the tests even if explanatory power is distributed diffusely across variables.

Table 3.1: A Priori Power Analysis Parameters and Results Using G*Power

Parameter	Symbol	Value Set
Statistical Power	$1 - \beta$	0.80
Significance Level	α	0.05
Expected Effect Size	f^2	0.02
Number of Predictors	k	15
Minimum Required Sample Size	N	421

Using the above parameters, G*Power 3.1 calculated a minimum theoretical sample size of 421 valid responses. This calculation rigorously follows the power analysis framework for multiple regression outlined by Cohen (1988), providing a statistically solid foundation for the study's sample size requirements.

ii. Considerations for PLS-SEM Methodological Specificities

While 421 responses satisfy the statistical power requirement, the target sample size was further informed by established PLS-SEM methodological guidelines to ensure analytical robustness:

Model Stability and the "10-Times Rule": A key heuristic in PLS-SEM suggests the sample size should be at least 10 times the maximum number of structural paths pointing to any endogenous construct in the model (Hair, Risher, Sarstedt, & Ringle, 2019). In this study, the endogenous variable Construction Safety Performance (CSP) is influenced by the 15 predictors mentioned, suggesting a minimum of 150 responses. Setting a target significantly above this heuristic threshold (421) provides a substantial stability margin for model estimation, particularly crucial for obtaining reliable standard errors via Bootstrap resampling (set at 5000 iterations).

Addressing Practical Challenges and Enabling In-Depth Analysis: A higher target sample size accounts for practical survey challenges such as invalid responses and missing data, ensuring a sufficient pool of high-quality data remains after rigorous cleaning. Furthermore, a substantial sample size exceeding 400 creates the potential for valuable post-hoc analyses, such as subgroup comparisons based on firm size or project type and more advanced model validation, thereby enhancing the study's theoretical contribution and practical relevance.

iii. Final Sample Size Determination and Implementation

Synthesizing the results of the power analysis with PLS-SEM best practices, this study set a target of distributing 500 questionnaires. This target aims to ensure the final valid sample size comfortably exceeds the minimum theoretical requirement of 421 derived from G*Power. Provide ample buffer for expected attrition during data collection and cleaning. Yield a dataset that is statistically powerful and methodologically robust for rigorously testing the proposed complex model.

3.3.3 Sample Method

This study employs convenience sampling, a non-probability sampling technique, to select participants from the target population of construction professionals in Jinan City.

3.3.3.1 The Reason for Choosing Convenience Sampling

The rationale for choosing convenience sampling includes practical accessibility, cost and time efficiency and industry collaboration.

i. Practical Accessibility

Construction project managers, engineers, and technical personnel are often dispersed across multiple sites and organizations, making random or stratified sampling logistically challenging. Convenience sampling allows for efficient data collection by targeting respondents who are readily accessible through professional networks, industry events, and online platforms.

ii. Cost and Time Efficiency

Given the large population size (N=237,000) and the geographic spread of Jinan City, convenience sampling reduces the time and financial resources required for data collection.

iii. Industry Collaboration

Partnerships with local construction associations and firms facilitated access to a pool of qualified respondents, ensuring that the sample includes professionals with relevant experience and expertise.

3.3.3.2 Limitations and Mitigation Strategies

While convenience sampling is practical, it can introduce selection bias, for example, overrepresentation of certain roles or organizations. In order to mitigate this situation, data was collected through a multi-channel strategy utilizing both professional online survey platforms and direct, supervised distribution during on-site visits to construction projects. To ensure data integrity and prevent duplicate responses from the same individual, stringent procedural controls were implemented. These controls included the use of platform-specific features to restrict multiple submissions from the same IP address or device for online surveys, coupled with on-site supervision during paper-based distributions to ensure single, voluntary participation. This approach secured a broad and authentic representation of key professional roles across the industry, including project managers, construction engineers, and skilled technicians.

3.4 Research Instrument Development

This section details the design and validation of the questionnaire used to investigate the relationship between organizational culture, workforce skills, and construction safety performance.

3.4.1 Questionnaire Design

The questionnaire design of this research meticulously covers three main sections: Demographic Information, Organizational Culture (OC), Workforce skill (WS), and Construction Safety Performance (CSP), in order to comprehensively collect the data required for the research. Initially, in the Demographic Information section, by inquiring about the respondents' gender, age group, educational level, work experience, occupation, and company size, it aims to understand the background of the respondents to provide a basis for subsequent analysis. Following that, the Organizational Culture section, based on existing research and literature, designs questions covering seven measurement indicators such as organizational values, management strategy, management style, organizational structure, manager behaviour, employee participation, and team collaboration. Using a 1 to

7 Likert scale, respondents rate their agreement based on personal experience and knowledge to assess the impact of organizational culture on safety performance.

In the Workforce Skill (WS) section, the questionnaire, also grounded in related research, evaluates aspects such as professional skills, safety awareness, team collaboration, technical training, task completion, and problem-solving ability, to explore the contribution of employee skill levels to safety performance. The Construction Safety Performance (CSP) section focuses on key indicators like safety awareness, safety training, safety measures, durability, safety performance, risk management, and safety culture. Through respondents' ratings of these issues, the safety performance of construction projects is assessed. The entire questionnaire design emphasizes collecting data from different dimensions, considering both internal factors such as organizational culture and employee skills, and safety practices during project execution, striving for a comprehensive understanding of the multifaceted factors affecting construction safety performance.

The Construction Safety Performance (CSP) section, based on significant literature, explores various aspects such as improving construction safety performance in developing contexts, the impact of emerging technologies on construction safety performance, the effect of Lean implementation on construction safety performance, and how risk assessment methods can enhance construction safety performance. Using a 7-point Likert scale, respondents rate several measurement indicators based on their experience, knowledge, etc., including safety awareness, safety training, safety measures, durability, safety performance, risk management, and safety culture. Each measurement indicator specifically inquiries about key aspects related to the safety performance of construction projects. For example, it evaluates whether the organization complies with building safety standards, whether all employees have received comprehensive safety training including emergency procedures, whether on-site safety measures effectively reduce accidents and injuries, whether the materials and structural design of projects ensure long-term durability, whether the project's safety performance meets or exceeds industry standards according to internal and external safety audits, whether the organization effectively identifies, assesses, and manages safety risks in the construction process, whether the organizational culture encourages a safety-first approach, and whether employees actively report potential safety issues.

3.4.2 Research Instruments

All the measurement items of the constructs in this study were measured using a 7-point Likert scale (1= "strongly disagree" to 7= "strongly agree"). Choosing this scale instead of the 5-point scale is to provide respondents with stronger discrimination, to capture more subtle perceptual differences, and thereby enhance the sensitivity of subsequent statistical analysis. The questionnaire items are not created out of thin air but are carefully adapted and integrated from mature scales that have been verified in previous literature on construction management, organizational behaviour, and occupational safety. This method ensures content validity and enhances the comparability of research findings with a broader research context. The design of each part is based on a targeted review of recent research. The questionnaire references are shown in table 3.2.

Table 3.2: Questionnaire Reference List

Questionnaire Section	The Title of the Reference	Author
Section B Organizational Culture (OC)	The Mediating Effect of Emotional Safety Perception on the Relationship between Safety Culture and Organizational Effectiveness of Construction Workers	Cho and Shin (2023)
	A Study on the Effect of Safety Leadership on Organizational Safety Culture and Safety Behavior in the Service Industry	Kim et al. (2023)
	National culture and occupational safety-a comparison of worker-level factors impacting safety for Danish and Swedish construction workers	Nielsen et al. (2023)
	The Impact of Organizational Safety Culture on the Resilience Ability: Focused on the Construction Industry	Chu et al. (2021)
Section C Workforce Skill (WS)	Promotion of Vocational Education and Training Career Pathways in the Australian Construction Industry	Skiba (2020)
	Risk Factors for Construction Workforce Safety towards Sustainability	Asad et al. (2020)
	Optimization Model of Technical Workers Allocation for Construction Safety Control in Prefabricated Building	Chang and Zuo (2022)
	Working Period Relationship, Safety Knowledge, and Safety Performance among the Construction Workforce of Light Rail Transit	Sinaga, G. O. and Sinaga, C. V. (2022)
Section D Construction Safety Performance (CSP)	Strategies for Improving Construction Safety Performance in Developing Context	Beitelmal et al. (2023)
	Investigating the impact of emerging technologies on construction safety performance	Dobrucali et al. (2024)
	Measuring impact of Lean implementation on construction safety performance: a structural equation model	Demirkesen (2020)
	A risk assessment approach for enhancing construction safety performance	Sanni-Anibire et al. (2020)

The organizational culture scale mainly integrates the research framework on safety leadership and safety culture by Kim et al. (2023), as well as the indicator system adopted by Chu et al. (2021) for measuring the dimensions of organizational safety culture in the construction industry. In the design of specific dimensions, this study mainly referred to the analysis of the influence path of organizational culture by Cho and Shin (2023), especially drawing on and transforming the measurement methods of the dimensions of "management style" and "team collaboration". The workforce skills scale is mainly based on the research framework and measurement methods of Asad et al. (2020) regarding the influencing factors of construction labour safety, and combines the analysis of Chang & Zuo (2022) on the ability structure and distribution mechanism of skilled workers to reflect the new requirements for labour skills brought about by technological changes in the construction industry. The construction safety performance scale mainly refers to the safety performance evaluation index system based on the structural equation model by Demirkesen (2020), and combines the research on the improvement strategies of construction safety performance in developing countries by Beitelmal et al. (2023) to adjust and form measurement items suitable for the Chinese context.

The internal consistency reliability of each construct was evaluated using the Cronbach coefficient. As shown in Table 3.3, all coefficient values exceed the common threshold of 0.70, and most are above 0.82, indicating excellent reliability and confirming that each item in the scale consistently measures the same latent construct.

Table 3.3: Measurement Summary of Research Variables

Variable	Construct Name	No. of Items	Scale	Cronbach's Alpha (α)
OC1	Organizational Values	4	7-point Likert	0.824
OC2	Management Strategy	4	7-point Likert	0.821
OC3	Management Style	4	7-point Likert	0.799
OC4	Organizational Structure	4	7-point Likert	0.830
OC5	Manager Behavior	4	7-point Likert	0.823
OC6	Employee Participation	4	7-point Likert	0.829
OC7	Team Collaboration	5	7-point Likert	0.856
WS	Workforce Skill	6	7-point Likert	0.850
CSP	Construction Safety Performance	7	7-point Likert	0.891

Th design and selection of the research instrument aim to align with the application of PLS-SEM (Section 3.6.1), ensuring consistency between the data analysis method and the research objectives. Detailed data processing and analytical procedures are elaborated in Section 3.6.2.

3.4.3 Pretest and Pilot Study

To ensure the validity and reliability of the research instrument, a two-stage testing procedure was employed: the pretest followed by the pilot study. These stages serve distinct yet complementary purposes. The pretest primarily assesses the content validity and clarity of the questionnaire through critical review by domain experts. In contrast, the pilot study evaluates the measurement reliability and practical administration of the instrument with a small sample of the target population. This rigorous approach ensures the questionnaire is both theoretically sound and empirically robust before full-scale deployment.

3.4.3.1 Pretest

The pretest aimed to identify and rectify potential issues in question wording, instruction clarity, logical flow, and relevance to the research constructs. A panel of three experts was convened to provide multi-faceted feedback, combining academic rigor with industry pragmatism: Professor Peidong Sang and Associate Professor Yuanyuan Li from the School of Management Engineering at Shandong Jianzhu University were invited. Their extensive publication records in construction safety management and organizational behavior ensured the questionnaire's theoretical grounding and construct validity. Senior Engineer Mingzhao Li from China Construction Second Engineering Bureau Ltd. was included. Her frontline experience in major construction projects provided critical insights into the contextual appropriateness, terminology accuracy, and practical relevance of the items to real-world site management.

This combined review by both academic and industry experts is essential. The academic reviewers ensured the questionnaire’s items were theoretically sound and accurately reflected the constructs under study. The industry expert verified that the language, context, and scenarios were relevant and understandable to practitioners in the field. This collaborative process helped produce a final instrument that is both rigorous and applicable. The experts provided detailed comments on phrasing ambiguity, response scale suitability, and missing dimensions. Their feedback led to targeted revisions across several constructs, as summarized in Table 3.4.

Table 3.4: Summary of Key Questionnaire Revisions

Construct	Original Item Wording	Final Item Wording	Rationale for Amendment
OC1	I share and endorse the core values advocated by the organization.	I understand and identify with the core values of the organization.	Shifted from endorsement to cognitive identification, reducing social desirability bias.
OC2	Safety strategies are communicated effectively throughout the organization.	I receive clear guidance and explanations regarding safety strategies.	Specified vague "effective communication" to a concrete, personal experience of receiving guidance.
OC3	Leaders are fair and transparent in their dealings.	The leadership style emphasizes fairness, transparency, and safety.	Explicitly integrated "safety" into the core description of leadership style to maintain contextual focus.
OC4	The organizational design allows for efficient safety management."	The organizational structure is capable of responding quickly to emerging safety issues.	Replaced abstract "allows for efficiency" with a tangible outcome measure: rapid response capability.
OC6	I am encouraged to participate in safety decision-making.	My safety suggestions are taken seriously by management and acted upon.	Moved from measuring perceived encouragement to measuring the concrete outcome and impact of participation.
WS	Employees possess the necessary professional competencies.	Our employees can quickly find solutions when faced with problems.	Changed from stating static competence to describing observable problem-solving behavior in a work context.
CSP	Our safety audit results are satisfactory.	According to internal and external safety audits, our project's safety performance meets or exceeds industry standards.	Anchored a subjective judgment ("satisfactory") to objective benchmarks (audits, industry standards) for precise measurement.

3.4.3.2 Pilot Study

A pilot study serves as a small-scale trial run of the entire research process, providing an opportunity to assess the reliability and validity of the research instrument. This step is crucial for ensuring the accuracy and trustworthiness of the study findings. Cooper and Schindler (2011) recommend a sample size ranging from 25 to 100 individuals for a pilot study, while Machin et al. (2018) suggest a sample size of 30. In this study, 40 responses were collected for the pilot study to accommodate data cleaning and refinement needs. This size is sufficient for conducting preliminary reliability analyses and exploratory factor analysis while allowing for data cleaning, without imposing excessive logistical burden. The pilot was conducted in May 2024 during a training conference on high-quality development of insurance business in housing, gas, and heating engineering construction held in Jinan City, where 40 professionals were recruited on-site to participate. Attendees holding relevant positions-including project managers, engineers, and technicians-were invited to participate, ensuring their professional roles aligned with the inclusion criteria established for the main study.

Following data collection, the pilot responses were analyzed to assess the measurement properties of the instrument. Reliability analysis indicated that all multi-item constructs demonstrated satisfactory internal consistency, with Cronbach's alpha coefficients exceeding the recommended threshold of 0.70, where Organizational Culture $\alpha = 0.89$, Workforce Skill $\alpha = 0.92$. No items were found to significantly degrade scale reliability if deleted. Feedback from participants regarding the clarity of instructions and the appropriateness of the response format was reviewed. Based on their feedback, minor final adjustments were made, primarily the optimization of the online survey's layout for mobile device compatibility.

This pre-test and pilot study process was instrumental in enhancing the quality of the research instrument, thereby contributing to the robustness of the study's findings.

3.5 Data Collection Procedure

This section outlines the systematic approach to data collection, emphasizing ethical compliance and methodological rigor. Participants were provided with informed consent documentation ensuring anonymity and voluntary participation, while data security was maintained through encrypted storage.

3.5.1 Ethical Considerations

Ethical considerations were rigorously addressed throughout the study: participants received a cover letter along with the questionnaire, explaining the principles of anonymity, voluntary participation, and data usage to ensure informed consent. Data security was maintained through encrypted storage on password-protected devices, with access strictly limited to the researcher.

3.5.2 Date Collection Technique

The data for this research was collected through a structured questionnaire administered over a defined period to ensure sufficient participation and comprehensive data coverage. The data collection process spanned from June 2024 to November 2024, allowing ample time for respondents to provide thoughtful and accurate answers. This time frame was selected to capture variations in responses that may arise due to operational or environmental factors within the construction industry. The extended duration also ensured the collection of a robust sample size, enhancing the reliability and validity of the study's findings.

i. Online Questionnaires

Tool Selection: Professional online questionnaire platforms such as SurveyMonkey or Qualtrics are used for questionnaire design and distribution.

Distribution Channels: The questionnaire is distributed through industry-related online communities, professional forums, and email lists.

ii. On-Site Surveys

Site Selection: Representative construction sites or industry-related conferences and training events are chosen.

Personnel Training: Special survey personnel are trained to ensure accurate and professional data collection.

iii. Collaborative Institutions

Industry Collaboration: Partnerships are established with construction industry associations or large construction companies to distribute the questionnaire through their networks.

Expert Participation: Experts and scholars within the industry are invited to participate in the questionnaire design and pre-testing to improve its scientific accuracy.

3.6 PLS-SEM Analytical Framework

This section elaborates the analysis framework of the Partial Least Squares Structural Equation Modelling (PLS-SEM) from the reasons for PLS-SEM selection and detailed analysis.

3.6.1 Rationale for Choosing PLS-SEM

Partial Least Squares Structural Equation Modelling (PLS-SEM) was selected as the primary analytical technique for this study. This decision is supported by the following key methodological considerations, each grounded in established literature.

i. Predictive Orientation and Model Complexity

PLS-SEM is fundamentally prediction-oriented and is particularly adept at explaining variance in dependent variables, making it ideal for causal-predictive analysis and theory development (Hair et al., 2019). It is also highly effective for estimating complex models with many constructs, indicators, and path relationships without imposing stringent distributional assumptions, which aligns with the multifaceted structure of our research model (Hair et al., 2022).

ii. Flexibility in Data Requirements

Compared to covariance-based SEM (CB-SEM), PLS-SEM has less restrictive requirements regarding sample size and residual distribution. It is robust with non-normal data and can provide stable results with smaller samples, which is advantageous in applied social science research where such conditions are common (Ringle et al., 2020).

iii. Suitability for Exploratory Research and Theory Development

PLS-SEM is well-suited for exploratory research aimed at extending existing theory. It prioritizes the explanation of variance and is therefore recommended in contexts where the goal is prediction and the identification of key driver constructs, rather than theory confirmation alone (Henseler et al., 2016).

iv. Integration of Formative and Reflective Measurement Models

PLS-SEM accommodates both formative (cause-and-effect) and reflective (effect-and-cause) measurement model specifications within the same structural model. This flexibility allows for a more theoretically accurate operationalization of complex constructs, such as organizational culture, which are often best modelled as formative (Hair et al., 2020).

In summary, PLS-SEM is the appropriate analytical tool for this study because it directly supports our predictive and exploratory research objectives, accommodates the complexity of our theoretical model, is robust to our data characteristics, and allows for appropriate construct measurement. This alignment ensures the methodological rigor and validity of our analysis in examining the intricate relationships between soft factors and construction safety performance.

3.6.2 Detailed Analysis Steps Based on PLS-SEM

In this research, Partial Least Squares Structural Equation Modelling (PLS-SEM) is adopted as the primary analytical tool to systematically test hypotheses and uncover the potential connections between organizational culture, workforce skill, and construction safety performance. PLS-SEM, as an advanced multivariate analysis method, is particularly suitable for complex models and research oriented towards prediction. The following are the detailed steps for implementing PLS-SEM.

i. Data Collection

Extensive data from the construction industry in Jinan City were collected through well-designed and targeted questionnaires. Each questionnaire aimed to gain in-depth insights into participants' personal experiences, viewpoints, and perceptions of their work environment. Ethical guidelines were strictly followed during the data collection process, ensuring the anonymity of all participants and the confidentiality of data.

ii. Data Preparation

After data collection, a meticulous data cleaning process was conducted. This included handling any missing values, transformations to ensure data quality and suitability for subsequent PLS-SEM analysis.

iii. Model Estimation

A theoretical-driven structural equation model was constructed using PLS-SEM software, such as Smart PLS. This model explicitly specified latent variables, observed indicators, and defined expected path relationships based on an in-depth literature review and predefined research hypotheses.

iv. Model Evaluation

The measurement and structural properties of the PLS-SEM model were thoroughly assessed and validated to ensure the reliability and validity of research results. This process covered several key aspects:

v. Internal Consistency Reliability

First, the internal consistency reliability of each latent variable in the model was examined. This was achieved by calculating Composite Reliability (CR) and Cronbach's alpha to ensure that indicators within each latent variable exhibited good consistency when measuring the same latent construct. Ideally, these values should be higher than the recommended minimum threshold of 0.7, indicating high internal consistency.

vi. Indicator Reliability

The reliability of each observed indicator was also assessed by examining the loadings of each indicator. Loadings greater than 0.7 were considered acceptable, indicating that most of the variance could be explained by their respective latent constructs.

vii. Convergent Validity

Convergent validity was evaluated through Average Variance Extracted (AVE) for each construct. AVE values should exceed 0.5 to ensure that the variance extracted by measured indicators within each construct is greater than the error variance, indicating accurate measurement of the constructs.

viii. Discriminant Validity

Discriminant validity was assessed by comparing the square root of AVE for each construct with the correlations of that construct with others. The square root of AVE for each construct should be greater than the correlation of that construct with other constructs, demonstrating sufficient discriminant validity.

ix. Structural Model Evaluation

After confirming the reliability and validity of the measurement model, the focus shifted to assessing the performance of the structural model. This involved examining the size and significance of path coefficients to determine the strength and direction of relationships between variables. R-squared values were used to assess how much variance in dependent variables could be explained by independent variables, while Q-squared values were employed to evaluate the predictive relevance of the model, indicating how well the model fits observed data points.

x. Model Fit

Lastly, the overall fit of the model was evaluated to ensure that the model is not only statistically significant but also relevant and practical in real-world applications. By comparing observed values with model-predicted values, the overall quality and applicability of the model were assessed.

a) Hypotheses Testing

Based on the statistical outputs of the model, each research hypothesis was systematically tested. The significance of path coefficients and explained variance was thoroughly analysed to determine the strength and direction of each causal relationship.

b) Results Interpretation

Finally, a comprehensive interpretation of the analysis results was conducted. This included discussions on how the findings either supported or refuted the research hypotheses and explored the potential implications of these discoveries on both theory and practice. Any unexpected findings were analysed in detail, providing insights for future research directions.

3.7 Data Screening and Preprocessing

Before proceeding to reliability and validity analysis, comprehensive data cleaning was performed to address missing values, outliers, and non-normality. First, missing data were handled through mean substitution for continuous Likert-scale items and listwise deletion for categorical variables such as occupation. Second, outliers were identified using

Mahalanobis distance ($p<0.001p<0.001$) and boxplot analysis, resulting in the exclusion of 12 extreme cases. Third, skewness and kurtosis values for all variables were within acceptable thresholds (skewness<|2.0|, kurtosis<|7.0|), though logarithmic transformation was applied to two slightly skewed items. Finally, z-score standardization was conducted to normalize scale differences. These steps were implemented using SPSS 28 for initial processing and Smart PLS 4 for PLS-specific diagnostics.

3.8 Measurement Model Assessment

This section describes the evaluation of measurement models from structural equation loading to Heterotrait-Monotrait Ratio (HTMT).

3.8.1 Loading

In Structural Equation Modeling (SEM), loading refers to the standardized regression coefficients between observed variables (indicators) and their corresponding latent variables. It represents the extent to which a measurement variable contributes to its latent variable and is often used to assess the validity and appropriateness of a measurement model. A higher loading value indicates a strong relationship between the measurement variable and the latent variable, suggesting a higher contribution of that indicator. Ideally, loadings should be greater than 0.7, indicating strong explanatory power, while loadings below 0.5 are considered weak and may suggest the indicator does not adequately represent its latent variable.

Loadings are used to assess convergent validity, which measures whether the indicators effectively reflect the latent variable. Low loadings may suggest that a measurement variable does not appropriately represent its latent variable, leading to potential removal or modification of the indicator. Loadings greater than 0.7 are considered ideal, and values below 0.5 typically require revision.

3.8.2 Cronbach's α Coefficient (α)

Cronbach's α Coefficient (α) is a widely used measure of internal consistency or reliability of a measurement instrument. Its value ranges from 0 to 1, with higher values indicating stronger internal consistency among the items. A high Cronbach's α suggests that the items within a measurement scale are strongly related, and thus, the scale reliably measures the intended construct. Generally, a Cronbach's α value greater than 0.7 indicates good reliability, while values below 0.6 are considered to reflect poor reliability, necessitating further refinement.

Cronbach’s α coefficient is commonly used to assess the internal consistency of scales or questionnaires, ensuring that each indicator effectively represents the latent variable. An α value greater than 0.7 indicates good internal consistency, while values below 0.6 may indicate the need for item modification or removal.

3.8.3 Composite Reliability (CR)

Composite Reliability (CR) is a measure of the reliability of a latent variable. Similar to Cronbach's α, CR considers the loadings of the measurement items, providing a more accurate reflection of the latent variable's internal consistency. CR values range from 0 to 1, with values greater than 0.7 indicating a reliable latent variable. CR is considered a more precise measure than Cronbach's α, as it corrects the bias by considering the actual contribution of each measurement item.

CR is used to assess the reliability of latent variables. It is considered more reliable than Cronbach's α, especially when loadings vary among indicators. A CR value greater than 0.7 indicates good reliability, and if the value is lower, the measurement items for that latent variable may need to be revised or replaced.

3.8.4 Average Variance Extracted (AVE)

Average Variance Extracted (AVE) is a measure used to assess convergent validity of a latent variable, indicating the average variance of measurement items explained by the latent variable. The higher the AVE, the more variance the latent variable explains, suggesting better convergent validity. AVE values above 0.5 are generally considered acceptable, meaning the latent variable explains at least 50% of the variance in its measurement items. If the AVE is below 0.5, it suggests poor convergent validity.

AVE is used to assess the convergent validity of a latent variable. Values greater than 0.5 indicate good convergent validity, meaning the latent variable effectively explains the variance in its indicators. If AVE is less than 0.5, it suggests that the latent variable does not adequately explain the measurement items, and the model may need adjustment.

3.8.5 Variance Inflation Factor (VIF)

Variance Inflation Factor (VIF) is used to detect multicollinearity in a regression model, indicating the strength of the linear relationship between an explanatory variable and all other explanatory variables. A higher VIF value suggests strong multicollinearity, which can lead to instability in the model's estimates. Generally, a VIF above 10 indicates severe multicollinearity, and the variables may need to be removed or combined. A smaller VIF value suggests lower multicollinearity, and the model is considered more stable.

VIF is primarily used to detect multicollinearity in regression models. VIF values above 10 indicate potential multicollinearity problems, and variables may need adjustment. VIF values less than 5 indicate low multicollinearity, suggesting a more stable model.

3.8.6 Heterotrait-Monotrait Ratio (HTMT)

Heterotrait-Monotrait Ratio (HTMT) is a metric used to assess discriminant validity between latent variables in Structural Equation Modeling (SEM). Discriminant validity ensures that different latent variables measure distinct constructs and that they do not overlap excessively with each other. The HTMT method was introduced to provide a more reliable measure of discriminant validity, addressing the potential issues with the Fornell-Larcker criterion when high multicollinearity is present. HTMT is calculated by taking the ratio of correlations between heterotrait (correlations between different latent variables) and monotrait (correlations within the same latent variable).

