THE IMPACT OF AN AGING WORKFORCE ON THE CONSTRUCTION INDUSTRY

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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ABSTRACT

Malaysia's construction industry is increasingly influenced by the aging workforce, a demographic shift with implications for productivity, innovation, and workplace safety. While extensive research has examined the implications of an aging workforce and explored mitigation strategies across various contexts, research in Malaysia is still lacking. Hence, this study aimed to (i) examine the effects of an aging workforce on the construction industry, (ii) identify the challenges faced by construction companies, and (iii) propose strategies for effective adaptation. A quantitative survey was distributed to construction professionals in the Klang Valley. 113 responses were obtained then examined using Cronbach's Alpha, mean ranking, Mann–Whitney U, Kruskal–Wallis, and Spearman's correlation tests. The results revealed that aged and experienced workers consistently rated positive effects more highly, particularly in relation to organisational learning, stronger work ethic, and safety, while also acknowledging key challenges such as the need for health promotion, workforce imbalance, lack of innovation, and mentoring pressures. Significant differences were observed across age, years of experience, position, and organisational size, with senior professionals and medium-sized firms perceiving innovation gaps and technology adoption as more critical. Strategies such as mentoring and knowledge transfer, safety measures, wellness programs, and skill development emerged as the most effective, with Spearman's correlation highlighting strong relationships between flexible work arrangements, refined HR practices, and improved working environments. Overall, the findings suggest that while the aging workforce presents notable challenges for Malaysia's construction sector, it also offers opportunities to leverage the strengths of aging professionals. This study supports policymakers, industry stakeholders, and construction firms in developing inclusive strategies for aging workers, fostering workforce resilience and ensuring alignment with national development agendas such as the Twelfth Malaysia Plan and Malaysia Madani.

Keywords: Aging workforce; Construction industry; Effect; Challenge; Strategy

Subject Area: HQ1060–1064: Aged. Gerontology (Social aspects). Retirement

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n	sample size
z	z-scores of the desired confidence level
p	estimated proportion of the population
q	1 – p
e	margin of error

AI	Artificial Intelligence
ASDA	Asda stores limited
BIM	Building Information Modelling
DT	Digital Transformation
FWA	Flexible work arrangements
HR	Human Resource
ICT	Information and Communication Technology
IoT	Internet of Things
JCM	Job Characteristics Model
SPSS	Statistical Practices for the Social Sciences
WAI	Work Ability Index

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

This chapter provides an overview of the study, including the background of the research, the problem statement, the research aims and objectives, the methodology employed, the scope of the study, and the overall chapter structure.

1.2 Background of Study

A viable population is critical in advancing Malaysia's sustainable development goals by ensuring workforce resilience and fostering long-term economic stability. However, United Nations population projections reveal a significant global demographic shift toward aging. By the late 2070s, the number of individuals aged 65 and above is expected to rise to 2.2 billion, exceeding the population of children under 18 (United Nations, 2024). As Yusuf, Mohamed and Ali Basah (2020) identified, an aging population refers to the segment of older individuals within a specific country. In Malaysia, individuals aged 65 and above are officially categorized as older adults (Department of Statistics Malaysia, 2024). At present, this age group, mainly from the baby-boomer generation, accounts for more than 15% of the world’s total population (Department of Statistics Malaysia, 2024). According to Loke, Lim and Senadjki (2020), the share of people aged 60 and above worldwide is expected to climb from 12% in 2015 to 22% by 2050. The majority, almost 80%, will reside in developing countries. In Malaysia, the same demographic trend is projected to accelerate, with seniors likely to represent about 16% of the national population by 2030 (Abdullah, Ismail and Yusoff, 2024).

In addition, Mansor, Awang, and Rashid (2019) highlighted the issue of rising life expectancy, which has accelerated the pace of population aging globally. Longer life expectancy at the individual level often results in an extended period of retirement. In many Asian countries, including Malaysia, this is compounded by insufficient or limited retirement and old-age benefits, leading to heightened financial strain and poverty. As such, Fan, et al. (2023) stressed out an aging population without doubt outcomes in an aging workforce,

significantly impacting industries like construction, which is widely regarded as one of the riskiest sectors. This perception of described construction industry as dirty, challenging and dangerous has deterred younger generations from pursuing careers in this field. Thus, the construction industry encounters a viable shortage of human resource reserves, worsening challenges in sustaining a skilled and resilient workforce for future demands.

On top of that, the Chinese government has adjusted the official retirement age from an average of 60 years old to 60.3 years old from 2020 to 2025 while the statistics in Malaysia remained as 60 years old in the past decades (Trading Economics, 2025). This policy shift has elicited mixed reactions from the public, with both positive and negative perspectives emerging. Despite the advantages of an aging workforce, such as extensive experience and valuable industry knowledge, it has become a significant challenge in the construction industry. This issue has been intensified by an increasing demand for construction activities while fewer young entrants are joining the industry. Health and wellbeing concerns affecting aging workers influence both their individual output and the overall efficiency of organisations. Hence, there is a pressing need to design practical measures that can accommodate the effects of this demographic change. A thorough assessment of reliable data concerning the physical and psychological challenges encountered by aging workers is therefore vital for the construction sector. Such assessment would form a sound basis for advancing recommendations aimed at enhancing work health and safety (WHS) (Ranasinghe et al., 2023).

1.3 Problem Statement

As the aging workforce trend intensifies in Malaysia's construction industry, there is a growing need to investigate its implications on productivity, sustainability, and safety. Numerous scholars have explored the challenges of an aging workforce in construction industry. Ranasinghe et al. (2023) and Peng and Chan (2020) highlighted the challenge of an aging workforce as the declining physical capacity of aging construction workers, which affects their ability to carry out physically demanding tasks. Fan et al. (2023) emphasized the challenge as increased vulnerability to workplace accidents, stemming from the strenuous nature of construction work. Li et al. (2022) and Luo et al. (2025)

highlighted the challenges of aging workforce as reduced adaptability to emerging technologies, posing barriers to digital transformation. Likewise, Lucchese, Panagou, and Sgarbossa (2024) identified the challenges as the difficulty aged workers face in utilizing assistive assembly technologies, indicating a technological integration gap.

In developed countries, several studies have also explored the challenges of an aging construction workforce, highlighting similar concerns. For example, Powell and Amna Shibeika (2025) identified the challenge of an aging workforce in the United Kingdom as an exacerbation of skill shortages in the construction sector. Koh, Rowlinson, and Pollock (2020) and Peng and Chan (2020) addressed the challenge in Hong Kong as disproportionately high accident rates among aging workers, largely due to institutional constraints and inadequate support systems. Lukyanets, Okhrimenko, and Egorova (2021) in Russia reported the challenge of economic policy disruptions arising from demographic imbalances. Fontaneda et al. (2022) described the challenge in Europe as the increasing pressure on pension systems due to a growing elderly population. In Brazil, de Freitas and Alberte (2023) emphasized the challenges of chronic health conditions and physical decline, making workforce retention more difficult.

Considering these concerns, numerous scholars have also proposed region-specific strategies to mitigate the challenges of an aging workforce. Haque and Afrin (2022) in Bangladesh introduced the strategy of an active aging framework that addresses workforce participation through integrated health and security measures. Peng and Chan (2020) examined strategies involving workplace adjustments aligned with Occupational Safety and Health (OSH) principles to retain older workers in Hong Kong. Tam et al. (2025) proposed workplace adaptability policies in Singapore as a key strategy to support aging employees. In advanced economies such as the United Kingdom (UK) and Germany, Agyekum et al. (2022) and RECM and Holt (2020) explored automation and robotics as strategies to reduce physical strain on older workers, though resistance to adopting new technologies remains a notable challenge. While extensive research has examined the implications of an aging workforce and explored mitigation strategies across various contexts, research in Malaysia

is still lacking. The absence of comprehensive research on how Malaysia's construction industry is adapting to this demographic shift highlights a critical gap in understanding and policy development. This study seeks to address this gap by examining the effects of an aging workforce, identifying key challenges faced by construction firms, and proposing targeted strategies to enhance workforce sustainability in Malaysia.

1.4 Research Aim

This research aims to uncover the impact of aging workforce on the construction industry in Malaysia.

1.5 Research Objectives

To fulfil the aim outlined above, the study was guided by three specific objectives:

i. To examine the effects of an aging workforce in the construction industry.
ii. To identify the challenges faced by construction companies due to an aging workforce.
iii. To propose strategies for construction companies to adapt to an aging workforce.

1.6 Research Methodology

A quantitative research design was adopted in this study using a structured questionnaire distributed via Google Forms to construction professionals representing various age and profession categories in Klang Valley region. In total, 113 valid responses were collected. The resulting data were subjected to statistical analysis employing Cronbach's Alpha reliability test, Arithmetic Mean, Spearman's Correlation, Mann–Whitney U, and Kruskal–Wallis tests.

1.7 Research Scope

This scope of study limited to construction professionals within the Klang Valley area, without restrictions on proficiency levels, business nature, gender, or work experience. The objective is to gather a diverse range of responses

across various demographic profiles to examine perspectives from different age groups.

1.8 Chapter Outline

This research paper is organised into five core sections, arranged in the following manner. Chapter 1 introduces the study by offering a general overview that includes the background of the research, aim, objectives, and problem statement. It also provides a brief explanation of the research methodology, scope, and the overall layout of the report. Chapter 2 presents a comprehensive review of related literature, examining prior studies that address the implications of an aging workforce and assessing international strategies that may be applicable to Malaysia's construction industry.

Chapter 3 elaborates on the research methodology adopted to accomplish the stated objectives, describing the data collection process and the analytical procedures employed. Chapter 4 discusses the analysis and interpretation of the data obtained from the questionnaire survey, highlighting the key results and findings. Finally, Chapter 5 concludes the study by summarising the principal outcomes, evaluating the fulfilment of research objectives, acknowledging limitations, and suggesting recommendations for future research efforts.

1.9 Chapter Summary

In summary, this section highlights the existing lack of studies concerning the challenges posed by an aging workforce and the strategies used to address this issue. A comprehensive background of the study and problem statement has been established, along with the formulation of research aims and three objectives to bridge the gap. Additionally, an overview of the research methodology, scope, and chapter outline has been thoroughly discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section explores the impact of aging workforce on construction industry in Malaysia by reviewing relevant literature. It begins with an overview of aging workforce, establishing a foundation for understanding its concept. The discussion then shifts to identifying the effects of aging workforce in Malaysia construction industry, challenges faced by construction companies due to an aging workforce and strategies for construction companies, adapt to an aging workforce.

2.2 Definition of aging workers

Aging is broadly characterized as a gradual biological decline in an individual's physical and functional capacities, leading to diminished effectiveness in carrying out everyday activities and job-related responsibilities (Rahim Abdul Hamid et al., 2018). This process is unidirectional and closely tied to the passage of time. Despite its importance, there is no universally accepted cut-off age for defining aging or older workers. Yang et al. (2018) noted that the U.S. Bureau of Labor Statistics frequently adopts 55 years as a statistical benchmark for identifying older workers. However, in construction-specific contexts, Kamardeen and Hasan (2022) highlighted considerable variation in age-based classifications and proposed a more tailored approach. They suggested that workers aged 45 to 54 be categorized as aging workers, while those aged 55 and above should be defined as older workers.

Eze, Sofolahan and Siunoje (2020) defined the term "construction workers" as site-based personnel with specialised trade skills typically acquired through hands-on training and job experience. These include carpenters, masons, plumbers, plasterers, painters, and glaziers. As these roles are physically demanding, the effects of aging, such as reduced muscle strength, slower recovery times, and sensory decline can significantly affect their performance and safety on-site (Truxillo, Cadiz and Hammer, 2015).

2.3 Global Issues of Aging workforce

Demographic trends show a growing aging workforce globally. For instance, Becker et al. (2022) emphasized the proportion of employed individuals aged 60 and above doubled between 2000 and 2020 for both men and women in the United States (U.S). During this period, the share of employed men in this age group increased from 7.4% to 14.8%, while the percentage of employed women rose from 6.3% to 14.0% (Becker et al., 2022).

Mendes and Robazzi (2021) stressed out that the aging trend is evident across many countries. According to their findings, 67% of individuals aged 55 to 59 and 27% of those aged 60 to 64 in Austria remain employed. Similarly, workforce participation rates for these age groups stand at 71% and 51% in Canada, 81% and 55% in Denmark, 71% and 28% in France, 79% and 56% in Germany, 69% and 54% in the United States, and 80% and 64% in Japan. Notably, since the 2000s, the employment rate of individuals aged 60–64 has been rising in G7 economies, including Canada, Japan, the United Kingdom, Italy, the United States, Germany, and France (Mendes and Robazzi, 2021).

Georgieva (2022) cited that global population aging and shifting patterns of labour force engagement are pushing up the median working age. The demographic transition is being driven by increasing life expectancy, declining fertility rates and advances in education, health care and public health, especially in developed countries. On top of that, Maestas et al. (2023) highlighted that aging workers generally prefer jobs that require moderate physical activity, seated tasks, and collaborative performance assessments. They also value roles that offer flexible work schedules and greater autonomy in decision-making.

2.4 Causes of an Aging Workforce

Referring to Zacher and Rudolph (2023), aging within the workplace and organizational settings is shaped by social and psychological perceptions, even though biological aging is an inevitable process beyond human control. In examining the causes of an aging workforce, Georgieva (2022) attributed the phenomenon to three key factors: financial, demographic, and social. From a financial standpoint, Tamburo, Switzer, and Gower (2019) asserted that inadequate pension plans and insufficient savings compel aging workers to

remain employed. Demographically, Georgieva and Kamburova (2016) explained that declining fertility rates and increased life expectancy extend working years to balance the dependency ratio. Socially, Tamburo, Switzer, and Gower (2019) emphasized that employment provides a sense of purpose, productivity, and social engagement, motivating older workers to remain active in the workforce.

Furthermore, Schulte et al. (2018) noted that increasing life expectancy has widened the gap between retirement age and lifespan, pushing more individuals to continue working. While some choose to remain employed due to good health and job satisfaction, others do so out of financial necessity. Additional contributing factors include rising dependency ratios, delayed pension eligibility, and the decline of employer-funded retirement plans. As a result, organizations and society face a pressing challenge, ensuring that aging workers remain safe, healthy, and productive in the workplace. Addressing this issue requires a comprehensive approach, balancing policies that support aging workers with strategies that sustain long-term organizational efficiency.

2.5 Effects of aging workforce in Malaysia Construction Industry

This section examines the effects of aging workforce in Malaysia construction industry.

2.5.1 Drivers of Organizational Learning

Aging workers serve as vital drivers of organizational learning by facilitating the transfer of knowledge within the construction industry. According to Hennekam and Dumazert (2021), aging workers hold substantial tacit knowledge built over years of practical experience, including problem-solving strategies, technical judgement, and industry insights that are not easily documented or replaced. They defined knowledge transfer as a purposeful process in which one party shares critical insights while another actively absorbs and applies them. Gerpott, Lehmann-Willenbrock and Voelpel (2017) supported this by asserted that mutual learning between aging workers and younger workers fosters a culture of collaboration, which strengthens innovation and

organizational memory. Burmeister et al. (2018) also emphasized that the presence of generational diversity creates opportunities for structured intergenerational knowledge exchange, which enhances productivity and learning capacity across the workforce. In this sense, aging workers contribute not only to continuity but also to future-readiness.

Although knowledge transfer can be challenging, the role of aging workers in preserving institutional expertise remains essential. Sumbal et al. (2017) warned that the retirement of experienced personnel risks weakening mentoring systems and overall knowledge retention. However, they also noted that effective knowledge-sharing mechanisms can counter this loss if aging workers are engaged before exit. Burmeister et al. (2018) acknowledged potential barriers, such as self-protective behaviours, but concluded that trust-building and inclusive workplace culture can motivate aging workers to share knowledge more openly. Hennekam and Dumazert (2021) further claimed that valuing aging workers' experience supports both talent development and industry resilience. Collectively, these studies affirmed that aging workers play a strategic role in promoting organizational learning, ensuring that critical expertise is passed on to sustain long-term performance in the construction sector.

2.5.2 Higher Safety Risk Perception

The role of age in construction safety performance has been widely studied, though scholars remain divided on its exact influence (Namian et al., 2022). Several studies suggest that aging workers tend to perceive workplace risks more acutely than their younger counterparts. Han et al. (2019) found that workers aged 45 to 56 exhibited the highest levels of safety risk perception, while Trillo-Cabello, Carrillo-Castrillo and Rubio-Romero (2021) confirmed a statistically significant link between age and perceived accident severity and likelihood. This heightened perception is often attributed to greater work experience, which enhances hazard recognition and cautious behaviour (Mučenski et al., 2015). Chen and Jin (2015) further supported this by noting that aging workers generally display stronger safety attitudes.

However, the effect of age is not purely positive. Namian et al. (2022) argued that while age improves safety behaviour through experience, it also

contributes to fatigue, which can impair hazard recognition. Additionally, organizational roles and employment type influence safety perception. For instance, general contractor workers often demonstrate stronger safety awareness than subcontractor staff (Chen and Jin, 2015). Despite these complexities, aging workers' ability to perceive and respond to risk remains an asset in enhancing overall construction site safety. As Inouye (2014) noted, accurate risk perception is essential in preventing incidents, and when paired with appropriate support, aging workers can play a crucial role in maintaining safe working environments.

2.5.3 Fatal Injuries Prevention

Fatal injuries remain a critical safety concern in the construction industry, with fatality rates serving as a key performance metric (Karimi and Taghaddos, 2020). Despite increasing preventive efforts, fatal accidents still occur at disproportionate rates. Human reliability analysis (HRA) revealed that personal characteristics such as age, education, and experience influence safety outcomes (Philippart, 2017). Alexander, Hallowell and Gambatese (2017) argued that lack of experience is a major precursor to fatalities. Supporting this, Karimi and Taghaddos (2019) found that higher education and experience significantly reduced accident severity, with each factor acting independently. Additionally, age has been shown to affect the seriousness rather than the frequency of accidents, suggesting aging workers contribute to harm reduction (Karimi and Taghaddos, 2020). These findings highlighted the value of experienced individuals in fatality prevention strategies.

Knowledge transfer has been identified as a key method to improve safety and reduce fatal risks. Xu et al. (2023) emphasized that transferring experience helps correct unsafe behaviours and lowers accident rates. Lindgren, Emmitt and Widén (2018) supported this by stating that sharing lessons learned reduces repeated mistakes. Moreover, lack of training and safety information has been linked to fatal incidents across Europe (Eurostat, 2023). Carrillo-Castrillo, Trillo-Cabello and Rubio-Romero (2017) claimed that unsafe behaviour often stems from poor instruction. A controversial opinion showed that management failures in regulation and training enforcement also contribute significantly (Ayob et al., 2018; Hamid et al., 2019). Wong et al. (2016) added

that inadequate hazard awareness further increases risk. Therefore, structured knowledge sharing and ongoing training are essential for preventing fatal injuries in construction.

2.5.4 Constructive conflict management

Aging workers are often more effective in managing workplace disputes due to their emotional maturity and life experience. As outlined by Yeung, Fung and Chan (2015), socioemotional selectivity theory (SST) suggested that aging workers tend to focus on emotionally significant goals, which shapes how they respond to interpersonal challenges. In support of this, their study found that aging workers typically rely on less confrontational methods, such as avoidance or compromise when resolving conflicts, while younger workers are more likely to adopt aggressive or dominating approaches. Beitler, Scherer and Zapf (2018) similarly noted that aging workers encounter fewer interpersonal disputes and tend to manage them with greater care and composure. They argued that the ability to regulate emotions is a key factor enabling this behaviour. These age-related conflict strategies are not only limited to personal life but are equally applicable in the workplace context, where aging workers demonstrate calm, constructive approaches in high-pressure situations (Yeung, Fung and Chan, 2015; Beitler, Scherer and Zapf, 2018).