HTMT reflects the degree of correlation between two latent variables by comparing the heterotrait correlations (correlations between different latent variables) with the monotrait correlations (correlations within the same latent variable). If the HTMT value is high, it suggests that the latent variables are highly correlated, which may indicate a lack of discriminant validity and potential measurement overlap. A commonly accepted threshold is that HTMT should be below 0.85; values higher than 0.85 may signal inadequate discriminant validity and the possibility of multicollinearity issues.

HTMT is primarily used to assess the discriminant validity between latent variables. High correlations between latent variables can lead to inaccurate model estimates and hinder the model's interpretability. The HTMT value should ideally be below 0.85 to ensure adequate discriminant validity. Values above this threshold suggest that the latent variables overlap too much and may require adjustments to the measurement model. In stricter models, a threshold of 0.90 may be applied, but the 0.85 threshold is widely accepted in most studies.

3.9 Structural Model Assessment

Structural Model Assessment is a critical step in evaluating the goodness-of-fit and explanatory power of a Structural Equation Model (SEM). While the measurement model focuses on the relationships between latent variables and observed indicators, the structural model focuses on the relationships between the latent variables themselves. To assess the structural model, key metrics such as Path Coefficient Significance, Coefficient of Determination (R^2), Effect Size (f^2), and Predictive Relevance (Q^2) are considered. Below is a detailed explanation of each of these metrics.

3.9.1 Path Coefficient Significance (Bootstrapping)

Path coefficient significance testing involves using the bootstrapping method to statistically infer the significance of the path coefficients, which reflect the strength of the relationships between latent variables in the structural model. Bootstrapping is used to estimate the standard errors and t-values of path coefficients by repeatedly sampling from the original dataset (typically 1000 times or more). The t-value is used to assess the significance of each path coefficient, with t-values greater than 1.96 indicating that the path coefficient is statistically significant at a 95% confidence level.

Path coefficient significance testing helps to verify whether the causal relationships in the structural model are meaningful. If the t-value exceeds 1.96, it indicates that the path coefficient is statistically significant. Additionally, p-values are used to further validate the significance, with p-values less than 0.05 or 0.01 indicating statistical significance.

3.9.2 Coefficient of Determination(R^2)

The Coefficient of Determination (R^2) is a measure of how well the independent variables in the model explain the variance in the dependent variables. It is a key indicator of the model's explanatory power, with values ranging from 0 to 1. Higher R^2 values indicate that a larger proportion of the variance in the dependent variable is explained by the independent variables in the model.

In PLS-SEM, R^2 is used to evaluate the goodness-of-fit of the structural model, reflecting the ability of the independent variables to explain the variance in the target latent variables. An R^2 value greater than 0.1 indicates moderate explanatory power, values greater than 0.25 indicate strong explanatory power, and values greater than 0.5 indicate very high explanatory power.

Purpose and Standards: The R^2 value helps assess the overall fit of the model and the extent to which the latent variables are explained by the predictors. HigherR^2 values indicate better model fit and greater predictive accuracy. However, excessively high R^2 values may indicate model overfitting, soR^2 should be evaluated in conjunction with other metrics.

3.9.3 Effect Size(f^2)

Effect size (f^2) measures the magnitude of the impact that an independent variable has on a dependent variable. It reflects the contribution of the independent variable to the overall explanatory power of the model. The size of f^2 determines how strongly each latent variable influences the changes in the dependent variable. Generally, values of f^2 are interpreted as small (0.02), medium (0.15), and large (0.35) effects. Purpose and Standards: Effect size helps to assess the relative importance of independent variables in explaining the dependent variable. Larger f^2 values indicate a stronger impact of the independent variable on the dependent variable. Typically, values of 0.02, 0.15, and 0.35 represent small, medium, and large effects, respectively.

3.9.4 Predictive Relevance(Q^2)

Predictive Relevance (Q^2) assesses the predictive ability of the structural model by evaluating how well the model can predict data for new observations. It is calculated using cross-validated redundancy, which indicates the model's ability to predict the variance in the endogenous constructs. Higher Q^2values indicate stronger predictive relevance of the model.

Purpose and Standards. Q^2 is used to assess the model's predictive capability, particularly in its ability to predict changes in the dependent variables. If Q^2 is greater than zero, it indicates that the model has predictive relevance. A Q^2value less than zero indicates poor predictive power. The higher the Q^2, the better the model's ability to predict changes in the data, making it a crucial metric for predictive analysis.

3.9.5 Moderation Analysis

Moderation analysis in Structural Equation Modeling (SEM) is used to investigate how a moderator variable influences the strength or direction of the relationship between an independent and dependent variable. The core idea of moderation analysis is to determine whether a moderator variable changes the impact of the independent variable on the dependent variable under different conditions. In this study, the focus is on how “Workforce Skill” (WS) moderates the relationship between “Organizational Culture” (OC) and “Construction Safety Performance” (CSP).

The first step in conducting moderation analysis is to establish a clear theoretical framework and propose relevant research hypotheses. In this study, it is hypothesized that workforce skill plays a critical moderating role in the relationship between organizational culture and construction safety performance. Specifically, the positive effect of organizational culture on construction safety performance may vary depending on the level of workforce skill. In high-skilled teams, the positive impact of organizational culture on safety performance may be amplified, whereas in low-skilled teams, the influence may be weaker or even insignificant. This study aims to explore how workforce skill moderates the relationship between organizational culture and safety performance, shedding light on how organizational culture can improve safety performance in construction sites under different workforce skill levels.

The core of moderation analysis is the construction of interaction terms, which are then incorporated into the SEM for path analysis. In this study, workforce skill is considered as the moderator, and interaction terms between workforce skill and organizational culture dimensions are constructed. These interaction terms help reveal the moderating role of workforce skill in the relationship between organizational culture and construction safety performance. Path analysis is then used to estimate the path coefficients, especially those involving interaction terms, and significance testing (such as t-values, p-values) is performed to check for the existence of moderation effects.

Path analysis, by calculating path coefficients, especially the coefficients of interaction terms, can reveal the moderating effect of workforce skill on the relationship between organizational culture and construction safety performance. The Bootstrapping method can further be used to test the significance of the interaction term's path coefficient.

Typically, when the t-value is greater than 1.96 and the p-value is less than 0.05, the interaction term is considered statistically significant, thus confirming the existence of a moderation effect.

Once the moderation analysis is completed, researchers can analyse the moderating role of workforce skill in the relationship between organizational culture and construction safety performance using path coefficients, t-values, and p-values. If the path coefficient for the interaction term is significant, it indicates that workforce skill plays a significant moderating role in the effect of organizational culture on construction safety performance, and this effect may change depending on the skill level of the workforce. The results will reveal how the strength and direction of the impact of organizational culture on construction safety performance varies at different levels of workforce skill. This analysis has significant practical implications, suggesting that optimizing the implementation of organizational culture according to workforce skill levels can better improve construction safety performance. Therefore, the moderation analysis in this paper not only provides deeper insights into the relationship between organizational culture and construction safety performance but also offers practical guidance for construction companies on how to design appropriate safety culture promotion strategies based on varying skill levels of the workforce.

3.10 Summary

This chapter has given an in-depth overview of the research methodology used in this research. To delve deeply into how Organizational Culture (OC) and Workforce skill (WS) impact Construction Safety Performance (CSP), this research plans to employ Partial Least Squares Structural Equation Modelling (PLS-SEM) as the primary analytical tool to conduct path analysis and moderation effect analysis. PLS-SEM allows for the modelling and estimation of complex relationships between latent variables without strict distributional assumptions, making it an ideal tool to explore the research questions posed in this research.

Through PLS-SEM analysis, the research aims to unveil the specific mechanisms by which organizational culturen and workforce skill influence construction safety performance. This will offer new perspectives and depth to existing theories on construction safety. Additionally, we anticipate discovering the moderation effects of these soft factors on construction safety performance, contributing to a more comprehensive understanding of how these factors interact.

CHAPTER 4

EMPRICAL RESULT AND FINDINGS

4.1 Introduction

This chapter aims to empirically verify and deeply understand the mechanisms and relational pathways through which Organizational Culture (OC) and Workforce skill (WS) influence Construction Safety Performance (CSP). To achieve this, the chapter begins with a rigorous preliminary examination of the collected questionnaire data to ensure their validity and representativeness. Subsequently, descriptive statistical analyses of demographic characteristics-such as gender, age, education level, work experience, occupation, company size, and project type-are performed, providing essential background context and reference points for subsequent model testing and path analyses.

With the foundational data examination completed, the chapter then focuses on the measurement model and structural model testing. Using reliability and validity analyses, including Cronbach's Alpha, Composite Reliability, AVE, KMO, Bartlett's Test of Sphericity, Harman's single-factor test, Fornell-Larcker criterion, and HTMT ratios, this chapter confirms the robust quality of the measurement model. By ensuring that each construct-ranging from various dimensions of organizational culture to workforce skills and construction safety performance - is reliably and validly measured, the subsequent PLS-SEM structural model testing becomes more meaningful and accurate.

Finally, the chapter conducts path analysis using PLS-SEM to test the research hypotheses. This includes examining both direct influences of organizational culture and workforce skill on CSP and exploring how WS moderates these relationships. The empirical findings and results presented here lay a solid empirical foundation for theoretical interpretations and practical recommendations in subsequent sections, revealing the complex interactions and essential roles of OC and WS in shaping construction safety outcomes.

4.2 Analysis of Questionnaire Collection Results

The questionnaire design of this research strictly adheres to academic standards, encompassing multiple dimensions such as Organizational Culture (OC), Workforce skill (WS), and Construction Safety Performance (CSP). Each section of the questionnaire was validated for relevance and scientific integrity through in-depth discussions with industry experts and comprehensive literature reviews, ensuring the validity and reliability of the questionnaire content.

The distribution of the questionnaire was primarily conducted through the Wen Juanxing.cn (WJX) platform to ensure efficient and widespread data collection. Specifically, the questionnaires were distributed through the following channels: firstly, leveraging industry-related online communities, professional forums, and social media platforms (such as DingTalk and WeChat construction industry groups) to promote the questionnaire, reaching a broad spectrum of construction professionals including project managers, safety managers, and other relevant personnel. Secondly, establishing partnerships with the Shandong Provincial Construction Industry Association and several large construction companies to distribute the questionnaire through their internal networks and communication channels, ensuring the representativeness and diversity of the sample. Additionally, questionnaires were distributed at construction industry conferences and safety training events held in Jinan City to obtain more direct feedback and data. To increase the response rate and participation enthusiasm, small cash rewards and gift cards were set up as incentives, ensuring a high response rate and data quality.

4.2.1 Implementation Details

In this study, all questionnaire data were collected and submitted uniformly through the "Wen Juanxing" online survey platform to ensure data integrity and consistency. To achieve comprehensive coverage of the target population, the survey was disseminated through two complementary channels: pure online distribution via professional networks on DingTalk and WeChat, and researcher-facilitated completion during on-site visits, where participants at construction sites were assisted in accessing the same online survey via mobile devices. A total of 516 valid responses were obtained, exceeding the designed sample size of 500, thereby ensuring robust statistical power for the analysis.

4.2.2 Analysis of Response Rates

A total of 600 questionnaires were initially distributed to account for potential non-response and invalid data, calculated based on an anticipated 85% response rate and 5% invalidity rate. The actual response rate reached 86%, yielding 516 valid responses, which slightly exceeded expectations. Among the 84 excluded questionnaires, 52 were incomplete answers and 32 were patterned responses.

Through the aforementioned multi-channel and diversified questionnaire distribution methods, this research ensures the breadth and depth of data collection, laying a solid foundation for subsequent PLS-SEM analysis. The high-quality questionnaire data collected not only enhances the empirical support of the research but also provides robust theoretical and practical guidance for safety management, risk control, and performance enhancement in the construction industry in Jinan City, Shandong Province, and beyond.

4.3 Descriptive Statistical Analysis

Following the preliminary organization and validation of the questionnaire collection results, this section will conduct a descriptive statistical analysis to comprehensively understand the basic characteristics of the sample and the distribution of major variables. The purpose of descriptive statistical analysis is to provide a detailed description of demographic characteristics such as gender, age, education level, work experience, occupation, company size, and the main types of construction projects engaged in. This analysis not only helps in identifying the primary features and potential distribution patterns within the sample but also offers essential background information and foundational data support for subsequent measurement model testing and structural model testing. By gaining an in-depth understanding of these fundamental characteristics, researchers can ensure that the construction and hypotheses testing processes in the following analyses are more scientifically grounded and accurate.

Moreover, the descriptive statistical analysis will employ basic statistical indicators such as frequency distribution, percentages, means, and standard deviations to quantify and describe each major variable. These statistical measures provide a clear and immediate visualization of the sample distribution across various dimensions, aiding researchers in identifying trends and outliers within the data. For instance, analysing the distribution of different age groups and education levels can uncover potential influences of these factors on organizational culture and workforce skills. Additionally, understanding the main types of construction projects that respondents are involved in helps contextualize the research of safety performance, ensuring that the research findings are both relevant and generalizable. In summary, descriptive statistical analysis plays a pivotal role in this research by laying a solid foundation for a comprehensive understanding of the sample characteristics and variable distributions, thereby enhancing the overall reliability and applicability of the research conclusions.

4.3.1 Gender

Table 4.1 presents the gender distribution of the respondents. It is evident that males constitute the majority with 87.40%, while females account for only 12.60%. This ratio reflects the dominant presence of male professionals in the construction industry, aligning with the current gender distribution trends within the sector.

Table 4.1: Gender

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Male	451	87.40%	87.40%	87.40%
Female	65	12.60%	12.60%	100.00%
Total	516	100.00%	100.00%	200.00%

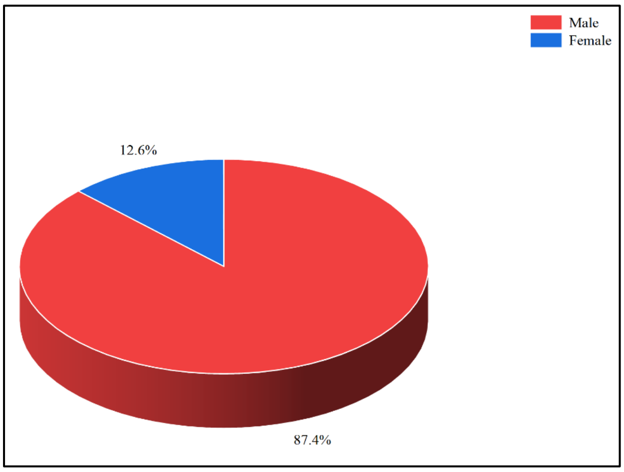

Figure 4.1: Gender

From Table 4.1 and Figure 4.1, it is clear that the high proportion of males in the construction industry may significantly influence organizational culture and safety performance. Firstly, the predominance of male professionals may lead to an organizational culture that emphasizes traditionally masculine values and behavioural patterns, which can affect team collaboration and communication styles. Secondly, the gender imbalance might impact safety performance, as males and females may exhibit different levels of safety awareness, safety behaviours, and risk management practices. These potential differences necessitate careful consideration in the analysis of how organizational culture and workforce skills affect construction safety performance. Additionally, a male-dominated environment may influence the development and implementation of safety management strategies, potentially affecting their effectiveness. Therefore, it is crucial to account for gender factors when examining the relationships between organizational culture, workforce skills, and construction safety performance to ensure the comprehensiveness and accuracy of the research findings.

4.3.2 Age

Table 4.2 presents the age distribution of the respondents. It is evident that the majority of respondents fall within the 41-50 years old (30.81%) and over 50 years old (30.43%) categories, collectively accounting for over 61% of the sample. The 31-40 years old group follows with 27.33%, while the 18-30 years old group constitutes the smallest proportion at only 11.43%. This age distribution reflects the dominance of mid-to-senior age professionals in the construction industry of Jinan City, which may significantly influence organizational culture and safety performance.

Table 4.2: Age

Age	Frequency	Percent	Valid Percent	Cumulative Percent
18 - 30 years old	59	11.43%	11.43%	11.43%
31 - 40 years old	141	27.33%	27.33%	38.76%
41 - 50 years old	159	30.81%	30.81%	69.57%
Over 50 years old	157	30.43%	30.43%	100.00%
Total	516	100.00%	100.00%	100.00%

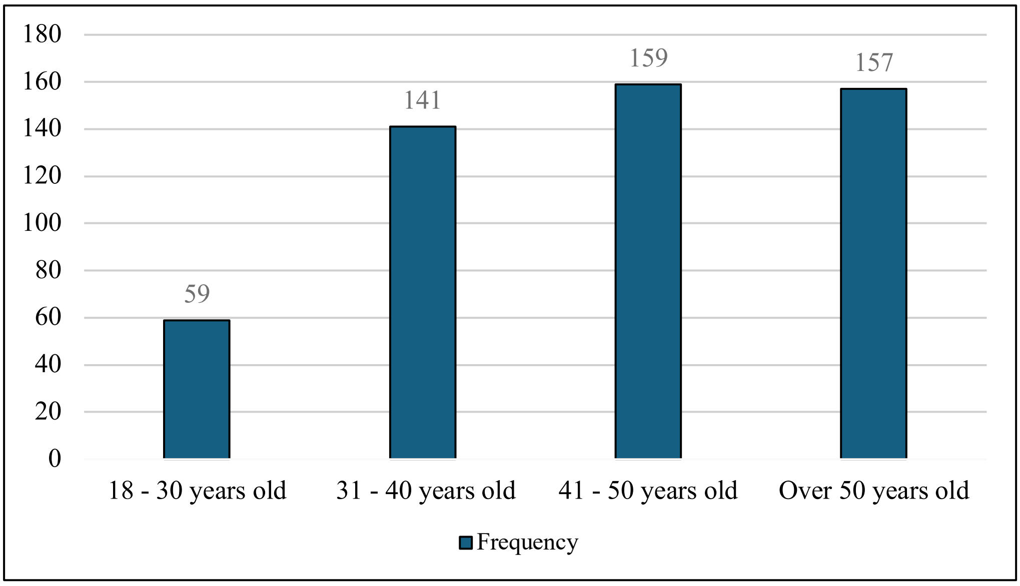

Figure 4.2: Age

From Table 4.2 and Figure 4.2, it is clear that mid-to-senior age professionals dominate the construction industry. This demographic trend may have profound implications for organizational culture, as these experienced workers often possess extensive industry knowledge and deep-seated values that can shape team dynamics and leadership styles. Furthermore, mid-to-senior age respondents are likely to exhibit higher levels of responsibility and safety awareness, contributing positively to overall safety performance. Therefore, the analysis of age distribution provides crucial background information for understanding how organizational culture and workforce skills influence construction safety performance, aiding in the development of more targeted and effective safety management strategies.

4.3.3 Educational Level

Table 4.3 presents the distribution of respondents' educational levels. It is evident that the majority of respondents hold a bachelor's degree, accounting for 64.92%, followed by those with a high school diploma or below at 20.74%. Respondents with a master's degree and doctorate or above constitute 7.95% and 6.40% of the sample, respectively. This educational distribution highlights the dominance of highly educated professionals within Jinan City's construction industry, which may significantly influence organizational culture and safety performance.

Table 4.3: Educational Level

Educational Level	Frequency	Percent	Valid Percent	Cumulative Percent
High school or below	107	20.74%	20.74%	20.74%
Bachelor's degree	335	64.92%	64.92%	85.66%
Master's degree	41	7.95%	7.95%	93.60%
Doctorate or above	33	6.40%	6.40%	100.00%
Total	516	100.00%	100.00%	300.00%

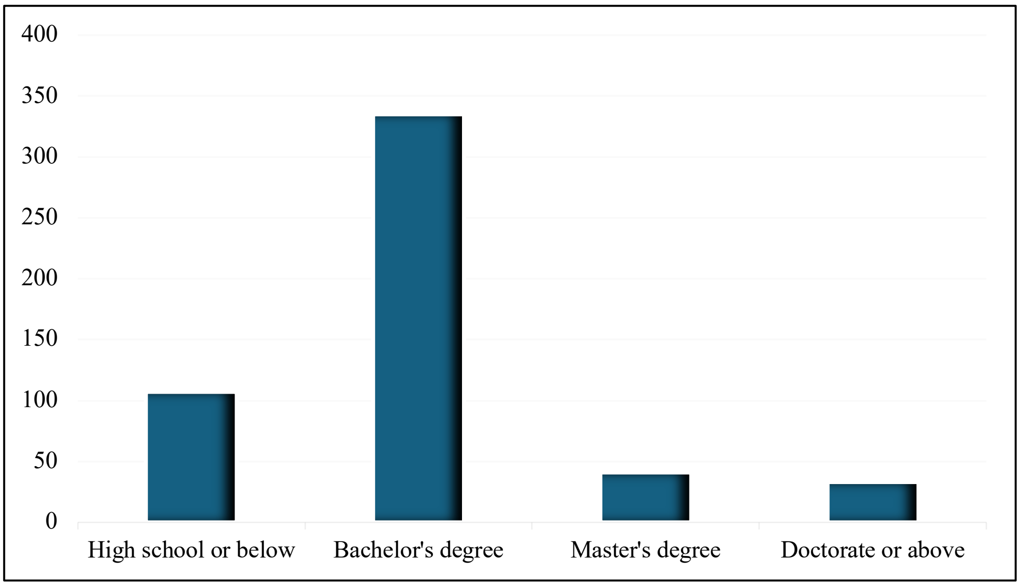

Figure 4.3: Educational Level

From Table 4.3 and Figure 4.3, it is clear that respondents with a bachelor's degree represent a significant proportion of the sample, indicating the prevalence of higher education backgrounds within Jinan City's construction industry. Highly educated professionals typically possess stronger technical knowledge and skills, which can contribute to a more scientific and systematic organizational culture. Furthermore, respondents with bachelor's degrees and above are likely to exhibit higher levels of safety awareness and more effective risk management capabilities, positively impacting overall safety performance in construction projects. In contrast, the lower proportion of respondents with high school diplomas or below suggests that higher educational qualifications are more common in managerial and decision-making roles, facilitating the advancement of organizational culture and the effective implementation of safety management strategies. Therefore, the analysis of educational levels provides crucial background information for understanding how organizational culture and workforce skills influence construction safety performance, aiding in the development of more precise and effective safety management measures.

4.3.4 Length of Working Experience

Table 4.4 presents the distribution of respondents' length of working experience. It is evident that respondents with 5-10 years and 11-20 years of experience account for 25.19% and 25.39% of the sample, respectively, collectively making up 50.58%. Those with less than 5 years and over 20 years of experience constitute 26.36% and 23.06%, respectively. This distribution indicates that Jinan City's construction industry comprises both relatively new and highly experienced professionals, which may have varying impacts on organizational culture and safety performance.

Table 4.4: Length of Working Experience

Length of Working Experience	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 5 years	136	26.36%	26.36%	26.36%
5 - 10 years	130	25.19%	25.19%	51.55%
11 - 20 years	131	25.39%	25.39%	76.94%
Over 20 years	119	23.06%	23.06%	100.00%
Total	516	100.00%	100.00%	100.00%

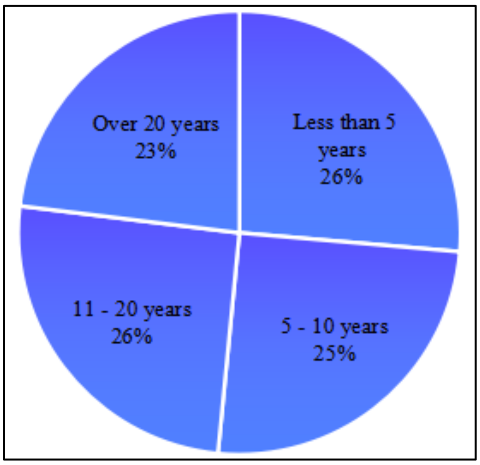

Figure 4.4: Length of Working Experience

From Table 4.4 and Figure 4.4, it is clear that the construction industry in Jinan City has a balanced distribution of working experience among respondents. Professionals with 5-10 years and 11-20 years of experience each represent approximately 25%, indicating that half of the sample consists of mid-level experienced workers. These mid-level professionals typically possess substantial technical knowledge and practical experience, enabling them to play a pivotal role in team dynamics and contribute to the continuity and innovation of organizational culture. Additionally, respondents with over 20 years of experience make up 23.06% of the sample, bringing deep expertise and leadership skills that are crucial for enhancing safety performance and implementing effective risk management practices. Conversely, the 26.36% of respondents with less than 5 years of experience may introduce fresh perspectives and new technological applications, though they may still be developing their safety awareness and management competencies. This multi-tiered distribution of work experience provides a rich context for examining how organizational culture and workforce skills influence construction safety performance, offering valuable insights for developing targeted and effective safety management strategies.

4.3.5 Occupation

Table 4.5 presents the distribution of respondents' occupations. It is evident that practitioners in the construction industry and technicians each constitute approximately 26.74% and 26.36% of the sample, respectively, while managers and labourers account for 24.22% and 22.67%. This occupational distribution indicates a balanced representation of various functional roles within Jinan City's construction industry, providing diverse perspectives for researching the impact of organizational culture and workforce skills on construction safety performance.

Table 4.5: Occupation

Occupation	Frequency	Percent	Valid Percent	Cumulative Percent
Practitioners in the construction industry	138	26.74%	26.74%	26.74%
Managers	125	24.22%	24.22%	50.97%
Technicians	136	26.36%	26.36%	77.33%
Laborers	117	22.67%	22.67%	100.00%
Total	516	100.00%	100.00%	100.00%

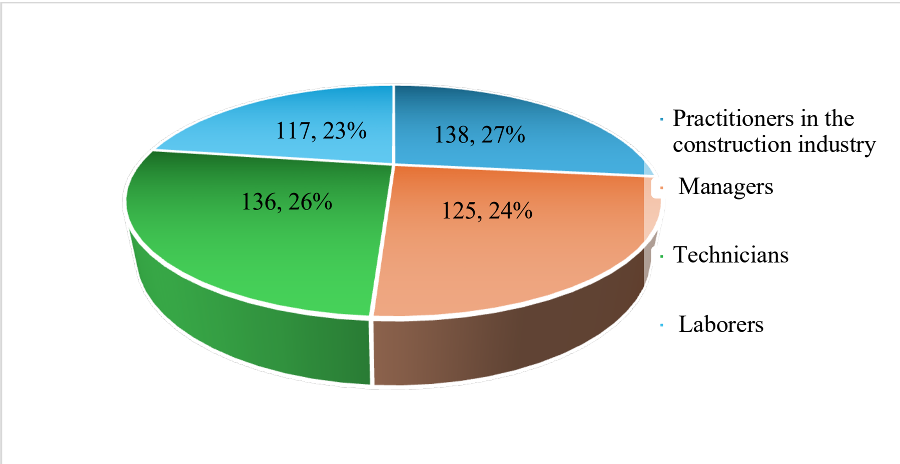

Figure 4.5: Occupation

From Table 4.5 and Figure 4.5, it is clear that the construction industry in Jinan City has a balanced distribution of occupational roles among respondents. Practitioners and technicians each account for approximately 26%, managers represent 24.22%, and labourers make up 22.67% of the sample. This diversified occupational structure highlights the importance and complementarity of various functional roles within construction projects. Managers play a crucial role in organizing and coordinating projects, while practitioners and technicians are directly involved in the execution and technical implementation of construction tasks. Laborers ensure the smooth execution of specific duties on-site. This occupational diversity provides a robust foundation for the formation of organizational culture and the enhancement of workforce skills, thereby contributing to overall safety performance. Additionally, the collaboration and communication between different occupational roles are significant factors influencing construction safety performance. Therefore, when analysing the impact of organizational culture and workforce skills on construction safety performance, it is essential to consider the potential moderating effects of occupational distribution to ensure the comprehensiveness and accuracy of the research findings.