Workplace conflict is widely seen as inevitable, but it can be productive if handled properly. Olafsen et al. (2021) argued that constructive disagreement may lead to positive change, if conflict is approached rationally. In this regard, aging workers are well-positioned to contribute, as their tenure and accumulated experience equip them with effective coping tools (Dodanwala, Shrestha and Santoso, 2021). These attributes also help mitigate job stress and burnout, which are known to affect both employee health and job satisfaction (Dodanwala and Shrestha, 2021; Robbins and Judge, 2019). Furthermore, empirical findings suggested that aging workers are more resilient to psychological strain and report greater workplace well-being compared to their younger colleagues (Dodanwala, Shrestha and Santoso, 2021). Altogether, these studies indicate that aging workers contribute positively to workplace cohesion through calm conflict resolution and emotional regulation, both of which are valuable in high-stress industries such as construction.

2.5.5 Stronger work ethic

Aging workers are increasingly recognized for their strong work ethic and professional reliability, traits that contribute positively to construction workforce performance. According to Gardiner and Chen (2022), many aging workers are choosing to remain in the labour market past traditional retirement age or even re-enter employment after a temporary exit, reflecting a sustained commitment to work. Similarly, Crawford et al. (2010) highlighted that aging workers tend to be more dependable and demonstrate higher levels of dedication compared to their younger counterparts. Supporting this, the Office of Industrial Relations (2019) reported that aging workers generally exhibit lower rates of absenteeism and turnover, and are often better at problem-solving, making them a stable and productive part of the workforce. Kamardeen and Hasan (2022) further asserted that these qualities make aging workers valuable assets for construction firms aiming to boost operational efficiency and workforce consistency.

In addition, positive perceptions of aging workers are often linked to their accumulated experience and dependable conduct. Oppert and O'Keeffe (2019) noted that common stereotypes surrounding aging workers include strengths such as reliability, strong work ethic, and valuable knowledge gained over time. Although some studies raise concerns regarding lower flexibility or slower adaptability among aging workers (Harris et al., 2018), these limitations are often outweighed by their advantages. North (2019) argued that job performance does not inherently decline with age, and in many cases, aging workers maintain or even improve in areas such as language control and complex problem-solving.

2.5.6 Low Physical Ability

Aging workers in the construction industry often experience a decline in physical ability, which directly impacts task performance, safety, and overall productivity. According to Koh, Rowlinson and Pollock (2020), aging workers experience a decline in both physical and mental capacity, which increases the effort required to meet the physical and cognitive demands of construction work. This is particularly critical in labour-intensive construction roles, where physical exertion is high and injury risk escalates with age (Varianou-

Mikellidou et al., 2019). Supporting this, Gardiner and Chen (2022) asserted that aging results in reduced bone density, muscle strength, and endurance, which heightens susceptibility to injuries and limits sustained performance. Thakurta and Iqbal (2021) agreed, emphasizing that although aging workers bring valuable experience, they are often physically unable to carry out strenuous tasks due to health-related constraints. This observation is reinforced by Martinez and Fischer (2019), who introduced the concept of functional aging, where cumulative physical and psychological strain leads to reduced work ability over time.

In addition to reduced strength and stamina, aging workers face an elevated risk of chronic illnesses and musculoskeletal disorders that further impair their performance. The Public Health Agency of Canada (2020) reported high prevalence of chronic conditions such as hypertension, osteoarthritis, and heart disease among aging workers. Similarly, Kohli et al. (2020) highlighted the increase in non-communicable diseases like diabetes and cardiovascular disorders, which hinder work ability and reduce employment consistency. Gardiner and Chen (2022) further noted that aging workers experience more frequent and longer health-related absences, while Demmin and Silverstein (2020) pointed to vision loss and sensory decline as added risk factors. According to Reynolds et al. (2022), these minor impairments, when accumulated, can evolve into serious disabilities that limit long-term employability.

2.5.7 Higher risk of Fatal Injuries

Fatal injuries in the construction industry have been consistently linked to aging, with several studies offering strong evidence. Sokas, Dong, and Cain (2019) emphasized that construction remains one of the most hazardous sectors, reporting injury rates significantly higher than most other industries. They pointed out that aging workers, especially those with a history of prior injuries, face greater risks due to accumulated physical strain over the years. Supporting this view, Dong et al. (2016) conducted National Longitudinal Youth Survey and confirmed that construction workers suffer more injuries requiring time off work compared to other sectors, with age being a contributing factor. Likewise, Karimi and Taghaddos (2020) highlighted that, despite increased awareness of

safety, fatality rates in construction remain high, especially among older age groups. They identified a clear trend showing that workers aged 65 to 75 face the greatest risk of fatal injuries, forming a U-shaped pattern of risk across age ranges.

Gardiner and Chen (2022) further explained that natural declines in sensory abilities such as vision, hearing, and balance make aging workers more prone to accidents on site. These limitations reduce their ability to detect hazards and respond quickly, especially in noisy or visually complex environments. They also stressed that communication becomes more difficult, increasing the chance of missing important safety signals. Moreover, they noted that workers above 55 are four times more likely to experience fatal incidents than younger workers. Altogether, these studies demonstrate that aging significantly increases vulnerability to fatal injuries in construction, reinforcing the need for safety measures that address both physical and sensory limitations of aging workers.

2.5.8 Skilled Labour Shortages

The aging workforce is contributing to a growing loss of skilled labour and industry experience in the construction sector. Karimi and Taghaddos (2020) highlighted that this trend has persisted for over thirty years, often leaving employers with no choice but to engage less experienced and lower-educated personnel, which compromises both productivity and safety. Phuong and ThiUyen (2019) supported this concern, stating that demographic shifts, particularly a shrinking youth population and growing number of aging workers, make it difficult to find candidates with the required skills, age range, and work attitudes. Powell and Amna Shibeika (2025) observed similar issues in the United Kingdom (UK), where outdated industry perceptions and weak training efforts have compounded the difficulty of recruiting new talent to replace outgoing veterans. Ranasinghe et al. (2023) further noted that unattractive working conditions, safety risks, and unstable job prospects deter young people from entering the field, deepening the dependency on an aging and soon-retiring workforce.

Beyond recruitment, the retirement of aging workers threatens the retention of technical expertise and institutional knowledge. Alexander, Hallowell and Gambatese (2017) emphasized that experience is a key factor in

preventing construction-related fatalities, and its loss creates safety vulnerabilities. According to Karimi and Taghaddos (2020), industry performance depends on practical knowledge acquired through education, skill, and long-term exposure. However, as Knippenberg, Nishii and Dwertmann (2020) asserted, employers often underestimate the value of aging workers, limiting retention through early exits or underinvestment in continued training. Hennekam and Dumazert (2021) claimed that age-related stereotypes restrict learning opportunities for aging workers, accelerating skill fade. Powell and Amna Shibeika (2025) concluded that without measures to preserve expertise before retirement, the construction industry faces a widening loss of valuable labour and operational knowledge. Together, these studies stress the urgent need to address both the depletion of skilled labour and the erosion of experience caused by an aging workforce.

2.5.9 Slow Learning Capabilities of Aging workers

The impact of aging on cognitive abilities is an emerging concern in the workforce, particularly as technological change and business demands accelerate. Aging workers now face increasing pressure to adapt to evolving tools and processes by continuously updating their skills. According to Vasconcelos (2015), while previous generations of aging workers could secure stable employment without fearing skill obsolescence, modern advancements have rendered entire sectors, intensifying the urgency to remain current. In this context, cognitive decline poses a significant barrier for aging workers, especially in technology-driven roles where digital proficiency is critical. Picchio (2021) asserted that reduced cognitive flexibility undermines the employability of aging workers, particularly as global policies push for longer working lives. As the demand for adaptability grows, the challenge of maintaining mental sharpness becomes increasingly relevant to workforce sustainability.

Despite these concerns, there remains limited public and institutional focus on the slower learning capabilities of aging workers. Picchio (2021) noted that aging workers tend to depend more on crystallized intelligence, such as accumulated experience and long-term memory, rather than fluid cognitive processes, such as learning speed and multitasking. Therefore, training methods

should be tailored to their learning preferences. Picchio (2021) recommended job-related, work-integrated training approaches that allow aging workers to apply past experiences, enhancing comprehension and retention. Furthermore, extended time for information processing and instructional methods like lectures, modelling, and active participation are more effective for this group. Self-paced learning modules that emphasize communication, supervisory, and problem-solving skills can also aid aging workers in adapting to new roles. Overall, while cognitive decline presents clear challenges, well-designed training programs can help aging workers continue to contribute meaningfully to a rapidly evolving industry.

2.5.10 Age-Based Discrimination (Ageism)

Ageism, defined as stereotyping and discrimination based on age, has significant consequences for aging workers' psychological, physical, and professional well-being. According to Reynolds et al. (2022) and Kohli et al. (2020), ageism is rooted in societal beliefs that aging leads to inevitable decline in both mental and physical capacity. These perceptions can be internalized by aging workers, leading to decreased self-efficacy, lower confidence, and adverse mental health outcomes such as anxiety and depression. Gardiner and Chen (2022) observed that although aging workers are often seen as reliable and interpersonally skilled, they are still disadvantaged in dynamic or technology-driven industries due to assumptions about their adaptability and digital skills. Kohli et al. (2020) further emphasized that in developing societies, ageism can manifest in harmful ways such as neglect or elder abuse, often resulting from institutional shortcomings or inadequate training among caregivers.

Mikton et al. (2021) warned that ageism extends beyond employment, as it limits access to essential services including healthcare, education, and workplace advancement, which in turn exacerbates physical and mental health issues. Social isolation, cognitive deterioration, and delayed recovery from illness are common outcomes when aging workers are excluded or undervalued. Reynolds et al. (2022) further noted that mental health stigma compounds the problem; for instance, dementia patients are often denied access to long-term care due to behavioural symptoms, reflecting broader societal reluctance to provide comprehensive support for aging populations. These findings

collectively reveal that ageism impacts aging workers not only at the individual level, but also through systemic inequalities that demand urgent cultural and policy reform to foster a more inclusive work environment.

2.5.11 Slow in Adopting Intelligent Technologies

Aging workers often face challenges in adopting intelligent technologies due to physical and cognitive changes associated with age. Lucchese, Panagou and Sgarbossa (2024) observed that aging workers may require more time and tailored training programs to learn new systems effectively, especially when coping with memory decline or reduced processing speed. These limitations underscore the need for adaptive strategies, including assistive technologies, to enhance workplace accessibility for aging workers (Lucchese, Panagou and Sgarbossa, 2024). Moxley, Sharit and Czaja (2022) noted that factors influencing technology adoption among aging workers include crystallized intelligence, prior technology experience, and a positive attitude toward innovation. Higher confidence in using technology correlates with reduced dependence on assistance and a sense of optimism about learning new systems (Moxley et al., 2022).

Despite these barriers, technology also presents valuable opportunities for aging workers. Berkowsky, Sharit and Czaja (2017) argued that digital tools, such as health monitors, communication platforms, and work-support systems can increase independence and overall quality of life for aging individuals. In agreement, Lucchese et al. (2024) stressed that the way aging workers engage with technology differs significantly from younger cohorts, requiring more inclusive approaches in design and training. They further asserted that as the pace of technological innovation accelerates, the construction industry must ensure aging workers are not excluded from its benefits. To achieve this, training environments must be adapted to aging workers' learning styles and physical capabilities, enabling them to remain effective contributors in a digitized workforce.

Table 2.1: Literature Map for Effects of aging workforce in Malaysia Construction Industry

No.	Effects	Previous Studies	Frequency
1	Drivers of Organizational Learning	(Gerpott, Lehmann-Willenbrock and Voelpel, 2017; Sumbal *et al.*, 2017; Burmeister *et al.*, 2018; Hennekam and Dumazert, 2021)	4
2	Higher Safety Risk Perception	(Schulte *et al.*, 2018; Tamburo, Switzer and Gower, 2019; Georgieva, 2022; Zacher and Rudolph, 2023)	4
3	Fatal Injuries Prevention	(Wong *et al.*, 2016; Alexander, Hallowell and Gambatese, 2017; Carrillo-Castrillo, Trillo-Cabello and Rubio-Romero, 2017; Philippart, 2017; Ayob *et al.*, 2018; Lindgren, Emmitt and Widén, 2018; Hamid *et al.*, 2019; Karimi and Taghaddos, 2020; Eurostat, 2023; Xu *et al.*, 2023)	10
4	Constructive conflict management	(Yeung, Fung and Chan, 2015; Beitler, Scherer and Zapf, 2018; Robbins and Judge, 2019; Dodanwala and Shrestha, 2021; Dodanwala, Shrestha and Santoso, 2021; Dodanwala and Santoso, 2022)	6
5	Stronger work ethic	(Crawford *et al.*, 2010; Harris *et al.*, 2018; North, 2019; Office of Industrial Relations, 2019; Oppert and O'Keeffe, 2019; Gardiner and Chen, 2022; Kamardeen and Hasan, 2022)	7

Table 2.1 (Continued)

No.	Effects	Previous Studies	Frequency
6	Low Physical Ability	(Martinez and Fischer, 2019; Demmin and Silverstein, 2020; Kohli *et al.*, 2020; Koh, Rowlinson and Pollock, 2020; Public Health Agency of Canada, 2020; Thakurta and Iqbal, 2021; Gardiner and Chen, 2022; Reynolds *et al.*, 2022; Micheli, Sgarbossa and Varianou-Mikellidou, 2024)	8
7	Higher risk of Fatal Injuries	(Dong *et al.*, 2016; Sokas, Dong and Cain, 2019; Karimi and Taghaddos, 2020; Gardiner and Chen, 2022)	4
8	Skilled Labour Shortages	(Alexander, Hallowell and Gambatese, 2017; Phuong and ThiUyen, 2019; Karimi and Taghaddos, 2020; van Knippenberg, Nishii and Dwertmann, 2020; Hennekam and Dumazert, 2021; Ranasinghe *et al.*, 2024; Powell and Shibeika, 2025)	6
9	Slow Learning Capabilities of Aging workers	(Vasconcelos, 2015; Picchio, 2021)	2
10	Ageism	(Kohli *et al.*, 2020; Mikton *et al.*, 2021; Gardiner and Chen, 2022; Reynolds *et al.*, 2022)	4
11	Slow in Adopting Intelligent Technologies	(Berkowsky, Sharit and Czaja, 2017; Moxley, Sharit and Czaja, 2022; Lucchese, Panagou and Sgarbossa, 2024)	3

2.6 Challenges faced by construction companies

The section evaluates the challenges faced by construction companies due to an aging workforce.

2.6.1 Necessity of health promotion

According to Peng and Chan (2020), aging construction workers face increasing physical challenges, as the physical demands of work often remain constant while their functional capacity declines with age. This mismatch between physical capacity and job demands heightens the risk of musculoskeletal disorders, reduced work ability, and frequent absences. In support of this, Koh, Rowlinson, and Pollock (2020) highlighted that construction site environments exacerbate susceptibility to work-related illnesses among aging workers, stressing the urgent need for a more integrated approach that combines both personal health and safety. Schulte et al. (2018) emphasized that aging involves varying physical and cognitive changes, further underlining the necessity of age-specific health care management strategies in the workplace. These factors collectively position health promotion not just as a benefit, but a pressing operational challenge for construction firms aiming to maintain a functional aging workforce.

Corroborating this viewpoint, Chiu et al. (2020) stressed that health promotion must go beyond treating illness and focus on proactively managing a broad range of age-related issues including chronic diseases, disability, and psychological health among them. They cited that nearly 65% of the elderly population report chronic illness, reinforcing the critical need to tailor workplace health policies to aging workers' needs. Jinnett et al. (2017) further pressed that rising chronic conditions and longer working lives contribute directly to reduced productivity and higher costs, urging a shift from reactive treatment to proactive workplace health promotion. Consequently, Rahim Abdul Hamid et al. (2018) supported this by pointing out the global need for institutional infrastructure to manage aging populations effectively. Construction companies, facing high injury rates and physically intensive roles, must therefore treat health promotion as a strategic imperative to sustain their aging labour force.

2.6.2 Refine working environment

Refining the working environment for aging workers has become a pressing challenge for construction companies, especially as demographic shifts amplify labour shortages. According to Peng and Chan (2020), the construction sector in Hong Kong faces a growing demand to retain aging workers due to workforce scarcity, but this is complicated by the natural decline in physical health and the prevalence of chronic health conditions among aging workers. The mismatch between aging workers' physical capacities and the physical demands of construction tasks has not been sufficiently addressed, creating a systemic issue in sustaining their participation. Similarly, Schulte et al. (2018) stressed that the continuation of work into aging age may result in increased risks such as injury, burnout, and slower recovery, particularly in physically intensive roles. In supporting view, Peng and Chan (2020) emphasized that job design must accommodate workers with chronic health concerns, not only those in good health. This requires proactive physical adjustments and task modifications, which present logistical and financial burdens for construction firms.

Moreover, Farr-Wharton et al. (2023) pointed out that the physical work environment is not the sole concern, organizational structure and culture also significantly shape aging workers' willingness to remain employed. In contrast to age-based assumptions, their review highlighted that well-being and job retention are more influenced by the environment's psychological safety and inclusiveness than by chronological age alone. This introduces another layer of complexity by fostering a culture that supports age-diverse teams while modifying physical demands. Schulte et al. (2018) expanded on this by presenting productive aging as dependent on a safe and health-oriented workplace, without which the intended benefits of extended work life become untenable. The cumulative evidence indicates that addressing this challenge is not merely a matter of ergonomics, but a multidimensional investment that touches on health, organizational practices, financial resources, and long-term workforce planning.

2.6.3 Necessity of Human Resource Practices

Managing an aging workforce in construction demands a shift in human resource (HR) practices, as conventional policies often fall short of addressing

aging workers' distinct needs. Older Worker-oriented Human Resource Practices (OW-HRPs) offer targeted strategies such as flexible work arrangements, mentorship roles, continued training, and phased retirement pathways (Farr-Wharton et al., 2023). These practices not only recognize the shifting motivations of workers over 45 but also help maintain productivity and knowledge retention in a physically demanding industry. In supporting view, Bentley et al. (2019) stressed that while human resource professionals recognize the challenges of workforce aging, many organizations still lack formal strategies. Without structured approaches, firms risk increased turnover, loss of expertise, and reduced morale among aging workers.

In elaboration, the significance of recognition and role adjustment is reinforced by Bentley et al. (2019), who found that respect and acknowledgment are key to prolonging aging workers' engagement. Forbes et al. (2015) further pointed out that many aging workers remain employed only because their roles have been physically modified to match their capacities, highlighting how human resource must evolve beyond a one-size-fits-all model. If construction companies neglect to implement responsive practices, they may face mounting project delays, skill shortages, and safety risks due to the rapid exit of experienced staff. The collective findings clearly reflect that aligning human resource practices with the realities of aging workers is not only a matter of workplace equity but also essential for long-term operational resilience.

2.6.4 Barrier to youth employment

The rising presence of aging workers in the labour market has created substantial barriers for youth employment, posing a structural challenge for construction companies already grappling with labour force renewal. As Rahat, Aliyu, and Iwu (2019) highlighted, increased labour force participation among aging workers and delayed retirement policies reduces job openings for younger workers, exacerbating youth unemployment. This imbalance is particularly detrimental in labour-intensive sectors like construction that rely on a steady influx of new talent. Bianchi and Paradisi (2024) offered a theoretical model of "negative career spillovers" to explain how tenure-related job locking, such as firm-specific human capital and wage stickiness, prevents job progression and role availability for younger workers. This restricts opportunities for younger

workers to advance or enter the industry, especially in firms constrained by limited high-level positions or stagnating productivity growth. Consequently, the dominance of aging workers may stall intergenerational workforce turnover and innovation, threatening the long-term sustainability of construction firms facing aging infrastructure and evolving project demands.

While some researchers, such as Fan (2022), argued that the displacement of youth workers by aging workers may be more prevalent in high-skilled sectors, evidence shows this issue still affects construction due to its rigid job structures and the need for physical capability adaptation. The phenomenon of "deyouthing," described by Barabaschi (2017), captures the broader demographic shift driven by low birth rates and delayed workforce entry, intensifying the scarcity of young worker in industries already suffering from skill shortages. If construction companies fail to address these barriers, the effects could be severe: decreased innovation, poor succession planning, reduced workforce diversity, and an erosion of long-term sectoral resilience. Thus, balancing aging workforce retention with strategic youth employment integration is not only a demographic imperative but a core business survival strategy.

2.6.5 Workforce Imbalance

The rapid aging of the construction workforce has emerged as a significant structural challenge, disrupting labour supply and skill continuity across the industry. Choi et al. (2018) emphasized that the average age in construction has been rising four times faster than in other U.S. industries, creating what Taylor et al. (2016) termed a "demographic labour cliff" that severely affects productivity, safety, and cost outcomes on projects. This demographic shift leads to a shrinking pipeline of skilled labour, worsened by declining vocational education and barriers such as limited access to training for underrepresented groups. Barabaschi (2017) similarly highlighted the consequences of demographic aging, pointing out that a growing retired population coupled with low birth rates is reducing the inflow of young workers, particularly in skilled trades. The resulting skill imbalances and rising dependency ratios force companies to rely more heavily on aging workers, raising concerns about physical capacity, knowledge transfer, and sustainable output levels.

This imbalance is compounded by the fact that aging workers, due to delayed retirement trends, continue to occupy roles that would otherwise be available to younger entrants. Fan (2022) noted that such retention policies can directly contribute to youth underemployment, creating long-term instability in workforce development. Although increasing the retirement age may temporarily sustain labour numbers, it constrains job creation for younger workers, whose employment rate is already under pressure. Without sufficient renewal of young talent, construction companies face not only labour shortages but also a weakened foundation for future growth. The erosion of career pathways for youth, exacerbated by educational system gaps and institutional inertia, further threatens industry resilience. Barabaschi (2017) urged companies to adopt proactive human resource (HR) strategies to address these age-related imbalances, as failing to do so would risk productivity loss, institutional knowledge decay, and long-term economic fragility.

2.6.6 Intergenerational gap

The emergence of multiple generations in today's construction workforce, ranging from Silent Generation workers to Millennials has created a complex inter-generational dynamic that construction companies are struggling to manage Barabaschi (2017) highlighted the coexistence of four distinct generations in the workplace has introduced diverging values, communication styles, and work preferences, yet implementation of intergenerational initiatives remains limited and poorly understood. This complexity is further exacerbated by national policies that delay retirement, keeping aging workers in the workforce longer. In construction, where collaboration and seamless coordination across disciplines are vital for project efficiency and safety, misalignment between generational expectations can cause friction, reduce team cohesion, and obstruct knowledge transfer between experienced and younger workers. This not only disrupts day-to-day operations but also weakens the long-term sustainability of institutional expertise within firms.

In parallel, the rapid digitalization of the industry, often referred to as Construction 4.0 is deepening the inter-generational divide. Adepoju and Aigbavboa (2021) and Bouwmans et al. (2024) emphasized that this transformation is unveiling a widening skill gap, particularly among aging

workers who may struggle to keep pace with the technological demands of digital tools and processes. This mismatch creates a workforce bottleneck where experienced workers risk obsolescence while younger workers, though more technologically adept, may lack the practical knowledge and mentorship needed for high-performance execution. The failure to bridge this divide may delay technology adoption, reduce project delivery quality, and increase operational costs due to inefficiencies and rework. Without proactive inter-generational workforce strategies, construction companies may find themselves hindered in both productivity and innovation, unable to fully leverage either the experience of aging workers or the tech-savviness of the younger generation.

2.6.7 Lack of innovation

The construction industry is undergoing a disruptive transition driven by Construction 4.0, which demands advanced digital competencies, yet the aging workforce struggles to keep pace with this technological evolution. Adepoju and Aigbavboa (2021) emphasized that although new digital skills, such as programming, data analytics, and human-machine interaction, are increasingly critical, the sector lacks empirical studies addressing the impact of this transformation on its aging workforce. Bouwmans et al. (2024) asserted that digital transformation (DT) is contingent on employees' adaptability, but the skill acquisition rate lags far behind the speed of technological change. Aging workers often lack both the technical and soft skills (e.g., collaboration, digital communication) now required in digitalized work environments, creating a widening skills gap that undermines workforce agility and project efficiency.

This misalignment between digital demands and the capability of an aging workforce introduces severe operational risks for construction firms. Soja and Soja (2020) emphasized how aging workers are disproportionately affected by digital divide phenomena, citing their lower confidence in using Information and Communication Technology (ICT) tools and increased anxiety toward emerging technologies. In addition, Cros, Bobillier Chaumon, and Cuvillier (2021) reinforced this by noting that aging workers accumulated experience, once a key asset, is being devalued as technological qualifications supersede experiential knowledge. Agbo (2020) further explained that human capital in construction is prone to erosion due to aging and skill atrophy, ultimately

affecting productivity. Without robust strategies to bridge this digital-competency gap, companies face growing inefficiencies, knowledge loss, and delays in technology integration, all of which threaten their competitive edge in a rapidly evolving market.

2.6.8 Skills obsolescence

The phenomenon of skill obsolescence poses a critical threat to construction companies, particularly as the industry grapples with a progressively aging workforce. Cros, Bobillier Chaumon, and Cuvillier (2021) outlined the convergence of demographic aging and rapid technological transformation renders aging workers increasingly vulnerable to professional displacement. The requirement for prolonged employment until the age of 64 demands sustained competence, yet aging inherently undermines workers' ability to keep pace with evolving industry expectations. Skill obsolescence manifests through both natural declines, such as age-related physical or cognitive deterioration and externally driven changes, such as the integration of new technologies or updated professional standards. The inability of aging workers to adapt to these changes' risks marginalizing their experiential knowledge and diminishing their capacity to remain active contributors in construction projects.

Agbo (2020) similarly emphasized that human capital, despite being the cornerstone of construction productivity, is susceptible to decay over time. As job functions evolve or are replaced by mechanized or digitized alternatives, previously valuable skills may no longer align with organizational needs. This leads to technical or economic obsolescence, both of which negatively impact performance, increase the risk of job displacement, and ultimately reduce organizational efficiency. McGuinness, Pouliakas, and Redmond (2021) categorized skill obsolescence into three types, physical (arising from aging), economic (resulting from shifts in technology or market demand), and atrophy (due to underutilization). Each form poses significant challenges in construction where continuous manual proficiency, technological adaptability, and role-specific knowledge are vital. Together, these findings underscored that the construction industry must address skill obsolescence not as a peripheral issue but as a central strategic concern. The sector's reliance on a physically intensive and increasingly tech-integrated workforce heightens the urgency for structured

upskilling initiatives. Without timely interventions, companies may face not only declining individual productivity but also systemic inefficiencies due to mismatches between workforce capabilities and project demands.

2.6.9 Low employment participation

Low employment participation among aging workers remains a systemic issue that threatens the sustainability of human resources in construction. Šrekl (2017) asserted that demographic restructuring, particularly the proportional increase of workers aged 55 to 64, is not matched by adequate policy responses to retain them in the workforce. In fact, many European countries historically adopted early retirement incentives as a mechanism to relieve labour market pressure during economic downturns. While temporarily effective, these strategies have had long-term repercussions, reducing the presence of aging workers in the active labour force and contributing to a loss of valuable industry experience. From an economic standpoint, this withdrawal represents a waste of both individual potential and societal investment in skills, while simultaneously straining pension and social welfare systems. In the context of construction, where knowledge transfer and supervisory expertise are critical, this underrepresentation impedes project continuity and workforce development.

On top of that, Jinnett et al. (2017) highlighted that chronic health conditions, common in aging populations, play a significant role in reducing employment participation through absenteeism and presenteeism. Employees may still report to work, but physical and cognitive limitations such as fatigue, mobility issues, and reduced concentration can drastically diminish productivity. The physical and mental demands of construction work exacerbate this issue, as tasks often require sustained strength, coordination, and vigilance. This dual burden, low participation and decreased functional capacity translates into higher operational risks and inefficiencies for construction companies. Šrekl (2017) further emphasized that continued exclusion of aging workers undermines not only organizational performance but also broader socio-economic stability. Therefore, the industry must reevaluate employment structures and implement targeted interventions that address the physical, cognitive, and policy-related barriers to aging workers inclusion.

2.6.10 Mentoring pressure on senior employees

Mentoring, while critical in sustaining knowledge within the construction industry, imposes rising pressures on aging professionals. In similar perspective, Nkomo and Thwala (2014) emphasized that increased project complexity demands structured knowledge transfer, often achieved through mentorship. Oke, Aigbavboa and Mutshaeni (2017) added that senior workers are expected to guide juniors but noted that experience alone does not guarantee mentoring ability. In contrast, Otasowie and Oke (2024) framed mentoring as a mutual exchange that benefits firms' competitiveness. Furthermore, mentoring helps reduce knowledge loss from high attrition (Nkomo, Thwala and Aigbavboa, 2018). In addition, the construction environment's fast-paced, hazardous, and technically demanding nature adds strain on mentors managing both productivity and people. This pressure increases especially when firms lack formal mentoring structures and rely solely on experienced individuals for informal coaching. Therefore, while mentoring is vital, it often becomes an additional burden for aging workers unless roles are clearly defined and supported by policy.

In opposing view, some scholars suggested mentoring enhances engagement. In addition, Sokas, Dong and Cain (2019) reported that union-led mentorship programs are crucial to workforce continuity. Otasowie and Oke (2024) agreed, seeing mentoring as an empowering process rather than a burden. In similar argument, these programs not only safeguard institutional knowledge but also support smoother onboarding of apprentices. However, despite these benefits, aging workers still face dual responsibilities, technical execution and developmental roles. This overlap, as noted by Nkomo, Thwala and Aigbavboa (2018), risks burnout, especially in firms lacking formal succession structures. Furthermore, reliance on aging workers for mentoring without compensation or support can discourage prolonged participation. In this context, mentoring becomes unsustainable when mentors are stretched between delivery deadlines and staff development needs. Therefore, while mentoring preserves institutional strength, its unbalanced execution amplifies the workload on aging professionals and requires systemic restructuring to remain effective.

Table 2.2: Literature Map for Challenges faced by construction companies

No.	Effects	Previous Studies	Frequency
1	Necessity of health promotion	(Jinnett *et al.*, 2017; Rahim Abdul Hamid *et al.*, 2018; Schulte *et al.*, 2018; Chiu *et al.*, 2020; Koh, Rowlinson and Pollock, 2020; Peng and Chan, 2020)	6
2	Refine working environment	(Schulte *et al.*, 2018; Peng and Chan, 2020; Farr-Wharton *et al.*, 2023)	3
3	Necessity of Human Resource Practices	(Forbes *et al.*, 2015; Bentley *et al.*, 2019; Farr-Wharton *et al.*, 2023)	3
4	Barrier to youth employment	(Barabaschi, 2017; Rahat, Aliyu and Iwu, 2019; Fan, 2022; Bianchi and Paradisi, 2024)	4
5	Workforce Imbalance	(Barabaschi, 2017; Choi *et al.*, 2018; Fan, 2022)	3
6	Intergenerational gap	(Barabaschi, 2017; Adepoju and Aigbavboa, 2021; Bouwmans *et al.*, 2024)	3
7	Lack of innovation	(Agbo, 2020; Soja and Soja, 2020; Adepoju and Aigbavboa, 2021; Cros, Bobillier Chaumon and Cuvillier, 2021; Bouwmans *et al.*, 2024)	5
8	Skills obsolescence	(Agbo, 2020; Cros, Bobillier Chaumon and Cuvillier, 2021; McGuinness, Pouliakas and Redmond, 2021)	3
9	Low employment participation	(Jinnett *et al.*, 2017; Šrekl, 2017)	2
10	Mentoring pressure on senior employees	(Oke, Aigbavboa and Mutshaeni, 2017; Nkomo, Thwala and Aigbavboa, 2018; Sokas, Dong and Cain, 2019; Otasowie and Oke, 2024)	4

2.7 Strategies for construction companies to adapt to an aging workforce.

This section identifies potential strategies for construction companies to adapt to an aging workforce.

2.7.1 Mentoring & Knowledge Transfer

Mentoring and knowledge transfer emerge as essential strategies for organizations in the construction industry to address the challenges posed by an aging workforce. As experienced workers retire, their departure often results in the loss of vast amounts of experiential knowledge that are vital for ongoing operations. This knowledge can range from explicit documents such as reports and emails to tacit knowledge that resides in individuals' minds, which is often not documented (van Dongen and Loos, 2018). Without structured methods to capture and share this knowledge, organizations may face inefficiencies, such as repeating work or overlooking lessons learned. In contrast, mentoring provides a formalized mechanism to ensure that knowledge is not only retained but also transferred to less experienced workers. According to Otasowie and Oke (2024), tacit knowledge, which is inherently personal and shaped by individual experiences, cannot simply be captured through formal documents. It requires interpersonal interaction and real-world application, both of which mentoring facilitates effectively.

Similarly, mentoring plays a significant role in preserving not only technical skills but also the nuanced understanding of work that comes with experience. This is further supported by Nkomo, Thwala, and Aigbavboa (2018), who emphasized the importance of mentoring as an integral part of employee development, facilitating continuous learning across generations. In this regard, mentoring enhances the development of younger workers by allowing them to learn from seasoned employees in real-world contexts. Moreover, mentoring supports organizational resilience by fostering strong intergenerational collaboration. However, it is essential to note that the benefits of mentoring extend beyond the mentee, as mentors themselves often experience increased job satisfaction and engagement through the act of sharing their knowledge. Thus, mentoring serves a dual purpose: it aids in preserving critical knowledge while also enriching the organizational culture. Ultimately, mentoring is not just

a tool for knowledge transfer, but a critical strategy to ensure the long-term success and sustainability of construction companies facing demographic shifts (Nkomo, Thwala and Aigbavboa, 2018).

2.7.2 Implementation of Job Model

Implementing a structured job model is a crucial strategy in helping construction companies adapt to an aging workforce, as it directly addresses how aging workers experience and engage with their work. Heisler and Bandow (2018) emphasized the relevance of the Job Characteristics Model (JCM), developed by Hackman and Oldham, which identified five core elements, skill variety, task identity, task significance, autonomy, and feedback, as foundational to meaningful job design. These elements collectively enhance workers' sense of purpose and engagement, which are critical for maintaining motivation among aging workers. In a similar view, Li, Zhang and Xiong (2020) highlighted that job characteristics influence workers' psychological experiences, such as perceiving their work as valuable, feeling connected to their tasks, and having clarity in performance evaluation. These dimensions are particularly beneficial to aging workers whose cognitive and physical capacities may require tailored engagement methods. Furthermore, by enabling autonomy and structured feedback, construction firms can reinforce self-efficacy and motivation among aging workers. This alignment between task structure and individual capability ultimately helps prolong employability and productivity in an aging workforce.

On top of that, Dimovski, Grah and Colnar (2019) provided a complementary approach through the development of a demographic-based multiple decrement model that forecasts workforce transitions and productivity states across age cohorts. Their model, although demographic in nature, reinforces the need for job frameworks that accommodate varying productivity levels, particularly among aging workers. When job characteristics are matched with the evolving capabilities of employees, it enables organizations to manage labour more dynamically and sustainably. In contrast to traditional static job roles, the job model introduces flexibility in task structure that supports both high-performing and transitioning aging workers. Likewise, the integration of age-sensitive tools within job designs not only aligns with physical and cognitive changes due to aging but also encourages long-term workforce

retention. Such alignment between job structure and human capital forecasting allows construction firms to proactively manage productivity outcomes, minimize early retirements, and enhance organizational stability.

2.7.3 Flexible Work Arrangements

Flexible work arrangements (FWA) are a strategic response to workforce aging, offering a practical and psychological solution to extend aging workers' participation in construction. Heisler and Bandow (2018) emphasized that flexible environments enhance autonomy, a key motivational driver, especially for aging workers who seek to balance job responsibilities with personal or social obligations. Similarly, Gardiner and Chen (2022) identified several common practices, such as flexible schedules, telecommuting, and phased retirement, that mitigate occupational stress, enhance work-life balance, and ultimately improve job satisfaction. These arrangements are particularly valuable for aging workers who may no longer wish to adhere to rigid work structures. Nagarajan and Sixsmith (2023) further argued that promoting flexible practices is essential to retaining aging workers with physical limitations. On top of that, they noted that organizations adopting age-friendly policies can benefit from a broader, experienced talent pool. This strategic approach not only attracts mature workers but also sustains workforce diversity and continuity.

In a similar view, van Dongen and Loos (2018) demonstrated how companies such as Asda stores limited (ASDA) successfully implemented age-specific flexibility through initiatives like "Benidorm leave" and "Grandparent leave," acknowledging life-stage demands. These targeted benefits align with aging workers' evolving priorities, encouraging continued employment without compromising personal obligations. Furthermore, the shift in workforce demographics and declining access to younger labour pools amplify the importance of mature talent retention. In contrast to conventional full-time roles, flexible models create avenues for aging workers to remain engaged at levels suited to their capacity. Heisler and Bandow (2018) also noted that many aging workers remain motivated by financial stability, social belonging, or purpose, and flexible work allows them to fulfil these needs without the strain of conventional scheduling. Collectively, these findings underscore flexible work

arrangement's role in improving retention, reducing physical strain, and creating inclusive construction environments that adapt to the demographic realities of an aging labour force.

2.7.4 Immigration of Work

Faced with the demographic pressures of an aging workforce, immigration has been widely recognized as a key countermeasure to replenish labour supply in critical sectors such as construction. Rahat, Aliyu and Iwu (2019) argued that relying solely on policies to extend the retirement age may prove inadequate, thus highlighting immigration, particularly of younger populations, as a vital supplement to support labour markets and maintain economic productivity. Correspondingly, Barysheva et al. (2020) observed that both internal and international migration predominantly channels into labour-intensive industries such as construction, where physical demands deter the aging workforce. This demographic infusion of younger migrant workers ensures that tasks requiring strength, endurance, and flexibility continue without disruption. Furthermore, migrants also alleviate shortages in emerging niches such as elderly care, which may indirectly support aging domestic workers by shifting labour burdens to younger entrants. In this sense, immigration functions as a balancing force, mitigating labour shortages while enhancing intergenerational workforce dynamics.

However, Camarota and Zeigler (2019) provided a contrasting view, asserting that while immigration significantly expanded the working-age population over a 27 year period, it also increased the overall dependent population, thus limiting the net impact on the ratio of active workers to dependents. This finding challenges the assumption that immigration alone can stabilize the economic consequences of population aging. In elaboration, Barysheva et al. (2020) noted that despite high demand, particularly in long-term care, immigration quotas remain capped and inadequate to address workforce deficits in aging-related services. In practice, construction and caregiving sectors remain underserved, and competition for migrant labour persists among these industries. Rahat, Aliyu and Iwu (2019) emphasized that well-structured immigration strategies targeting younger cohorts can still play a vital role, particularly when combined with complementary workforce policies.

Thus, while immigration is not a standalone solution, it remains a critical element in sustaining labour-intensive sectors amid a shrinking domestic workforce.

2.7.5 Wellness and Health Programs

To sustain aging workers in physically demanding sectors such as construction, implementing robust wellness and health programs is vital. Magnavita et al. (2018) emphasized that the workplace serves as a critical venue for promoting health, especially as it concentrates large groups of active adults within structured schedules. As the workforce ages, the need for integrated health promotion grows, particularly in preventing occupational health decline and prolonging employability. Initiatives like the European "ProHealth65+" project have demonstrated the significance of workplace-driven preventive measures tailored to aging workers (Magnavita *et al.*, 2018). These programs not only support physical well-being but also align with broader workforce retention strategies. Tonnon et al. (2018) categorized sustainable employability efforts in the Dutch construction sector into four domains: ergonomic enhancements, health-related practices, personal development, and work organization.