4.3.6 Company Size

Table 4.6 presents the distribution of respondents' company sizes. It is evident that companies with 51-200 employees represent the highest percentage at 27.91%, followed by those with fewer than 50 employees at 24.61%. Companies with 201-500 employees and those with more than 501 employees account for 23.84% and 23.64%, respectively. This distribution indicates a high level of diversity in company sizes within Jinan City's construction industry, encompassing small, medium, and large enterprises. Such diversity provides a broad perspective and rich data support for researching the impact of organizational culture and workforce skills on construction safety performance.

Table 4.6: Company Size

Company Size	Frequency	Percent	Valid Percent	Cumulative Percent
Fewer than 50 people	127	24.61%	24.61%	24.61%
51 - 200 people	144	27.91%	27.91%	52.52%
201 - 500 people	123	23.84%	23.84%	76.36%
More than 501 people	122	23.64%	23.64%	100.00%
Total	516	100.00%	100.00%	100.00%

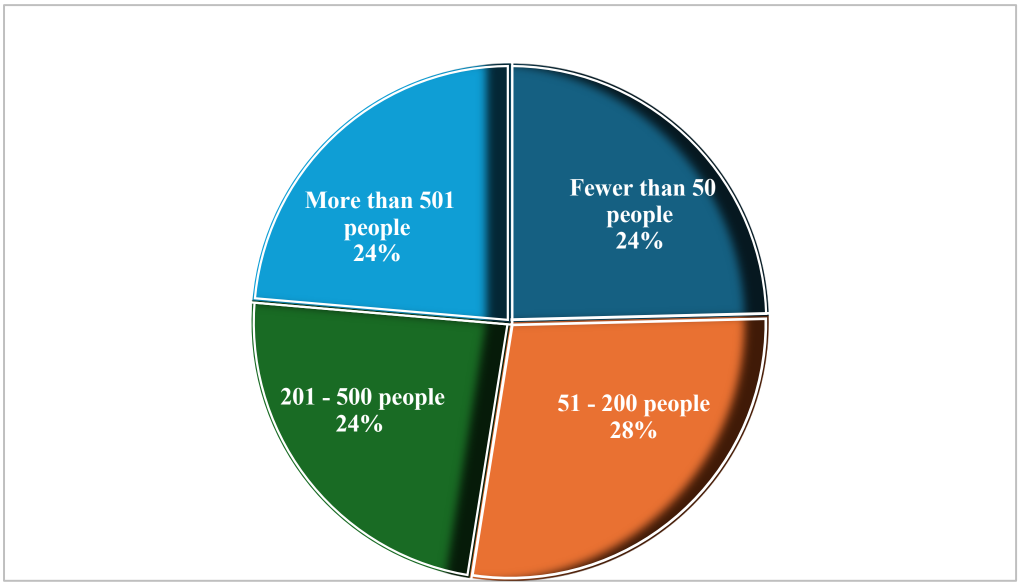

Figure 4.6: Company Size

From Table 4.6 and Figure 4.6, it is clear that the construction industry in Jinan City exhibits a balanced distribution of company sizes. Companies with 51-200 employees hold the largest share, indicating the significant role of medium-sized enterprises in the industry. These medium-sized companies typically possess robust resource integration capabilities and project management competencies, enabling them to maintain steady growth in a competitive market. Additionally, the presence of small enterprises with fewer than 50 employees and mid-to-large enterprises with 201-500 employees further demonstrates the coexistence and collaborative development of various company sizes within the industry. Although large enterprises with over 501 employees are relatively fewer, their advantages in managing large-scale projects and resource allocation have a substantial impact on overall safety performance.

This diverse distribution of company sizes provides rich background information for examining how organizational culture and workforce skills influence construction safety performance. Different-sized enterprises may exhibit significant variations in organizational culture development, employee skill training, and safety management practices, directly affecting the manifestation of construction safety performance. Therefore, in subsequent measurement model and structural model testing, it is essential to consider the potential moderating effect of company size on the relationships between organizational culture and workforce skills, ensuring the comprehensiveness and accuracy of the research conclusions.

4.3.7 Construction Projects

Figure 4.7 presents the distribution of the main types of construction projects that respondents are engaged in. It is evident that infrastructure projects constitute the highest frequency with 270 responses (52.33%), followed closely by commercial projects with 268 responses (51.94%), residential projects with 258 responses (50.00%), and mixed-use projects with 259 responses (50.19%). This distribution indicates a diverse range of project types within Jinan City's construction industry, encompassing infrastructure, commercial, residential, and mixed-use sectors. Such diversity provides a broad perspective and rich data support for researching the impact of organizational culture and workforce skills on construction safety performance.

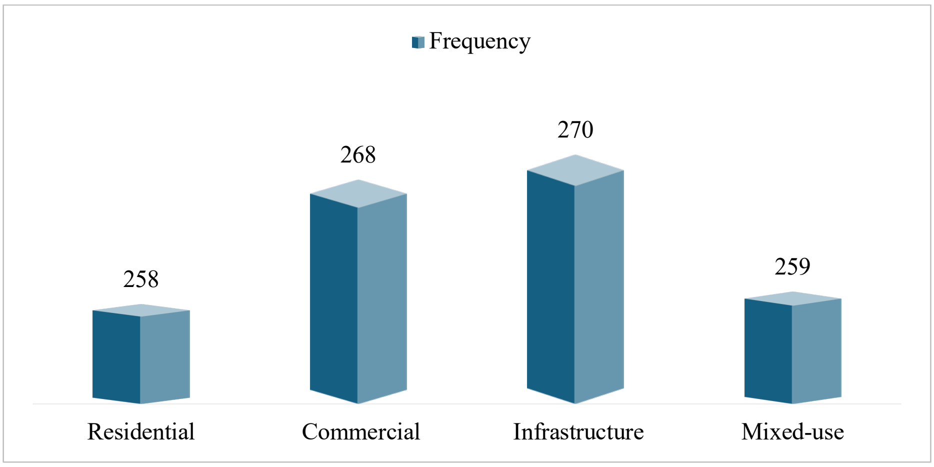

Figure 4.7: Construction Projects

From Figure 4.7, it is clear that infrastructure projects hold the highest proportion within the sample, closely followed by commercial and residential projects, with mixed-use projects also maintaining a significant share. This broad distribution of project types reflects the diversified development trend of Jinan City's construction industry. The high proportion of infrastructure projects may be closely related to the city's rapid development and the demand for enhanced infrastructure. Meanwhile, the balanced distribution of commercial and residential projects highlights the diversity and stability of market demand. Additionally, the presence of mixed-use projects further showcases the construction industry's flexibility and innovation in meeting varied functional requirements.

This diverse range of construction project types provides rich background information for examining how organizational culture and workforce skills influence construction safety performance. Different types of projects may exhibit significant differences in safety management, risk control, and organizational culture development. For instance, infrastructure projects often involve large-scale equipment and complex engineering management, requiring higher levels of technical skills and more stringent safety management systems. In contrast, residential and commercial projects may place greater emphasis on on-site personnel management and daily safety practices. Mixed-use projects, due to their multifunctionality, may necessitate effective coordination and management across different project types. Therefore, in subsequent measurement model and structural model testing, it is essential to consider the potential moderating effects of construction project types on the relationships between organizational culture and workforce skills to ensure the comprehensiveness and accuracy of the research conclusions.

4.3.8 Position Level

Table 4.7 presents the distribution of respondents' position levels, revealing a well-balanced sample across three tiers: Junior Staff (34.50%), Middle-Level Managers (34.88%), and Senior Managers (30.62%). This distribution indicates a balanced representation of different position levels within Jinan City's construction industry, providing diverse perspectives and rich data support for researching the impact of organizational culture and workforce skills on construction safety performance.

Table 4.7: Position Level

Position Level	Frequency	Percent	Valid Percent	Cumulative Percent
Junior staff	178	34.50%	34.50%	34.50%
Middle-level managers	180	34.88%	34.88%	69.38%
Senior managers	158	30.62%	30.62%	100.00%
Total	516	100.00%	100.00%	100.00%

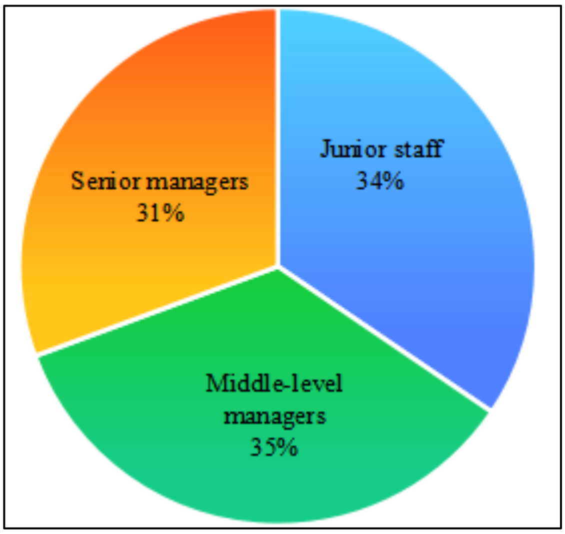

Figure 4.8: Position Level

From Table 4.7 and Figure 4.8, the sample demonstrates a balanced distribution across hierarchical levels. Junior staff, constituting 34.5% of respondents, are operationally defined in this study as frontline technical personnel, including site technicians, skilled equipment operators, and junior engineers. These individuals are the direct implementers of safety protocols and the immediate recipients of managerial directives. Their inclusion is crucial for a key research objective: to assess whether the organizational culture and safety strategies perceived by management are consistently understood and enacted at the operational level. Their responses provide essential, ground-level data to validate the downward transmission and practical effectiveness of the cultural mechanisms posited in the theoretical model.

The sample also includes substantial representation from middle management (34.88%) and senior management (30.62%). This balanced distribution of position levels reflects a well-distributed workforce across different management tiers within Jinan City's construction industry, encompassing a substantial number of frontline employees responsible for specific construction and operational tasks, as well as a significant number of middle and senior managers overseeing project organization and coordination. Middle-level managers, acting as key connectors between junior staff and senior management, likely play a pivotal role in fostering organizational culture and enhancing workforce skills. Additionally, the relatively high proportion of senior managers suggests their critical influence in formulating and implementing safety management strategies, promoting safety culture development, and elevating overall safety performance. This multi-tiered occupational structure provides valuable background information for examining how organizational culture and workforce skills impact construction safety performance, facilitating a comprehensive understanding of the roles and contributions of different management levels in safety outcomes.

4.3.9 Research and Statistics on Dedicated Safety Management Departments and Personnel

Table 4.8 presents the distribution of whether the respondent's company has a dedicated safety management department or personnel. The data indicates that 46.12% of the respondents reported having a dedicated safety management department or personnel, while 53.88% did not. This result highlights the current state of safety management within Jinan City's construction industry, revealing that nearly half of the companies recognize the importance of dedicated safety management and have implemented it in their operations, whereas the other half may still be lacking in establishing and enhancing their safety management systems.

Table 4.8: Research and Statistics on Dedicated Safety Management Departments and Personnel

Is there a dedicated safety management department or personnel?	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	238	46.12%	46.12%	46.12%
NO	278	53.88%	53.88%	100.00%
Total	516	100.00%	100.00%	100.00%

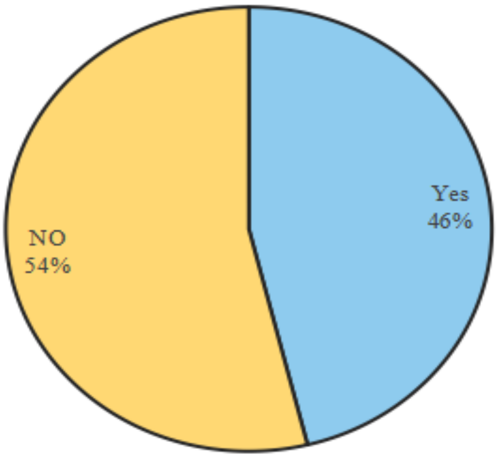

Figure 4.9: Research and Statistics on Dedicated Safety Management Departments and Personnel

From Table 4.9 and Figure 4.9, it is evident that while a majority of companies do not have dedicated safety management departments or personnel, a significant portion (46.12%) has recognized and implemented such measures. This disparity may be influenced by factors such as company size, project type, and the management's emphasis on safety culture. Companies with dedicated safety management departments or personnel typically demonstrate higher safety performance, as dedicated staff can systematically conduct safety training, risk assessments, and safety supervision, thereby enhancing overall safety management standards. Moreover, the presence of dedicated safety management contributes to the development and maintenance of a positive safety culture, increasing employees' safety awareness and participation, which in turn improves construction project safety performance. Conversely, companies lacking dedicated safety management may experience gaps in their safety practices, leading to inconsistencies in safety performance and potential safety hazards. Therefore, when examining the impact of organizational culture and workforce skills on construction safety performance, the presence or absence of dedicated safety management departments and personnel serves as a crucial moderating factor, necessitating thorough consideration to ensure the comprehensiveness and accuracy of the research findings.

4.3.10 Central Tendencies Measurement of Constructs

In this section, statistical analysis was conducted using SPSS 27.0 software on data from 516 respondents. The independent variables in this research include Organizational Culture (OC) and Workforce skill (WS), while the dependent variable is Construction Safety Performance (CSP). The researcher calculated the means and standard deviations of each independent and dependent variable to assess the central tendencies and data dispersion of each construct. Specifically, detailed analyses of the mean and standard deviation were performed for each dimension of organizational culture, components of workforce skill, and key indicators of construction safety performance. This approach enabled the identification of trends within the dataset, as well as potential outliers or distribution characteristics. Furthermore, these statistical results provided a deeper understanding of the performance levels of each variable in the context of construction projects and the potential interactions among them, thereby laying a solid foundation for subsequent measurement and structural model testing.

4.3.10.1 Organizational Values (OC1)

Table 4.9 provides the descriptive statistics for four items (OC11 to OC14) that measure Organizational Values (OC1). Each item's number of respondents (N), minimum (Min), maximum (Max), mean (Mean), and standard error (SE) are presented, offering a quantitative snapshot of how respondents perceive the core values emphasized within their construction enterprises.

Table 4.9: Number of Respondent(N), the Min, the Max, Mean for Organizational Values

Item	N	Min	Max	Mean	
				Statistics	Standard Error
OC11	516	1	7	4.44	0.082
OC12	516	1	7	4.60	0.081
OC13	516	1	7	4.46	0.084
OC14	516	1	7	4.72	0.081

All four items show mean scores above the neutral point of 4, indicating a generally positive alignment and endorsement of organizational values among the surveyed employees. This suggests that, within the context of these construction enterprises, employees perceive a clear presence and influence of organizational values in their day-to-day work. Notably, OC14 attains the highest mean (4.72), reflecting an even stronger affirmation or identification with the company's fundamental values or the opportunities for employees to engage with these values.

The standard errors, ranging from approximately 0.081 to 0.084, are relatively low, signalling a stable and consistent response pattern with limited extreme variability. Such consistency suggests a broad consensus among respondents regarding the organizational values' importance and integration into the work environment.

Overall, these findings underscore the significance of organizational values in shaping a supportive cultural backdrop that can foster improvements in construction safety performance. When employees experience alignment with and recognition of organizational values-manifested through clarity, active participation, and daily reflection-these values can serve as a guiding framework that encourages safe behaviours, enhances collective responsibility for safety outcomes, and ultimately contributes to improved safety performance across the enterprise.

4.3.10.2 Management Strategy (OC2)

Table 4.10 presents the descriptive statistics for the four items (OC21 to OC24) measuring Management Strategy (OC2). This dimension focuses on how well the organization develops, communicates, and updates its safety management strategies, ensuring that they cover all major risks and remain adaptable in a changing environment. The table includes the number of respondents (N), minimum (Min), maximum (Max), mean (Mean), and standard error (SE) for each item.

Table 4.10: Number of Respondent(N), the Min, the Max, Mean for Management Strategy

Item	N	Min	Max	Mean	
				Statistics	Standard Error
OC21	516	1	7	4.48	0.080
OC22	516	1	7	4.67	0.081
OC23	516	1	7	4.36	0.083
OC24	516	1	7	4.52	0.079

All four items have mean scores above the neutral point of 4, indicating a generally positive perception of the management’s approach to safety strategies. more specifically as follows:

OC21 shows a mean of 4.48, suggesting that respondents believe the organization has established clear safety management strategies. Clarity in these strategies helps reduce uncertainty and provides employees with a solid framework for safe operations.

OC22, with a mean of 4.67, is the highest among the four items. This result implies that the safety management strategies are viewed as comprehensive, covering all major safety risks. A broad, inclusive approach to risk mitigation is critical for ensuring that no hazards are overlooked, thereby strengthening overall safety performance.

OC23 has a mean of 4.36, which, while still positive, is slightly lower compared to other items. This indicates that while there is recognition of guidance and explanations regarding safety strategies, there may be some room for improvement in how these strategies are communicated. Enhancing clarity and accessibility of safety instructions and training materials could further bolster employees' understanding and compliance.

OC24 records a mean of 4.52, reflecting that the organization regularly evaluates and updates safety management strategies to address new risks. Such adaptability and responsiveness are essential for staying ahead of evolving industry challenges, technological changes, and regulatory requirements, ensuring the long-term relevance and effectiveness of safety initiatives.

The standard errors, ranging from approximately 0.079 to 0.083, are quite low, indicating a concentrated distribution of responses and limited variability. This consistency suggests a shared, cohesive view among respondents, reinforcing the notion that the organization's management strategies resonate well with its workforce.

In summary, these findings paint a picture of an organization with a relatively mature safety management strategy framework: strategies are clear, comprehensive, and responsive to change. However, there is an opportunity to further enhance communication and understanding of these strategies among all staff members. Strengthening the clarity and dissemination of safety-related information can help align workforce skills, reinforce positive organizational culture, and ultimately improve construction safety performance.

4.3.10.3 Management Style (OC3)

Table 4.11 presents the descriptive statistics for four items (OC31 to OC34) measuring Management Style (OC3). This dimension centres on leadership quality, decision-making transparency, employee motivation, and the degree of managerial attention given to safety matters within construction enterprises. The table provides the number of respondents (N), minimum (Min), maximum (Max), mean (Mean), and standard error (SE) for each item.

Table 4.11: Number of Respondent(N), the Min, the Max, Mean for Management Style

Item	N	Min	Max	Mean	
				Statistics	Standard Error
OC31	516	1	7	4.40	0.081
OC32	516	1	7	4.47	0.081
OC33	516	1	7	4.34	0.082
OC34	516	1	7	4.44	0.079

All four items show mean scores above the neutral point of 4, indicating a generally positive assessment of the management style regarding safety management. More specifically:

OC31 has a mean of 4.40, suggesting that respondents acknowledge the fairness, transparency, and safety emphasis of the leadership style. Management's commitment to equitable treatment and clear communication about safety can help establish trust and encourage employees to adhere to safety protocols.

OC32, with a mean of 4.47-the highest in this dimension-indicates that employees recognize consistent, stable leadership in safety management. When managers maintain a steady, reliable stance on safety standards and expectations, employees are more likely to feel confident in following these guidelines and integrating them into daily operations.

OC33 reports a mean of 4.34, slightly lower than the other items yet still indicative of a positive response. While managers' leadership style does motivate employees to follow safety procedures, there may be room for further improvements. Enhancing incentive mechanisms, communication strategies, or training programs could further strengthen employees' intrinsic motivation towards safe practices.

OC34 has a mean of 4.44, reflecting that managers devote adequate support and attention to safety issues. Consistent managerial involvement in addressing safety concerns fosters a proactive safety environment, encouraging employees to report hazards, share suggestions, and collaboratively improve safety performance.

The standard errors, ranging from 0.079 to 0.082, are low, indicating that the data is relatively concentrated and that respondents' opinions on management style are generally aligned. This consistency suggests a shared understanding and appreciation of the leadership's role in cultivating a positive safety culture.

In summary, these findings illustrate that the enterprise's management style has successfully supported safety management initiatives. Fair, transparent, and consistently safety-oriented leadership can enhance employees' willingness to engage in safe behaviours and assume greater responsibility for safety outcomes. By building upon these foundations-such as refining motivation strategies and reinforcing managerial involvement-organizations can further optimize safety performance and strengthen their overall safety culture.

4.3.10.4 Organizational Structure (OC4)

Table 4.12 presents the descriptive statistics for four items (OC41 to OC44) measuring the Organizational Structure (OC4) dimension. These items evaluate how well a company's organizational framework supports the development of a safety culture, defines safety responsibilities, facilitates effective communication of safety information, and enables rapid responses to emerging safety issues. The dataset, with N=516 and a seven-point scale, provides robust evidence for interpretation.

Table 4.12: Number of Respondent (N), the Min, the Max, Mean for Organizational Structure

Item	N	Min	Max	Mean	
				Statistics	Standard Error
OC41	516	1	7	4.51	0.080
OC42	516	1	7	4.33	0.080
OC43	516	1	7	4.54	0.081
OC44	516	1	7	4.48	0.080

OC41 (Support for Developing a Safety Culture) has a mean of 4.51, indicating that respondents broadly agree that the organizational structure fosters a positive safety culture. This suggests that hierarchical arrangements, procedural clarity, and cooperative workflows help employees internalize safety norms as part of their daily routines.

OC42 (Clarity of Safety Responsibilities) registers a mean of 4.33, slightly lower than the other items yet still firmly positive. While the definition of safety responsibilities across departments is largely recognized, there is room for improvement. Enhancing clarity in cross-departmental roles and responsibilities could further streamline safety-related tasks and improve coordinated action.

OC43 (Effectiveness of Communication Channels) achieves the highest mean at 4.54, reflecting respondents' strong confidence in the organization's ability to disseminate safety information promptly and accurately. Effective communication not only raises safety awareness but also aids in promptly identifying and addressing potential hazards.

OC44 (Ability to Respond Quickly to Emerging Safety Issues) records a mean of 4.48, suggesting that the organizational structure is relatively agile and adept at handling new safety challenges-be they technological, regulatory, or environmental. Such structural responsiveness is crucial in the construction industry, where conditions and hazards can rapidly evolve.

All four items have standard errors around 0.080 to 0.081, indicating a concentrated and consistent response pattern. This consistency confirms that the positive assessments of organizational structure are widely shared, lending credibility to the conclusion that the company's structural attributes are well-aligned with its safety objectives.

In summary, these findings portray an organizational structure that effectively supports safety culture formation, clarifies roles and responsibilities, enhances information exchange, and responds dynamically to emerging risks. By further refining departmental responsibilities and continually improving internal communication mechanisms, the organization can maintain its structural agility, provide a safer working environment for employees, and ultimately improve overall construction safety performance.

4.3.10.5 Manager Behaviour (OC5)

Table 4.13 presents the descriptive statistics for four items (OC51 to OC54) measuring Manager Behaviour (OC5). These items focus on how managers prioritize on-site safety issues, inspect and supervise the implementation of safety standards, take timely corrective action against non-compliant behaviours, and communicate with employees to provide feedback on safety-related opinions and suggestions.

Table 4.13: Number of Respondent (N), the Min, the Max, Mean for Manager Behaviour

Item	N	Min	Max	Mean	
				Statistics	Standard Error
OC51	516	1	7	4.48	0.081
OC52	516	1	7	4.36	0.082
OC53	516	1	7	4.45	0.085
OC54	516	1	7	4.51	0.081

All items have mean values between 4.36 and 4.51, which are above the neutral point of 4, indicating a generally positive perception of managers' involvement in safety management. Managers' Prioritization of On-Site Safety Issues (OC51) has a mean of 4.48, suggesting that respondents believe managers place a high priority on safety concerns at the construction site. This prioritization often translates into a stronger safety culture, as employees tend to mirror leadership's emphasis on following safety norms and practices. Managers' Regular Site Inspections (OC52) shows a mean of 4.36, slightly lower compared to other items but still indicative of a positive assessment. While managers are recognized for conducting routine inspections to ensure compliance with safety standards, there may be opportunities to increase inspection frequency or thoroughness to bolster adherence to safety protocols.

Timely Corrective Actions for Non-Compliance(OC53) has a mean of 4.45, indicating that managers are generally prompt in addressing and rectifying unsafe behaviours.

This timeliness is essential for preventing hazards from escalating into more severe incidents, thereby reinforcing the credibility of safety policies and standards.

Managers' Communication and Feedback on Safety Opinions and Suggestions (OC54) registers the highest mean at 4.51. This suggests employees appreciate the channels through which they can share their safety-related opinions and receive constructive feedback. Such open communication fosters a receptive and inclusive environment, encouraging employees to be proactive in identifying and resolving safety issues.

The standard errors, ranging from 0.081 to 0.085, are relatively low, implying a concentrated distribution of responses and a consistent view among respondents regarding managerial behaviour. This consensus underscores that the management team's approach-prioritizing safety, enforcing standards, swiftly correcting non-compliance, and maintaining open communication-is well-received across the workforce.

In summary, these findings indicate that managers play a vital role in shaping a robust safety culture within the organization. By valuing on-site safety, performing regular checks, rapidly addressing unsafe behaviours, and actively engaging with employees' feedback, managers create an environment conducive to continuous improvement in safety performance. Further strengthening these managerial attributes can lead to sustained enhancements in construction safety outcomes.

4.3.10.6 Employee Participation (OC6)

Table 4.14 provides the descriptive statistics for four items (OC61 to OC64) measuring Employee Participation (OC6). These items focus on employees' proactivity in safety improvements, the degree to which their suggestions are valued, the presence of incentives, and their influence in the safety decision-making process.

Table 4.14: Number of Respondent (N), the Min, the Max, Mean for Employee Participation

Item	N	Min	Max	Mean	
				Statistics	**Standard Error**
OC61	516	1	7	4.62	0.080
OC62	516	1	7	4.43	0.081
OC63	516	1	7	4.58	0.083
OC64	516	1	7	4.39	0.083

All item means range from 4.39 to 4.62, which are above the neutral point of 4, indicating a generally positive perception of employee involvement in safety initiatives:

Active Participation in Safety Improvements (OC61) has the highest mean at 4.62, suggesting that most respondents feel engaged and willing to contribute to safety enhancement measures. This reflects an encouraging work environment where employees feel empowered to take part in safety-related activities.