Despite the presence of such measures, ranging from medical examinations to training and ergonomic equipment, their utilization remains inconsistent. Creating a culture of health and safety requires more than tools; it demands management leadership, accountability systems, and psychological safety that empower employees to voice concerns and adopt wellness initiatives. Complementing this, Mokarami, Cousins and Kalteh (2022) presented the Work Ability Index (WAI) as a practical tool to assess a worker's capacity by linking health status to job requirements. The work ability index's structured self-assessment format supports early detection of fitness gaps, enabling targeted interventions before irreversible decline occurs. Together, these insights highlight that a comprehensive wellness strategy, grounded in proactive assessments, environmental adaptation, and managerial support is critical for retaining aging workers in the labour force.

2.7.6 Implement safety measures

Ensuring a safe and controlled work environment is fundamental to sustaining aging workers in construction, where physical risk is heightened by age-related vulnerability. Fan et al. (2023) highlighted the importance of integrating early-warning systems that track worker proximity to machinery in real time, thereby reducing the likelihood of hazardous interactions. Their study emphasized stricter control of environmental factors, such as dust, noise, and working hours as essential to safeguarding the health and safety of aging workers. Proactive regulation of these elements addresses both acute and chronic occupational health risks, which are particularly consequential for aging workers with diminished physical resilience. Complementing technological interventions, Mneymneh, Abbas and Khoury (2018) underscored the adoption of wearable safety devices and intelligent recognition systems to protect indoor construction workers. They emphasized that consistent use of personal protective equipment (PPE), especially hard hats, is non-negotiable in mitigating common risks such as falls, head injuries, and electrical hazards.

However, the effectiveness of these measures depends significantly on managerial enforcement and workforce compliance. Peng and Chan (2021) asserted that the behaviour and actions of supervisors have a direct impact on safety culture. Their findings stress that safety leadership must transition from reactive enforcement to proactive training and preventive management. Managers who model and enforce safety protocols help cultivate a climate of vigilance and risk-awareness, conditions that are especially critical for retaining and protecting aging construction workers. Therefore, embedding safety at both procedural and behavioural levels enhances not only immediate safety outcomes but also long-term workforce sustainability.

2.7.7 Assistive Technology Implementation

The adoption of assistive technologies is increasingly pivotal in facilitating the continued participation of aging workers in construction. van Dongen and Loos (2018) argued that, in addition to flexible work schedules, technologies such as telecommuting can offer significant benefits for mature workers. By alleviating the burden of commuting, which can be physically taxing, telecommuting provides aging workers with the autonomy to manage both work and personal

responsibilities. However, to mitigate challenges such as social isolation and coordination difficulties, regular office visits coupled with tailored training and support can help aging workers adapt to remote work arrangements. Likewise, Nagarajan and Sixsmith (2023) emphasized the transformative role of ergonomic tools and technology in accommodating the physical limitations of aging workers. These innovations include movable instruction screens with larger text, ergonomic back supports, and height-adjustable workstations. By reducing the physical strain associated with repetitive tasks, these tools can enhance safety and productivity for aging workers. Moreover, incorporating artificial intelligence (AI) to automate physically demanding tasks offers a promising solution for workers with reduced flexibility or strength.

For instance, AI-assisted devices can assist aging workers in tasks that require reaching, lifting, or performing intricate movements, ensuring both efficiency and safety. Karakhan et al. (2020) highlighted the impact of Industry 4.0 technologies, particularly the Internet of Things (IoT) and smart devices, in reshaping the construction industry. These technologies, which enable seamless communication between interconnected devices, can be integrated into construction workflows to reduce physical exertion and streamline task execution. Furthermore, Ginigaddara et al. (2024) pointed out that the promotion of advanced tools like Building Information Modelling (BIM) and prefabrication can mitigate skill mismatches, enabling aging workers to perform tasks with greater ease and accuracy. The combination of these assistive technologies not only aids in retaining aging workers but also increases overall productivity, demonstrating that innovation in the workplace can benefit both the workforce and the organization.

2.7.8 Age-Inclusive Culture and Policies

The importance of creating an age-inclusive culture and implementing supportive policies cannot be overstated, especially in the context of adapting to an aging workforce in construction. As the construction industry faces the challenge of an aging labour force, fostering a culture that promotes trust, respect, and performance-based rewards is essential for retaining aging workers. Heisler and Bandow (2018) emphasized that aging workers must feel that job retention is based on skill proficiency and performance, not age or other non-

performance-related factors. This approach encourages aging workers to maintain their skills, stay engaged, and continue contributing effectively to the organization. Moreover, research indicates that when organizations foster an age-inclusive culture, they create an environment where aging workers feel valued and respected, reducing the potential for age discrimination (Gardiner and Chen, 2022). This sense of inclusion not only improves job satisfaction but also strengthens the overall engagement of aging workers, thus enhancing their productivity and reducing turnover rates in a sector that already struggles with workforce shortages.

Furthermore, organizational support systems, such as age-inclusive HR policies and training, play a pivotal role in retaining aging workers in the construction industry. Nagarajan and Sixsmith (2023) pointed out that many countries, including the USA, Germany, and Canada, have implemented programs aimed at supporting aging workers through extended job search assistance and self-employment opportunities. Such programs are particularly important in construction, where physically demanding tasks may limit the ability of aging workers to perform at their peak. By aligning HR policies with the needs of an aging workforce, organizations can help retain skilled aging workers, ensuring their continued participation in the workforce and contributing to the overall economic growth. The creation of an age-inclusive work environment is also reinforced by van Dam, van Vuuren, and Kemps (2017), who argued that organizational culture and climate are key to fostering positive perceptions of aging workers. When senior management adopts supportive attitudes toward aging workers, it fosters a work environment where aging workers are respected and motivated to remain in the workforce. Thus, adopting an age-inclusive culture in the construction industry not only reduces the impact of age discrimination but also enhances worker satisfaction, retention, and overall productivity, which are crucial for adapting to the demographic challenges posed by an aging workforce.

2.7.9 Skill Development for aged workers

Skill development plays a fundamental role in supporting aging workers in construction, ensuring that they remain competitive, qualified, and productive in a rapidly evolving industry. As the construction sector increasingly faces challenges related to an aging workforce, offering training and development opportunities becomes essential for maintaining workforce retention and performance. Heisler and Bandow (2018) highlighted that aging workers who desire to extend their careers place a high value on job retention, and employers can increase motivation by providing training that enhances skills and competencies. This, in turn, improves the expectancy of aging workers, as they believe their efforts will help them maintain job security. Training and skill development not only enable aging workers to stay relevant in the face of technological advancements but also ensure they remain capable of performing their tasks effectively, adapting to changing work conditions and requirements. Gardiner and Chen (2022) underscored that training is imperative for the long-term health and productivity of aging workers, yet it is often underutilized for aging workers in comparison to their younger counterparts. This gap in development opportunities can hinder the performance and retention of aging workers, further exacerbating workforce shortages in construction.

Moreover, the need for upskilling and reskilling aging workers is increasingly critical as the construction industry integrates more advanced technologies and complex processes. Nagarajan and Sixsmith (2023) emphasized that on-the-job training and acquiring technological skills are key to reducing the productivity challenges that often arise with aging. As aging workers may face age-related physical and cognitive limitations, providing them with the right training allows them to maintain their competency and adapt to new technological demands, such as those introduced by Industry 4.0. Deb and Li (2024) also stressed the importance of targeted upskilling initiatives in aligning workforce competencies with the evolving demands of the sector, particularly as new construction technologies, such as Building Information Modelling (BIM), become increasingly integral to project execution. Thus, investing in training programs that address both the physical and technological aspects of construction work is essential for mitigating the impacts of an aging workforce. By ensuring aging workers remain equipped with the skills

necessary for success, construction companies can enhance worker retention, reduce turnover, and address the industry's growing labour shortages.

2.7.10 Review Benefits Plan to retain workers

Reviewing and adjusting benefit plans is a vital strategy for retaining aging workers in the construction industry. Heisler and Bandow (2018) suggested that companies can create more attractive benefit plans by offering flexible options, such as "cafeteria plans," which allow workers to allocate their benefit dollars according to their personal priorities. For aging workers, this could mean directing more funds towards retirement savings or healthcare, which are typically greater concerns as workers age. Such customization within benefit plans can make employees feel more valued, thus encouraging them to stay longer in their roles. Additionally, benefit adjustments can address specific needs and priorities, such as long-term healthcare coverage, which becomes especially relevant as workers transition to later stages of their careers. By reviewing and refining these benefit plans, employers can enhance worker satisfaction and loyalty, ensuring that aging workers feel supported and incentivized to continue their employment. (Heisler and Bandow, 2018)

Furthermore, research by Chen and Gardiner (2019) emphasized that retaining aging workers requires not only offering attractive incentives but also removing barriers that discourage their continued participation in the workforce. Countries like France, the Netherlands, Norway, and Switzerland have already implemented national strategies aimed at improving aging workers' engagement by offering financial rewards, removing disincentives such as age-based pension cuts, and reducing discrimination in the workplace. In the construction industry, these policies can be mirrored by offering comprehensive retirement benefits, healthcare packages, and removing structural barriers that limit aging workers' opportunities. Tichá et al. (2020) also pointed to the value that younger generations, such as Gen Z, place on non-monetary benefits, including above-standard health care and retirement benefits, which further reflects the growing importance of long-term benefits in retaining workers across all age groups. As the construction industry adapts to an aging workforce, focusing on enhancing benefit plans will be crucial for both attracting and retaining skilled o aging workers, ultimately supporting a more sustainable and productive workforce.

Table 2.3: Literature Map for strategies for construction companies to adapt to an aging workforce

No.	Effects	Previous Studies	Frequency
1	Mentoring & Knowledge Transfer	(Nkomo, Thwala and Aigbavboa, 2018; van Dongen and Loos, 2018; Otasowie and Oke, 2024)	3
2	Implementation of Job Model	(Heisler and Bandow, 2018; Dimovski, Grah and Colnar, 2019; Li, Zhang and Xiong, 2020)	3
3	Flexible Work Arrangements	(Heisler and Bandow, 2018; van Dongen and Loos, 2018; Gardiner and Chen, 2022; Nagarajan and Sixsmith, 2023)	4
4	Immigration of Work	(Camarota and Zeigler, 2019; Rahat, Aliyu and Iwu, 2019; Barysheva *et al.*, 2020)	3
5	Wellness and Health Programs	(Magnavita *et al.*, 2018; Tonnon *et al.*, 2018; Mokarami, Cousins and Kalteh, 2022)	3
6	Implement safety measures	(Mneymneh, Abbas and Khoury, 2018; Peng and Chan, 2020; Fan *et al.*, 2023)	3
7	Assistive Technology Implementation	(van Dongen and Loos, 2018; Karakhan *et al.*, 2020; Nagarajan and Sixsmith, 2023; Ginigaddara *et al.*, 2024)	4
8	Age-Inclusive Culture and Policies	(van Dam, van Vuuren and Kemps, 2017; Heisler and Bandow, 2018; Eppler-Hattab, Meshoulam and Doron, 2020; Gardiner and Chen, 2022; Nagarajan and Sixsmith, 2023)	5
9	Skill Development for aged workers	(Heisler and Bandow, 2018; Gardiner and Chen, 2022; Nagarajan and Sixsmith, 2023)	3
10	Review Benefits Plan to retain workers	(Heisler and Bandow, 2018; Chen and Gardiner, 2019; Tichá *et al.*, 2020)	3

2.8 Summary of findings from literature review

Figure 2.1 presents a consolidated summary of the key insights derived from the literature review. The content is organized into three principal sections that collectively offer a comprehensive understanding of the aging workforce issue within the construction industry. The first section outlines eleven (11) notable effects, such as increased prevalence of chronic health conditions, physical limitations, and a higher incidence of workplace injuries, all of which compromise productivity, safety, and workforce longevity. The second section identifies ten (10) critical challenges faced by construction companies, including labour shortages, skill gaps, and intergenerational conflict. The third section highlights ten (10) strategic responses adopted to mitigate these challenges and adapt effectively to demographic shifts. These strategies include mentoring and knowledge transfer, targeted skill development, flexible working arrangements, and the revision of benefit plans to improve retention. Collectively, the summary encapsulates how aging affects both workers and organizational systems while emphasizing the need for comprehensive, proactive strategies to maintain operational efficiency and workforce sustainability in the evolving construction landscape.

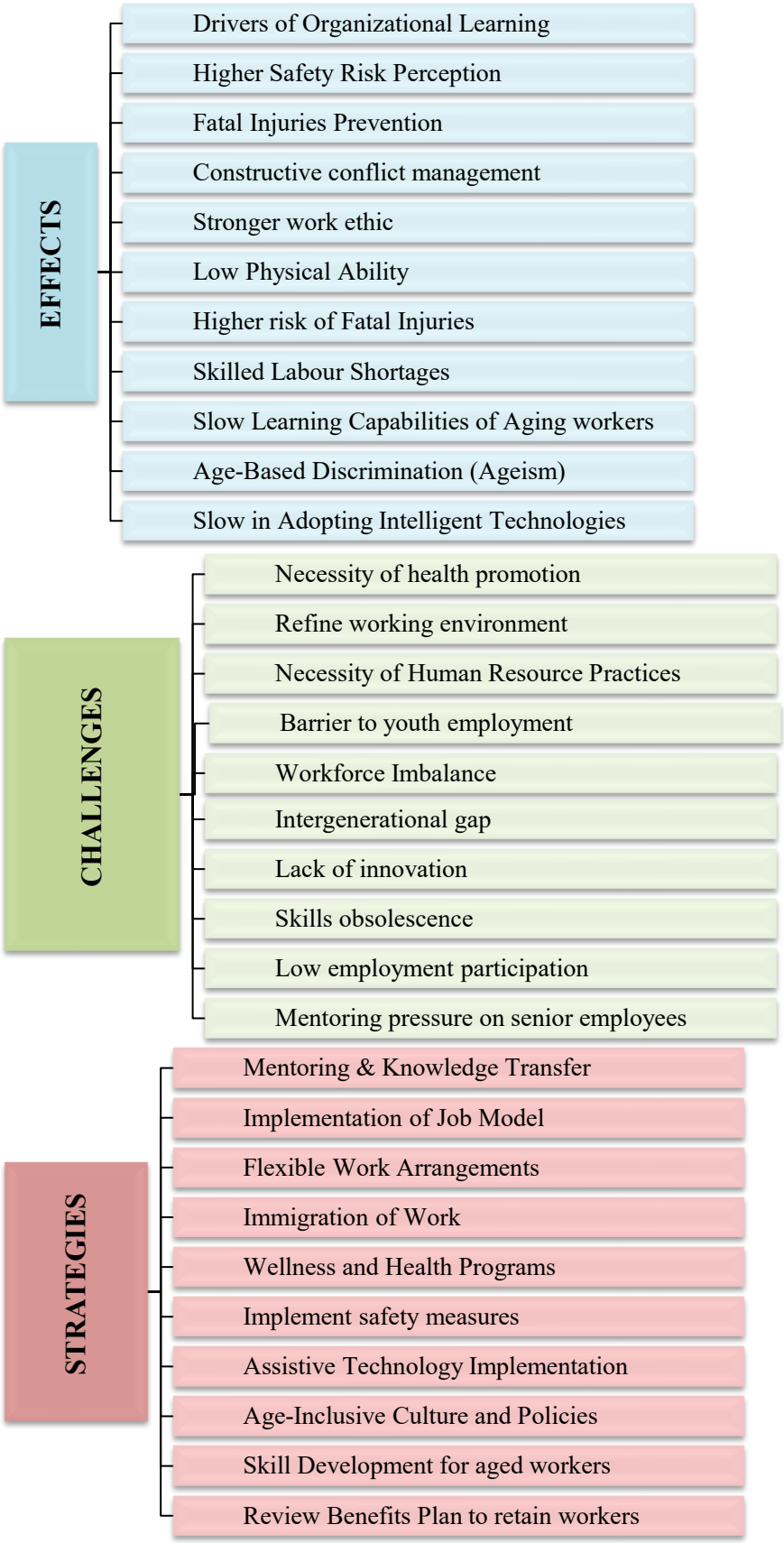

Figure 2.1: Summary of the key insights derived from the literature review

2.9 Summary of Chapter

In short, this chapter presents a comprehensive examination of the aging workforce within Malaysia's construction industry by reviewing relevant literature. It explores the concept of an aging workforce, its adverse effects on productivity and safety, and the challenges it poses to construction companies, such as labour shortages and rising costs. Additionally, it discusses ten strategic approaches to address these challenges, including mentoring, upskilling, flexible work arrangements, and benefit plan revisions.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

This chapter presents the research methodology adopted for the study and the rationale behind its selection. It covers the literature review process, the design and development of the questionnaire, sampling approach, pilot testing, and distribution. The chapter also outlines the statistical techniques used to analyse the data and interpret the findings.

3.2 Research Methodology

According to Creswell (2009), research methodology refers to a structured framework that guides the entire research process, encompassing everything from overarching philosophical assumptions to the specific techniques used for data gathering and analysis. This framework consists of a series of decisions, which do not necessarily follow a fixed sequence Creswell (2009) categorized research methods into three primary types: quantitative, qualitative, and mixed methods. Quantitative research is cantered on the use of numerical data and measurable indicators to test hypotheses. On the other hand, qualitative research emphasizes descriptive, non-numerical data and employs interpretive approaches to explore meanings, perspectives, and symbolic content (Creswell, 2009).

3.2.1 Qualitative Research Methodology

Qualitative research focuses on gaining a deep understanding of how individuals or groups perceive and interpret social or human-related phenomena. Unlike methods that rely on predefined hypotheses, qualitative research is grounded in open-ended questions that evolve throughout the study. These questions guide the inquiry in a flexible and adaptive manner, allowing the research to respond to new insights as they emerge. Data is usually gathered in the natural environment of the participants and analysed through an inductive process that moves from specific observations to broader themes. The role of the researcher

is central in interpreting the meaning of the data, and the final report structure is often fluid to accommodate the complexity of the subject matter (Creswell, 2009).

Denny and Weckesser (2022) highlighted that qualitative research allows for iterative development, where the direction of the study can be refined progressively. This adaptability is crucial for identifying unexpected themes or behaviours, ultimately improving the contextual relevance of the findings. Glaser and Strauss (1967) further elaborated on qualitative induction, which involves four key stages: identifying emerging patterns from raw data to form categories; comparing incidents to refine these categories; gradually narrowing the theory by confirming and consolidating categories; and finally, constructing theoretical insights and generalizations from the findings. This bottom-up approach makes qualitative research especially valuable for developing new theories that are closely tied to real-world observations.

3.2.2 Quantitative Research Methodology

Quantitative research employs a structured and objective approach aimed at testing theoretical assumptions by examining measurable relationships between variables. These variables are often quantified using standardized instruments, allowing researchers to apply statistical methods for data analysis. The reporting format typically follows a clear sequence, including the introduction, literature review, methodology, results, and discussion sections. Researchers using this method adopt a deductive approach, emphasizing objectivity, control over external influences, and a focus on replicability and generalizability of findings (Creswell, 2009).

Among the most widely used tools in quantitative studies are surveys, which offer a systematic way of collecting data from a defined group. These instruments consist of predetermined questions and are analysed using descriptive and inferential statistical techniques. According to Busetto, Wick, and Gumbinger (2020), the reliability of survey outcomes largely depends on the method of data collection, whether online platforms, telephone interviews, postal surveys, or face-to-face sessions. Factors such as time constraints, financial resources, and operational challenges often dictate the choice of

method. Moreover, a high response rate from the targeted population is essential to ensure the validity and reliability of the survey findings.

3.3 Justification of Selection

Quantitative research methodology was selected for this study to investigate the impact of an aging workforce on the construction industry in Malaysia, as it allows for systematic measurement and statistical analysis aligned with the research objectives. These objectives include examining the effects of an aging workforce, identifying the challenges faced by construction companies due to an aging workforce, and proposing strategies for construction companies to adapt to these changes. The quantitative approach enables the collection of data from a wide sample of respondents using structured questionnaires, ensuring diverse perspectives from different demographic and construction professional backgrounds. This approach is particularly effective for identifying patterns, making comparisons, and establishing correlations between variables such as age, job role, company size, and perceptions of workforce challenges.

By employing Likert-scale questions, the study can quantify respondents' views on how aging impacts productivity, safety, and technology adaption while also ranking the severity of various challenges. Additionally, statistical tools can be used to evaluate the level of agreement or support for proposed strategies, such as training programs. The standardised nature of quantitative research helps reduce researcher bias, ensures consistency across responses, and produces results that can be generalized to a larger population. Furthermore, this method is time-efficient and scalable, making it highly suitable given the study's aim to provide data-driven insights for industry practices.

In contrast, qualitative research methods were not selected because they are less suitable for achieving the specific objectives of this study. Qualitative approaches focus on obtaining detailed, in-depth insights from a smaller number of participants, which limits the ability to generalize findings across the construction industry. While they are valuable for exploring individual experiences, qualitative methods are inherently subjective and may introduce bias during data interpretation. Additionally, open-ended interviews

or focus group discussions are time-consuming and resource-intensive in ranking or quantifying factors such as perceived challenges or the effectiveness of adaptation strategies.

3.4 Literature Review

According to McColl-Kennedy et al. (2017), a literature review is a systematic and structured method of identifying, organizing, and evaluating existing research related to a specific topic. It plays a vital role in establishing the foundation for new research by highlighting existing knowledge, identifying research gaps, and consolidating findings within a discipline (McColl-Kennedy et al., 2017). This review method supports the development of theoretical frameworks and informs the direction of current studies by integrating diverse viewpoints from prior research.

This study applied the six-step literature review process as synthesized by Durach, Kembro and Wieland (2017), and later refined by Sauer and Seuring (2023). The first step involved defining the review topic based on the study's aim, to explore the effects of an aging workforce in Malaysia's construction industry. In the second step, inclusion and exclusion criteria were established, focusing on peer-reviewed empirical studies published within the last 5 to 10 years. Only journal articles or academic books addressing the impact, challenges, or strategic adaptation to an aging construction workforce in Malaysia were selected. The unit of analysis was individual papers that employed quantitative or mixed methods.

For step three, relevant literature was sourced from academic databases such as ScienceDirect, Emerald, ResearchGate, and Google Scholar. In step four, articles were screened for relevance by examining their abstracts, research background, and literature reviews. The selected studies were then evaluated and synthesized in step five. Findings were categorized into three thematic sections: the effects of an aging workforce in construction, challenges faced by companies, and proposed adaptation strategies. These themes were illustrated in Figure 2.2 to clarify the relationship between the categories. The final step focused on reporting the synthesized literature coherently, emphasizing key

findings, diverse academic perspectives, and recent research trends. All sources were cited appropriately to ensure academic integrity.

3.5 Quantitative Data Collection

A quantitative approach was employed in this study to obtain measurable and statistically analysable data. To gather the necessary information, a structured questionnaire was utilized as the primary data collection tool.

3.5.1 Questionnaire Design

The questionnaire used in this study was divided into four main sections: Section A, Section B, Section C, and Section D. Section A was structured to collect demographic and professional background information from respondents, including age category, job role and years of experience. Since the targeted respondents were professionals actively engaged in the Malaysian construction industry, this section ensured that the data gathered was contextually relevant.

Sections B, C, and D were designed to align with the three core research objectives of this study. Specifically, Section B focused on assessing the perceived effects of an aging workforce within the construction sector. Section C addressed the challenges that construction firms encounter due to an aging labour demographic. Section D gathered insights into potential strategies that companies could implement to adapt to this demographic shift. Each section presented a series of statements rated using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), enabling participants to express their views based on experience and perception.

A sample of the questionnaire instrument is available in Appendix A for reference. In addition, table 3.1 provides an overview of the contents for each section of the questionnaire.

Table 3.1: Summary of sections in the questionnaire

Section	Question Types	No. of questions	Data Types	Purpose
A	Closed-Ended and Semi-Ended question	6	Nominal	To collect demographic data of respondents.
B	5-Points Likert Scale	11	Ordinal	To achieve objective 1 of the study.
C	5-Points Likert Scale	10	Ordinal	To achieve objective 2 of the study.
D	5-Points Likert Scale	10	Ordinal	To achieve objective 3 of the study.

3.5.2 Sampling Determination

A survey that involves examining every individual within the target population is referred to as a census. However, conducting such a comprehensive study is often impractical due to the large size of most populations. In these situations, it is essential to apply a suitable sampling method to extract a representative subset. According to Krieger (2012), a population refers to all individuals, occurrences, or items within a clearly defined group that share at least one common trait or feature. Therefore, a population must exhibit a unifying characteristic across its members. In research, the population defines the specific group under investigation, aligned with the study's aim and objectives.

To determine a statistically valid and practically feasible sample size for this study on the aging workforce in the Malaysian construction industry, the Cochran formula was employed. This method is widely used when working with large populations and allows for precise estimation based on a predetermined margin of error and confidence level. Using a confidence level of 95% (z-score = 1.96) and drawing from Department of Statistics Malaysia (2024), total construction workforce in Malaysia was identified as 1,272,928 (1.27 million), while the total workforce across all sectors was reported as 16.78 million in 2024. Based on this population size and the proportion of construction

workers (7.6%), the calculated values for p and q were 0.076 and 0.924 respectively. With these figures and a 5% margin of error, the Cochran formula yielded a sample size of approximately 108 respondents.

However, to enhance reliability and generalizability, the Central Limit Theorem (CLT) was also considered. CLT supports that with a sample size of at least 30, the sampling distribution approximates normality, which is critical for making population inferences. Given the study's intent to analyse differences across age groups in the construction industry, the sample was segmented accordingly, with 30 participants targeted per age category. This decision reflects established statistical principles suggesting that larger sample sizes yield more accurate estimates of population parameters and reduce potential sampling error (Salkind, 2010; Oribhabor and Anyanwu, 2023). The calculation using Cochran formula to determine sample size was presented as follow:

$$n = \frac{z^2 pq}{e^2}$$

Where,

n = sample size

z = the z-scores at 95% confidence level, 1.96

p = the proportion of the population with attributes understudy,
= (1,272,928 /16,780,000) = 0.076

q = 1 – p
= 1 – 0.076
= 0.924

e = Margin of error, 5%

$$n = \frac{1.96 \text{ x } ^2 (0.076)\ (0.924)}{0.05\ ^2} = 108$$

3.5.3 Pre-Test

Reynolds, Diamantopoulos and Schlegelmilch (1993) identified the pre-test stage as a critical role in questionnaire development, as it helps evaluate the effectiveness and clarity of the instrument before it is officially distributed to

the target population. This process is conducted to identify and refine any potential issues in wording, structure, or comprehension that may affect the quality of the data collected. For this study, the questionnaire was pre-tested with five construction professionals, including engineers, project executives, and inspectors of works, aged between 22 and 59 years old. Feedback from the pre-test highlighted several concerns, particularly in Section B, which addresses the effects of an aging workforce, and Section C, which focuses on challenges faced by construction companies. Common suggestions included revising overly lengthy statements, standardizing technical terms, and providing clearer instructions. Based on these insights, the questionnaire was refined to improve clarity and professionalism by using concise language, consistent terminology, and more detailed guidance for respondents.

3.5.4 Questionnaire Distribution

The questionnaire, serving as the primary research instrument, was developed using the online survey tool Google Form. To reach the intended participants, the survey link, or uniform resource locator (URL), was distributed through various communication platforms, including email, LinkedIn, and social media channels such as WhatsApp, Facebook, Twitter, and Instagram. The target respondents consisted of construction workers holding diverse job titles such as engineers, architects, and quantity surveyors located within the Klang Valley area. The distribution and data collection process were carried out over a five-week period.

3.6 Data Analysis

Data analysis is a structured process of interpreting and organizing information to draw meaningful conclusions. In this study, responses were analysed using Statistical Package for the Social Sciences (SPSS) through five statistical tests. Cronbach's Alpha to assess reliability, Arithmetic Mean to determine central tendency, Mann–Whitney U and Kruskal–Wallis to identify group differences, and Spearman's Correlation to examine associations. Together, these analyses validated the data and provided insights into the effects, challenges, and strategies related to the aging workforce in Malaysia's construction industry.

3.6.1 Cronbach's Alpha Reliability Test

Bonett and Wright (2015) described Cronbach's alpha, introduced by Cronbach (1951), as one of the most widely applied measures for evaluating the reliability or internal consistency of questionnaire items. It determines how effectively a set of items captures a unidimensional construct by testing the extent to which they yield consistent results. Cronbach's alpha is particularly valuable for assessing coherence among test items, with values above 0.70 generally regarded as acceptable and values around 0.85 considered excellent, though ranges between 0.65 and 0.85 may still be valid depending on context. In this study, Cronbach's alpha was employed to test the reliability of the questionnaire developed to address three key objectives, to examine the effects of an aging workforce in the construction industry, to identify the challenges faced by construction companies due to an aging workforce, and to propose strategies for construction companies to adapt to an aging workforce. The test ensured that the items related to each objective demonstrated acceptable internal consistency and measured their intended constructs reliably.

3.6.2 Arithmetic Mean Test

According to Marnich (2008), the arithmetic mean is a statistical measure of central tendency that represents the average value of a dataset and provides a simple yet effective way to summarize quantitative responses. In this study, the mean was employed to analyse the perceived effects of the aging workforce, the challenges faced by construction companies, and the strategies proposed to adapt to an aging workforce. As the questionnaire responses were collected using Likert-scale items, the mean is particularly suitable because it allows ordinal data to be treated as interval-level measurements, enabling clearer comparisons across different factors. By calculating the mean values, this study was able to identify which effects, challenges, and strategies were perceived as most critical by respondents, offering a concise representation of overall industry perceptions.

3.6.3 Spearman's Correlation Test

Spearman's correlation coefficient is a non-parametric statistical method used to measure the strength and direction of a monotonic relationship between two ranked variables (Ali and Al-Hameed, 2022). Unlike parametric techniques, it does not assume linearity or normal distribution, making it particularly suitable for ordinal data such as Likert-scale responses. The coefficient ranges from -1 to +1, where values near +1 indicate a strong positive relationship, values near -1 represent a strong negative relationship, and values around zero suggest little to no association. Interpretation of the values provides practical insights into the strength of the relationship. A coefficient above 0.70 reflects a very strong association, 0.40–0.69 indicates a strong relationship, 0.30–0.39 suggests a moderate link, 0.20–0.29 represents a weak relationship, and values below 0.20 imply little or no meaningful correlation. This study applied Spearman's correlation to identify significant relationships between the challenges of an aging workforce and the strategies for construction companies to adapt to an aging workforce. By doing so, it highlighted which strategies were most strongly aligned with specific workforce challenges, thereby offering evidence-based recommendations for targeted interventions in the Malaysian construction industry.

3.6.4 Kruskal-Wallis Test

The Kruskal–Wallis Test, as described by Ostertagová, Ostertag and Kováč (2014), is a non-parametric alternative to the one-way ANOVA and is used to determine whether statistically significant differences exist in a dependent variable across two or more independent groups. In this study, the independent variables were respondents' position, profession, and organization size, while the dependent variables were their perceptions of the aging workforce in terms of effects, challenges, and strategies, measured using a Likert scale. The test was applied to evaluate variations in perceptions of the aging workforce among construction professionals based on their organizational roles and professional backgrounds.

Two hypotheses were established for the analysis. The null hypothesis (H_0) states that there are no statistically significant differences in perceptions of

the aging workforce across position, profession, or organization size. In contrast, the alternative hypothesis (H_1) posits that such differences do exist among these groups. By applying this test, the study identified whether workforce perceptions vary meaningfully according to demographic and organizational characteristics, thereby providing insights into how professional roles and firm size shape views on the challenges and strategies of an aging workforce (Ostertagová, Ostertag and Kováč, 2014).

3.6.5 Mann Whitney U Test

The Mann–Whitney U Test, as described by MacFarland and Yates (2016), is a non-parametric alternative to the independent samples t-test. It is used to determine whether there are statistically significant differences between two independent groups when the dependent variable is measured at an ordinal or continuous level but does not meet the assumptions of normality. In this study, the independent variables were the respondents' age groups and years of experience, while the dependent variables included perceptions of the effects, challenges, and strategies related to the aging workforce, assessed using a Likert scale. The test was applied to evaluate variations in perceptions between younger and aged professionals, as well as between early and late career respondents.

To conduct the analysis, two hypotheses were established. The null hypothesis (H_0) assumes that no significant differences exist in perceptions of the aging workforce between the two groups. Conversely, the alternative hypothesis (H_1) posits that such differences are present. By employing this test, the study was able to determine whether generational and experiential factors meaningfully influence how construction professionals perceive the impacts, challenges, and strategies associated with an aging workforce.

3.7 Summary of Chapter

To conclude, this study employed a quantitative research approach to effectively address its stated aim and objectives. This method was chosen for its efficiency in gathering large volumes of data within a limited timeframe. Data collection was conducted through the dissemination of structured questionnaires targeted

at construction professionals in the Klang Valley region. The subsequent analysis of responses involved several statistical techniques, including Cronbach's Alpha to assess internal consistency, Arithmetic Mean to identify central tendencies, the Mann–Whitney U Test to examine differences between two independent groups, as well as the Kruskal–Wallis Test and Spearman's Correlation Test to evaluate variations and relationships across broader demographic factors.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter analyses data from Klang Valley construction professionals, covering demographics, questionnaire reliability, and perceptions of effects, challenges, and strategies of the aging workforce. Statistical tests including the Arithmetic Mean, Mann–Whitney U, Kruskal–Wallis, and Spearman's Correlation were applied to identify group differences and relationships.

4.2 Demographic Background of Respondents

A total of 113 responses were collected from construction professionals within the Klang Valley. The demographic and background information of the respondents is presented in Table 4.1.

Table 4.1: Summary of Respondents' Demographics

Demographic Information	Categories	Frequency (n)	Percentage (%)
Company Business	Consultant	29	25.7
	Contractor	31	27.4
	Developer	29	25.7
	Sub-Contractor/Supplier	24	21.2
Position	Assistant Director / Technical Director	13	11.5
	Director	8	7.1
	Junior Executive	25	22.1
	Manager / Team Leader / Supervisor	32	28.3
	Senior Executive	35	31.0

Table 4.1 (Continued)

Demographic Information	Categories	Frequency (n)	Percentage (%)
Profession	Architect	26	23
	Quantity Surveyor	29	25.7
	Engineer	33	29.2
	Others	25	22.1
Age Group	22 – 30 years old	28	24.8
	31 – 45 years old	46	40.7
	46 - 59 years old	27	23.9
	60 years old and above	12	10.6
Years of experience	1 – 5 years	32	28.3
	6 – 10 years	23	20.4
	11 – 15 years	20	17.7
	16 – 20 years	14	12.4
	More than 20 years	24	21.2
Organization Size	Less than 5 employees	5	25.7
	5 - 29 employees	40	27.4
	30 - 75 employees	31	27.4
	More than 75 employees	37	21.2

Table 4.1 summarises the demographic profile of the 113 construction professionals who participated in the survey. In terms of company business, the distribution was relatively even, with contractors representing 27.4% of respondents, consultants and developers each accounting for 25.7%, and sub-contractors or suppliers comprising 21.2%. By professional role, engineering formed the largest group (29.2%), followed by quantity surveying (25.7%) and architecture (23.0%), while 22.1% were from other related fields such as project executives, inspectors of works, and allied specialists.

For positions within organisations, senior executives made up 31.0% of the sample, managers, team leaders, and supervisors comprised 28.3%, and junior executives represented 22.1%. A smaller proportion included assistant or technical directors (11.5%) and directors (7.1%). Regarding age, most

respondents were between 31 and 45 years old (40.7%), followed by 22–30 years (24.8%), 46–59 years (23.9%), and 60 years and above (10.6%).

Industry experience varied across the sample, with 28.3% having 1–5 years of experience, 20.4% with 6–10 years, and 17.7% with 11–15 years. Another 12.4% had 16–20 years, while 21.2% possessed more than 20 years of exposure. In terms of organisational size, 4.4% were in micro-enterprises with fewer than 5 employees, 35.4% worked in firms with 5–29 employees, 27.4% were in organisations with 30–75 employees, and 32.7% were employed in large firms with more than 75 staff.

4.3 Cronbach's Alpha Reliability Test

A reliability analysis using Cronbach's Alpha was carried out to examine the internal consistency of the survey data. As presented in Table 4.2, the Cronbach's Alpha value for Section B: Effects of the Aging Workforce on the construction industry was 0.785, while Section C: Challenges of Aging Workforce faced by construction companies and Section D: Strategies for construction companies adapt to an aging workforce recorded values of 0.820 and 0.818, respectively. According to Bonett and Wright (2015), values ranging between 0.7 and 0.8 are considered satisfactory when comparing groups. Therefore, the results suggest that the dataset is reliable and suitable for subsequent analysis.

Table 4.2: Reliability Statistics of Impacts of Aging Workforce on the Construction Industry

Section	Number of Items	Cronbach's Alpha Values
Section B: Effects of an aging workforce in the construction industry.	11	0.785
Section C: Challenges faced by construction companies due to an aging workforce.	10	0.820
Section D: Strategies for construction companies to adapt to an aging workforce.	10	0.818

4.4 Arithmetic Mean Test

The Arithmetic Mean test was carried out to measure the relative importance of the identified effects of an aging workforce (Section A), the level of significance attributed to the challenges it poses (Section B), and the perceived usefulness of the strategies proposed to address these issues (Section C).

4.4.1 Mean Ranking of Effects of Aging Workforce in the Construction Industry

The overall mean ranking of the eleven identified effects of the aging workforce is presented in Table 4.3 The effect with the highest mean score indicates the factor considered most influential by construction professionals in the Klang Valley in shaping perceptions of the aging workforce.

Table 4.3: Mean Ranking of Effects of Aging Workforce in the Construction Industry

Code	Effects of Aging Workforce	Mean	Std. Deviation	Rank
A2	Higher Safety Risk Perception	4.29	0.7157	1
A3	Fatal Injuries Prevention	4.25	0.8077	2
A1	Drivers of Organizational Learning	4.24	0.7592	3
A5	Stronger work ethic	4.17	0.9249	4
A4	Constructive conflict management	4.11	0.8800	5
A8	Skilled Labour Shortages	4.05	0.9896	6
A11	Slow in Adopting Intelligent Technologies	3.92	0.8675	7
A9	Slow Learning Capabilities of Aging workers	3.90	0.9255	8
A10	Age-Based Discrimination (Ageism)	3.88	0.9234	9
A7	Higher risk of Fatal Injuries	3.51	1.0866	10
A6	Low Physical Ability	3.31	1.1958	11

Based on Table 4.3, the effect with the highest mean score was Higher Safety Risk Perception (A2) with a mean score of 4.29. This finding highlights that

safety concerns remain central in construction, as workers perceive greater risks in workplace conditions. Han et al. (2019) reported that workers aged 45 to 56 demonstrated the highest levels of safety risk perception, while Trillo-Cabello, Carrillo-Castrillo and Rubio-Romero (2021) confirmed a significant relationship between age and perceived accident severity and likelihood. Such heightened perceptions are often linked to longer experience, which improves hazard recognition and cautious behaviour (Mučenski et al., 2015).

The second highest effect was Fatal Injuries Prevention (A3) with a mean score of 4.25. This shows the strong value placed on preventive measures aimed at reducing fatalities. Fatal injuries remain a major issue in construction, with fatality rates often used as a benchmark for safety performance (Karimi & Taghaddos, 2020). Despite preventive initiatives, accidents continue to occur disproportionately. Human reliability analysis (HRA) further indicates that personal characteristics such as age, education, and experience influence safety outcomes (Philippart, 2017).