Management Taking Safety Suggestions Seriously and Acting on Them (OC62) at 4.43 indicates that while employees' suggestions are largely valued and acted upon, there may still be room to refine feedback loops or communicate how suggestions are implemented more transparently.

Incentives for Active Participation in Safety Activities (OC63) with a mean of 4.58 shows that the company provides effective incentives, further motivating employees to share ideas and commit to ongoing safety improvements.

Employee Influence in Safety Improvement Decision-Making (OC64) has a mean of 4.39, slightly lower than the others but still positive. This suggests employees do have a voice in safety-related decisions, although enhancing transparency and collaborative decision-making processes could further strengthen their impact.

All standard errors, between 0.080 and 0.083, are low, indicating consistent responses and reinforcing the reliability of these positive perceptions. In essence, employees feel supported and incentivized to contribute to safety improvements, and while there's room to refine feedback and decision-making processes, these findings lay a solid foundation for continuous safety performance enhancement.

4.3.10.7 Team Collaboration (OC7)

Table 4.15 displays the descriptive statistics for five items (OC71 to OC75) measuring Team Collaboration (OC7). These items focus on how team members work together to build a safety culture, improve safety awareness and performance, clarify responsibilities, support each other, and discuss potential hazards to propose improvements.

Table 4.15: Number of Respondent (N), the Min, the Max, Mean for Team Collaboration

Item	N	Min	Max	Mean	
				Statistics	Standard Error
OC71	516	1	7	4.54	0.079
OC72	516	1	7	4.48	0.081
OC73	516	1	7	4.60	0.077
OC74	516	1	7	4.47	0.082
OC75	516	1	7	4.48	0.081

All item means range from 4.47 to 4.60, which are above the neutral point of 4, reflecting a generally favourable assessment of team collaboration in promoting safety:

Cooperation in Building a Safety Culture (OC71) at 4.54 suggests that team members actively work together towards nurturing a robust safety culture.

Teamwork Improves Safety Awareness and Performance (OC72) has a mean of 4.48, indicating that team synergy contributes to enhancing overall safety awareness and outcomes. Still, there may be opportunities to deepen coordination for even stronger results.

Clearly Defined Responsibilities within the Team (OC73) at 4.60 is the highest in this dimension, highlighting that well-defined roles and responsibilities help ensure consistent adherence to safety practices.

Mutual Support for Safe Operations (OC74) at 4.47, while slightly lower, still suggests a strong sense of mutual assistance, enabling timely identification and resolution of safety issues.

Team Discusses Hazards and Proposes Improvements (OC75) at 4.48 demonstrates that teams actively engage in identifying and addressing potential safety threats, contributing to preventive measures and continuous improvement.

Standard errors, ranging from 0.077 to 0.082, are low, indicating a high level of consistency among respondents' views. This consensus underscores the importance of teamwork in shaping a proactive safety culture, promoting effective communication, and ultimately improving safety performance. By further enhancing communication, training, and interaction mechanisms among team members, organizations can build on these strengths to achieve ongoing safety performance gains.

4.3.10.8 Workforce Skill (WS)

Table 4.16 presents the descriptive statistics for six items (WS1 to WS6) measuring Workforce skill (WS). These items cover employees' professional skills, safety awareness, teamwork capability, participation in technical training, on-time task completion, and problem-solving ability. By examining these indicators, we can gain insights into how well-equipped the workforce is to support construction safety performance.

Table 4.16: Number of Respondent (N), the Min, the Max, Mean for Workforce Skill

Item	N	Min	Max	Mean	
				Statistics	Standard Error
WS1	516	1	7	5.33	0.075
WS2	516	1	7	5.20	0.074
WS3	516	1	7	5.05	0.076
WS4	516	1	7	5.34	0.073
WS5	516	1	7	5.26	0.077
WS6	516	1	7	5.22	0.074

All item means exceed 5.0, ranging from 5.05 to 5.34, which are significantly above the neutral midpoint, indicating a generally high level of workforce skill and performance.

Professional Skills (WS1) has a mean of 5.33, suggesting that employees possess strong professional competencies. This proficiency underpins their ability to adhere to technical and safety standards effectively, ensuring orderly and compliant construction processes.

Safety Awareness (WS2) with a mean of 5.20 highlights a commendable level of safety consciousness among employees. Such awareness encourages proactive adherence to safety protocols, reducing the risk of accidents and thereby enhancing overall safety performance.

Teamwork Performance (WS3) scores a mean of 5.05, slightly lower than others but still positive. It indicates that employees can collaborate effectively to overcome construction challenges. Strengthening team-building and communication initiatives could further leverage this foundation for improved synergy and safety outcomes.

Participation in Technical Training (WS4) attains the highest mean at 5.34, reflecting that employees actively engage in training opportunities offered by the organization. Continuous skill development ensures that employees remain aligned with evolving technical and safety standards, fostering ongoing improvements in safety management practices.

On-Time Task Completion (WS5) with a mean of 5.26 suggests that employees are recognized for their efficiency and discipline. Timely completion of tasks ensures that safety measures and enhancements can be implemented without delay, maintaining a stable and secure work environment.

Problem-Solving Ability (WS6) at 5.22 indicates that employees can quickly address and resolve issues as they arise. In a dynamic and often unpredictable construction setting, this adaptability is crucial for sustaining high levels of safety and managing risks effectively.

The standard errors, ranging from 0.073 to 0.077, are low and fairly consistent across items, implying that respondents' views on workforce skills are relatively aligned.

In summary, these findings illustrate a workforce well-endowed with professional skills, strong safety awareness, effective teamwork, ongoing training participation, timely task execution, and adept problem-solving capabilities. Such a skilled and responsive workforce provides a solid foundation for building a robust safety culture and driving continuous improvements in construction safety performance. As employees adapt to changing conditions, collaborate effectively, and uphold professional and safety standards, the organization's overall safety outcomes are likely to benefit significantly.

4.3.10.9 Construction Safety Performance (CSP)

Table 4.17 presents the descriptive statistics for seven items (CSP1 to CSP7) measuring Construction Safety Performance (CSP). These items collectively assess the enterprise's compliance with construction safety standards, the comprehensiveness of safety training, the effectiveness of safety measures, project durability, performance against industry standards, risk management capabilities, and the presence of a proactive safety culture. By examining these indicators, we gain insights into the overall state of safety performance as perceived by the respondents.

Table 4.17: Number of Respondent (N), the Min, the Max, Mean for Construction Safety Performance

Item	N	Min	Max	Mean	
				Statistics	Standard Error
CSP1	516	1	7	4.43	0.082
CSP2	516	1	7	4.70	0.081
CSP3	516	1	7	4.62	0.079
CSP4	516	1	7	4.38	0.081
CSP5	516	1	7	4.49	0.083
CSP6	516	1	7	4.51	0.081
CSP7	516	1	7	4.52	0.081

All mean values range from 4.38 to 4.70, which are above the neutral midpoint, indicating a generally positive assessment of construction safety performance.

Compliance with Construction Safety Standards (CSP1) at 4.43 suggests that while the organization meets industry regulations, there remains room for improvement to achieve higher levels of compliance and consistency.

Comprehensive Safety Training for All Employees (CSP2) has the highest mean of 4.70, reflecting strong confidence in the organization's training efforts. Proper training ensures that employees understand emergency procedures and safety protocols thoroughly, enhancing overall safety competence.

Effective Safety Measures Reducing Accidents and Injuries (CSP3) at 4.62 indicates that implemented safety measures significantly contribute to accident prevention, helping establish a safer working environment and reinforcing safe behaviours among employees.

Materials and Structural Durability Ensuring Long-Term Stability (CSP4) at 4.38 is slightly lower, suggesting some reservation regarding project quality and durability. Improving material selection, structural design, and quality control might increase confidence in long-term safety and integrity.

Meeting or Exceeding Industry Safety Standards (CSP5) at 4.49 shows that the organization's safety performance aligns with or surpasses industry benchmarks. Nonetheless, striving for continuous improvement can solidify a competitive advantage in safety excellence.

Effective Identification, Assessment, and Management of Safety Risks (CSP6) at 4.51 implies that the organization's risk management mechanisms are functioning reasonably well. Enhancing risk assessment tools and response strategies can further bolster safety resilience.

A “Safety First” Culture Encouraging Reporting of Potential Issues (CSP7) at 4.52 indicates a positive safety culture that supports open communication and proactive hazard reporting. Such a supportive environment drives continuous safety improvements by leveraging frontline feedback and insights.

Standard errors range from 0.079 to 0.083, remaining low and relatively uniform, suggesting consistent responses and reinforcing the reliability of these perceptions.

In summary, these findings reveal that the organization has established a solid foundation in construction safety performance, marked by effective training, robust safety measures, and a positive safety culture. Nevertheless, opportunities exist to enhance project durability, refine risk management strategies, and continually strive to exceed industry standards. By strengthening professional training programs, improving construction quality control, and intensifying risk assessment and mitigation efforts, the organization can advance its safety performance to even higher levels.

4.4 Reliability Analysis

When conducting the reliability analysis, SPSS 27.0 software was utilized to examine the questionnaire data. The purpose of reliability analysis is to assess the internal consistency and stability of the scale in measuring the intended constructs. Common indicators include Cronbach’s Alpha, Corrected Item-Total Correlation (CITC), and the “Cronbach’s Alpha if Item Deleted” value. Cronbach’s Alpha is one of the most frequently used measures of internal consistency; generally, a value above 0.7 indicates acceptable internal consistency, above 0.8 is considered good, and above 0.9 suggests excellent internal consistency (Kennedy, 2022). CITC is used to examine the correlation between each individual item and the total scale score; a CITC value greater than 0.3 typically indicates that the item contributes adequately to the overall construct (Bujang, Omar, & Baharum, 2018). The "Cronbach's Alpha if Item Deleted" value is employed to determine how the overall Alpha would change if a specific item were removed. A substantial increase in the total Alpha after removing an item may suggest that the item warrants further review or revision (Hu et al., 2021).

Table 4.18: Alpha of the Whole Questionnaire

Cronbach's Alpha	Number of Items
0.935	42

Table 4.18 shows that the Cronbach's Alpha for the entire questionnaire is 0.935, with a total of 42 items. This value is significantly above 0.9, indicating an extremely high level of internal consistency for the entire scale. In other words, the measurement indicators used in this research exhibit excellent reliability when assessing the target constructs (such as organizational culture, workforce skill, and construction safety performance). This high reliability provides a solid foundation for subsequent model testing and theoretical verification.

The reliability analysis results for the Organizational Values (OC1) scale in Table 4.19 indicate that all items demonstrate strong internal consistency and meaningful contributions to the overall construct. Each item's Corrected Item-Total Correlation (CITC) value ranges between approximately 0.62 and 0.66, signifying that every item has a substantial correlation with the total scale score.

Table 4.19: Alpha of Organizational Values (OC1)

Variables	CITC	Cronbach's Alpha Value with Item Deleted	Sample Size
OC11	0.662	0.771	516
OC12	0.663	0.771	516
OC13	0.640	0.782	516
OC14	0.625	0.788	516
Reliability Statistics		Cronbach's alpha	Number of Items
		0.824	4

Additionally, the "Cronbach's Alpha Value with Item Deleted" figures show that removing any single item would result in a lower alpha value than the current 0.824. Specifically, deleting OC11 or OC12 reduces alpha to 0.771, removing OC13 brings it down to 0.782, and removing OC14 leads to 0.788-all lower than the original alpha. Since the initial Cronbach's Alpha of 0.824 already surpasses the commonly accepted 0.7 threshold, these results confirm that each item plays a vital role in maintaining the scale's reliability. In short, the organizational values scale is robust, and all included items contribute to a stable and reliable measurement of the intended construct.

Table 4.20: Alpha of Management Strategy (OC2)

Variables	CITC	Cronbach's Alpha Value with Item Deleted	Sample Size
OC21	0.669	0.763	516
OC22	0.627	0.782	516
OC23	0.634	0.779	516
OC24	0.644	0.774	516
Reliability Statistics		Cronbach's alpha	Number of Items
		0.821	4

The reliability analysis results for the Management Strategy (OC2) scale, as presented in Table 4.20, demonstrate a high level of internal consistency. The overall Cronbach's Alpha is 0.821, substantially surpassing the common 0.7 threshold and indicating excellent reliability. Each item's Corrected Item-Total Correlation (CITC) is robust: OC21at 0.669, OC22 at 0.627, OC23 at 0.634, and OC24 at 0.644-all comfortably exceeding the commonly accepted minimum of 0.3. These CITC values suggest that every item strongly correlates with the overall construct, capturing essential aspects of management strategy. Moreover, the "Cronbach's Alpha if Item Deleted" values show that removing any item would reduce the alpha to between 0.763 and 0.782, underscoring each item's positive contribution. In essence, none of the items detract from the scale's reliability. This analysis confirms the OC2 scale's robust internal consistency and the appropriateness of all included items, ensuring a sound foundation for evaluating organizational management strategies related to safety.

Table 4.21: Alpha of Management Style (OC3)

Variables	**CITC**	**Cronbach's Alpha Value with Item Deleted**	**Sample Size**
OC31	0.632	0.738	516
OC32	0.647	0.731	516
OC33	0.567	0.771	516
OC34	0.600	0.754	516
Reliability Statistics		Cronbach's alpha	Number of Items
		0.799	4

Table 4.21 presents the reliability analysis results for the Management Style (OC3) scale. Comprising four items, the scale achieves a Cronbach's Alpha of 0.799, near the 0.8 threshold, which suggests a strong level of internal consistency. The CITC (Corrected Item-

Total Correlation) values-OC31 at 0.632, OC32 at 0.647, OC33 at 0.567, and OC34 at 0.600- are all above 0.5, indicating that each item correlates substantially with the overall scale score and meaningfully contributes to capturing the construct of management style.

The "Cronbach's Alpha if Item Deleted" values further confirm the importance of each item. Removing any single item would decrease the overall Alpha to a range between 0.731 and 0.771, which is lower than the current 0.799. This outcome demonstrates that no single item adversely affects the scale's reliability. Although OC33 shows a slightly lower CITC value compared to the other items, it remains within an acceptable range and does not warrant exclusion. In summary, the OC3 scale shows good internal consistency and reliable measurement properties, making it a dependable tool for assessing management style in subsequent analyses.

Table 4.22: Alpha of Organizational Structure (OC4)

Variables	**CITC**	**Cronbach's Alpha Value with Item Deleted**	**Sample Size**
OC41	0.656	0.786	516
OC42	0.628	0.799	516
OC43	0.668	0.781	516
OC44	0.678	0.776	516
Reliability Statistics	Cronbach's alpha		Number of Items
	0.830		4

Table 4.22 presents the reliability analysis for the Organizational Structure (OC4) scale, which comprises four items. The overall Cronbach's Alpha is 0.830, exceeding the commonly accepted threshold of 0.8 and indicating strong internal consistency. The CITC (Corrected Item-Total Correlation) values for OC41 (0.656), OC42 (0.628), OC43 (0.668),

and OC44 (0.678) are all comfortably above 0.5, reflecting a robust correlation between each item and the total scale score. Furthermore, the "Cronbach's Alpha if Item Deleted" values show that removing any item would lower the Alpha to between 0.776 and 0.799, underscoring that each item contributes positively to the scale's reliability. In essence, all items meaningfully support the measurement of organizational structure-related aspects, such as safety culture facilitation, communication efficacy, responsibility delineation, and adaptive responsiveness. This solid reliability ensures that the OC4 scale provides a stable and credible foundation for subsequent analyses and research applications.

Table 4.23: Alpha of Manager Behaviour (OC5)

Variables	**CITC**	**Cronbach's Alpha Value with Item Deleted**	**Sample Size**
OC51	0.650	0.776	516
OC52	0.637	0.781	516
OC53	0.645	0.778	516
OC54	0.654	0.774	516
Reliability Statistics		Cronbach's alpha	Number of Items
		0.823	4

Table 4.23 presents the reliability analysis results for the Manager Behaviour (OC5) scale, comprising four items. The overall Cronbach's Alpha is 0.823, surpassing the common benchmark of 0.8 and indicating strong internal consistency. In terms of Corrected Item-Total Correlation (CITC), OC51 (0.650), OC52 (0.637), OC53 (0.645), and OC54 (0.654) all significantly exceed the usual reference value of 0.5, suggesting that each item closely aligns with the total scale score. These robust correlations confirm that each question effectively captures aspects of managerial prioritization, oversight, and communication in safety matters. Additionally, the "Cronbach's Alpha if Item Deleted" analysis shows that

removing any single item would lower the alpha to between 0.774 and 0.781, which is below the current 0.823. This indicates that all items contribute positively to the scale's reliability. Overall, the OC5 scale exhibits excellent internal consistency and serves as a reliable measure of managerial behaviour in relation to safety, supporting further empirical analysis and model testing.

Table 4.24: Alpha of Employee Participation (OC6)

Variables	**CITC**	**Cronbach's Alpha Value with Item Deleted**	**Sample Size**
OC61	0.663	0.781	516
OC62	0.654	0.785	516
OC63	0.668	0.778	516
OC64	0.637	0.793	516
Reliability Statistics		Cronbach's alpha	Number of Items
		0.829	4

Table 4.24 presents the reliability analysis for the Employee Participation (OC6) scale. The overall Cronbach's Alpha is 0.829, exceeding the 0.8 threshold and indicating strong internal consistency. Examining the Corrected Item-Total Correlation (CITC) values: OC61 at 0.663, OC62 at 0.654, OC63 at 0.668, and OC64 at 0.637-each surpasses a robust benchmark of 0.6, suggesting that all items correlate well with the total scale. The "Cronbach's Alpha if Item Deleted" results further confirm each item's positive contribution; removing any single item would lower Alpha to between 0.778 and 0.793, less than the current 0.829. This finding implies that no single item diminishes the scale's reliability. In essence, the OC6 scale demonstrates excellent internal consistency and a coherent item structure, effectively capturing employees' proactivity in safety improvements, the degree to which their suggestions are considered, the presence of incentives, and their influence in

the decision-making process. Such robust reliability ensures that this scale can reliably inform research on how employee engagement impacts construction safety performance.

Table 4.25: Alpha of Team Collaboration (OC7)

Variables	CITC	Cronbach's Alpha Value with Item Deleted	Sample Size
OC71	0.683	0.823	516
OC72	0.632	0.836	516
OC73	0.682	0.823	516
OC74	0.682	0.823	516
OC75	0.673	0.826	516
Reliability Statistics		Cronbach's alpha	Number of Items
		0.856	5

The reliability analysis results for the Team Collaboration (OC7) scale, shown in Table 4.25, indicate a high level of internal consistency across its five items. The overall Cronbach's Alpha is 0.856, exceeding the 0.8 threshold commonly considered indicative of strong reliability. Corrected Item-Total Correlation (CITC) values-ranging from 0.632 (OC72) to approximately 0.683 (OC71, OC73, OC74)-illustrate that each item is substantially correlated with the overall scale, effectively capturing various facets of team collaboration critical to safety performance and culture. Furthermore, the "Cronbach's Alpha if Item Deleted" metrics show that removing any single item would lower Alpha to between 0.823 and 0.836, underscoring that each question contributes positively to the scale's reliability. In sum, the OC7 scale offers a robust and trustworthy measure of how teamwork, role clarity, mutual support, and collective problem-solving influence construction safety outcomes.

Table 4.26: Alpha of Workforce Skill (WS)

Variables	CITC	Cronbach's Alpha Value with Item Deleted	Sample Size
WS1	0.654	0.822	516
WS2	0.611	0.830	516
WS3	0.619	0.828	516
WS4	0.635	0.825	516
WS5	0.643	0.824	516
WS6	0.641	0.824	516
Reliability Statistics		Cronbach's alpha	Number of Items
		0.850	6

Table 4.26 presents the reliability analysis for the Workforce skill (WS) scale, comprising six items. The overall Cronbach's Alpha is 0.850, surpassing the 0.8 threshold for strong internal consistency. The Corrected Item-Total Correlation (CITC) values-WS1 (0.654), WS2 (0.611), WS3 (0.619), WS4 (0.635), WS5 (0.643), and WS6 (0.641)-are all well above the minimum reference standard of 0.3, and most approach or exceed 0.6. This indicates that each item substantially contributes to the total score, capturing essential facets of workforce skill, such as professional expertise, safety awareness, teamwork, technical training engagement, task completion punctuality, and problem-solving capabilities.

Moreover, the "Cronbach's Alpha if Item Deleted" values show that removing any single item would lower Alpha to between 0.822 and 0.830, still strong but consistently lower than the current 0.850. This suggests that every item adds value to the scale's reliability, and none is redundant or detrimental. In essence, the WS scale demonstrates excellent internal consistency and structural stability, ensuring a reliable measure of workforce skills and providing a solid empirical basis for examining how these skills influence construction safety performance.

Table 4.27: Alpha of Construction Safety Performance (CSP)

Variables	CITC	Cronbach's Alpha Value with Item Deleted	Sample Size
CSP1	0.728	0.870	516
CSP2	0.693	0.874	516
CSP3	0.684	0.875	516
CSP4	0.655	0.879	516
CSP5	0.716	0.871	516
CSP6	0.680	0.876	516
CSP7	0.651	0.879	516
Reliability Statistics		Cronbach's alpha	Number of Items
		0.891	7

Table 4.27 presents the reliability analysis for the Construction Safety Performance (CSP) scale, comprising seven items. The overall Cronbach's Alpha is 0.891, well above the 0.8 threshold for high internal consistency, indicating an exceptionally reliable scale. The Corrected Item-Total Correlation (CITC) values are notably strong: CSP1 at 0.728 and CSP5 at 0.716 stand out, while CSP2, CSP3, CSP6, CSP4, and CSP7 all exceed 0.65. These elevated CITC values confirm that each item correlates strongly with the total score and contributes meaningfully to capturing the multifaceted aspects of construction safety performance.

Examining the "Cronbach's Alpha if Item Deleted". results, removing any single item reduces the Alpha to a range of approximately 0.870 to 0.879, lower than the current 0.891. This suggests that each item supports the scale's internal consistency, and none is superfluous or detrimental to its reliability. In sum, the CSP scale robustly measures various elements-compliance with safety standards, comprehensive safety training, effectiveness of safety measures, project durability, performance relative to industry benchmarks, risk management efficacy, and a "safety first" culture. These findings provide a stable and trustworthy foundation for subsequent empirical analyses and theoretical validations related to construction safety performance. Following the reliability analysis for all nine constructs, examination of the "Cronbach's Alpha if Item Deleted" metric uniformly indicated that removing any item would degrade internal consistency, as each hypothetical deletion yielded a lower alpha value than the original scale. Consequently, all items were retained across all measurement instruments.

4.5 Validity Analysis

When conducting validity analysis, SPSS 27.0 software was employed to assess the suitability of the questionnaire data for exploratory factor analysis, focusing on two key indicators: the KMO (Kaiser-Meyer-Olkin) measure and Bartlett's Test of Sphericity. The KMO value evaluates whether the sample data are suitable for factor analysis by examining the adequacy of correlations among variables. Typically, a KMO between 0.7 and 0.8 indicates moderate suitability, between 0.8 and 0.9 is considered good, and above 0.9 suggests excellent suitability, implying a high level of commonality and potential factor structure (Shrestha, 2021). Bartlett's Test of Sphericity uses a Chi-Square test to determine if the correlation matrix significantly differs from an identity matrix (no correlations). A significant result (usually Sig.<0.05) indicates that there is substantial correlation among variables, supporting the feasibility of factor analysis (Hadi, Abdullah, & Sentosa, 2016).

Table 4.28: KMO and Bartlett's Test of Sphericity for the Whole Questionnaire

KMO Measure of Sampling Adequacy		**0.938**
	Chi-Square	9924.471
Bartlett's Test of Sphericity	Df	861
	Sig.	0.000

In Table 4.28, the KMO value is 0.938, reaching the threshold of excellent suitability for factor analysis. Additionally, Bartlett's Test of Sphericity yields a Sig. of 0.000, confirming that the correlation matrix is not an identity matrix and that the data exhibit sufficient inter-variable correlations. With these indicators in place, this research can confidently proceed with factor analysis to further validate the construct validity of the scale.

Table 4.29: KMO and Bartlett's Test of Sphericity for Each Variable

Variables	**KMO**	**Chi-Square**	**df**	**Sig.**
OC1	0.811	700.810	6	<0.001
OC2	0.805	692.657	6	<0.001
OC3	0.791	606.158	6	<0.001
OC4	0.807	738.552	6	<0.001
OC5	0.806	700.204	6	<0.001
OC6	0.809	729.923	6	<0.001
OC7	0.871	1024.987	10	<0.001
WS	0.886	1095.290	15	<0.001
CSP	0.928	1659.830	21	<0.001

Table 4.29 presents the KMO and Bartlett's Test of Sphericity results for each construct individually, encompassing Organizational Values (OC1), Management Strategy (OC2), Management Style (OC3), Organizational Structure (OC4), Manager Behaviour (OC5), Employee Participation (OC6), Team Collaboration (OC7), Workforce skill (WS),

and Construction Safety Performance (CSP). KMO values and Bartlett's tests are crucial for determining the appropriateness of conducting factor analysis. Except for OC3 (KMO=0.791), which is slightly below 0.8 but still indicates moderate suitability, all other constructs show KMO values above 0.8, with OC7 at 0.871, WS at 0.886, and CSP at a notably high 0.928. These figures suggest excellent sampling adequacy and a strong underlying factor structure. Even for OC3, a KMO of 0.791 remains acceptable and close to the "good" range. Furthermore, the Bartlett's Test of Sphericity is significant at $p < 0.001$ for all constructs, confirming that none of the correlation matrices resemble an identity matrix and that sufficient inter-variable correlations exist. Overall, these results highlight that the data for each examined construct-across organizational culture dimensions, workforce skill, and construction safety performance-are well-suited for factor analysis. This provides a robust foundation for subsequent validity testing and the extraction of meaningful factors.