Conversely, the lowest-ranked effect was Low Physical Ability (A6), with a mean score of 3.31. This suggests that reduced physical capacity among workers, often associated with aging, was not regarded as a critical factor compared to other challenges. Kooij et al. (2020) explained that the ability to continue working depends on the balance between job demands and workers' capacities. When physical demands exceed the abilities of aging workers, their health may decline, leading to physical inability to continue working. Conversely, when their knowledge and skills are underutilised, cognitive functions such as memory may weaken, resulting in psychological inability to remain in employment.

The second lowest effect identified was Higher Risk of Fatal Injuries (A7), which recorded a mean score of 3.51. In contrast to the strong emphasis placed on accident prevention, the notion that aging workers are inherently more vulnerable to fatal accidents was not considered a major concern. This suggests that the construction industry has greater confidence in its existing safety management systems, or alternatively, that professionals perceive risk to be more strongly influenced by workplace conditions than by age alone. Supporting this view, Castellucci et al. (2018) observed that organisational

disclosure regarding aging workforce issues remains limited, with such topics receiving little attention in institutional reporting and communication. Similarly, Bravo et al. (2020) highlighted that when it comes to non-fatal injuries, age by itself does not necessarily determine vulnerability. Instead, a range of mediating factors, such as the nature of the industry, specific job roles, individual health conditions, and accumulated work experience may play a more decisive role in shaping injury risks.

4.4.1 Mean Ranking of Challenges Faced by Construction Companies Due to an Aging Workforce.

Table 4.4: Mean Ranking of Challenges Faced by Construction Companies Due to an Aging Workforce.

Code	Challenges of Aging Workforce	Mean	Std. Deviation	Rank
B1	Necessity of health promotion	4.35	0.7992	1
B6	Intergenerational gap	4.26	0.8104	2
B2	Refine working environment	4.23	1.0001	3
B10	Mentoring pressure on senior employees	4.22	0.7287	4
B3	Necessity of Human Resource Practices	4.13	0.9683	5
B7	Lack of innovation	4.05	0.8948	6
B5	Workforce Imbalance	3.88	0.9832	7
B8	Skills obsolescence	3.76	1.0201	8
B4	Barrier to youth employment	3.58	1.1402	9
B9	Low employment participation	3.44	1.1645	10

Based on table 4.4, the highest-ranked challenge was Necessity of Health Promotion (B1) (mean = 4.35), which indicates that respondents placed strong importance on safeguarding the health of aging workers. This highlights the belief that promoting workplace health is essential for sustaining productivity and reducing risks in physically demanding industries. Jinnett et al. (2017)

confirmed that health promotion reduces absenteeism, while Schulte et al. (2018) emphasised its role in prolonging employability among aging workers.

The second most significant challenge was Intergenerational Gap (B6) (mean = 4.26). This suggests that differences in work styles, values, and communication between younger and aging workers are viewed as a critical issue. Adepoju and Aigbavboa (2021) highlighted that such gaps, if unmanaged, can harm collaboration, while Bouwmans et al. (2024) stressed that closing these divides is vital for knowledge transfer and organisational success.

At the lower end, Low Employment Participation (B9) (mean = 3.44) was among the least significant challenges. While recognised, it is not seen as an urgent concern compared to other issues. Jinnett et al. (2017) linked low participation to health-related restrictions, whereas Šrekl (2017) connected it to early retirement trends that reduce long-term engagement of aging workers.

Similarly, Barrier to Youth Employment (B4) (mean = 3.58) was ranked second lowest challenges. This indicates that while the issue of limited opportunities for younger employees is acknowledged, it is not perceived to be as critical as health or intergenerational concerns. Chmelova (2013) examined whether higher labour force participation by aging workers worsens the employment situation for youth and found that a 10 percent increase in older workers' participation correlated with a 1 percentage point decline in youth employment and a 2 percent rise in youth inactivity.

This suggests that prolonged careers among aging workers can contribute to youth unemployment. However, Queiroz (2016) noted that only limited studies directly address the extent of this relationship, leaving the evidence inconclusive. As such, respondents in this study may have considered the impact of aging workers on youth employment to be less pressing compared to other organisational challenges (Rahat, Aliyu and Iwu, 2019).

4.4.2 Mean Ranking of Strategies for Construction Companies to Adapt to an Aging Workforce

Table 4.5: Mean Ranking of Strategies for Construction Companies to Adapt to an Aging Workforce

Code	Strategies of Aging Workforce	Mean	Std. Deviation	Rank
C1	Mentoring & Knowledge Transfer	4.45	0.7558	1
C6	Implement safety measures	4.41	0.7275	2
C5	Wellness and Health Programs	4.34	0.7513	3
C8	Age-Inclusive Culture and Policies	4.30	0.8225	4
C2	Implementation of Job Model	4.30	0.7779	4
C9	Skill Development for aged workers	4.22	0.7408	6
C10	Review Benefits Plan to retain workers	4.19	0.7967	7
C3	Flexible Work Arrangements	4.18	0.8476	8
C7	Assistive Technology Implementation	4.15	0.9470	9
C4	Immigration of Work	3.86	0.9437	10

According to table 4.5, the most significant effect was Mentoring and Knowledge Transfer (C1), with a mean value of 4.45. This result highlights that respondents placed strong emphasis on the role of knowledge sharing between generations in sustaining organisational growth. Mentoring not only preserves valuable tacit knowledge but also ensures that critical skills and experiences are effectively passed on to younger professionals. Supporting this view, Nkomo, Thwala, and Aigbavboa (2018) stressed that mentoring serves as a cornerstone of employee development, fostering continuous learning while bridging generational gaps. By enabling younger workers to learn directly from seasoned employees in real-world contexts, mentoring promotes competence, confidence, and long-term workforce resilience.

Closely following, Implement Safety Measures (C6), recorded a mean score of 4.41. This reflects the industry's recognition that maintaining safety remains a fundamental priority, particularly as aging workers may face increased vulnerability to site-related hazards. Mneymneh, Abbas, and Khoury (2018) emphasised that integrating advanced tools, such as wearable devices and intelligent recognition systems, significantly improves the protection of construction workers. They further highlighted that consistent adherence to safety protocols, especially the use of personal protective equipment (PPE) like hard hats, is indispensable for reducing accidents linked to falls, head injuries, and electrical risks. The high mean score suggests that respondents strongly associate worker well-being with organisational sustainability, reinforcing the centrality of safety interventions in managing an aging workforce.

At the other end, the lowest-rated effect was Immigration of Work (C4), with a mean value of 3.86. This comparatively lower score implies that respondents viewed reliance on migrant labour as a less effective or less sustainable approach to addressing workforce challenges. While immigration has been shown to increase the overall working-age population, Camarota and Zeigler (2019) argued that it also raises the dependent population, limiting the net benefits to the labour market. This suggests that, from the perspective of respondents, depending on immigration alone does not adequately resolve the long-term issues associated with an aging workforce.

The second-lowest effect was Assistive Technology Implementation (C7), which achieved a mean score of 4.15. Although technology is widely acknowledged as a critical enabler of productivity, the moderate ranking suggests that practical barriers hinder its perceived usefulness in managing aging workers. Karakhan et al. (2020) pointed out that Industry 4.0 technologies, such as the Internet of Things (IoT) and smart devices hold great potential for reducing physical strain and optimising construction workflows. However, Rasouli et al. (2023) noted that challenges such as high costs, complex design requirements, rapid technological advancements, and disagreements on prioritisation often limit successful implementation. The mean score therefore reflects a cautious stance, where respondents recognised the benefits of assistive

technologies but also acknowledged the barriers preventing their widespread adoption in practice.

4.5 Mann Whitney U-Test

A Mann–Whitney U Test was conducted to examine differences in perceptions of the effects, challenges, and strategies of an aging workforce across age groups and years of experience. The null hypothesis (H_0) assumes no significant differences exist ($p > 0.05$), whereas the alternative hypothesis (H_1) holds that significant differences are present ($p \leqslant 0.05$).

For age, respondents aged 22 to 30 and 31 to 45 were grouped as "Young," while those aged 46 to 59 and 60 and above were grouped as "Aged." This classification aligns with the Australian HR Institute (2025), which reported that workers as early as 46 years old are increasingly perceived as "aged" due to declining physical capacity and workplace stereotypes.

For years of experience, respondents with less than 10 years were categorized as "Early Career," and those with more than 10 years as "Late Career." This approach is consistent with Hasanzadeh, Esmaeili and Dodd (2017), who used 5–10 years as a threshold to differentiate between lower and higher levels of professional experience.

4.5.1 Effects of an Aging Workforce in the Construction Industry.

A Mann–Whitney U test was conducted in Section B of the questionnaire to evaluate the effects associated with an aging workforce in the construction industry.

4.5.1.1 Mann-Whitney U Test on Age Groups

The respondents were classified into two age categories. Specifically, those aged 22 to 30 and 31 to 45 was grouped as "Young", while those aged 46–59 and 60 and above were grouped as "Aged".

Two hypotheses were formulated for this test:

Null hypothesis (H_0): No significant difference exists between younger and aged construction professionals in their perceptions on effects of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between younger and aged construction professionals in their perceptions on effects of the aging workforce.

Table 4.6: Mann-Whitney U Test of Effects of Aging Workforce across age groups

Code	Effects of Aging Workforce	Mann-Whitney U	Wilcoxon W	Asymp. Sig (2-tailed)
A1	Drivers of Organizational Learning	1034.000	3809.000	0.006
A2	Higher Safety Risk Perception	1046.500	3821.500	0.007
A3	Fatal Injuries Prevention	1038.000	3813.000	0.007
A4	Constructive conflict management	1107.000	3882.000	0.031
A5	Stronger work ethic	1039.000	3814.000	0.008
A8	Skilled Labour Shortages	1091.500	3886.500	0.023
A9	Slow Learning Capabilities of Aging workers	1131.500	3906.500	0.042
A10	Age-Based Discrimination (Ageism)	1111.000	3886.000	0.033

Table 4.6 presents the results of the Mann-Whitney U test, examining differences in perceptions between younger and aged construction professionals on the effects of the aging workforce. The findings reveal that eight out of eleven identified effects demonstrated statistically significant differences between the two age groups. These include A1 = "Drivers of Organisational Learning", A2 = "Higher Safety Risk Perception", A3 = "Fatal Injuries Prevention", A4 = "Constructive Conflict Management", A5 = "Stronger Work Ethic", A8 = "Skilled Labour Shortages", A9 = "Slow Learning Capabilities of Aging Workers", and A10 = "Age-Based Discrimination (Ageism)".

Table 4.7: Mean Ranking of Effects of Aging Workforce across age groups

Code	Effects of Aging Workforce	Age Group	N	Mean Rank	Sum of Ranks
A1	Drivers of Organisational Learning	Young	74	51.47	3809.00
		Aged	**39**	**67.49**	**2632.00**
A2	Higher Safety Risk Perception	Young	74	51.64	3821.50
		Aged	**39**	**67.17**	**2619.50**
A3	Fatal Injuries Prevention	Young	74	51.53	3813.00
		Aged	**39**	**67.38**	**2628.00**
A4	Constructive Conflict Management	Young	74	52.46	3882.00
		Aged	**39**	**65.62**	**2559.00**
A5	Stronger work ethic	Young	74	51.54	3814.00
		Aged	**39**	67.36	2627.00
A8	Skilled Labour Shortages	Young	74	52.25	3866.50
		Aged	**39**	**66.01**	**2574.50**
A9	Slow Learning Capabilities of Aging workers	Young	74	52.79	3906.50
		Aged	**39**	**64.99**	**2534.50**
A10	Age-Based Discrimination (Ageism)	Young	74	52.51	3886.00
		Aged	**39**	**65.51**	**2555.00**

*Bold indicates a higher mean ranking

The Mann–Whitney U test revealed eight effects of the aging workforce showing a significant difference between young and aged professionals. Among which five were positive effects, including A1 = "Drivers of Organisational Learning", A3 = "Fatal Injuries Prevention", A4 = "Constructive Conflict Management", and A5 = "Stronger Work Ethic". Across all positive effects, aged respondents consistently reported higher mean ranks, with the magnitude of difference between the two groups greater than those observed for the negative effects. This is consistent with findings from Hennekam and Dumazert (2021), who emphasised that aging workers contribute significantly to organisational learning through the transfer of tacit knowledge. Similarly, Trillo-Cabello, Carrillo-Castrillo and Rubio-Romero (2021) confirmed a statistically significant relationship between age and the perception of accident

severity and likelihood, underscoring the heightened safety awareness of older workers. In addition, Dodanwala, Shrestha and Santoso (2021) reported that aging workers tend to be more resilient under psychological strain and display greater overall workplace well-being compared to their younger counterparts.

In comparison, three negative effects, A8 = "Skilled Labour Shortages", A9 = "Slow Learning Capabilities of Aging Workers", and A10 = "Age-Based Discrimination (Ageism)" also recorded higher mean ranks among aged respondents. However, the differences between groups were less pronounced than those for positive effects, suggesting that while aged professionals acknowledge the challenges associated with aging, these are perceived with less divergence across age groups. This highlights that the negative impacts of an aging workforce are not dismissed but rather recognised as common industry concerns. This finding aligns with Phuong and Thi Uyen (2019), who noted that a shrinking youth population combined with a growing number of aging workers has reduced the pool of suitable candidates with the required skills. Picchio (2021) further asserted that declining cognitive flexibility undermines the employability of aging workers. Similarly, Kohli et al. (2020) observed that ageism is often rooted in societal beliefs that aging inevitably leads to diminished mental and physical capacity.

4.5.1.2 Mann-Whitney U Test on Years of Experience

The respondents were classified into two age categories. Specifically, those with less than 10 years working experience was grouped as “Early Career”, while those with 10 years working experience and above were grouped as “Late Career”.

Two hypotheses were formulated for this test:

Null hypothesis (H_0): No significant difference exists between early career and late career construction professionals in their perceptions on effects of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between early career and late career construction professionals in their perceptions on effects of the aging workforce.

Table 4.8: Mann-Whitney U Test of Effects of Aging Workforce across years of experiences

Code	Effects of Aging Workforce	Mann-Whitney U	Wilcoxon W	Asymp. Sig (2-tailed)
A1	Drivers of Organizational Learning	1121.000	2661.000	0.002
A2	Higher Safety Risk Perception	1199.000	2739.000	0.010
A5	Stronger work ethic	1050.000	2590.000	0.001
A11	Slow in Adopting Intelligent Technologies	1278.500	2989.500	0.047

Table 4.8 presents the results of the Mann-Whitney U test, examining differences in perceptions of the effects of the aging workforce across years of experience. The findings reveal that four out of eleven effects demonstrated statistically significant differences between the groups. These include A1 = "Drivers of Organisational Learning", A2 = "Higher Safety Risk Perception", A5 = "Stronger Work Ethic", and A11 = " Slow in Adopting Intelligent Technologies".

Table 4.9: Mean Ranking of Effects of Aging Workforce across years of experience

Code	Effects	Experiences	N	Mean Rank	Sum of Ranks
A1	Drivers of Organisational Learning	Early Career	74	48.38	2661.00
		Late Career	**39**	**65.17**	**3780.00**
A2	Higher Safety Risk Perception	Early Career	74	49.80	2739.00
		Late Career	**39**	**63.83**	**3702.00**
A5	Stronger work ethic	Early Career	74	47.09	2590.00
		Late Career	**39**	**66.40**	**3851.00**
A11	Slow in Adopting Intelligent Technologies	**Early Career**	**74**	**62.75**	**3451.50**
		Late Career	39	51.54	2989.50

*Bold indicates a higher mean ranking

The Mann–Whitney U test revealed four effects of the aging workforce showing a significant difference across years of experience. Among these, three were

positive effects, including A1 = "Drivers of Organisational Learning", A2 = "Higher Safety Risk Perception", and A5 = "Stronger Work Ethic". Respondents with longer experience consistently reported higher mean ranks, indicating that experienced professionals place stronger emphasis on knowledge transfer, workplace safety, and disciplined work culture. Burmeister et al. (2018) emphasised that generational diversity fosters opportunities for structured intergenerational knowledge exchange, enhancing both productivity and learning capacity within the workforce. Namian et al. (2022) further confirmed that aging workers tend to perceive workplace risks more acutely than their younger counterparts, which strengthens their commitment to safety. Similarly, Crawford et al. (2010) observed that aging workers often demonstrate greater dependability and dedication, reinforcing their perceived value in maintaining consistent work standards.

In contrast, one negative effect, A11 = " Slow in Adopting Intelligent Technologies", also showed a significant difference across years of experience. Respondents with less experience assigned higher mean ranks, reflecting greater concern about the challenges posed by rapid technological advancements. Sgarbossa (2024) noted that aging workers often require more time and tailored training programs to adapt to new systems effectively, particularly when facing natural declines in memory or processing speed.

4.5.2 Challenges Faced by Construction Companies due to an Aging Workforce.

A Mann–Whitney U test was conducted in Section C of the questionnaire to evaluate the challenges associated with an aging workforce by construction companies.

4.5.2.1 Mann-Whitney U Test on Age Groups

Table 4.10: Mann-Whitney U Test of Challenges of Aging Workforce across age groups

Code	Challenges of Aging Workforce	Mann-Whitney U	Wilcoxon W	Asymp. Sig (2-tailed)
B1	Necessity of health promotion	1034.000	3809.000	0.006

Table 4.11 (Continued)

Code	Challenges of Aging Workforce	Mann-Whitney U	Wilcoxon W	Asymp. Sig (2-tailed)
B3	Necessity for Human Resource Practices	1046.500	3821.500	0.007
B5	Workforce Imbalance	1038.000	3813.000	0.007
B6	Intergenerational gap	1107.000	3882.000	0.031
B7	Lack of innovation	1039.000	3814.000	0.008
B10	Mentoring pressure on senior employees	1091.500	3886.500	0.023

Table 4.10 presents the results of the Mann-Whitney U test, examining differences in perceptions of the challenges of the aging workforce across age groups. The findings reveal six challenges demonstrated statistically significant differences between the groups. These include B1 = "Necessity of Health Promotion", B3 = "Necessity for Human Resource Practices", B5 = "Workforce Imbalance", B6 = "Intergenerational Gap", B7 = "Lack of Innovation", and B10 = "Mentoring Pressure on Senior Employees".

Table 4.12: Mean Ranking of Challenges of Aging Workforce across age groups

Code	Challenges	Age Group	N	Mean Rank	Sum of Ranks
B1	Necessity of health promotion	Young	74	52.82	3909.00
		Aged	**39**	**64.92**	**2532.00**
B3	Necessity for Human Resource Practices	Young	74	52.88	3913.00
		Aged	**39**	**64.82**	**2528.00**
B5	Workforce Imbalance	Young	74	52.32	3872.00
		Aged	**39**	**65.87**	**2569.00**
B6	Intergenerational gap	Young	74	52.57	3890.00
		Aged	**39**	**65.41**	**2551.00**

Table 4.13 (Continued)

Code	Challenges	Age Group	N	Mean Rank	Sum of Ranks
B7	Lack of innovation	Young	74	50.84	3762.00
		Aged	**39**	**68.69**	**2679.00**
B10	Mentoring pressure on senior employees	Young	74	51.45	3807.00
		Aged	**39**	**67.54**	**2634.00**

*Bold indicates a higher mean ranking

The Mann–Whitney U test results indicate that six challenges of the aging workforce demonstrated statistically significant differences between younger and aged construction professionals. These included B1 = "Necessity of Health Promotion", B3 = "Necessity for Human Resource Practices", B5 = "Workforce Imbalance", B6 = "Intergenerational Gap", B7 = "Lack of Innovation", and B10 = "Mentoring Pressure on Senior Employees". Across all six challenges, aged respondents consistently recorded higher mean ranks compared to their younger counterparts, suggesting that aging professionals are more responsive to the difficulties associated with an aging workforce.

The largest disparities were observed in B7 = "Lack of Innovation" and B10 = "Mentoring Pressure on Senior Employees", where aged professionals reported markedly stronger concerns. This highlights their recognition of the difficulties in keeping pace with rapid technological advancements and the burden of being heavily relied upon in mentoring roles. In line with these results, Bouwmans et al. (2024) argued that digital transformation depends heavily on employees' adaptability; however, the pace of skill acquisition among aging workers often lags behind the speed of technological change, leading to innovation bottlenecks. Similarly, Oke, Aigbavboa and Mutshaeni (2017) observed that while senior workers are frequently expected to mentor younger colleagues, practical mentoring effectiveness requires more than technical expertise, thereby increasing psychological and professional pressure on aging employees.

4.5.2.2 Mann-Whitney U Test on years of experience

Table 4.14: Mann-Whitney U Test of Challenges of Aging Workforce across years of experience

Code	Challenges of Aging Workforce	Mann-Whitney U	Wilcoxon W	Asymp. Sig (2-tailed)
B2	Refine working environment	1256.000	2796.000	0.033

Table 4.12 presents the results of the Mann-Whitney U test, examining differences in perceptions of the challenges of the aging workforce across years of experience. The findings reveal only one challenges demonstrated statistically significant differences between the groups which is B2 = "Refine working environment".

Table 4.15: Mean Ranking on Challenges of Aging Workforce across years of experience

Code	Challenges	Experiences	N	Mean Rank	Sum of Ranks
B2	Refine working environment	Early Career	55	50.84	2796.00
		Late Career	**58**	**62.84**	**3645.00**

*Bold indicates a higher mean ranking

The Mann–Whitney U test results show that B2 = "Refine working environment" demonstrated a statistically significant difference across years of experience. Less experienced professionals recorded a lower mean rank compared to experienced professionals, indicating that those with more years of experience place greater emphasis on structured health promotion initiatives. This suggests that experienced professionals are more attuned to the health implications of aging within the workforce and view proactive health measures as critical for sustaining productivity and employability. Farr-Wharton et al. (2023) pointed out that the physical work environment is not the sole concern, organizational structure and culture also significantly shape aging workers' willingness to remain employed., while Peng and Chan (2020) emphasised its role in

prolonging the active participation of aging workers in physically demanding sectors such as construction.

4.5.3 Strategies for Construction Companies to Adapt to an Aging Workforce.

A Mann–Whitney U test was conducted in Section D of the questionnaire to assess the strategies for construction companies to adapt to an aging workforce.

4.5.3.1 Mann-Whitney U Test on Strategies of aging workforce across age groups

Table 4.16: Mann-Whitney U Test of Strategies of Aging Workforce across age groups

Code	Strategies of Aging Workforce	Mann-Whitney U	Wilcoxon W	Asymp. Sig (2-tailed)
C5	Wellness and Health Programs	1055.000	3830.000	0.010

Table 4.14 presents the results of the Mann–Whitney U test, examining differences in perceptions of the strategies of the aging workforce across years of experience. The findings reveal that C5 = "Wellness and Health Programs" demonstrated a statistically significant difference between the groups.

Table 4.17: Mean Ranking on Strategies of Aging Workforce across age groups

Code	Strategies	Age Group	N	Mean Rank	Sum of Ranks
C5	Wellness and Health Programs	Young	74	51.76	3830.00
		Aged	**39**	**66.95**	**2611.00**

*Bold indicates a higher mean ranking

The Mann–Whitney U test results show that C5 = "Wellness and Health Programs" demonstrated a statistically significant difference across age groups. Younger professionals recorded a lower mean rank than their aged counterparts, indicating that aging workers place greater importance on structured wellness

initiatives. This suggests that they are more aware of the health challenges associated with prolonged working lives and view proactive wellness measures as vital for sustaining employability and well-being. Magnavita et al. (2018) highlighted the workplace as a key setting for health promotion, particularly in preventing occupational decline among aging workers. Consistently, Tonnon et al. (2018) identified ergonomic measures, health-focused practices, personal development, and work organisation as essential strategies for supporting long-term employability in the construction sector.

4.5.3.2 Mann-Whitney U Test on Strategies of aging workforce across years of experience

Table 4.18: Mann-Whitney U Test of Strategies of Aging Workforce across years of experience

Code	Strategies of Aging Workforce	Mann-Whitney U	Wilcoxon W	Asymp. Sig (2-tailed)
C1	Mentoring & Knowledge Transfer	1194.000	2734.000	0.009
C6	Implement safety measures	1083.000	2623.000	0.001

Table 4.16 presents the results of the Mann–Whitney U test, examining differences in perceptions of the strategies for managing the aging workforce across years of experience. The findings reveal that two strategies demonstrated statistically significant differences between the groups. These include C1 = "Mentoring and Knowledge Transfer" and C6 = "Implement Safety Measures".

Table 4.19: Mean Ranking on Strategies of Aging Workforce across years of experience.

Code	Strategies	Experiences	N	Mean Rank	Sum of Ranks
C1	Mentoring & Knowledge Transfer	Early Career	55	49.71	2734.00
		Late Career	**58**	**63.91**	**3707.00**

Table 4.20 (Continued)

Code	Strategies	Experiences	N	Mean Rank	Sum of Ranks
C6	Implement safety measures	Early Career	55	47.69	2623.00
		Late Career	**58**	**65.83**	**3818.00**

*Bold indicates a higher mean ranking

The Mann–Whitney U test results indicate that C1 = "Mentoring and Knowledge Transfer" and C6 = "Implement Safety Measures" demonstrated statistically significant differences across years of experience, with late-career professionals recording substantially higher mean ranks than their early-career counterparts. The magnitude of the differences suggests that experienced workers attach far greater importance to both mentoring responsibilities and structured safety initiatives. This reflects their recognition that sustaining an aging workforce requires not only knowledge continuity but also proactive protection against occupational risks.

The stronger emphasis on mentoring highlights the pivotal role of late-career professionals in transferring tacit knowledge, skills, and industry judgement to younger colleagues. Otasowie and Oke (2024) explained that tacit knowledge, being deeply personal and experience-driven, cannot be fully captured in manuals but instead requires interpersonal exchange facilitated through mentoring. Similarly, the greater priority placed on safety reflects an acute awareness of heightened risks faced by aging workers in physically demanding environments. Fan et al. (2023) supported this view, noting that innovations such as real-time early-warning systems can significantly reduce hazards, reinforcing the perception among experienced professionals that safety measures are indispensable for extending employability and well-being.

4.6 Kruskal-Wallis Test

The Kruskal–Wallis test was conducted to assess significant differences in perceptions of the aging workforce across position, profession, and organizational size, with $p \leqslant 0.05$ as the threshold.

Positions were categorized into Assistant Director/Technical Director, Director, Junior Executive, Manager/Team Leader/Supervisor, and Senior Executive, aligning with Peng et al. (2022), who highlighted that managerial hierarchy influences workforce supervision and decision-making capacity.

Professions were divided into Architect, Engineer, Quantity Surveyor, and others related professions, consistent with Mahmood et al. (2023), who these consultant groups in analysing professional perceptions on project delivery and workforce issues.

Organizational size was classified into micro (<5 employees), small (5–29 employees), medium (30–75 employees), and large (>75 employees), as supported by Kamaruddeen, Yahaya and Mohd Nawi (2023), who noted that firm size determines resource capacity, with larger firms more able to implement structured human resource strategies than micro-enterprises.

Accordingly, the critical chi-square values used as reference were 9.488 for position (df = 4), 7.815 for profession (df = 3), and 7.815 for organizational size (df = 3).

4.6.1 Effects of an Aging Workforce in the Construction Industry.

A Kruskal–Wallis test was conducted to examine differences in the perceived effects of the aging workforce across three variables: position, profession and organization size.

4.6.1.1 Kruskal Wallis Tests on position

Two hypotheses were formulated for this test as follows:

Null hypothesis (H_0): No significant difference exists between different position of construction professionals in their perceptions on effects of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between different position of construction professionals in their perceptions on effects of the aging workforce.

A Kruskal Wallis tests was conducted on position. However, the results showed that there is no significant difference observed. Thus, the null hypothesis is failed to reject.

4.6.1.2 Kruskal Wallis Tests on profession.

Two hypotheses were formulated for this test as follows:

Null hypothesis (H_0): No significant difference exists between different profession of construction professionals in their perceptions on effects of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between different profession of construction professionals in their perceptions on effects of the aging workforce.

A Kruskal Wallis tests was conducted on profession. However, the results showed that there is no significant difference observed. Thus, the null hypothesis is failed to reject.

4.6.1.3 Kruskal Wallis Tests on organization size.

Two hypotheses were formulated for this test as follows:

Null hypothesis (H_0): No significant difference exists between different organisation size of construction professionals in their perceptions on effects of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between different organisation size of construction professionals in their perceptions on effects of the aging workforce.

Table 4.21: Kruskal Wallis Test on Effects of Aging Workforce across organization size.

Code	Effect of Aging Workforce	Kruskal-Wallis H	df	Asymp. Sig
A5	Stronger work ethic	10.109	3	0.018

Table 4.18 presents the results of the Kruskal–Wallis test. The analysis revealed that one effect of the aging workforce recorded a p-value below 0.05. This effect was A5 = “Stronger Work Ethic.” Accordingly, the null hypothesis (H_0) is rejected for this item.

Table 4.22: Mean Rank on the Effects of Aging Workforce across organization size

Code	Effect	Size	N	Mean Rank
A5	Stronger work ethic	**Small**	**5**	**59.40**
		Micro	*40*	*55.76*
		Medium	31	56.63
		Large	37	58.32

Note: **Bold** indicates the highest mean rank

Italic indicates the lowest mean rank

Table 4.19 shows the mean rankings for A5 = "Stronger Work Ethic" across different organization sizes. The highest mean rank was observed among professionals in small firms (<5 employees), followed by those in large organizations (>75 employees). Medium-sized organizations (30–75 employees) recorded slightly lower mean rankings, while the lowest was reported in micro-sized firms (5–29 employees). This distribution suggests that stronger work ethic is particularly valued in very small firms, where every worker's contribution is critical, and in large firms, where discipline and reliability are essential to managing complex operations. Medium-sized firms still recognize this effect but to a slightly lesser degree, while micro-sized firms may place greater emphasis on other operational challenges. Supporting this, Crawford et al. (2010) emphasized that aging workers are generally more dependable and dedicated, while the Office of Industrial Relations (2019) noted that they also display lower absenteeism and turnover rates, contributing to workplace stability and problem-solving capacity.

4.6.2 Challenges Faced by Construction Companies due to an Aging Workforce.

A Kruskal–Wallis test was conducted to examine differences in the perceived challenges of the aging workforce across three variables: position, profession and organization size.

4.6.2.1 Kruskal Wallis Tests on position

Two hypotheses were formulated for this test as follows:

Null hypothesis (H_0): No significant difference exists between different position of construction professionals in their perceptions on challenges of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between different position of construction professionals in their perceptions on challenges of the aging workforce.

Table 4.23: Kruskal Wallis Test on Challenges of Aging Workforce across Position.

Code	Challenge of Aging Workforce	Kruskal-Wallis H	df	Asymp. Sig
B7	Lack of innovation	9.761	4	0.045

Table 4.20 presents the results of the Kruskal–Wallis test. The analysis revealed that one challenge of the aging workforce recorded a p-value below 0.05. This effect was B7 = "Lack of innovation". Accordingly, the null hypothesis (H_0) is rejected for this item.

Table 4.24: Mean Rank on the Challenges of Aging Workforce across Position

Code	Challenge	Position	N	Mean Rank
B7	Lack of innovation	**Assistant Director / Technical Director**	**13**	**71.08**
		Director	8	57.00
		Junior Executive	25	60.12
		Manager / Team Leader / Supervisor	*32*	*51.88*
		Senior Executive	35	54.23

Note: **Bold** indicates the highest mean rank

Italic indicates the lowest mean rank

Table 4.21 presents the mean rankings for B7 = "Lack of Innovation" across different position groups. The results indicate that Assistant Directors and Technical Directors recorded the highest mean rank, suggesting that those in senior technical leadership roles perceive the lack of innovation as a more pressing challenge compared to other groups. Junior Executives and Directors

followed, though with lower mean values, while Managers, Team Leaders, Supervisors, and Senior Executives reported the lowest mean ranks. This pattern implies that individuals at higher technical and decision-making levels are more attuned to the challenges posed by insufficient innovation, likely because of their involvement in strategic planning and technology adoption. In contrast, mid-level managerial and supervisory roles may focus more on operational performance and workforce coordination, which could explain their relatively lower concern for innovation-related issues.

Supporting this interpretation, de Vries, Tummers and Bekkers (2018) argued that senior managers play a decisive role in innovation adoption through their control over resources and their influence on high-level decisions, making them either strong enablers or barriers to innovation. Similarly, Chang and Wu (2021) observed that directors' oversight can limit executives' discretion over strategic decisions, particularly those related to innovation, reinforcing the notion that leadership positions hold greater responsibility in shaping organizational capacity for innovation.

4.6.2.2 Kruskal Wallis Tests on profession.

Two hypotheses were formulated for this test as follows:

Null hypothesis (H_0): No significant difference exists between different profession of construction professionals in their perceptions on challenges of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between different profession of construction professionals in their perceptions on challenges of the aging workforce.

A Kruskal Wallis tests was conducted on profession. However, the results showed that there is no significant difference observed. Thus, the null hypothesis is failed to reject.

4.6.2.3 Kruskal Wallis Tests on organization size.

Two hypotheses were formulated for this test as follows:

Null hypothesis (H_0): No significant difference exists between different organisation size of construction professionals in their perceptions on challenges of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between different organisation size of construction professionals in their perceptions on challenges of the aging workforce.

A Kruskal Wallis tests was conducted on organization size. However, the results showed that there is no significant difference observed. Thus, the null hypothesis is failed to reject.

4.7 Strategies for Construction Companies to Adapt to an Aging Workforce

Kruskal–Wallis test was conducted to examine differences in the perceived strategies for construction companies to adapt to an aging workforce across three variables: position, profession and organization size.

4.7.1.1 Kruskal Wallis Tests on position

Two hypotheses were formulated for this test as follows:

Null hypothesis (H_0): No significant difference exists between different position of construction professionals in their perceptions on strategies of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between different position of construction professionals in their perceptions on strategies of the aging workforce.

Table 4.25: Kruskal Wallis Test on Strategies of Aging Workforce across Position.

Code	Strategy of Aging Workforce	Kruskal-Wallis H	df	Asymp. Sig
C2	Implementation of Job Model	9.981	4	0.041

Table 4.22 presents the results of the Kruskal–Wallis test. The analysis revealed that one strategy of the aging workforce recorded a p-value below 0.05. This effect was C2 = "Implementation of Job Model". Accordingly, the null hypothesis (H_0) is rejected for this item.

Table 4.26: Mean Rank on the Strategies of Aging Workforce across Position

Code	Strategy	Position	N	Mean Rank
C2	Implementation of Job Model	**Assistant Director / Technical Director**	**13**	**70.62**
		Director	*8*	*38.81*
		Junior Executive	25	46.16
		Manager / Team Leader / Supervisor	32	61.41
		Senior Executive	35	59.81

Note: **Bold** indicates the highest mean rank

Italic indicates the lowest mean rank

Table 4.23 presents the mean rankings for C2 = "Implementation of Job Model" across different position groups. The results show that Assistant Directors and Technical Directors recorded the highest mean rank, indicating that these roles perceive the adoption of structured job models as particularly important for managing an aging workforce. Managers, Team Leaders, and Supervisors, together with Senior Executives, also reported relatively high mean rankings, reflecting an acknowledgment of the benefits that clear role definitions and structured responsibilities bring to sustaining productivity. Conversely, Junior Executives and Directors recorded the lowest mean ranks, suggesting either limited engagement with strategic workforce planning or a perception that job models hold less immediate relevance to their roles.

Supporting these findings, Li, Zhang and Xiong (2020) observed that job characteristics significantly shape workers' psychological experiences, influencing how they perceive task value, maintain engagement, and interpret performance clarity. Likewise, Dimovski, Grah and Colnar (2019) introduced a demographic-based multiple decrement model to predict workforce transitions and productivity states across age cohorts. Their work underscores the

importance of job frameworks that adapt to varying productivity capacities, particularly in the context of an aging workforce where task demands must align with evolving worker capabilities.

4.7.1.2 Kruskal Wallis Tests on profession

Two hypotheses were formulated for this test as follows:

Null hypothesis (H_0): No significant difference exists between different profession of construction professionals in their perceptions on strategies of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between different profession of construction professionals in their perceptions on strategies of the aging workforce.

Table 4.27: Kruskal Wallis Test on Strategies of Aging Workforce across Profession.

Code	Strategy of Aging Workforce	Kruskal-Wallis H	df	Asymp. Sig
C9	Skill Development for aged workers	7.985	3	0.046

Table 4.22 presents the results of the Kruskal–Wallis test. The analysis revealed that one strategy of the aging workforce recorded a p-value below 0.05. This effect was C9 = “Skill Development for aged workers”. Accordingly, the null hypothesis (H_0) is rejected for this item.

Table 4.28: Mean Rank on the Strategies of Aging Workforce across Profession

Code	Strategies	Position	N	Mean Rank
C9	Skill Development for aged workers	Architect	26	55.92
		Engineer	**33**	**65.18**
		Quantity Surveyor	29	60.40
		Others	*25*	*43.38*

Note: **Bold** indicates the highest mean rank

Italic indicates the lowest mean rank

Table 4.25 shows the mean rankings for C9 = “Skill Development for Aged Workers” across different professional backgrounds. The findings reveal that Engineers recorded the highest mean rank, followed by Quantity Surveyors and Architects, suggesting that technical professions place stronger emphasis on continuous upskilling of aging workers. This reflects the dynamic nature of engineering and surveying tasks, which are heavily impacted by technological advancements and evolving industry standards, making skill renewal essential for sustaining performance. By contrast, respondents categorised under other related professions reported the lowest mean rank, indicating that in certain supporting or less technically intensive roles, skill development for aging workers may be seen as less immediately critical.

Consistent with these results, Gardiner and Chen (2022) argued that training is vital for maintaining the productivity and employability of aging workers, though it is often less prioritised compared to younger employees. Likewise, Nagarajan and Sixsmith (2023) emphasised that structured on-the-job training and the acquisition of technological skills are particularly important in addressing the productivity challenges faced by aging workers. Providing appropriate opportunities for learning enables older employees to overcome physical or cognitive limitations while adapting to technological change, particularly in fields such as engineering where Industry 4.0 is rapidly reshaping work practices.

4.7.1.3 Kruskal Wallis Tests on organization size.

Two hypotheses were formulated for this test as follows:

Null hypothesis (H_0): No significant difference exists between different organisation size of construction professionals in their perceptions on strategies of the aging workforce.

Alternative hypothesis (H_1): A significant difference exists between different organisation size of construction professionals in their perceptions on strategies of the aging workforce.

Table 4.29: Kruskal Wallis Test on Strategy of Aging Workforce across organization size.

Code	Strategies of Aging Workforce	Kruskal-Wallis H	df	Asymp. Sig
C1	Mentoring & Knowledge Transfer	9.988	3	0.019
C7	Assistive Technology Implementation	12.656	3	0.005

Table 4.26 presents the results of the Kruskal–Wallis test, examining differences in strategies of adapting to an aging workforce across organization sizes. The analysis revealed two strategies with p-values below 0.05. These were C1 = "Mentoring & Knowledge Transfer" and C7 = "Assistive Technology Implementation." Accordingly, the null hypothesis (H_0) is rejected for both items, indicating that perceptions of these strategies differ significantly depending on the size of the organization.