Table 4.30: Total Variance Explained

Component	Initial Eigenvalue			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	Percentage of variance	Cumulative %	Total	Percentage of variance	Cumulative %	Total	Percentage of variance	Cumulative %
1	12.045	28.678	28.678	12.045	28.678	28.678	4.419	10.522	10.522
2	3.443	8.197	36.875	3.443	8.197	36.875	3.481	8.289	18.811
3	2.026	4.824	41.699	2.026	4.824	41.699	3.268	7.781	26.592
4	1.852	4.410	46.110	1.852	4.410	46.110	2.709	6.451	33.043
5	1.752	4.172	50.282	1.752	4.172	50.282	2.636	6.276	39.319
6	1.635	3.893	54.175	1.635	3.893	54.175	2.618	6.234	45.553
7	1.487	3.540	57.715	1.487	3.540	57.715	2.613	6.223	51.775
8	1.397	3.326	61.041	1.397	3.326	61.041	2.595	6.180	57.955
9	1.240	2.953	63.993	1.240	2.953	63.993	2.536	6.038	63.993
10	0.712	1.695	65.689						
11	0.670	1.594	67.283						
12	0.642	1.529	68.812						
13	0.622	1.481	70.293						
14	0.612	1.458	71.751						
15	0.593	1.411	73.162						

Table 4.30 continued

16	0.583	1.387	74.549
17	0.556	1.323	75.872
18	0.550	1.310	77.181
19	0.538	1.280	78.462
20	0.520	1.238	79.700
21	0.499	1.189	80.889
22	0.481	1.146	82.034
23	0.475	1.130	83.164
24	0.468	1.114	84.278
25	0.462	1.099	85.378
26	0.454	1.081	86.459
27	0.438	1.043	87.502
28	0.428	1.019	88.521
29	0.423	1.007	89.528
30	0.400	0.952	90.480
31	0.393	0.935	91.415
32	0.380	0.906	92.320
33	0.376	0.896	93.216
34	0.360	0.857	94.073
35	0.348	0.829	94.902
36	0.337	0.802	95.704
37	0.332	0.790	96.494
38	0.323	0.769	97.263
39	0.310	0.737	98.000
40	0.296	0.705	98.706
41	0.276	0.657	99.363
42	0.268	0.637	100.000

Table 4.30 presents the results of the Total Variance Explained for the questionnaire data, including the Initial Eigenvalue, Extraction Sums of Squared Loadings, and Rotation Sums of Squared Loadings. According to the Initial Eigenvalue column, the first nine components have eigenvalues greater than 1, meeting the Kaiser Criterion, which indicates that these components significantly contribute to the variance in the data. The first component has an eigenvalue of 12.045, explaining 28.678% of the total variance, making it the most influential component. However, a single component is insufficient to account

for the majority of the variance, necessitating the use of rotation to better distribute variance across multiple components.

In the Rotation Sums of Squared Loadings section, the cumulative variance explained by the first nine components reaches 63.993%, which exceeds the 50% threshold commonly used to indicate an adequate factor structure. This indicates that the questionnaire data have a strong and interpretable factor structure. After rotation, the variance contributions of the nine retained components are more evenly distributed, with the highest at 10.522% (first component) and the lowest at 6.038% (ninth component). This balanced distribution ensures that no single component dominates the explanation of variance, reducing the risk of over-reliance on one factor. The remaining components with eigenvalues less than 1 were excluded. For instance, the tenth component, with an eigenvalue of 0.712, accounted for only 1.695% of the total variance.

Overall, the results in Table 4.30 indicate that the questionnaire data possess a clear factor structure, with the first nine components effectively capturing the shared variance among variables. This provides a robust foundation for subsequent factor analysis and model validation.

Table 4.31 presents the rotated component matrix, which reveals the loadings of measurement variables on different components after applying principal component analysis with varimax rotation. Nine components were extracted, each corresponding to a key construct. Variables exhibit high loadings on their respective components (typically above 0.6) and low loadings on others, demonstrating good factor differentiation.

Table 4.31: Rotated Component Matrix

No.	Component								
	1	2	3	4	5	6	7	8	9
CSP1	0.747								
CSP2	0.715								
CSP3	0.697								
CSP4	0.718								
CSP5	0.740								
CSP6	0.688								
CSP7	0.661								
OC11					0.709				
OC12					0.711				
OC13					0.750				
OC14					0.713				
OC21						0.736			
OC22						0.704			
OC23						0.704			
OC24						0.724			
OC31								0.744	
OC32								0.746	
OC33								0.685	
OC34								0.723	
OC41									0.697
OC42									0.687
OC43									0.717
OC44									0.734
OC51							0.713		
OC52							0.747		
OC53							0.710		
OC54							0.749		
OC61				0.714					
OC62				0.720					
OC63				0.765					
OC64				0.745					

Table 4.31 continued

OC71		0.749
OC72		0.660
OC73		0.708
OC74		0.760
OC75		0.726
WS1	0.771	
WS2	0.738	
WS3	0.738	
WS4	0.756	
WS5	0.764	
WS6	0.748	

Firstly, the Construction Safety Performance (CSP) construct is represented by seven indicators (CSP1 to CSP7), all of which load strongly onto the first component, with loadings ranging from 0.661 to 0.747. This consistency indicates that the variables collectively capture the underlying dimension of safety performance. Secondly, the Workforce skill (WS) construct, comprising six indicators (WS1 to WS6), loads highly onto the second component, with loadings ranging from 0.738 to 0.771, demonstrating its ability to capture workforce skill effectively. Third, the Team Collaboration (OC7) construct, represented by five indicators (OC71 to OC75), loads onto the third component, with loadings between 0.660 and 0.760, reflecting the clarity of this construct.

Similarly, the Employee Participation (OC6) construct's four indicators (OC61 to OC64) load strongly on the fourth component, with loadings ranging from 0.714 to 0.765, further validating the scale's construct validity.

The Management Strategy (OC2) construct is supported by four indicators (OC21 to OC24), which load onto the fifth component, with loadings between 0.704 and 0.736, indicating good internal consistency.

The Management Style (OC3) construct has four indicators (OC31 to OC34) loading onto the sixth component, with values ranging from 0.685 to 0.746, showing good discriminant and convergent validity.

The Manager Behaviour (OC5) construct's four indicators (OC51 to OC54) load onto the seventh component, with loadings from 0.710 to 0.749, validating its distinct construct.

The Organizational Structure (OC4) construct is represented by four indicators (OC41 to OC44) loading on the eighth component, with loadings ranging from 0.687 to 0.734, reflecting strong internal consistency.

Finally, the Organizational Values (OC1) construct, represented by four indicators (OC11 to OC14), loads onto the ninth component, with loadings ranging from 0.709 to 0.750, demonstrating robust content validity.

In summary, the rotated component matrix clearly delineates the variables belonging to each construct, verifying the structural validity of the measurement model. The high loadings on corresponding components and the strong differentiation among constructs confirm that the questionnaire effectively captures the essence of each key variable, providing a solid foundation for subsequent structural model analysis.

4.6 Common Method Bias Test

To ensure that the results of this research are not significantly influenced by common method bias (CMB), the Harman's single-factor test was conducted, utilizing principal component analysis (PCA) with unrotated factor extraction (Chin et al., 2012). Table 4.32 presents the results of the total variance explained, which indicate that nine components with eigenvalues greater than 1 were extracted. Importantly, the first component explains only

28.678% of the total variance, which is well below the threshold of 50%, indicating that no single factor dominates the variance in the data. This result suggests that the dataset does not suffer from severe common method bias.

The rotation sums of squared loadings further support this conclusion. After rotation, the variance explained by the first factor is reduced to 10.522%, with the nine components collectively explaining 63.993% of the total variance. These findings reinforce the robustness of the research's data collection process and suggest that the observed relationships among constructs are unlikely to be artifacts of common method bias. Consequently, the reliability and validity of the subsequent analyses and results are further enhanced, providing confidence in the integrity of the research findings.

4.7 Measurement Model Testing

The measurement model was evaluated using Smart PLS 4, focusing on critical indicators such as Cronbach's Alpha, Composite Reliability (rho_a and rho_c), and Average Variance Extracted (AVE). These indicators assess the internal consistency reliability, convergence validity, and construct validity of the latent variables in the model.

Cronbach's Alpha measures internal consistency reliability, evaluating how closely related the items within a construct are. Generally, a value of 0.7 or above indicates acceptable reliability, while values exceeding 0.8 suggest high reliability (Hair Jr et al., 2021). Composite Reliability (rho_a and rho_c): Composite reliability is a more precise measure of reliability compared to Cronbach's Alpha, reflecting the shared variance among the items. Values of 0.7 or higher are considered acceptable, indicating good reliability of the measurement model (Junejo et al., 2023). Average Variance Extracted (AVE) evaluates convergence validity by representing the proportion of variance explained by the latent variables for all its items. An AVE value of 0.5 or higher indicates that the variance explained by the construct is greater than the variance due to measurement error, signifying good convergence validity(Pehlivan et al., 2024).

Table 4.32: Results of Measurement Model Reliability and Convergence Validity

Item	Cronbach Alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	AVE
CSP	0.891	0.892	0.915	0.605
OC1	0.824	0.826	0.883	0.654
OC2	0.821	0.823	0.882	0.651
OC3	0.799	0.8	0.869	0.624
OC4	0.83	0.831	0.887	0.662
OC5	0.823	0.824	0.883	0.653
OC6	0.829	0.835	0.886	0.661
OC7	0.856	0.861	0.897	0.634
WS	0.85	0.885	0.887	0.566

Table 4.32 presents the statistical results for the reliability and convergence validity of the measurement model. It is evident that all constructs exhibit Cronbach's Alpha values exceeding 0.7, indicating good internal consistency reliability across all latent variables. Notably, OC7 (Team Collaboration) achieves a high Cronbach's Alpha of 0.856, demonstrating excellent reliability. Furthermore, the composite reliability (rho_a and rho_c) values are all above 0.8, confirming the strong reliability of the measurement model. Additionally, all AVE values surpass 0.5, signifying that the latent variables explain a substantial proportion of variance in their respective measurement items, thus demonstrating strong convergence validity.

Specifically, CSP (Construction Safety Performance) achieves a Cronbach's Alpha of 0.891, a composite reliability (rho_c) of 0.915, and an AVE of 0.605, reflecting a high level of internal consistency among its measurement items and robust convergence validity within both theoretical and empirical contexts. The Cronbach's Alpha values for OC1 to OC7 range from 0.799 to 0.856, with AVE values ranging from 0.624 to 0.662, indicating that the dimensions such as organizational values, management strategies, and organizational structure, reliably and effectively capture the underlying constructs.

The Workforce skill (WS) construct achieves a Cronbach's Alpha of 0.85 and an AVE of 0.566, slightly lower than other constructs but still within the acceptable range. This suggests that while WS effectively explains its measurement items within the research context, there may be some room for improvement in its reliability and validity. Overall, these results confirm that the measurement model exhibits strong reliability and convergence validity, providing a solid foundation for subsequent structural model analysis.

To evaluate the discriminant validity of the constructs, the Heterotrait-Monotrait Ratio (HTMT) approach was utilized, as presented in Table 4.35. Discriminant validity ensures that constructs that are theoretically distinct are also empirically distinct, avoiding the issue of overlap between constructs. HTMT values are used to assess the degree of similarity between constructs, and the following standards are commonly applied: an HTMT value below 0.85 indicates satisfactory discriminant validity, while values below 0.90 are acceptable in more lenient conditions(Ab Hamid et al., 2017). When HTMT values exceed these thresholds, it suggests that the constructs may not be distinct enough, and further refinement of the measurement items may be necessary. Table 4.33 presents the HTMT values to assess discriminant validity. All values fall well below the conservative threshold of 0.85, providing strong evidence that the constructs in our model-CSP, WS, and the seven dimensions of OC-are empirically distinct from one another.

Table 4.33: Results of Discriminant Validity Testing (HTMT)

Item	CSP	OC1	OC2	OC3	OC4	OC5	OC6	OC7	WS
CSP									
OC1	0.547								
OC2	0.547	0.549							
OC3	0.508	0.451	0.520						
OC4	0.578	0.570	0.603	0.518					
OC5	0.531	0.530	0.570	0.504	0.501				
OC6	0.537	0.516	0.485	0.460	0.587	0.490			
OC7	0.559	0.551	0.531	0.530	0.555	0.472	0.481		
WS	0.145	0.176	0.044	0.06	0.106	0.190	0.114	0.101	

The low HTMT values between CSP and the OC dimensions (ranging from 0.508 to 0.578) confirm that safety performance is a unique outcome that is not redundant with any of the cultural dimensions measured. Similarly, the very low HTMT value between CSP and WS (0.145) robustly supports the theoretical stance that workforce skill is a construct separate from safety performance itself. The HTMT values among the OC dimensions themselves (ranging from 0.451 to 0.603) demonstrate that while these cultural facets are related, they are not synonymous and each captures a unique aspect of the organizational environment. In summary, the HTMT analysis conclusively establishes the discriminant validity of our measurement model. This clear separation between constructs ensures that any relationships identified in the subsequent structural model analysis are genuine and not an artifact of measurement overlap.

To further test the discriminant validity of the measurement model, the Fornell-Larcker criterion was applied, as shown in Table 4.34.

According to this criterion, the square root of the average variance extracted (AVE) for each construct should be greater than the correlations between that construct and other constructs. This ensures that each construct captures its unique theoretical domain without significant overlap with other constructs, thereby reducing ambiguity in theoretical interpretation.

Table 4.34: Results of Discriminant Validity Testing (Fornell-Larcker criterion)

Item	CSP	OC1	OC2	OC3	OC4	OC5	OC6	OC7	WS
CSP	0.778								
OC1	0.470	0.809							
OC2	0.470	0.452	0.807						
OC3	0.430	0.367	0.421	0.790					
OC4	0.497	0.471	0.498	0.422	0.814				
OC5	0.456	0.437	0.469	0.408	0.414	0.808			
OC6	0.466	0.429	0.403	0.376	0.486	0.406	0.813		
OC7	0.493	0.466	0.446	0.437	0.467	0.396	0.411	0.796	
WS	0.136	0.155	0.025	0.044	0.095	0.165	0.098	0.081	0.753

Table 4.34 presents the discriminant validity results for CSP (Construction Safety Performance), WS (Workforce Skill), and the seven dimensions of OC (Organizational Culture). The square root of AVE for all constructs (diagonal values) is higher than the correlations with other constructs, demonstrating strong discriminant validity.

CSP and Other Variables: The AVE square root for CSP is 0.778, which exceeds its correlations with other variables (ranging from 0.136 to 0.497). This indicates that CSP is a distinct construct, and its measurement indicators effectively capture the essence of construction safety performance without overlapping with other variables such as organizational culture dimensions or workforce skill.

OC1-OC7 (Organizational Culture Dimensions): The AVE square root values for OC1-OC7 are consistently higher than the correlations between these dimensions. For example, OC4 (Organizational Structure) has an AVE square root of 0.814, which is greater than its correlations with other variables (ranging from 0.414 to 0.498). This confirms that each dimension of organizational culture is unique and measures a specific aspect of organizational culture without overlapping with other dimensions.

WS and Other Variables: The AVE square root for WS is 0.753, significantly higher than its correlations with other variables (ranging from 0.025 to 0.165). This reinforces WS's independence as a construct, highlighting its distinct role in influencing CSP independently of organizational culture.

Overall Discriminant Validity: The AVE square roots for all constructs exceed their respective correlations with other constructs, confirming that the measurement model has strong discriminant validity. This finding provides robust evidence for the validity of the theoretical framework and ensures that the constructs are empirically distinct.

The Fornell-Larcker criterion results provide strong support for the measurement model of this research, demonstrating good discriminant validity. The theoretical distinction between constructs is clearly reflected through their measurement indicators, which is significant for both theoretical interpretation and empirical application. Specifically, the discriminant validity results between CSP, OC1-OC7, and WS indicate that these variables can independently capture the unique characteristics of construction safety performance, organizational culture, and workforce skill, thereby reinforcing the theoretical rationality of the causal paths between constructs in the model. Moreover, the good discriminant validity eliminates the risk of measurement overlap between constructs, enhancing the reliability and interpretability of empirical results. This ensures that the model accurately captures the independent effects of each variable, providing strong support for the validity of the research conclusions. Additionally, by verifying the discriminant validity of organizational culture, workforce skill, and construction safety performance using the Fornell-Larcker criterion, this research provides theoretical guidance for future research to expand the model or introduce new variables. Ensuring discriminant validity allows future studies to delve deeper into the interactions among these variables and their impacts on construction safety, thereby offering stronger support for both theoretical advancement and practical application.

Table 4.35: Results of VIF

Item	VIF	Item	VIF
CSP1	2.141	OC43	1.84
CSP2	1.934	OC44	1.872
CSP3	1.909	OC51	1.748
CSP4	1.76	OC52	1.69
CSP5	2.058	OC53	1.717
CSP6	1.872	OC54	1.763
CSP7	1.749	OC61	1.805
OC11	1.782	OC62	1.758
OC12	1.786	OC63	1.817
OC13	1.7	OC64	1.691
OC14	1.645	OC71	1.88
OC21	1.815	OC72	1.671
OC22	1.67	OC73	1.873
OC23	1.687	OC74	1.886
OC24	1.713	OC75	1.84
OC31	1.677	WS1	1.752
OC32	1.719	WS2	1.647
OC33	1.491	WS3	1.635
OC34	1.591	WS4	1.696
OC41	1.756	WS5	1.721
OC42	1.661	WS6	1.729

Table 4.35 presents the Variance Inflation Factor (VIF) results for the measurement items in this research. The primary purpose of the VIF test is to detect multicollinearity among variables to ensure the robustness and predictive capability of the model. Generally, VIF values between 1 and 5 are considered acceptable, and many studies adopt a threshold of VIF < 10 as an indicator of no severe multicollinearity. In this research, all variables have VIF values below 2.2, which is well within acceptable limits, indicating no significant multicollinearity issues. This finding provides strong support for the applicability and accuracy of the model estimations. From the table, it can be observed that the VIF values for CSP (Construction Safety Performance) range from 1.749 to 2.141, indicating a relatively strong but acceptable correlation among these items, aligning with theoretical expectations. Similarly, the VIF values for OC (Organizational Culture) and WS (Workforce skill) items are all below 2, further confirming that the measurement items of these latent variables exhibit low inter-correlation and can independently reflect the distinct characteristics of each construct. Specifically, OC31 and OC33 have the lowest VIF values of 1.677 and 1.491 within the Organizational Culture dimension, suggesting these items may carry less weight in the construct. On the other hand, CSP1 has the highest VIF value of 2.141 within the CSP dimension, indicating its stronger explanatory power for construction safety performance. These results demonstrate the high independence and reliability of the model's construct measurements, providing a solid foundation for subsequent path analysis.

4.8 Structural Model Testing

In the structural model testing, Q^2 (predictive relevance) and R^2 (coefficient of determination) are two crucial metrics used to evaluate the quality of the model. R^2 indicates the explanatory power of the model, reflecting the proportion of variance in the endogenous latent variable that can be explained by exogenous latent variables. The R^2 value ranges from 0 to 1, where values below 0.19 indicate weak explanatory power, values above 0.33 suggest moderate explanatory power, and values exceeding 0.67 represent strong explanatory power(do Nascimento & da Silva Macedo, 2016). A higher R^2value signifies better model fit, indicating that the model has a stronger ability to explain the data. Q^2, on the other hand, assesses the model's predictive relevance and is calculated through the blindfolding procedure. A, Q^2value greater than 0 suggests that the model has good predictive capability. Like R^2, Q^2can be categorized into weak (>0.02), moderate (>0.15), and strong (>0.35) levels. In this research, SmartPLS4 is employed to test the structural model, with a particular focus on evaluating the $R^2$and Q^2 values of the endogenous latent variables to verify the explanatory power and predictive relevance of the model(Ringle et al., 2015). These metrics provide empirical support for the model and further validate the significant impacts of organizational culture and workforce skill on construction safety performance, as well as the theoretical soundness of the proposed relationships.

Table 4.36: Results of R^2

Variable	**R^2**	**Adjusted R^2**
CSP	0.577	0.564

Table 4.36 presents the calculated $R^2$and Adjusted R^2values for the key endogenous variable, Construction Safety Performance (CSP). The R^2 value of 0.577 indicates that the exogenous variables such as organizational culture and workforce skill collectively explain 57.7% of the variance in CSP. According to academic standards for R^2interpretation, a value of 0.577 indicates a relatively high level of explanatory power, suggesting that the exogenous variables in the model significantly contribute to explaining CSP. The Adjusted R^2, which

accounts for the impact of model degrees of freedom, is slightly lower at 0.564 but remains at a high level. This adjustment provides a more accurate reflection of the model's overall fit and the true relationships among variables.

These results demonstrate that exogenous variables, such as Organizational Culture (OC) and Workforce skill (WS), have a strong and significant influence on CSP, validating the theoretical rationale of the hypothesized relationships within the model. Moreover, the high R^2 and Adjusted R^2 values enhance the reliability of the model results, providing empirical support for the robustness of the research's conclusions. This finding is crucial for a deeper understanding of the factors influencing construction safety performance and offers a theoretical foundation for future research aiming to optimize related models.

Table 4.37: Results of Q^2

Variable	SSO	SSE	Q^2 (=1-SSE/SSO)
CSP	3612	2388.481	0.339

Table 4.37 presents the results of the predictive relevance test for Construction Safety Performance (CSP), including the total variance (SSO), residual variance (SSE), and the Q^2value. $Q^2$is a critical indicator for assessing the predictive relevance of the model and is calculated as $Q^2=1-SSE/SSO$. Based on the data in the table, the SSO value for CSP is 3612, and the SSE value is 2388.481, resulting in a Q^2 value of 0.339. According to academic standards, a Q^2value greater than 0 indicates predictive relevance, and values close to or exceeding 0.3 signify strong predictive power.

In this research, the Q^2value for CSP is 0.339, indicating that the model demonstrates a strong predictive capacity for CSP. This result further validates the model's fit, showing that exogenous variables such as Organizational Culture (OC) and Workforce skill (WS) not only have significant explanatory power for CSP (as reflected by R^2) but also reliably predict changes in CSP. This predictive relevance provides additional support for the model's robustness and practical applicability, offering a solid theoretical foundation for its use in real-world construction safety management.

In conclusion, the Q^2value highlights the strong predictive performance of the model, demonstrating that the theoretical framework developed in this research effectively captures and predicts the key drivers of construction safety performance.

4.9 Path Analysis Results Analysis

In this section, path analysis was conducted using Partial Least Squares Structural Equation Modelling (PLS-SEM) to evaluate the significance and directionality of the hypothesized paths within the theoretical model. The path analysis results reveal the direct effects and significance levels between exogenous variables, such as organizational culture and workforce skill, and the endogenous variable, construction safety performance. Path analysis serves as a central component of structural equation modelling, enabling the validation of theoretical hypotheses and quantification of the strength of each path, thereby elucidating the mechanisms of key driving factors. Additionally, the significance of path coefficients was assessed using the Bootstrap resampling method, with P-values serving as the basis for determining significance levels. The results of the path analysis are presented in both graphical and tabular formats (see Figure 4.10 and Table 4.39), providing a clear illustration of the strength and significance of relationships among variables. These findings offer empirical support for the theoretical framework and practical insights for optimizing safety performance in the construction industry.

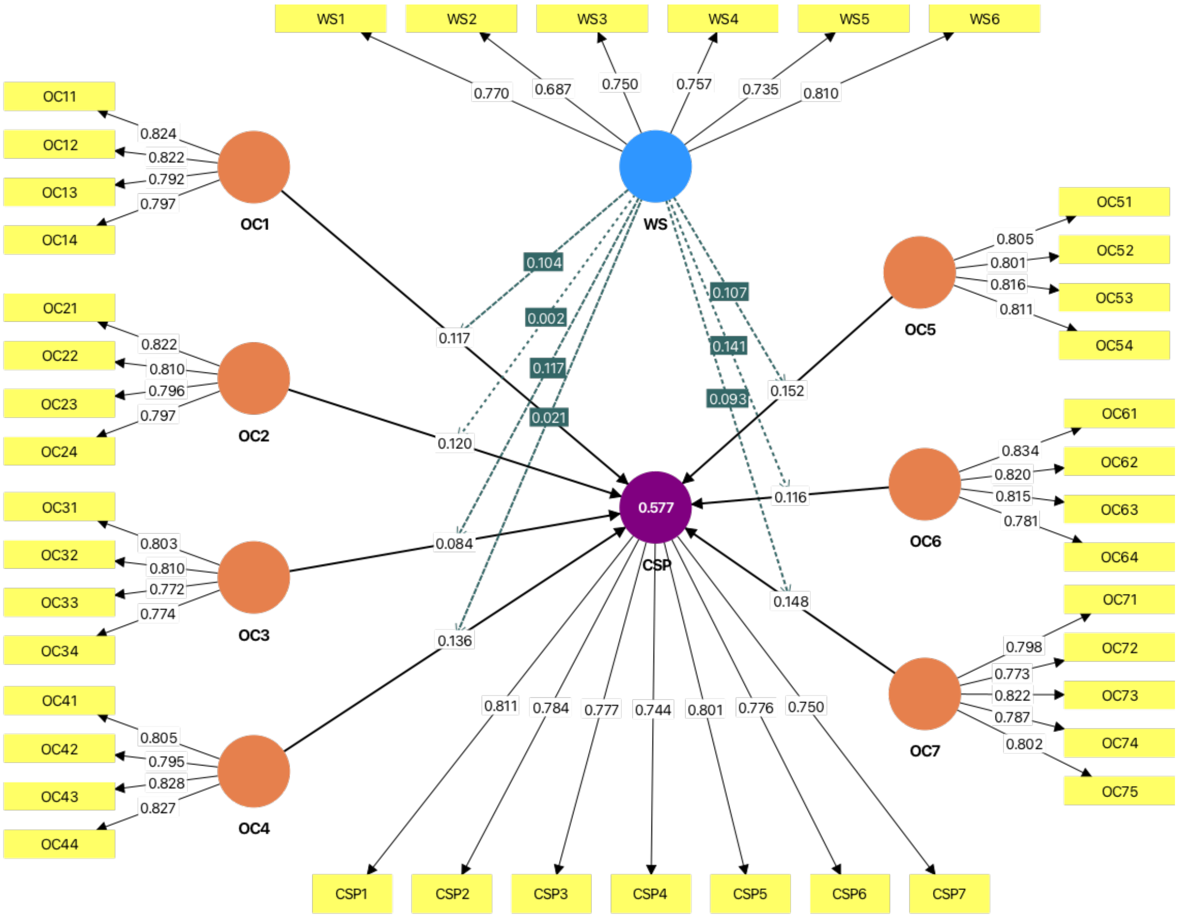

Figure 4.10: Path Analysis Results

Table 4.38: Hypotheses Testing Results

H	Path	Coefficient	STDEV	T	P	2.5%	97.5%
H1	OC1 -> CSP	0.117	0.042	2.828	0.005	0.038	0.202
H2	OC2 -> CSP	0.120	0.040	3.048	0.002	0.042	0.195
H3	OC3 -> CSP	0.084	0.037	2.300	0.021	0.017	0.16
H4	OC4 -> CSP	0.136	0.041	3.324	0.001	0.057	0.216
H5	OC5 -> CSP	0.152	0.038	3.999	0.000	0.073	0.223
H6	OC6 -> CSP	0.116	0.043	2.733	0.006	0.037	0.201
H7	OC7 -> CSP	0.148	0.037	3.998	0.000	0.076	0.223
H8	WS x OC1 -> CSP	0.104	0.046	2.281	0.023	0.008	0.187
H9	WS x OC2 -> CSP	0.002	0.049	0.048	0.962	-0.091	0.101
H10	WS x OC3 -> CSP	0.117	0.044	2.648	0.008	0.015	0.189
H11	WS x OC4 -> CSP	0.021	0.041	0.514	0.607	-0.06	0.103
H12	WS x OC5 -> CSP	0.107	0.047	2.295	0.022	0.016	0.199
H13	WS x OC6 -> CSP	0.141	0.049	2.884	0.004	0.04	0.226
H14	WS x OC7 -> CSP	0.093	0.043	2.164	0.03	0.002	0.172

i. H1: Organizational Values (OC1) have a significant positive effect on Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for OC1 → CSP is 0.117, indicating a positive influence of organizational values on construction safety performance. The T-value is 2.828, exceeding the critical threshold of 1.96 for statistical significance, and the P-value is 0.005, which is less than 0.05. Furthermore, the confidence interval [0.038, 0.202] does not include zero, providing additional support for the validity of H1.

This finding empirically underscores the critical role of organizational values in influencing construction safety performance. Specifically, organizational values represent the core principles and behavioural norms advocated by a company, forming the foundation of its corporate culture. Strong and clearly communicated organizational values not only enhance employees' alignment with corporate goals but also guide their proactive engagement in safety-related practices in daily operations. For instance, when a company prioritizes the value of "safety first" and effectively disseminates this principle through training and communication, employees are more likely to comply with safety standards and avoid unsafe behaviours, thereby reducing the likelihood of accidents.

Moreover, the impact of organizational values extends beyond individual behaviours to shape collective organizational culture, fostering teamwork and influencing management decisions. When employees' personal values align closely with the company's core values, they are more likely to adopt an ownership mindset in safety management. This includes actively reporting potential safety hazards, offering constructive suggestions for improvement, and promoting a culture of mutual accountability. Such collective awareness and action significantly enhance overall project safety management and, ultimately, improve construction safety performance.

Given the high-risk nature of the construction industry, safety remains a paramount concern. These research findings highlight the importance of fostering and strengthening organizational values in this context. In practice, companies are advised to integrate organizational values into daily operations through regular discussions, cultural activities, and leadership role modelling. Additionally, mechanisms for employee participation should be implemented to encourage discussions and refinements of organizational values, enhancing employees' sense of belonging and responsibility. This, in turn, can drive the comprehensive optimization of construction safety performance.

ii. H2: Management Strategy (OC2) has a significant positive effect on Construction Safety Performance (CSP)

As shown in Table 4.38, the path coefficient for OC2 → CSP is 0.120, indicating a positive influence of management strategy on construction safety performance. The T-value is 3.048, exceeding the critical threshold of 1.96 for statistical significance, and the P-value is 0.002, which is less than 0.05. Additionally, the confidence interval [0.042, 0.195] does not include zero, further supporting the validity of H2.

This result highlights the critical role of systematic and well-designed management strategies in improving construction safety performance. Management strategies typically encompass setting clear safety objectives, optimizing safety management processes, allocating resources efficiently, and implementing specific measures for risk assessment and control. Effective safety management strategies enable organizations to comprehensively monitor safety issues on construction sites, promptly identify potential hazards, and take appropriate actions to mitigate risks, thereby reducing accidents. Particularly in the construction industry, characterized by complexity and dynamic environments, robust management strategies are essential for ensuring safety.

Specifically, companies that adopt comprehensive and detailed safety management strategies-such as establishing clear safety standards and operational procedures, conducting regular safety training, and using advanced technology for real-time safety monitoring-can significantly enhance safety performance. For instance, in high-risk operations, clearly defined safety procedures and the use of risk assessment tools can greatly reduce the likelihood of accidents. Furthermore, direct involvement of management in implementing and evaluating safety strategies, such as conducting regular inspections and making timely adjustments, can motivate employees to prioritize safety in their work.

The findings also underscore that management strategies should go beyond formal institutional frameworks. Their effectiveness lies in practical implementation and continuous refinement. Construction firms can establish robust feedback mechanisms to collect opinions and suggestions from site workers, enabling them to adjust safety strategies based on real-world conditions. This flexibility and dynamic adjustment capability can significantly enhance the applicability of management strategies, thereby improving construction safety performance.

In conclusion, management strategies serve as a critical link between leadership and construction sites, profoundly impacting safety performance. Companies are advised to adopt advanced management tools, streamline management processes, and strengthen oversight of strategy implementation to enhance the scientific rigor and operability of management strategies, ensuring the achievement of safety objectives.

iii. H3: Management Style (OC3) has a significant positive effect on Construction Safety Performance (CSP)

As indicated in Table 4.38, the path coefficient for OC3 → CSP is 0.084, showing a positive influence of management style on construction safety performance. The T-value of 2.300 exceeds the critical value of 1.96 for statistical significance, and the P-value of 0.021 is less than 0.05, confirming the statistical significance of the path. Additionally, the confidence interval [0.017, 0.16] does not include zero, providing further support for the validity of H3.

This result underscores the critical role of management style in enhancing construction safety performance. A good management style is characterized by transparent and fair management mechanisms, consistent leadership in safety management, and supportive and motivating actions toward employees. Such a management style not only fosters trust in safety management among employees but also encourages active participation in safety practices, thereby cultivating a robust organizational safety culture.

Specifically, when leaders demonstrate a strong commitment to safety management and employ fair and transparent management practices, employees are more likely to actively engage in safety initiatives, significantly reducing the likelihood of safety incidents. For example, leaders who set a good example in safety practices, take swift action against safety violations, and actively respond to employees' safety suggestions send a clear message about the organization's prioritization of safety. This consistent management style reinforces employees' adherence to safety protocols.

Furthermore, management style plays a crucial role in fostering teamwork and communication. A collaborative and communicative management style can break down silos between departments, facilitating timely information sharing and feedback. This enables employees to access critical safety information more efficiently, leading to more accurate and effective safety measures in practice. For instance, regular team meetings and safety inspections conducted by management can ensure smooth communication of safety management information across all organizational levels, ultimately enhancing overall safety performance.

However, it is important to note that the effectiveness of management style depends on its alignment with the organization's specific circumstances. If the chosen management style does not align with the needs of the construction site or the actual conditions of the workforce, its positive impact on safety performance may be diminished. Therefore, construction firms must tailor their management styles to align with their organizational culture and employee characteristics to maximize their contribution to safety performance.

In conclusion, a strong management style serves not only as a supplement to formal safety management systems but also as a key driver of improved construction safety performance. Construction companies are advised to cultivate safety-oriented leaders, establish transparent and fair management systems, and strengthen interactions and communication between management and employees to advance the development of a safety-oriented construction culture.

iv. H4: Organizational Structure (OC4) has a significant positive effect on Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for OC4 → CSP is 0.136, with a T-value of 3.324, which exceeds the significance threshold of 1.96, and a P-value of 0.001, which is less than 0.05. Furthermore, the confidence interval [0.057, 0.216] does not include zero, indicating that the effect of organizational structure on construction safety performance is statistically significant. Thus, hypothesis H4 is supported.

This result highlights the critical role that an effective and efficient organizational structure plays in improving construction safety performance. Specifically, a well-designed organizational structure enhances safety management by ensuring clear role definitions, effective information dissemination mechanisms, and flexible emergency response capabilities. By optimizing their organizational structure, construction firms can better integrate resources and ensure that safety management covers all aspects of construction activities.

Clear role definitions in safety responsibilities are a hallmark of an effective organizational structure. When construction firms clearly delineate the roles and responsibilities of various departments and individuals in safety management, it enhances employees' sense of accountability and execution efficiency. Such clarity minimizes ambiguities and inefficiencies in safety management, thereby improving overall effectiveness. For instance, assigning specific safety management departments and personnel to construction projects ensures the rapid identification and resolution of safety hazards, thereby reducing the likelihood of accidents.

Additionally, an organizational structure with effective information dissemination mechanisms can significantly improve the timeliness and fluidity of information in safety management. Construction projects often require multi-department collaboration, and without efficient information-sharing channels, delays or omissions in safety information may occur, increasing construction risks. By establishing efficient information dissemination mechanisms, such as regular cross-department meetings or adopting digital management platforms, companies can ensure that safety information is promptly delivered to relevant parties, facilitating quick problem resolution.

Flexible emergency response capabilities also play a vital role in the positive impact of organizational structure on safety performance. In construction, unexpected safety incidents are inevitable. An organizational structure with high flexibility can quickly mobilize resources and implement emergency measures to minimize the impact of accidents.

For example, a flexible organizational structure can establish dedicated emergency response teams and conduct regular emergency drills to enhance the company's response speed and coordination capabilities in crisis situations.

However, it is important to note that the effectiveness of an organizational structure depends on the complexity and scale of the construction project. For large-scale projects, an overly complex organizational structure may lead to elongated decision-making chains, reducing flexibility. Conversely, for smaller-scale projects, an overly simplistic organizational structure may result in unclear role definitions. Therefore, construction firms should tailor their organizational structure to the specific characteristics and needs of their projects to maximize its contribution to safety performance.

In conclusion, as a critical component of construction safety management, organizational structure significantly enhances safety responsibilities, efficient information dissemination, and emergency response capabilities. It also optimizes the allocation of resources and management practices, providing a solid foundation for improving construction safety performance. Construction firms should continuously refine their organizational structure during project implementation to adapt to the evolving construction environment and safety requirements.

v. H5: Manager Behaviour (OC5) has a significant positive effect on Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for OC5 → CSP is 0.152, with a T-value of 3.999, which significantly exceeds the threshold of 1.96, and a P-value of 0.000, which is well below 0.05. Additionally, the confidence interval [0.073, 0.223] does not include zero, further confirming that manager behaviour has a significant positive impact on construction safety performance. Thus, hypothesis H5 is supported.

Manager behaviour, as a key component of organizational culture, positively influences construction safety performance through several mechanisms. First, managers' high attention to safety issues and their exemplary behaviour effectively communicate the organization's commitment to safety management. Second, managers' direct involvement and timely feedback significantly enhance the efficiency of safety management execution. Third, ongoing site supervision and strict corrective measures by managers effectively reduce safety hazards during construction.

First, managers' high attention to safety issues establishes a "safety-first" cultural atmosphere within the organization. This cultural atmosphere subtly influences employees' safety behaviours, encouraging them to comply more consciously with safety regulations and standards. For instance, when managers conduct regular safety inspections on construction sites, they not only identify potential safety hazards but also convey their commitment to safety through their actions, thereby raising employees' safety awareness.

Second, timely feedback from managers and their adoption of safety suggestions can significantly improve the effectiveness of safety management. In the construction process, employees are often the group most directly exposed to the working environment and, therefore, may be more sensitive to safety risks. When managers promptly listen to employees' opinions and take corresponding actions, they not only address issues quickly but also enhance employees' sense of participation and responsibility, creating a virtuous cycle in safety management.

Moreover, direct site supervision and timely corrective actions by managers help reduce the occurrence of safety incidents. For example, by strictly penalizing unsafe behaviours or correcting non-compliance with safety standards, managers can effectively deter inappropriate actions and reinforce safe practices. This supervisory mechanism not only reduces the likelihood of safety hazards but also establishes clear safety management standards within the organization.

However, it is important to note that the effectiveness of manager behaviour depends on the capabilities and attitudes of the managers themselves. If managers pay insufficient attention to safety issues or fail to take timely action to resolve risks, the positive impact of their behaviour may be diminished. Therefore, construction firms should focus on providing safety training for managers to enhance their understanding of and competency in safety management.

In conclusion, manager behaviour significantly and positively impacts construction safety performance, primarily through strengthening the safety culture, improving the efficiency of safety management, and reducing safety hazards. Construction firms should recognize the critical role of manager behaviour and enhance its influence on safety performance through training and performance evaluations for managers. This will ensure a comprehensive improvement in construction safety performance.

vi. H6: Employee Participation (OC6) has a significant positive effect on Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for OC6 → CSP is 0.116, with a T-value of 2.733, exceeding the threshold of 1.96, and a P-value of 0.006, which is less than 0.05. Additionally, the confidence interval [0.037, 0.201] does not include zero, further confirming that employee participation has a significant positive impact on construction safety performance. Thus, hypothesis H6 is supported.

Employee participation plays a critical role in enhancing construction safety performance, and its positive impact is reflected in several key aspects: first, encouraging employees to participate in safety improvement measures enhances their sense of responsibility and initiative; second, management's adoption of employees' safety suggestions allows for more precise identification and resolution of potential safety hazards; and third, through incentive mechanisms and granting employees more say in safety decisions, organizations can foster a culture of safety-oriented collaboration and engagement.

Firstly, active employee participation effectively improves organizational safety performance. The complexity and dynamic nature of construction sites mean that employees are often the most familiar with frontline safety risks. When employees actively participate in safety improvement measures and share their observations and experiences with management, the likelihood of risk incidents is significantly reduced. Furthermore, increased participation fosters a stronger sense of responsibility among employees, motivating them to consider how their actions impact overall safety.

Secondly, management's adoption of employees' safety suggestions establishes an efficient safety management mechanism. Employees, as the direct executors of on-site operations, have a more immediate perception of specific processes and potential risk points compared to management. If management listens to and adopts these suggestions, safety management becomes more targeted and practical. Moreover, this demonstrates respect for and recognition of employees, further encouraging their active involvement in safety management.

Additionally, appropriate incentive mechanisms and empowerment strategies are essential for increasing employee participation. Reward systems that encourage employees to propose constructive safety suggestions significantly enhance their willingness to engage. At the same time, granting employees greater decision-making authority and opportunities to voice their opinions about safety increases their attention to and responsibility for safety management. This positive interaction fosters safety-oriented working habits and cultivates a proactive safety culture throughout the organization.

However, it is essential to note that the effectiveness of employee participation depends on several factors, such as the extent to which management values employee suggestions, the fairness of incentive mechanisms, and employees' professional competencies. Therefore, construction firms seeking to maximize the impact of employee participation on safety performance must address these factors through improvements in organizational culture and incentive structures.

In conclusion, employee participation has a significant positive impact on construction safety performance. By enhancing employees' sense of responsibility, optimizing safety management processes, and fostering a safety-oriented organizational culture, employee participation provides critical support for effective safety management on construction sites. Construction firms should focus on developing employees' safety awareness and participation capabilities while implementing incentive mechanisms and empowerment strategies to maximize the positive effects of employee participation, ultimately improving construction safety performance.

vii. H7: Team Collaboration (OC7) has a significant positive effect on Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for OC7 → CSP is 0.148, with a T-value of 3.998, exceeding the threshold of 1.96, and a P-value of 0.000, which is significantly less than 0.05. Additionally, the confidence interval [0.076, 0.223] does not include zero, further confirming that team collaboration has a significant positive impact on construction safety performance. Thus, hypothesis H7 is supported.

Team collaboration is a critical component of safety management in the construction industry, contributing to improved communication efficiency, clear role delineation, and the ability to solve problems collaboratively. The complexity and high-risk nature of the construction industry make effective team collaboration particularly essential for achieving safety performance. The following points elaborate on the mechanisms through which team collaboration impacts construction safety performance:

Firstly, team collaboration significantly enhances safety awareness and responsiveness on construction sites. In high-risk construction environments, close collaboration among team members reduces communication errors and ensures that crucial safety information is conveyed and executed promptly. For instance, through regular safety meetings and feedback mechanisms, team members can identify potential safety hazards early and take swift action to mitigate them.

Secondly, clear role delineation and mutual support are central to improving safety performance. In a well-coordinated team, members clearly understand their responsibilities and tasks, minimizing safety incidents caused by unclear accountability. Furthermore, when individual members face complex tasks or emergencies, the team's mutual support and collaboration enable quick responses and problem resolution, preventing risks from escalating.

Thirdly, team collaboration fosters a safety-oriented cultural environment within the organization. When team members collectively focus on safety goals and actively engage in safety improvements, these behaviours gradually become ingrained in the organization's safety culture. This cultural shift not only increases employees' sense of responsibility but also strengthens the organization's systematic approach to managing construction safety.

Additionally, the effectiveness of team collaboration depends on factors such as team management mechanisms, the level of trust among members, and communication channels. For example, effective team leadership can enhance collaboration motivation through incentives and clear objectives, while trust and respect among members are crucial for ensuring smooth collaboration. Therefore, to maximize the impact of team collaboration on safety performance, construction firms must provide support at both the managerial and cultural levels.

In conclusion, team collaboration has a significant positive impact on construction safety performance. By improving internal communication efficiency, clarifying role responsibilities, and enabling collaborative responses to safety risks, team collaboration provides strong support for enhancing construction safety. Construction firms should focus on developing team collaboration capabilities and optimizing team dynamics through effective management mechanisms and incentive policies to further enhance overall safety performance.

4.10 Moderation Effect Test Results Analysis

The moderation effect test aims to examine how workforce skill (WS) influences the relationship between organizational culture factors and construction safety performance (CSP). By introducing workforce skill as a moderating variable, the study seeks to identify whether it amplifies, weakens, or alters the strength of the relationships between key variables. The following sections provide a detailed analysis of each hypothesis related to moderation effects, with a focus on the statistical significance, path coefficients, and confidence intervals to validate the proposed hypotheses.

i. H8: Workforce skill (WS) significantly moderates the relationship between Organizational Values (OC1) and Construction Safety Performance (CSP)

According to the regression results in Table 4.38, hypothesis H8 (that Workforce skill (WS) significantly moderates the relationship between Organizational Values (OC1) and Construction Safety Performance (CSP)) is empirically supported.

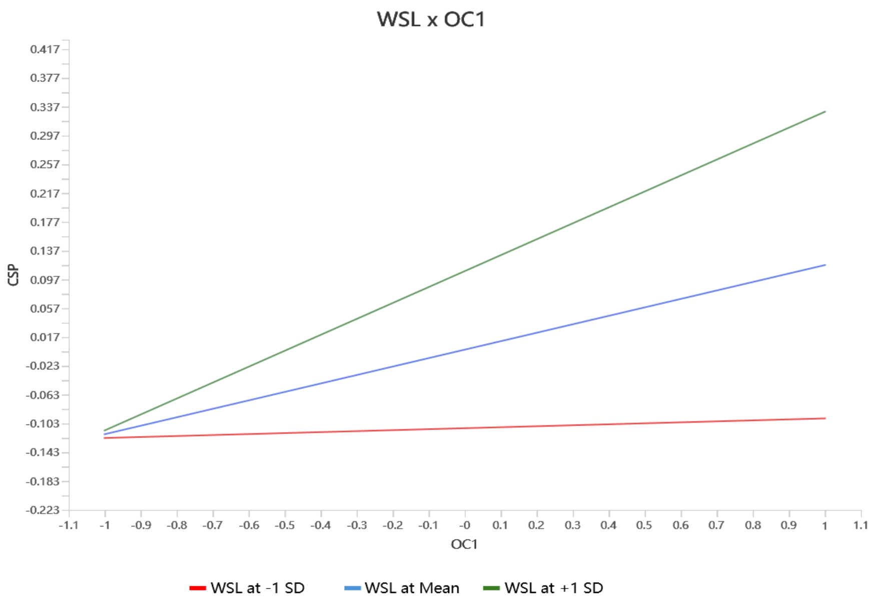

Figure 4.11: Moderating Effect H8 Test Results

Specifically, the path coefficient for WS×OC1→CSP is 0.104, with a T-value of 2.281 (exceeding the 1.96 threshold) and a P-value of 0.023 (less than 0.05). Additionally, the confidence interval [0.008, 0.187] does not include zero, confirming the presence of the moderating effect. The graphical representation of the moderation effect in Figure 4.11 aligns with the statistical findings. When WS is low (red line), the impact of OC1 on CSP is weak or nearly negligible. At a moderate level of WS (blue line), the effect of OC1 on CSP becomes more pronounced, and at a high level of WS (green line), the positive influence of OC1 on CSP is the strongest. In other words, as workforce skill increases, the relationship between organizational values and construction safety performance is amplified.

This result indicates that the influence of organizational values on CSP is not uniformly strong under all conditions; it depends on the skill level of the workforce. When employees possess higher professional skills and stronger safety awareness, they are more likely to understand, internalize, and apply the organization's core values to their daily work, thus translating these values into improved safety outcomes. Conversely, if the workforce skill is insufficient, even well-established and positive organizational values may not be effectively realized in practice.

This finding has important implications for construction firms. If companies aim to enhance safety performance through strengthening their organizational values, it is not sufficient to focus solely on cultural messaging. They must also invest in workforce training and development to elevate employees' technical competencies and safety consciousness. Only when workforce skills are elevated can organizational values exert a more potent effect on safety performance, thereby laying a robust foundation for effective construction safety management.

ii. H9: Workforce skill (WS) significantly moderates the relationship between Management Strategy (OC2) and Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for WS ×OC2→CSP is 0.002, with a T-value of 0.048, which is below the significance threshold of 1.96, and a P-value of 0.962, exceeding the commonly used 0.05 standard.

These statistical outcomes indicate that the moderating path is not statistically significant. Additionally, the confidence interval includes zero, further confirming the lack of a significant moderating effect. Therefore, hypothesis H9 is not supported, meaning that Workforce skill (WS) does not significantly moderate the relationship between Management Strategy (OC2) and Construction Safety Performance (CSP).

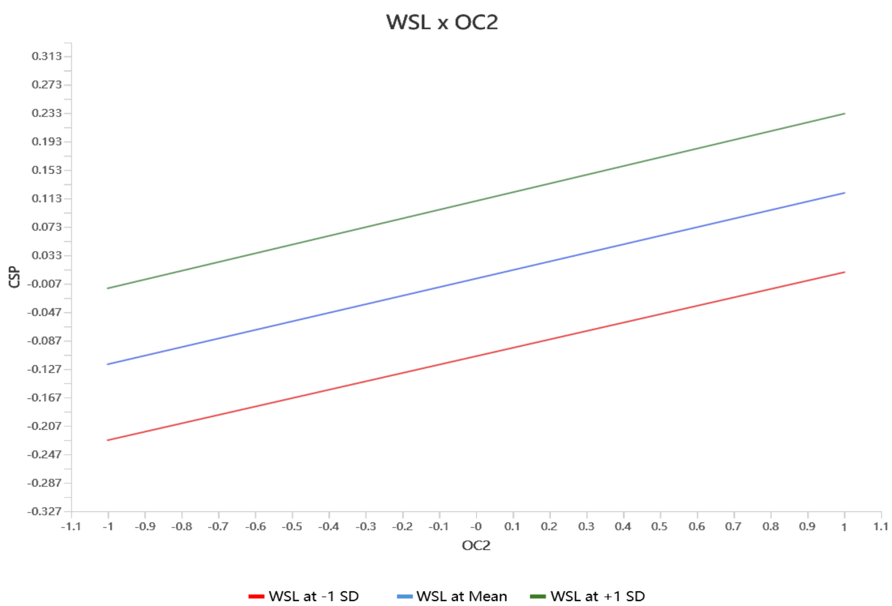

Figure 4.12: Moderating Effect H9 Test Results

The visual representation of the moderating effect in Figure 4.12 also supports this conclusion. Regardless of whether WS is low, average, or high, the positive relationship between OC2 and CSP does not exhibit noticeable changes. In other words, under the conditions of this research's data, the influence of management strategy on CSP does not significantly vary based on the level of workforce skill. Although both management strategy and workforce skill are important factors affecting construction safety performance, WS does not fulfil its expected moderating role in the relationship between management strategy and CSP.

This finding suggests that when formulating and implementing management strategies, the degree to which these strategies affect safety performance is not substantially constrained by the skill level of the workforce. It may imply that management strategy possesses a certain level of universality and independence, and its positive impact on safety performance remains generally stable regardless of changes in workforce skills.

iii. H10: Workforce skill (WS) significantly moderates the relationship between Management Style (OC3) and Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for WS ×OC3→CSP is 0.117, with a T-value of 2.648 (exceeding the 1.96 threshold) and a P-value of 0.008 (below 0.05). Additionally, the confidence interval [0.015, 0.189] does not include zero, indicating that H10 is empirically supported in this research.

These findings suggest that when workforce skill is higher, the positive influence of management style on construction safety performance becomes more pronounced. In contrast, when workforce skill is low, even improvements in management style may yield only limited safety performance benefits. In other words, workforce skill acts as a key amplifier: skilled and safety-aware workers can more effectively internalize and implement the management strategies, leadership behaviours, and organizational norms designed to enhance safety outcomes.

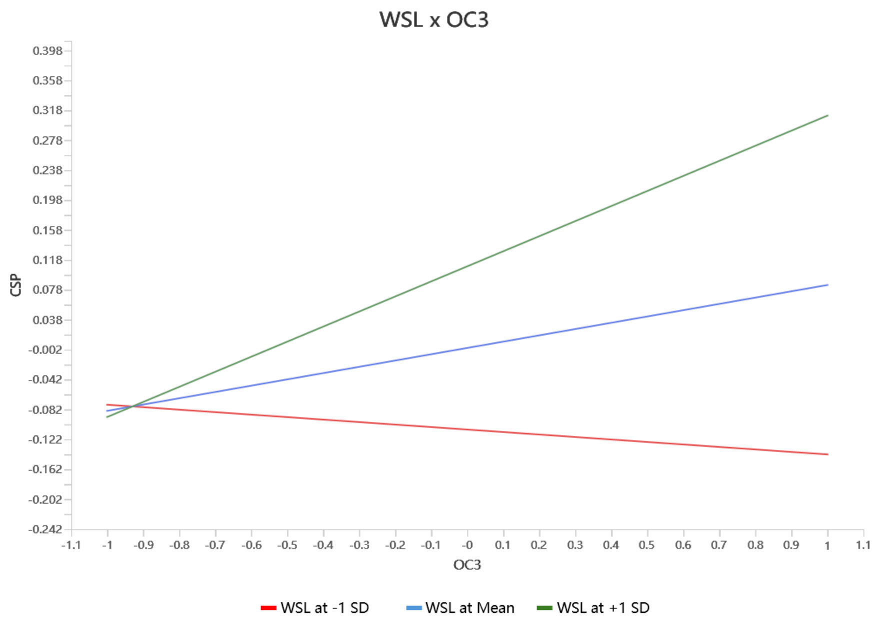

Figure 4.13: Moderating Effect H10 Test Results

Figure 4.13 visually illustrates this moderating effect. Under low WS conditions (red line), the slope of the OC3-CSP relationship is minimal or even slightly negative, indicating a weak or negligible influence of management style on CSP. As WS increases to medium levels (blue line), the positive effect of OC3 on CSP emerges more clearly. At high WS levels (green line), the positive impact of OC3 on CSP is substantially magnified, demonstrating that improved management style, combined with high-skilled employees, can significantly boost safety performance.

In essence, the validation of H10 underscores the dynamic interplay between organizational-level changes and workforce competencies. To achieve meaningful and sustained improvements in safety performance, construction firms must not only focus on refining management style-promoting fairness, transparency, and safety leadership-but also concurrently invest in enhancing workforce skills. By aligning managerial improvements with a workforce that possesses the requisite professional expertise and safety awareness, organizations can fully realize the potential of their management interventions to positively shape construction safety performance.

iv. H11: Workforce skill (WS) significantly moderates the relationship between Organizational Structure (OC4) and Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for WS ×OC4→CSP is 0.021, with a T-value of 0.514 (well below the 1.96 threshold for statistical significance) and a P-value of 0.607 (greater than the commonly accepted 0.05 significance level). The confidence interval also includes zero, indicating a lack of statistical support for H11. In other words, Workforce skill does not significantly moderate the relationship between Organizational Structure and Construction Safety Performance.

Theoretically, organizational structure improvements-such as clarifying safety responsibilities, optimizing communication channels, and enhancing emergency response capabilities-are expected to boost safety performance. However, this research's findings suggest that when WS is introduced as a moderator, the positive influence of organizational structure on CSP does not vary meaningfully with different levels of workforce skill. This outcome implies that organizational structure enhancements provide a relatively stable improvement in safety performance regardless of employee skill levels.

The visual representation in Figure 4.14 further supports this conclusion. The three lines representing WS at -1 SD, mean, and +1 SD appear relatively parallel, indicating that variations in WS do not significantly alter the slope of the OC4-CSP relationship. In other words, unlike other organizational culture dimensions that may interact more closely with workforce skills, organizational structure appears to exert its positive effect on safety performance quite independently of skill variations.

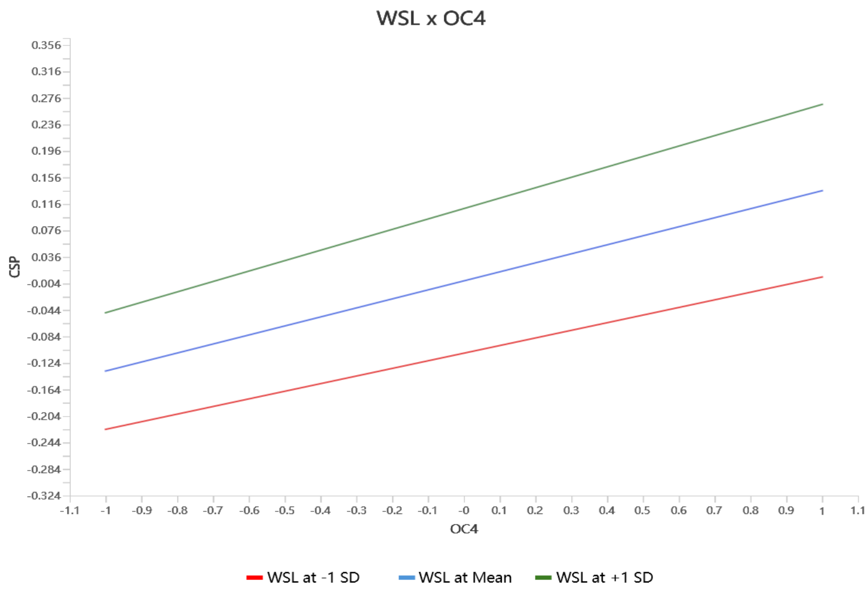

Figure 4.14: Moderating Effect H11 Test Results

This finding offers practical insights for construction firms' safety management strategies. While elevating employee skills and safety awareness remains important for overall safety outcomes, in this research's context, the improvement in safety performance resulting from organizational structure enhancements does not depend heavily on workforce skills. Consequently, companies can focus on refining organizational structure-through better policies, processes, and workflows-to achieve stable and reliable safety performance gains, regardless of the skill composition of their workforce.

v. H12: Workforce skill (WS) significantly moderates the relationship between Manager Behaviour (OC5) and Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for WS ×OC5→CSP is 0.107, with a T-value of 2.295, exceeding the critical threshold of 1.96, and a P-value of 0.022, which is below 0.05. Additionally, the confidence interval [0.016, 0.199] does not include zero, indicating that H12 is empirically supported in this research. In other words, the positive effect of manager behaviour on construction safety performance intensifies as workforce skill increases, whereas at lower skill levels, the enhancement is relatively weaker.

From a theoretical and practical perspective, manager behaviour-such as stringent safety inspections, timely feedback, and exemplary leadership-plays a pivotal role in shaping a strong safety culture. However, this research reveals that its effectiveness is contingent on workforce skill. When employees possess higher professional skills and safety awareness, they can better understand and execute the safety regulations and strategies set by managers.

As a result, improvements in managerial behaviour are more readily translated into tangible safety performance gains. Skilled employees not only apply safety knowledge more proficiently but also respond more effectively to managerial guidance, thereby amplifying the positive impact of manager behaviour on CSP.

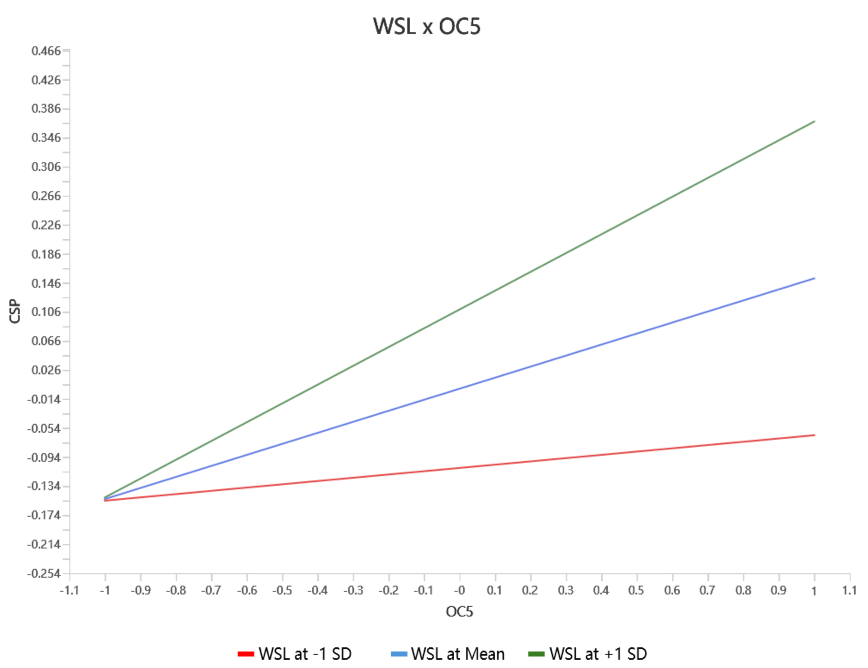

Figure 4.15: Moderating Effect H12 Test Results

The moderation effect is visually evident in Figure 4.15. When WS is low (red line), the positive impact of OC5 on CSP is subdued; as WS reaches an average level (blue line), the slope increases, indicating a more pronounced effect of manager behaviour on CSP and at high WS levels (green line), the slope rises sharply, showing that, in a high-skill workforce environment, the positive influence of manager behaviour on CSP becomes significantly stronger.

In conclusion, the confirmation of H12 underscores the importance of considering the interplay between manager behaviour and workforce skill in efforts to enhance safety performance. Even if managers demonstrate positive safety management styles, achieving maximum effectiveness requires a highly skilled workforce. By investing in employee training, skill development, and safety education, companies can ensure that managerial efforts more readily translate into substantial improvements in construction safety performance.

vi. H13: Workforce skill (WS) significantly moderates the relationship between Employee Participation (OC6) and Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for WS ×OC6→CSP is 0.141, with a T-value of 2.884 (exceeding the 1.96 threshold), and a P-value of 0.004 (less than 0.05). Additionally, the confidence interval [0.04, 0.226] does not include zero, indicating that H13 is empirically supported. In other words, workforce skill plays a crucial moderating role in the relationship between employee participation and construction safety performance.

From a theoretical standpoint, employee participation involves proactive engagement in safety management processes, such as proposing safety suggestions, participating in safety improvement decisions, and cooperating with safety audits and training. When workforce skills are higher, employees better understand safety regulations, quickly acquire safety skills, and more efficiently translate managerial safety strategies into actual safe behaviours. Under these conditions, even moderate increases in employee participation can lead to more substantial improvements in safety outcomes.

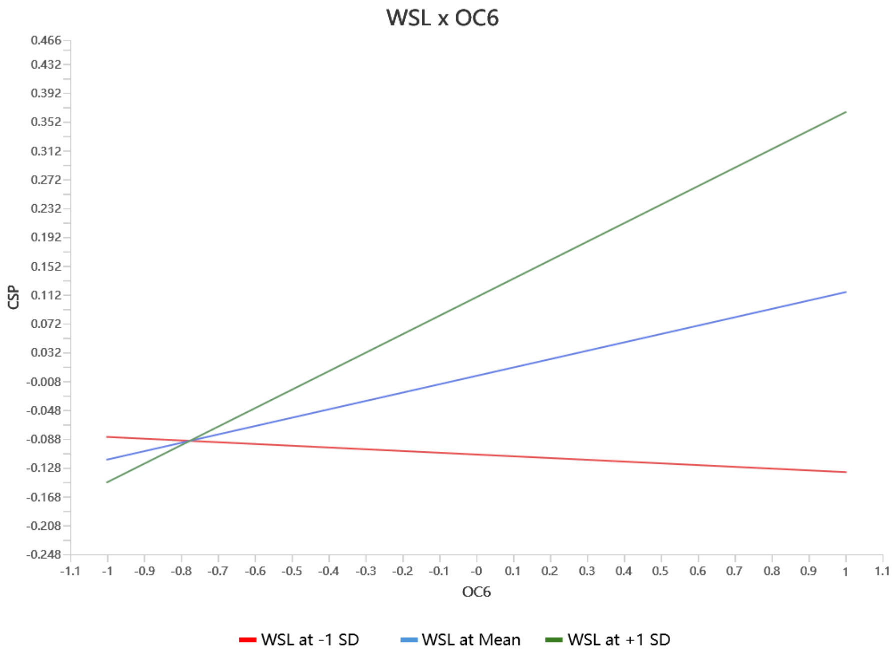

Figure 4.16: Moderating Effect H13 Test Results

The moderation effect depicted in Figure 4.16 further confirms this perspective. When WS is low (red line), the impact of OC6 on CSP is weak or negligible; at the medium WS level (blue line), the positive influence of OC6 on CSP begins to emerge and at high WS levels (green line), incremental increases in employee participation yield significantly greater improvements in CSP. This reveals a synergistic effect between employee participation and workforce skill: in a high-skill environment, employee suggestions, opinions, and safe practices are implemented more effectively, maximizing the benefits of participation for safety performance. Conversely, if workforce skill is insufficient, even enhanced participation may be limited in its ability to substantially improve safety outcomes.

This finding holds important implications for construction firms. To leverage employee participation effectively in improving safety performance, companies must not only grant employees a greater voice and participation opportunities but also invest in enhancing their skills and safety competencies. By combining improvements in workforce skills with robust participation mechanisms, organizations can comprehensively strengthen their safety management framework and achieve more meaningful and sustained advancements in construction safety performance.

vii. H14: Workforce skill (WS) significantly moderates the relationship between Team Collaboration (OC7) and Construction Safety Performance (CSP)

According to the path analysis results in Table 4.38, the path coefficient for WS ×OC7→CSP is 0.093, with a T-value of 2.164 (exceeding the 1.96 threshold) and a P-value of 0.03 (less than 0.05). Furthermore, the confidence interval [0.002, 0.172] does not include zero, confirming empirical support for H14. In other words, as the workforce skill increases, the positive influence of team collaboration on construction safety performance is significantly amplified.

From a theoretical perspective, team collaboration is a crucial factor influencing construction safety performance. It enhances the efficiency of information exchange, clarifies responsibilities, and improves the team’s collective ability to address safety risks. However, this research reveals that the positive effect of team collaboration is not uniform across all skill levels. Under higher workforce skill conditions, the impact of team collaboration on CSP becomes more pronounced. This occurs because skilled employees can better understand and implement team goals, safety strategies, and agreed-upon protocols, thereby fully realizing the advantages of collaboration.

Figure 4.17: Moderating Effect H14 Test Results

The moderating effect depicted in Figure 4.17 further supports this argument. When WS is low (red line), the contribution of OC7 to CSP is limited and the slope is relatively flat. As WS reaches a moderate level (blue line), the positive relationship between OC7 and CSP emerges, indicating that even moderate skill improvements enable some safety performance gains through teamwork. However, when WS is high (green line), the slope of the OC7-CSP relationship rises sharply, demonstrating that a highly skilled workforce can more effectively absorb and execute team decisions and safety recommendations, leading to a substantial improvement in safety outcomes. In other words, the marginal benefit of team collaboration is greater in a high-skill labour context, forming a positive interaction between team collaboration and skill level.

These findings have meaningful implications for construction firms. If companies aim to enhance safety performance through improved team collaboration, they must also invest in raising workforce skills. By strengthening employee training and skill development, team members become better equipped to understand, implement, and capitalize on collaborative safety strategies. Under such conditions, the combination of a high-skilled workforce and robust team collaboration yields superior construction safety performance.

4.11 Summary

This chapter, through a multi-layered statistical and empirical approach, systematically tested the proposed hypotheses. The results of the 14 hypotheses are shown in Table 4.39.

Table 4.39: Hypotheses Testing Results

No.	Hypothesis	Result
1	Organizational Values (OC1) has a significant positive impact on Construction Safety Performance (CSP)	Supported
2	Management Strategy (OC2) has a significant positive impact on Construction Safety Performance (CSP)	Supported
3	Management Style (OC3) has a significant positive impact on Construction Safety Performance (CSP)	Supported
4	Organizational Structure (OC4) has a significant positive impact on Construction Safety Performance (CSP)	Supported
5	Manager Behavior (OC5) has a significant positive impact on Construction Safety Performance (CSP)	Supported
6	Employee Participation (OC6) has a significant positive impact on Construction Safety Performance (CSP)	Supported
7	Team Collaboration (OC7) has a significant positive impact on Construction Safety Performance (CSP)	Supported
8	Workforce skill (WS) can significantly moderate the relationship between Organizational Values (OC1) and construction safety performance (CSP)	Supported

Table4.39 continued

9	Workforce skill (WS) can significantly moderate the relationship between Organizational Values (OC2) and construction safety performance (CSP)	No Supported
10	Workforce skill (WS) can significantly moderate the relationship between Organizational Values (OC3) and construction safety performance (CSP)	Supported
11	Workforce skill (WS) can significantly moderate the relationship between Organizational Values (OC4) and construction safety performance (CSP)	No Supported
12	Workforce skill (WS) can significantly moderate the relationship between Organizational Values (OC5) and construction safety performance (CSP)	Supported
13	Workforce skill (WS) can significantly moderate the relationship between Organizational Values (OC6) and construction safety performance (CSP).	Supported
14	Workforce skill (WS) can significantly moderate the relationship between Organizational Values (OC7) and construction safety performance (CSP)	Supported

Initially, descriptive statistical analyses offered comprehensive insights into the sample's demographic characteristics and data distribution for key constructs. By detailing the distributions of gender, age, education, work experience, occupation, company size, project type, and position level, this chapter established the foundational context for understanding the interplay among constructs. Subsequently, meticulous reliability and validity checks of the measurement model ensured the soundness of the instrument. The results confirmed high internal consistency for all constructs (with Cronbach's Alpha and Composite Reliability values mostly above 0.8) and strong convergent and discriminant validity (AVE values above 0.5, and HTMT and Fornell-Larcker criteria satisfied). These findings guaranteed that the measurement model was both stable and reliable, setting the stage for accurate structural model estimation.

As shown in Figure 4.18, the structural model testing and hypotheses verification revealed that all examined dimensions of organizational culture-including organizational values, management strategy, management style, organizational structure, manager behaviour, employee participation, and team collaboration-positively impact construction safety performance. These results underscore the critical importance of cultural factors and workforce skills in achieving robust safety performance. Moreover, the moderation analysis showed that workforce skill indeed enhances or amplifies certain OC-CSP pathways, while others remain unaffected by skill variations. This complex pattern of moderation effects offers nuanced insights into when and how workforce skills can serve as a strategic lever to boost the efficacy of organizational initiatives aimed at improving safety performance.

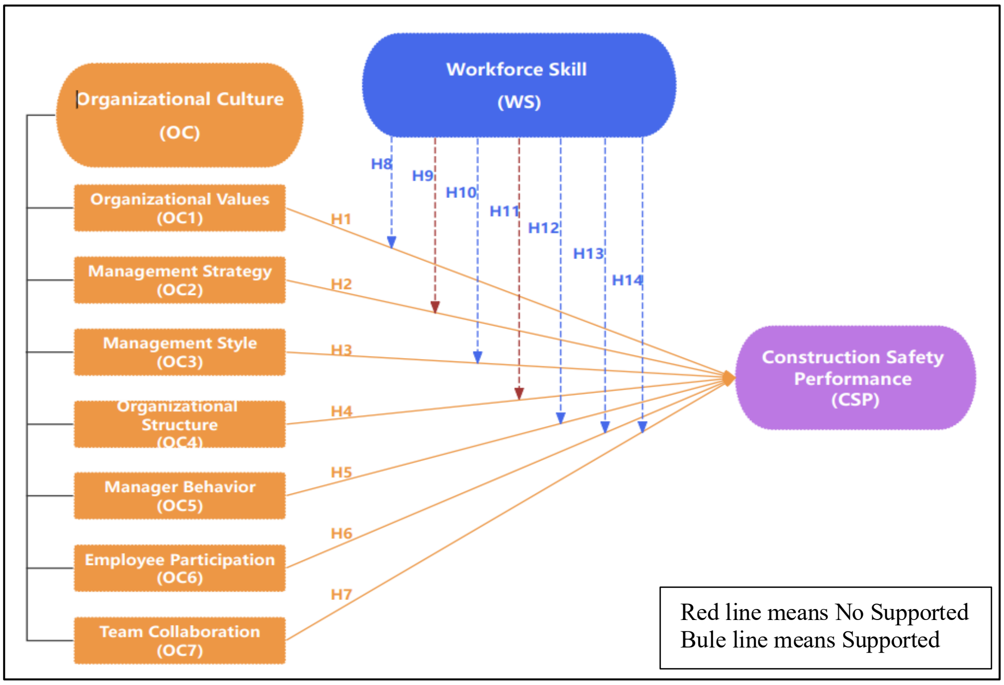

Figure 4.18: Research Conceptual Framework

In essence, this chapter's findings and empirical evidence provide a firm empirical basis for subsequent theoretical discussions and practical recommendations. It reinforces the notion that optimizing safety performance in the construction industry demands a strategic combination of fostering the right organizational culture and enhancing workforce skills. These insights guide practitioners toward targeted strategies-such as improving workforce competencies, refining managerial behaviours, optimizing organizational structures, and strengthening team collaboration-to achieve sustained and meaningful improvements in construction safety performance.

CHAPTER 5

DISCUSSIONS, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion of Research Findings

This section delves into the study's key research findings by synthesizing the results presented in the previous chapter. It focuses on interpreting the relationships between organizational culture, workforce skills, and construction safety performance, as well as the moderating role of workforce skills. Through a detailed examination of each research objective, this discussion highlights both theoretical and practical implications, providing insights into strategies for improving construction safety performance. The following subsections address each objective in detail, offering a comprehensive understanding of the study's contributions and potential applications.

5.1.1 Research Objective i: to Investigate Whether Organizational Culture Has a Significant Impact on Construction Safety Performance

In addressing Research Objective i, this research employed path analysis to empirically examine the impact of seven specific elements of organizational culture on construction safety performance (CSP) and validate Hypotheses H1 to H7. Organizational culture was divided into seven dimensions: Organizational Values (OC1), Management Strategy (OC2), Management Style (OC3), Organizational Structure (OC4), Manager Behaviour (OC5), Employee Participation (OC6), and Team Collaboration (OC7). The results showed that all seven elements had significant positive impacts on CSP, with statistical significance achieved (T-values > 1.96, P-values < 0.05). Path coefficients and confidence intervals further supported these findings.

The extent of influence varied among the elements of organizational culture. Among these, the effect of Manager Behaviour (OC5) was the most pronounced, providing strong support for H5. It exhibited the highest path coefficient (0.152), with a T-value of 3.999 and a P-value of 0.000, highlighting the critical role of managers in safety performance management. Managers' high safety awareness, active involvement, and timely feedback on safety issues contribute significantly to reducing safety risks on construction sites and improving overall safety performance. The findings also confirm H7 and H4, as both Team Collaboration (OC7) and Organizational Structure (OC4) demonstrated strong positive impacts on CSP. Their path coefficients of 0.148 and 0.136, respectively, and T-values exceeding 3.3 ($P < 0.05$). Team collaboration enhances communication efficiency and collective responsiveness, facilitating the implementation of safety management measures. Meanwhile, a well-designed organizational structure, through clear role delineation and efficient information flow, improves the execution and flexibility of safety management processes.

The findings also provide support for H1 and H2. Organizational Values (OC1) and Management Strategy (OC2), although exhibiting slightly lower path coefficients (0.117 and 0.120, respectively), also showed significant positive effects, indicating that core organizational values and systematic management strategies provide cultural and institutional support for safety management.

i. Manager Behavior (OC5) and its Key Role in CSP

The findings provide strong empirical support for H5. Manager Behavior (OC5) emerges as the most influential cultural dimension, exhibiting the highest path coefficient ($\beta = 0.152$, $T = 3.999$, $p < 0.001$). This statistical dominance underscores that managerial conduct is the paramount driver of safety performance within the organizational culture framework. Specifically, managers improve CSP by demonstrating exemplary safety commitment, conducting proactive site supervision, and ensuring timely remediation of hazards. These behaviors directly reduce accident rates and establish a visible standard of safety prioritization on-site.

This result substantiates and extends the conclusions of prior research. It aligns with Bathan (2023), who emphasized that managerial leadership and employee participation positively influence construction safety management. Bathan highlighted that managers improve CSP by providing safety training, supervision, and decision-making participation (Bathan & Joy, 2023). Similarly, Rad (2006) stressed the central role of leadership in quality management, noting that upper management's support and commitment are crucial for successfully implementing safety management practices.

ii. The Positive Impact of Team Collaboration (OC7) on CSP

The research results confirm H7, as Team Collaboration (OC7) demonstrates a significant positive impact on CSP, with a path coefficient of 0.148 ($T = 3.998$, $p < 0.05$). Effective team collaboration improves communication, task allocation, and coordinated efforts, which are vital for implementing safety management measures and reducing communication errors.

These findings are supported by Ankrah (2007), who demonstrated that team-oriented organizational culture enhances participant satisfaction and safety outcomes. Ankrah argued that efficient teamwork enables organizations to resolve complex project issues, thereby improving health and safety performance. Similarly, Fong & Kwok (2009) highlighted the importance of collaboration within project cultures, stating that a "collaborative-oriented" organizational culture enhances project stability and safety through knowledge sharing and efficient communication.

iii. The Role of Organizational Structure (OC4) in CSP

The research revealed that Organizational Structure (OC4) has a path coefficient of 0.136, a T-value of 3.324, and a P-value of less than 0.05, thereby supporting H4. A well-structured organization improves CSP by ensuring clear role definitions, efficient communication mechanisms, and robust emergency response capabilities. Clear roles and responsibilities reduce ambiguity in safety management and improve accountability, leading to lower safety risks.

This result corroborates Rad (2006), who found that organizations with organic structures perform better in quality management than those with mechanistic structures. Rad attributed this to the flexibility and emphasis on cross-departmental cooperation in organic structures (Mohammad Mosadegh Rad, 2006). Likewise, Bathan (2023) noted that optimizing organizational processes and role definitions supports effective safety management and improves CSP.

iv. The Foundational Role of Organizational Values (OC1) and Management Strategy (OC2)

The results provide empirical support for both H1 and H2. Organizational Values (OC1) and Management Strategy (OC2) exhibited path coefficients of 0.117 and 0.120, respectively, with T-values exceeding 2.8 and P-values less than 0.05. Despite their relatively lower influence, both elements play foundational roles in CSP by providing cultural and institutional frameworks. Organizational values shape employees' safety-first behavior, while management strategies ensure systematic and resource-driven implementation of safety goals.

Ankrah (2007) further validates these findings, emphasizing that performance-oriented and project-oriented cultures significantly improve project safety outcomes. Similarly(Ankrah, 2007), Bathan (2023) highlighted the role of systematic safety strategies, which effectively reduce accident rates and enhance overall organizational performance.

v. Comparative Analysis and Practical Implications

The findings of this research align closely with those of Bathan (2023), Rad (2006), Ankrah (2007), and Fong & Kwok (2009), reinforcing the critical role of organizational culture in CSP. However, this research extends previous research by providing a detailed quantitative analysis of the relative influence of different cultural elements on CSP. The results highlight the particularly strong impact of Manager Behavior, Team Collaboration, and Organizational Structure, offering targeted insights for improving safety management in construction. In practice, construction firms should focus on:

a) Enhancing Manager Behavior: Strengthen managerial leadership, ensure high-level commitment to safety, and implement timely corrective measures.

b) Promoting Team Collaboration: Foster efficient communication and task coordination to address safety risks, particularly in complex project environments.

c) Optimizing Organizational Structure: Define roles and responsibilities clearly, improve information flow, and establish flexible emergency response mechanisms.

d) Reinforcing Organizational Values and Management Strategies: Integrate core safety values into daily operations and develop systematic safety management strategies to provide cultural and institutional support for CSP.

The results of this research provide empirical evidence of the significant positive impact of organizational culture elements on CSP. By comparing these findings with existing literature, this research deepens the understanding of how organizational culture functions as a key driver of safety performance. Construction firms should leverage these insights to develop a safety-oriented organizational culture, optimize managerial practices, and enhance team collaboration, thereby improving construction safety performance and ensuring sustainable project development.

5.1.2 Research Objective ii: to Assess the Extent of the Impact that Organizational Culture Has on Construction Safety Performance

To address Research Objective ii, this research utilized Partial Least Squares Structural Equation Modelling (PLS-SEM) to quantify the extent of the impact of organizational culture on construction safety performance (CSP). By conducting a detailed path analysis, the path coefficients and significance levels of each element of organizational culture were calculated. Overall, the findings revealed that organizational culture exerts a significant and positive impact on CSP, confirming its role as a critical soft management factor in improving safety performance. The results demonstrated that the seven dimensions of organizational culture contribute differently to CSP, with managerial behavior (OC5), team collaboration (OC7), and organizational structure (OC4) showing the most significant effects.

Specifically, managerial behavior (OC5) achieved the highest path coefficient of 0.152, accounting for 15.2% of the total effect. This highlights the central role of managers in safety performance improvement, including their strong commitment to safety, effective supervision, and proactive response to hazards. This finding aligns with Bathan (2023), who emphasized the significant influence of managerial leadership and employee participation on occupational safety and health management, stating that managers play a pivotal role in safety training, supervision, and decision-making. Similarly, Rad (2006) underscored the importance of leadership commitment in achieving successful Total Quality Management (TQM) outcomes, validating the role of managers in improving CSP.

Team collaboration (OC7) also exhibited a strong positive effect, with a path coefficient of 0.148, accounting for 14.8% of the total contribution. Effective team collaboration enhances communication, collective responsiveness, and problem-solving capabilities, thereby improving the implementation of safety measures. Ankrah (2007) supports this conclusion by demonstrating that team-oriented cultures significantly improve participant satisfaction and safety outcomes in construction projects. Similarly, Fong & Kwok (2009) found that collaboration-oriented organizational cultures promote knowledge sharing and project stability, providing essential support for safety management practices.

Organizational structure (OC4) also demonstrated a significant impact, with a path coefficient of 0.136 and a 13.6% contribution rate. A well-designed organizational structure enhances role clarity, information flow efficiency, and emergency response capabilities, significantly improving safety performance. Rad (2006) similarly found that organic organizational structures outperform mechanistic ones in quality management due to their flexibility and emphasis on inter-departmental collaboration. Bathan (2023) further validated this by highlighting the role of organizational processes and role allocation in supporting safety management.

Although organizational values (OC1) and management strategy (OC2) showed relatively lower path coefficients of 0.117 and 0.120, respectively, their contributions remain critical as foundational elements. Organizational values shape employee safety awareness and behavioral norms, while management strategy enhances the systematic execution of safety objectives. These findings align with Shanmugapriya & Subramanian (2016), who emphasized the importance of leadership and strategic processes in improving safety performance, particularly through institutionalized safety strategies.

The remaining dimensions, employee participation (OC6) and management style (OC3), also exhibited significant but relatively lower impacts, with path coefficients of 0.116 and 0.084, respectively. Employee participation fosters proactive engagement and accountability, while management styles enhance safety management execution through fairness and transparency. These results are consistent with Demirkesen (2020), who highlighted the role of lean management practices in improving CSP (Demirkesen, 2020), and Yiu et al. (2019) emphasized the importance of institutionalized safety management systems and employee involvement.

In conclusion, this research deepens our understanding of the quantifiable impact of organizational culture on CSP and highlights the varying degrees of influence among its dimensions. While managerial behavior, team collaboration, and organizational structure play central roles, organizational values, management strategy, and employee participation provide foundational support. Compared to studies by Bathan (2023), Rad (2006), Ankrah (2007), Shanmugapriya & Subramanian (2016), and Demirkesen (2020), this research further quantifies the relative contributions of each element using PLS-SEM, providing practical insights for construction companies. By optimizing key cultural dimensions such as managerial leadership, team collaboration, and organizational structure, construction firms can maximize CSP improvements and promote sustainable project outcomes.

5.1.3 Research Objective iii: to Explore How Workforce Skill Moderates the Relationship Between Organizational Culture and Construction Safety Performance, and to Specify the Concrete Manifestation of Its Moderating Effect

To address Research Objective iii, this research analyzed the moderating effect of workforce skill (WS) on the relationship between various organizational culture elements and construction safety performance (CSP). The path analysis results reveal that workforce skill exhibits significant moderating effects on certain cultural elements, including organizational values (OC1), management style (OC3), managerial behavior (OC5), employee participation (OC6), and team collaboration (OC7), while no significant moderating effects were observed for management strategy (OC2) and organizational structure (OC4). This indicates that workforce skill selectively amplifies the influence of organizational culture on safety performance, highlighting the importance of skilled labor in enhancing safety outcomes.

Firstly, workforce skill significantly moderates the relationship between OC1 (organizational values) and CSP, with a moderation coefficient of 0.104 (T=2.281, P=0.023). This result supports H8, suggesting that skilled workers are better able to comprehend and implement organizational safety values, thereby enhancing their positive impact on safety performance. Feng et al. (2014) similarly found that workforce comprehension and alignment with safety culture significantly influence the practical outcomes of safety investments, reinforcing the role of skilled labor in executing core cultural values. Zhu et al. (2023) also highlighted that highly skilled workers exhibit superior adaptability and proactivity, allowing them to internalize and execute safety principles effectively.

Secondly, workforce skill significantly moderates the relationships between OC3 (management style) and OC5 (managerial behavior) with CSP, with moderation coefficients of 0.117 and 0.107, respectively. These findings provide support for H10 and H12, emphasizing that skilled workers can respond more efficiently to managerial directives and safety requirements, thereby reducing risks and improving on-site safety performance. Naji et al. (2021) found similar results, indicating that safety culture reduces workplace psychosocial hazards, especially among skilled employees who exhibit higher levels of compliance and accuracy.

Thirdly, workforce skill also moderates the effects of OC6 (employee participation) and OC7 (team collaboration) on CSP, with coefficients of 0.141 and 0.093, respectively. These outcomes lend support to H13 and H14, indicating that skilled workers are more likely to participate actively in safety initiatives, offer constructive feedback, and coordinate effectively within teams, amplifying the impact of these cultural elements on safety performance. Zhu et al. (2023) noted that workforce agility, including proactivity and resilience, significantly influences safety participation and compliance, particularly among skilled workers.

However, the moderating effects of workforce skill on the paths from OC2 (management strategy) to CSP and from OC4 (organizational structure) to CSP were not supported. The two hypotheses are as follows.

H9: Workforce skill (WS) significantly moderates the relationship between Management Strategy (OC2) and construction safety performance (CSP).

H11: Workforce skill (WS) significantly moderates the relationship between Organizational Structure *(OC4) and construction safety performance (CSP).*

This lack of significance can be theoretically explained by the institutionalized and normative nature of these two cultural dimensions. For Management Strategy (OC2): A well-defined safety strategy operates as a top-down, institutional blueprint. Its effectiveness in reducing accidents relies primarily on the clarity of its goals, the adequacy of allocated resources such as budget and time, and the consistency of its enforcement through formal controls. Once established and communicated, its impact on safety performance is designed to be system-wide and relatively stable, less contingent on the variable skill levels of individual employees. A skilled workforce may execute tasks more efficiently, but the strategic direction and resource framework that enable safe work are set at a higher, organizational level.

For Organizational Structure (OC4): The structure defines formal reporting relationships, authority channels, and procedural workflows. Its contribution to safety lies in creating clear accountability and enabling efficient information flow. Like strategy, a well-designed structure functions as a formalized system. While high skill may help individuals navigate this system more adeptly, the system’s core ability to define roles and coordinate actions-and thus its direct effect on safety outcomes-is inherent to its design, not dynamically amplified by workforce skill in the same way that leadership styles or team collaboration might be.

In essence, OC2 and OC4 establish the "rules of the game" and the "playing field." Workforce skill influences how well the "game" is played within these boundaries (affecting other relationships like OC3→CSP or OC7→CSP), but it does not significantly alter the impact of the rules and the field themselves on the final safety outcome. Maeni et al. (2024) similarly observed that the effects of management strategy and organizational structure on performance outcomes were relatively stable and less influenced by workforce characteristics.

In summary, this research highlights the selective and hierarchical moderating role of workforce skill in the relationship between organizational culture and CSP. Skilled workers amplify the effects of organizational values, managerial behavior, management style, employee participation, and team collaboration by enhancing their understanding and execution capabilities. However, for management strategy and organizational structure, the moderating effect is less significant, suggesting that these elements rely more on systemic management practices. Comparisons with Feng et al. (2014), Zhu et al. (2023), Naji et al. (2021), and Maeni et al. (2024) demonstrate that workforce skill is a critical factor in safety management, particularly in areas requiring execution, proactivity, and coordination.

This research provides important practical implications for construction firms: companies should prioritize workforce skill development through regular training and education programs to enhance safety execution. Furthermore, aligning organizational culture elements with workforce skills is essential to ensure the effective implementation of safety management measures, thereby improving overall safety performance.

5.2 Contribution of the Research

This research contributes to both theory and practice by developing a comprehensive model that examines the relationship between organizational culture (OC), workforce skill (WS), and construction safety performance (CSP). The theoretical contributions deepen the understanding of the mechanisms and pathways through which organizational culture influences safety performance, while the practical implications offer actionable guidance for construction firms to enhance safety management practices.

5.2.1 Theoretical Contributions

i. Expanding the Theoretical Framework for OC-CSP Relationships

This study subdivides organizational culture into seven dimensions-organizational values, management strategy, management style, organizational structure, managerial behavior, employee participation, and team collaboration- and quantitatively identifies their differential impacts on construction safety performance (CSP). The results indicate that managerial behavior (OC5), team collaboration (OC7), and organizational structure (OC4) play critical roles. This granular analysis fills a research gap by clarifying the specific cultural components that most strongly influence CSP.

ii. Elucidating Multi-Level Mechanisms

Three key mechanisms-behavioral guidance, process optimization, and cultural shaping-are identified through which organizational culture affects CSP. This insight advances the understanding of how organizational culture operates at multiple levels to influence safety performance, providing a valuable reference for future research in safety management and organizational behavior.

iii. Highlighting the Moderating Role of Workforce Skill

By introducing workforce skill as a moderator, this study reveals its selective and hierarchical effects on the OC-CSP relationship. Skilled labor amplifies the positive effects of cultural components such as organizational values, managerial behavior, and team collaboration. This finding broadens the application of moderating variables in OC-CSP research and offers a novel perspective for integrating human capability into cultural influence models.

iv. Contributions to the Three Theories

Building on the above empirical findings, this study further contributes to three major theoretical frameworks-Organizational Culture Theory (OCT), Knowledge Management Theory (KMT), and Safety Culture Theory (SCT). Firstly, the dimension-level operationalization of organizational culture and the identification of multi-level mechanisms enrich OCT by clarifying which cultural components are most influential and how they function across behavioral, procedural, and structural pathways in high-risk environments. Secondly, by positioning workforce skill as a moderating factor, the study extends KMT, demonstrating that employees' absorptive capacity and tacit knowledge condition the translation of cultural norms into safe practices, highlighting knowledge capability as a key boundary condition for organizational effectiveness. Finally, the quantitative verification of cultural effects strengthens SCT by providing empirical grounding and revealing the pathways through which safety culture shapes performance. Collectively, these insights deepen OCT, KMT, and SCT individually while also offering an integrated perspective on how organizational culture and workforce skill jointly influence construction safety outcomes.

5.2.2 Practical Implications

The findings of this study can be translated into actionable guidance at two levels: specific recommendations for the construction industry in Jinan City, where the data originated, and broader strategic insights for the construction industry.

5.2.2.1 Specific Recommendations for the Jinan Construction Industry

Based on data collected within Jinan, the following recommendations are designed to address the safety challenges faced by the local industry amidst its rapid development.

i. Focus on Safety Leadership at the Frontline Supervisor Level

The research found that on-site managerial behavior has the greatest impact on safety performance. Therefore, construction companies in Jinan should make enhancing the safety leadership of project managers and safety officers a core priority. Concrete actions include conducting case-based training focused on local common risks, such as deep excavation, high formwork; and incorporating specific behaviors such as safety inspections and crew safety talks into managers' key performance indicators.

ii. Establish Effective On-Site Coordination Mechanisms

Team collaboration and organizational clarity are critical. Given the prevalent use of multiple subcontractors on Jinan projects, the main contractor should take the lead in instituting regular safety coordination meetings involving all subcontractors. Simple digital tools including WeChat work groups and collaboration platforms should be utilized to ensure safety information and instructions are communicated in real-time and clearly to every work crew, preventing accidents caused by miscommunication.

iii. Address Skilled Labor Shortcomings through University-Industry Collaboration

Workers' skill levels significantly amplify the effects of safety culture. Major construction firms in Jinan can partner with local institutions like Shandong Jianzhu University to develop "tailored, order-based training programs." This ensures graduates possess not only technical knowledge but also strong safety awareness and risk identification skills, enhancing the "safety competency" of the workforce at its source.

iv. Use a Quantitative Tool to Diagnose Safety Culture Gaps

This study provides an assessment framework. Leading enterprises in Jinan can use it periodically to conduct a "diagnostic check-up" of their own safety culture. Through surveys, they can gauge employee perceptions across the seven dimensions, such as leadership commitment, teamwork, employee participation, thereby precisely identifying specific weaknesses, such as a lack of leadership emphasis or low employee involvement. This allows for targeted investment of improvement resources, moving beyond guesswork to data-informed action.

5.2.2.2 Broader Implications for the Construction Industry

This study also offers new perspectives for enhancing safety management across the industry.

i. Invest in a "Proactive Prevention" Culture on Top of Regulatory Compliance

While adhering to laws and regulations is the baseline, achieving higher safety standards requires consciously fostering a culture where "everyone values safety and proactively manages safety." This means corporate decision-makers must treat safety culture development as a strategic priority, akin to schedule and quality, allocating dedicated budget and attention to it. Focus should be placed on areas proven effective: improving frontline supervision, strengthening team communication, and clarifying responsibilities.

ii. Integrate Safety Competency into Employee Development Systems

The study found that skilled workers are better at enacting safety culture. Therefore, close collaboration between a company's Human Resources and Safety departments is essential. During recruitment, training, and promotion, assessments should evaluate not only technical skills but also safety behavior and awareness, making "strong safety capability" a key criterion for excellent employees.

iii. Adopt Data-Driven Safety Decision-Making, Moving Beyond Reliance on Experience

This study demonstrates the value of using data models to analyze safety issues. The industry should gradually promote such management methods based on surveys and data analysis. Companies can regularly collect safety-related data to analyze the underlying cultural and managerial causes of incidents or hazards. This enables more scientific and forward-looking decision-making, shifting away from practices overly reliant on post-accident response and subjective judgment.

In summary, for the construction industry in Jinan, this research provides a practical toolkit for improvement, derived from and tailored to local practice. For the broader Chinese construction industry.it proposes a forward-looking pathway: by developing an integrated safety management system underpinned by cultural leadership, skilled workforce support, and data-informed decision-making, the industry can evolve towards a more proactive and resilient safety paradigm.

5.3 Limitations of Research

Despite the significant theoretical and practical contributions, this study also has several limitations that should be acknowledged.

5.3.1 Sample Limitations

The data for this study were concentrated on construction firms and project types within a specific region, Jinan City. While this focus provided depth and contextual relevance, it may limit the generalizability of the findings. The applicability of the proposed model to different geographical areas, cultural settings, or substantially different types of construction projects requires further empirical validation.

5.3.2 Cross-Sectional Data Constraints

The research relies on cross-sectional data, capturing relationships at a single point in time. This approach fails to account for the dynamic evolution of organizational culture and its interaction with safety performance over extended periods. Furthermore, despite implementing controls such as respondent anonymity, the reliance on self-reported perceptual data carries an inherent risk of common method bias.

5.3.3 Self-Reported Bias

Data collection relied primarily on self-reported surveys, which may introduce bias due to social desirability effects. Respondents may have provided answers they believed were expected, potentially compromising data objectivity and accuracy.

5.4 Recommendations for Future Research

To address these limitations and advance the understanding of the OC-WS-CSP relationship, future research could focus on the following areas:

Firstly, expanding sample scope and diversity. Future studies should include a more diverse and representative sample, encompassing construction projects from multiple regions, industries, and organizational sizes. Comparative studies across countries or industries would further validate the generalizability and robustness of the findings.

Secondly, adopting longitudinal research designs. Longitudinal studies are recommended to capture the dynamic interactions between organizational culture and safety performance over time. Tracking changes in cultural dimensions and CSP across different project phases would provide a more comprehensive understanding of these relationships.

Finally, employing diverse data collection and validation methods. To overcome self-reporting bias, future studies should incorporate multiple data collection methods, including direct observations, interviews, and experimental simulations. Integrating big data and artificial intelligence technologies could offer real-time monitoring and analysis of safety performance, ensuring more objective and precise data.

In conclusion, addressing these limitations and recommendations would enhance the theoretical depth, methodological rigor, and practical applicability of future studies on organizational culture and construction safety performance. By adopting longitudinal approaches, expanding contextual analyses, and leveraging advanced data tools, future research can further advance the understanding of safety management in construction projects.

5.5 Conclusion

This research explores the impact of organizational culture (OC) on construction safety performance (CSP) and further investigates the moderating role of workforce skill (WS) in these relationships. Using Partial Least Squares Structural Equation Modelling (PLS-SEM) for data analysis, this research verifies the validity of hypotheses H1 to H14 and provides empirical insights into the mechanisms through which organizational culture affects construction safety performance. The main conclusions drawn from this research are as follows:

Organizational culture has a significant positive impact on construction safety performance. The research reveals that all seven dimensions of organizational culture-organizational values (OC1), management strategy (OC2), management style (OC3), organizational structure (OC4), manager behavior (OC5), employee participation (OC6), and team collaboration (OC7)-positively influence construction safety performance. Among these, manager behavior (OC5), team collaboration (OC7), and organizational structure (OC4) exhibit the strongest effects. This suggests that leadership commitment, effective teamwork, and well-structured organizational processes are critical drivers of safety performance. Construction companies should prioritize enhancing these aspects by fostering strong leadership, encouraging team collaboration, and refining organizational structures to ensure role clarity and efficient communication.

Manager behavior (OC5) has the most significant impact on construction safety performance. The results demonstrate that manager behavior plays a central role in improving construction safety performance, with the highest path coefficient (0.152). Managers' proactive involvement, safety leadership, and swift responses to safety concerns substantially reduce workplace hazards and improve safety compliance. This aligns with findings from prior studies, such as those of Bathan (2021) and Fang & Wu (2013), which emphasize the role of management leadership in fostering a strong safety culture. Companies should invest in safety leadership training for managers to amplify their impact on site safety performance.

Team collaboration (OC7) and organizational structure (OC4) significantly enhance safety performance. The research confirms that team collaboration (path coefficient=0.148) and organizational structure (path coefficient=0.136) are key enablers of safety performance.

Effective team collaboration improves communication, coordination, and collective problem-solving, reducing safety risks during construction. Similarly, a well-defined organizational structure enhances accountability, information flow, and adaptability to safety challenges. This is consistent with findings by Ankrah (2007) and Fong & Kwok (2009), which highlight the importance of team and structural dimensions in improving project safety outcomes. Companies should promote teamwork through collaborative practices and optimize organizational processes to streamline safety management.

Workforce skill (WS) significantly moderates the relationship between specific organizational culture dimensions and construction safety performance. Workforce skill is found to significantly strengthen the positive impacts of organizational values (OC1), management style (OC3), manager behavior (OC5), employee participation (OC6), and team collaboration (OC7) on construction safety performance. For instance, WS enhances the pathway between manager behavior and safety performance (moderating coefficient=0.107, $p<0.05$), indicating that skilled workers better execute safety instructions and leadership guidance. This underscores the importance of workforce training and skill development to maximize the effectiveness of organizational culture in improving safety performance. However, WS does not significantly moderate the effects of management strategy (OC2) and organizational structure (OC4), suggesting that these elements are less dependent on workforce skill and more reliant on systemic implementation.

The mechanisms through which organizational culture influences construction safety performance involve behavior guidance, process optimization, and cultural shaping. The research reveals that organizational culture impacts safety performance through multi-layered mechanisms. Manager behavior and team collaboration directly guide employee behaviors and enhance safety compliance. Management strategy and organizational structure optimize safety management processes, improving efficiency and responsiveness. Organizational values and employee participation play a foundational role in shaping a safety-oriented culture, fostering long-term improvements in safety performance. These findings resonate with the conclusions of Orikpete & Ewim (2024) and Naji et al. (2021), who highlight the multi-faceted nature of safety culture in driving safety outcomes.

Practical implications for construction companies include optimizing organizational culture and workforce skill development to enhance safety performance. The findings suggest that construction firms should adopt a multi-pronged approach to improve safety performance. Companies must focus on cultivating safety-conscious leadership, promoting team collaboration, and refining organizational structures. Workforce training programs should be implemented to align employee skills with organizational safety objectives, enabling workers to better understand and execute safety protocols.

In summary, this research provides new empirical evidence on the significant role of organizational culture in enhancing construction safety performance and reveals the moderating effect of workforce skill on these relationships. The research demonstrates that key dimensions of organizational culture, particularly manager behavior, team collaboration, and organizational structure, play vital roles in driving safety performance. Furthermore, workforce skill enhances the effectiveness of certain cultural dimensions, highlighting the need for workforce training and skill enhancement. The findings emphasize the importance of integrating cultural and human resource strategies to create safer construction environments.

This research contributes to both theory and practice by offering a comprehensive understanding of the pathways through which organizational culture influences safety performance and by identifying the conditions under which these effects are amplified. Construction managers and policymakers are encouraged to focus on strengthening leadership, fostering collaboration, optimizing organizational processes, and investing in workforce development to achieve sustainable safety performance improvements. Ultimately, this research provides valuable guidance for enhancing safety management practices and achieving long-term success in construction projects.

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APPENDICES

RESEARCH INSTRUMENTS (QUESTIONNAIRES)

UNIVERSITI MALAYSIA SARAWAK

Dear respondent,

The researcher is a Doctor of Philosophy (Ph.D.) candidate at Universiti Malaysia Sarawak Researching the topic **“The Influence of Organizational Culture in Construction Safety Performance： The Moderating Role of Workforce Skill”**. The purpose of this research is to delve deeply into how soft factors such as organizational culture and workforce skill influence the safety performance of construction projects, as well as the roles and significance of these factors in construction safety management. You have been contacted because the researcher believes that you can provide valuable, accurate, and detailed information to help achieve the research objectives. Your assistance and contribution to this research are greatly appreciated. I, therefore, desire your cooperation in completing this questionnaire. Ethical protocols concerning research data collection strictly guide the research. Therefore, the researcher would be most grateful if you could give your views by answering these questions below. The information obtained will be used for purely academic purposes, specifically in fulfillment of the award of the Ph.D. degree in Management. It will be treated with the utmost confidentiality. I am available for any further clarification, and you may contact me via 13156185209 or (21010193@siswa.unimas.my). More so, further concerns may be directed to the Director, Center For Graduate Studies, Universiti Malaysia, Sarawak
Universiti Malaysia Sarawak
94300, Kota Samarahan
Sarawak, Malaysia

Thank you

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SECTION A Demographic Information

1.Gender: Male☐ Female☐

2.Age Group:

18-30 years old ☐ 31-40 years old☐ 41-50 years old☐ Above 50 years old☐

3.Educational Level:

High School or below☐ Bachelor's Degree☐ Master's Degree☐

Doctorate or above☐

4.Work Experience:

Less than 5 years☐ 5-10 years☐ 11-20 years☐ More than 20 years☐

5.Occupation:

Construction Industry Practitioner☐ Management Personnel☐

Technical Personnel☐

Labor Personnel☐ Other, please specify: ___________

6.Size of the Company:

Below 50 people☐ 51-200 people☐ 201-500 people☐ Above 501 people☐

7.What type of construction projects does your company primarily engage in?

Residential☐ Commercial☐ Infrastructure☐ Mixed-use☐

Other, please specify: ___________

8.Your Position Level:

Entry-level Employee☐ Middle Management☐ Senior Management☐

Other, please specify: ___________

9.Does your company have a dedicated safety management department or personnel?

Yes☐ No☐

SECTION B: Organizational Culture (OC)

Please check or circle the following options that meet your psychological expectations based on your experience, experience, knowledge, etc. Where 1= strongly disagree, 2=mostly disagree, 3=slightly disagree, 4= neutral, 5= slightly agree,6= mostly agree, 7= strongly agree.

Measurement Indicator	Questionnaire	Scoring						
Organizational Values (OC1)	My organizational values align with my personal values.	1	2	3	4	5	6	7
	I understand and identify with the core values of the organization.	1	2	3	4	5	6	7
	The organizational values are reflected in my daily work.	1	2	3	4	5	6	7
	I have opportunities to participate in discussions and shaping of organizational values.	1	2	3	4	5	6	7
Management Strategy (OC2)	My organization adopts clear safety management strategies.	1	2	3	4	5	6	7
	The safety management strategies cover all major safety risks.	1	2	3	4	5	6	7
	I receive clear guidance and explanations regarding safety strategies.	1	2	3	4	5	6	7
	The management regularly evaluates and updates safety management strategies to address new risks.	1	2	3	4	5	6	7
Management Style (OC3)	The leadership style emphasizes fairness, transparency, and safety.	1	2	3	4	5	6	7
	Managers demonstrate consistent leadership in safety management.	1	2	3	4	5	6	7
	The leadership style motivates me to actively follow safety procedures.	1	2	3	4	5	6	7
	Managers provide adequate support and attention to safety issues.	1	2	3	4	5	6	7
Organizational Structure (OC4)	The organizational structure supports the development of a safety culture.	1	2	3	4	5	6	7
	Responsibilities for safety management are clearly defined across departments.	1	2	3	4	5	6	7

Measurement Indicator	Questionnaire	Scoring						
	Communication channels within the organization facilitate timely dissemination of safety information.	1	2	3	4	5	6	7
	The organizational structure is capable of responding quickly to emerging safety issues.	1	2	3	4	5	6	7
Manager Behavior (OC5)	Managers highly prioritize on-site safety issues.	1	2	3	4	5	6	7
	Managers regularly inspect the construction site to ensure safety standards are met.	1	2	3	4	5	6	7
	Management takes timely corrective actions for behaviors that do not meet safety standards.	1	2	3	4	5	6	7
	Managers communicate with me and provide feedback on safety-related opinions and suggestions.	1	2	3	4	5	6	7
Employee Participation (OC6)	I actively participate in safety improvement measures.	1	2	3	4	5	6	7
	My safety suggestions are taken seriously by management and acted upon.	1	2	3	4	5	6	7
	There are incentives to encourage me to actively participate in safety activities.	1	2	3	4	5	6	7
	I have sufficient say in the process of safety improvements.	1	2	3	4	5	6	7
Team Collaboration (OC7)	Team members cooperate with each other to build a safety culture.	1	2	3	4	5	6	7
	Teamwork helps improve our safety awareness and safety performance.	1	2	3	4	5	6	7
	Responsibilities are clearly defined within the team to ensure safe practices.	1	2	3	4	5	6	7
	Team members support each other to ensure safe operations at work.	1	2	3	4	5	6	7
	The team discusses and proposes improvement plans to address safety hazards.	1	2	3	4	5	6	7

SECTION C: Workforce Skill (WS)

Please check or circle the following options that meet your psychological expectations based on your experience, experience, knowledge, etc. Where 1= strongly disagree, 2=mostly disagree, 3=slightly disagree, 4=neutral, 5=slightly agree, 6=mostly agree, 7= strongly agree.

Measurement Indicator	Questionnaire	Scoring						
Professional Skills (WS1)	The workforce within this organization possesses high levels of professional skills	1	2	3	4	5	6	7
Safety Awareness (WS2)	The workforce within this organization demonstrates a strong sense of safety awareness	1	2	3	4	5	6	7
Team Collaboration (WS3)	The workforce within this organization excels in team collaboration	1	2	3	4	5	6	7
Technical Training (WS4)	The workforce within this organization frequently participates in technical training	1	2	3	4	5	6	7
Task Completion (WS5)	The workforce within this organization consistently completes tasks on schedule	1	2	3	4	5	6	7
Problem-Solving (WS6)	The workforce within this organization can quickly identify solutions when faced with problems	1	2	3	4	5	6	7

SECTION D: Construction Safety Performance (CSP)

Please check or circle the following options that meet your psychological expectations based on your experience, experience, knowledge, etc. Where 1= strongly disagree, 2= mostly disagree, 3=slightly disagree, 4= neutral, 5= slightly agree,6= mostly agree,7= strongly agree.

Measurement Indicator	Questionnaire	Scoring						
Safety Awareness (CSP1)	My organization's compliance with building safety standards	1	2	3	4	5	6	7
Safety Training (CSP2)	All employees have received comprehensive safety training, including emergency procedures	1	2	3	4	5	6	7
Safety Measures (CSP3)	Safety measures implemented on-site effectively reduce accidents and injuries	1	2	3	4	5	6	7
Durability (CSP4)	The materials and structural design of our construction projects ensure long-term durability	1	2	3	4	5	6	7
Safety Performance (CSP5)	According to internal and external safety audits, our project's safety performance meets or exceeds industry standards	1	2	3	4	5	6	7
Risk Management (CSP6)	The organization effectively identifies, assesses, and manages safety risks in the construction process	1	2	3	4	5	6	7
Safety Culture (CSP7)	My organizational culture encourages a safety-first approach, and employees actively report potential safety issues	1	2	3	4	5	6	7