Table 4.30: Mean Rank on the Strategy of Aging Workforce across organization size

Code	Strategies of Aging Workforce	Size	N	Mean Rank
C1	Mentoring & Knowledge Transfer	*Small*	*5*	*30.40*
		Micro	40	49.91
		Medium	**31**	**65.06**
		Large	37	61.50
C7	Assistive Technology Implementation	*Small*	*5*	*23.70*
		Micro	40	60.78
		Medium	**31**	**67.15**
		Large	37	48.92

Note: **Bold** indicates the highest mean rank

Italic indicates the lowest mean rank

Table 4.27 presents the mean rankings for C1 = "Mentoring & Knowledge Transfer" and C7 = "Assistive Technology Implementation" across different

organizational sizes. For C1, the highest mean rank was reported in medium-sized organizations, followed closely by large firms. This indicates that both medium and large firms place strong emphasis on mentoring as a structured mechanism to transfer tacit knowledge and sustain organizational learning. In contrast, micro-enterprises recorded a lower mean rank, while small organizations reported the lowest, likely due to limited resources and the absence of formal mentoring structures. Otasowie and Oke (2024) noted that tacit knowledge is inherently personal and best transferred through direct interpersonal interaction, while Nkomo, Thwala, and Aigbavboa (2018) highlighted mentoring as essential for employee development and intergenerational learning.

For C7, medium-sized organizations again recorded the highest mean rank, suggesting that they place the strongest focus on adopting assistive technologies to support aging workers. Micro-enterprises also showed relatively high prioritization, whereas large organizations placed less emphasis, possibly due to reliance on existing systems. The lowest ranking was observed among small firms, which often lack the financial and technical capacity to invest in such solutions. Nagarajan and Sixsmith (2023) emphasized that ergonomic tools and digital technologies are transformative in extending the productive working life of aging employees. However, Wilson Lourenço et al. (2025) cautioned that widespread adoption remains limited due to barriers such as high implementation costs, technical complexity, and social stigma, underscoring the importance of tailored approaches suited to different organizational sizes.

4.8 Spearman's Correlation Test

In this section, Spearman's Correlation test is applied to examine the relationship between the challenges posed by an aging workforce in construction companies and the strategies implemented to address these challenges. Table 4.28 presents the correlations between the challenges and strategies related to managing an aging workforce. A total of 77 significant correlations were identified, highlighting the interdependent nature of workforce challenges and organizational responses.

The strongest correlation was observed between **C3 = "Flexible Work Arrangements"** and **B3 = "Necessity of Human Resource Practices"** (ρ = 0.561). This indicates that refining human resource practices is highly dependent on the incorporation of flexible working systems, which accommodate the physical and personal needs of older workers. In practice, this means that organizations must integrate flexibility into human resource policies, such as phased retirement, reduced hours, or job-sharing arrangements. These measures not only extend the employability of aging workers but also reduce turnover costs for firms. Supporting this Nagarajan and Sixsmith (2023) further argued that promoting flexible practices is essential to retaining aging workers with physical limitations.

The second-strongest correlation was found between **C3 = "Flexible Work Arrangements"** and **B2 = "Refine Working Environment"** ($\rho = 0.545$), suggesting that ergonomic improvements and flexible job structures work in tandem to reduce strain and maintain performance among aging workers. This finding underscores that flexibility is not just about working hours but also about rethinking the physical and organizational work environment to suit the needs of an older workforce. For instance, introducing ergonomic tools, redesigning workstations, or modifying task allocation can directly reduce musculoskeletal risks and fatigue. As van Dongen and Loos (2018) demonstrated how companies such as Asda Stores Limited (ASDA) successfully implemented age-specific flexibility through initiatives like "Benidorm leave" and "Grandparent leave," acknowledging life-stage demands. These targeted benefits align with aging workers' evolving priorities, encouraging continued employment without compromising personal obligations.

The third-highest correlation was identified between **C9 = "Skill Development for Aged Workers"** and **B10 = "Mentoring Pressure on Senior Employees"** (ρ = 0.476). This finding reflects the importance of continuous training in reducing the strain placed on aging workers, who are often expected to mentor younger workers while simultaneously adapting to new industry practices. In other words, without opportunities for upskilling, aging workers may experience a dual burden, keeping up with technological advancements while bearing responsibility for knowledge transfer. Training initiatives thus

serve a dual purpose, enabling aging workers to stay relevant and easing the mentoring load by equipping them with updated competencies. Gardiner and Chen (2022) argued that training programs for aging workers remain underutilised despite their proven effectiveness in sustaining employability, while Nagarajan and Sixsmith (2023) stressed that targeted technological training reduces age-related productivity gaps, particularly in industries undergoing digital transformation.

Table 4.31: Correlation between Challenges faced by construction firm due to an aging workforce and strategy for construction companies to adapt to an aging workforce

Strategy \ Challeng	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Total Correlation
C1	.421**	.348**	.378**		.244**	.336**				.467**	**6**
C2	.260**	.479**	.426**		.356**	.291**	.292**		.227*	.355**	**8**
C3	.413**	.545**	.561**		.375**	.323**	.356**	.188*	.268**	.476**	**10**
C4		.196*	.197*	.256**	.253**		.200*	.262**	.331**	.219*	**9**
C5	.443**	.409**	.477**		.312**	.274**	.375**	.212*	.189*	.463**	**10**
C6	.400**	.385**	.298**			.326**		.205*		.320**	**6**
C7	.248**	.296**	.218*		.251**					.314**	**5**
C8	.421**	.437**	.308**		.207*	.242**				.326**	**6**
C9	.243**		.275**		.331**	.466**	.331**	.187*	.204*	.476**	**9**
C10	.342**	.250**	.355**		.341**	.272**	.366**			.410**	**8**

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This concluding chapter provides a comprehensive summary of the study. It begins by outlining the extent to which the research objectives have been achieved, followed by a synthesis of the key findings. The chapter then discusses the theoretical and practical contributions of the study, acknowledges the limitations encountered during the research process, and concludes with recommendations for future investigations in this area.

5.2 Accomplishments of Research Objectives

Malaysia's construction industry faces growing challenges from an aging workforce, a trend accelerated by demographic shifts where individuals aged 65 and above are projected to comprise 16% of the national population by 2030 (Abdullah, Ismail and Yusoff, 2024). While aging workers bring strengths such as experience and mentoring capacity, prior studies highlight key challenges including declining physical ability, higher accident risks, and slower adaptation to new technologies (Ranasinghe et al., 2023; Luo et al., 2025). Research in developed economies has explored strategies like workplace safety adjustments, active aging frameworks, and robotics adoption (Peng and Chan, 2020; Agyekum et al., 2022), yet similar evidence in Malaysia is scarce. To address this gap, this study investigates the effects, challenges, and strategies of an aging workforce in Malaysia's construction sector. A quantitative survey of construction professionals in Klang Valley was conducted, 113 responses were collected and analysed using the Arithmetic Mean, Mann–Whitney U, Kruskal–Wallis, and Spearman's Correlation tests. The following sections summarise how the three research objectives were achieved.

5.2.1 Objective 1: To examine the effects of an aging workforce in the construction industry.

A total of 11 effects of an aging workforce in Malaysia's construction industry were identified in literature review. These include positive contributions such as drivers of organizational learning, higher safety risk perception, fatal injuries prevention, constructive conflict management, and stronger work ethic. On the other hand, negative effects include low physical ability, higher risk of fatal injuries, skilled labor shortages, slow learning capabilities, age-based discrimination (ageism), and slow adoption of intelligent technologies.

The Arithmetic Mean Test revealed that higher mean scores indicated stronger perceived effects of the aging workforce. Among the effects, A5 = "Stronger Work Ethic" consistently ranked among the most highly perceived. The low mean score for 'Slow Learning Capabilities' (A9) indicates that this is perceived as a less prevalent or critical issue compared to other effects

The Mann–Whitney U test identified statistically significant differences across both age groups and years of experience. For age groups, eight effects demonstrated significant differences, namely A1 = "Drivers of Organisational Learning", A2 = "Higher Safety Risk Perception", A3 = "Fatal Injuries Prevention", A4 = "Constructive Conflict Management", A5 = "Stronger Work Ethic", A8 = "Skilled Labour Shortages", A9 = "Slow Learning Capabilities of Aging Workers", and A10 = "Age-Based Discrimination (Ageism)". Aged respondents consistently recorded higher mean ranks across both positive and negative effects, indicating stronger recognition of the contributions and challenges posed by an aging workforce. The largest differences were observed in A1 and A3, where aged professionals emphasised knowledge transfer and safety awareness.

For years of experience, four significant effects were identified: A1 = "Drivers of Organisational Learning", A2 = "Higher Safety Risk Perception", A5 = "Stronger Work Ethic", and A11 = "Limitations in Adopting Intelligent Technologies". Professionals with longer tenure recorded higher mean ranks for positive effects, while less experienced respondents placed greater emphasis on technological limitations. These results suggest that experienced professionals

value knowledge, discipline, and safety contributions of older workers, whereas younger professionals are more concerned about the adaptability of aging employees in a technology-driven industry.

Finally, the Kruskal–Wallis test revealed one significant difference across organization size, with A5 = “Stronger Work Ethic” showing a p-value below 0.05. The highest mean ranks were recorded by both micro-firms with fewer than five employees and large firms with more than 75 employees, highlighting that a strong work ethic is critical in both resource-constrained and complex organizational environments.

5.2.2 Objective 2: To identify the challenges faced by construction companies due to an aging workforce.

The literature review highlighted 10 challenges faced by construction companies in managing an aging workforce. These are the necessity of health promotion, refinement of the working environment, necessity of human resource practices, barriers to youth employment, workforce imbalance, intergenerational gap, lack of innovation, skills obsolescence, low employment participation, and mentoring pressure on senior employees.

The Arithmetic Mean Test demonstrated that the highest-rated challenges included B1 = “Necessity of Health Promotion” and B7 = “Lack of Innovation”, while relatively lower scores were recorded for B4 = “Barrier to Youth Employment”. This suggests that respondents perceive health-related issues and innovation gaps as key challenges arising from an aging workforce.

The Mann–Whitney U test further revealed statistically significant differences between younger and aged professionals for six challenges: B1 = “Necessity of Health Promotion”, B3 = “Necessity for Human Resource Practices”, B5 = “Workforce Imbalance”, B6 = “Intergenerational Gap”, B7 = “Lack of Innovation”, and B10 = “Mentoring Pressure on Senior Employees”. Across all six, aged respondents consistently recorded higher mean ranks, indicating stronger concern about health, innovation, and mentoring burdens. The largest disparities were observed in B7 and B10, reflecting that older professionals are more conscious of the difficulties in keeping pace with technological change and the strain of being relied upon for mentoring roles.

Across years of experience, the Mann–Whitney U test identified one significant challenge: B1 = "Necessity of Health Promotion". Professionals with longer tenure assigned higher mean ranks, suggesting that experienced workers are more aware of the health implications of extended careers in physically demanding environments. Additionally, the Kruskal–Wallis test revealed one significant difference across position groups for B7 = "Lack of Innovation." The highest mean rank was recorded by Assistant and Technical Directors, followed by Junior Executives, while mid-level managers and senior executives recorded lower values. This pattern suggests that top technical leaders are most concerned with innovation challenges, given their involvement in strategic planning and technology adoption.

5.2.3 Objective 3: To propose strategies for construction companies to adapt to an aging workforce.

A total of 10 strategies were identified for effective adaptation of aging workforce in literature review. They include mentoring and knowledge transfer, implementation of job models, flexible work arrangements, immigration of work, wellness and health programs, implementation of safety measures, adoption of assistive technologies, fostering an age-inclusive culture and policies, skill development for aged workers, and reviewing benefits plans to retain workers.

The Arithmetic Mean Test results showed that strategies with the highest mean rankings included C1 = "Mentoring and Knowledge Transfer" and C5 = "Wellness and Health Programs", while lower scores were observed for C4 = "Immigration of Work." This reflects that construction professionals prioritise internal, people-oriented strategies over external workforce solutions.

The Mann–Whitney U test revealed significant differences across both age and experience groups. For age groups, C5 = "Wellness and Health Programs" recorded a significant difference, with aged professionals assigning higher mean ranks, reflecting their stronger emphasis on proactive wellness initiatives. For years of experience, two significant strategies emerged: C1 = "Mentoring and Knowledge Transfer" and C6 = "Implement Safety Measures." In both cases, late-career professionals recorded substantially higher mean ranks,

suggesting that experienced workers place greater importance on intergenerational knowledge sharing and structured safety protocols.

The Kruskal–Wallis test results showed two significant differences across organization size. C1 = “Mentoring and Knowledge Transfer” and C7 = “Assistive Technology Implementation” both recorded p-values below 0.05. Medium-sized firms with 30–75 employees reported the highest mean ranks for both, suggesting that these organizations are most proactive in balancing human-centered mentoring with technological solutions. Micro-firms with fewer than five employees recorded the lowest ranks, likely due to limited resources.

Finally, Spearman’s Correlation analysis identified 77 significant correlations between challenges and strategies, highlighting their interdependent nature. The strongest strategy–challenge relationships were C3 = “Flexible Work Arrangements” and B3 = “Necessity of Human Resource Practices” ($\rho = 0.561$), C3 = “Flexible Work Arrangements” and B2 = “Refine Working Environment” ($\rho = 0.545$), and C9 = “Skill Development for Aged Workers” and B10 = “Mentoring Pressure on Senior Employees” ($\rho = 0.476$). These findings emphasise that flexibility, ergonomics, and continuous training are critical strategies for addressing the dual challenges of innovation gaps, mentoring burdens, and human resource adaptation in an aging workforce.

5.3 Research Contribution

This study provides comprehensive examination on the impact of an aging workforce on the construction industry in Malaysia by examining its effects, identifying the key challenges faced by construction companies, and proposing adaptive strategies for construction companies on aging workforce. The findings of this study provide valuable input for enhancing workforce strategies and ensuring the long-term resilience of Malaysia’s construction industry. These insights support national urgencies outlined in government initiatives such as the Twelfth Malaysia Plan and the Malaysia Madani framework, particularly in addressing demographic shifts within the workforce. Government bodies, including the Ministry of Human Resources (MOHR and relevant advocacy

groups such as the Malaysia Healthy Ageing Society (MHAS), can utilise the findings to inform targeted interventions for aging workers.

From an industry viewpoint, this study serves as a practical reference for construction companies, project managers, and human resource professionals. The findings highlight the operational and organizational challenges arising from an aging workforce, including decreased physical capacity and generational skill gaps. With this knowledge, companies can implement proactive measures such as task restructuring, ergonomic interventions, and mentorship systems to retain experienced workers while ensuring a safe and productive working environment. Furthermore, industry stakeholders can use the proposed strategies to design more inclusive employment practices, enhance workforce planning, and promote knowledge transfer, contribute to sustaining productivity and quality in project delivery.

A methodological strength of this study is the application of the Kruskal–Wallis test, which revealed statistically significant differences in perceptions of aging workforce impacts across various demographic and organizational variables, such as company size, job role, and years of experience. These findings provide a detailed understanding of how workforce aging is perceived differently within the construction industry. For instance, senior site supervisors may report different challenges compared to younger project executives, enabling tailored strategies to be developed for different roles. Additionally, policymakers and training institutions can leverage these insights to create more focused and role-specific upskilling programs, targeted awareness campaigns, and company-level interventions. By anchoring recommendations in data-driven evidence, this research enhances its academic rigour and contributes to the formulation of practical solutions to address one of the most pressing workforce challenges in Malaysia's construction industry.

5.4 Research Limitation

Despite having contribution, this study is subject to several limitations that should be acknowledged. The adoption of a quantitative research design, relying solely on structured questionnaires, may have constrained comprehensiveness of participant perspectives. While the use of closed-ended questions enabled

efficient data analysis and comparison, it limited participants' ability to elaborate on their personal experiences, perceptions, and contextual challenges related to the aging workforce. Consequently, certain nuanced or situational insights may not have been captured, which could have provided a more holistic understanding of the issue.

In addition, the research was geographically limited to the Klang Valley region, which may affect the generalisability of the findings to other parts of Malaysia. Construction practices, workforce dynamics, and demographic patterns may vary between urban and rural areas, and across different states, particularly in East Malaysia such as Sabah and Sarawak. As such, the findings may not fully reflect the challenges or perceptions present in other regions with different labour market conditions, regulatory frameworks, or workforce compositions.

Moreover, while the study successfully identified the effects of an aging workforce and ranked key challenges faced by construction companies, it did not explore in depth the organisational or policy-level constraints that may influence strategy implementation. Without qualitative data such as interviews or case studies, the study was unable to assess how companies are currently responding to workforce aging, nor the practical barriers encountered in implementing age-inclusive policies. As a result, the research offers limited insight into the real-world feasibility and effectiveness of the proposed strategies, which may impact the applicability of the recommendations across varying operational contexts.

5.5 Research Recommendation

Several recommendations are proposed for future research to address the limitations identified in this study. Future studies are encouraged to adopt a mixed-methods approach, combining both quantitative and qualitative techniques. While this study utilised structured questionnaires to obtain measurable data, integrating qualitative methods such as semi-structured interviews or focus group discussions would allow for a more nuanced understanding of how construction professionals experience and perceive the challenges of an aging workforce. This would provide valuable insights into

contextual factors, policy gaps, and company-specific constraints that may not be fully captured through closed-ended questions.

In addition, subsequent research should consider broadening the geographic scope beyond the Klang Valley. Expanding the study to include respondents from a wider range of regions, including East Malaysia and less urbanised states, would improve the generalisability of the findings. Construction practices, workforce compositions, and employer attitudes may vary significantly across regions, and a more geographically diverse sample could uncover regional disparities or localised solutions to managing an aging workforce. Comparative studies between urban centres and rural construction sites could also highlight the different strategies required in varying operational settings.

Another key recommendation is to enhance sampling strategies by reaching out to underrepresented demographic groups, especially older aging workers or those with limited access to digital technology. Future researchers may consider using a combination of online and on-site survey distribution or leveraging professional associations and construction unions to ensure broader participation. This would help capture perspectives that were potentially excluded in this study due to its reliance on digital platforms.

Finally, further research should focus on evaluating the implementation and effectiveness of the proposed strategies for adapting to an aging workforce. This may involve pilot studies within construction firms, stakeholder engagement sessions, or policy simulation exercises to test the feasibility of initiatives such as job redesign, mentorship programs, or ergonomic interventions. Assessing real-world outcomes and potential barriers to adoption will provide practical insights and contribute to more robust, actionable recommendations for both industry and policymakers.

5.6 Summary of Chapter

This chapter has provided an overview of the research context, highlighted the gaps in existing literature, and clearly stated the aim and objectives guiding the study. It also outlined the key contributions made by the research to both theory and practice. Lastly, the limitations encountered during the study were

acknowledged, and several recommendations were proposed to guide future research in addressing these constraints.

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APPENDICES

Appendix A: Questionnaire

Section A: Demographic Section

The following questions refer to the demographic profile of the respondents.

Which of the following best describes your company's business? activities?

○ Developer

○ Consultant

○ Contractor

○ Sub- Contractor / Supplier

○ Others (Please specify):_____

2. Which of the following best describes your profession?

○ Architect

○ Engineer

○ Quantity Surveyor

○ Others (Please specify): _____

3. What is your position in your organization?

○ Junior Executive

○ Senior Executive

○ Manager/ Team Leader / Supervisor

○ Assistant Director / Technical Director

○ Director

○ Others (Please specify):_____

4. What is your age group?

○ Below 21 years old

○ 22 – 30 years old

○ 31 – 45 years old

○ 46 - 59 years old

○ 60 years old and above

5. How long have you been working in the construction industry?

○ 1 – 5 years

○ 6 – 10 years

○ 11 – 15 years

○ 16 – 20 years

○ More than 20 years

6. How many employees are in your organization?

○ Less than 5 employees

○ 5 - 29 employees

○ 30 - 75 employees

○ More than 75 employees

Section B: The Effects of an Aging Workforce in the Construction Industry

This section explores the possible effects of an aging workforce in the construction industry. Based on your current working experience, please indicate the extent to which you agree or disagree with the following statements. [Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5]

Effects of aging	1	2	3	4	5
Aging workers contribute to organizational learning through the sharing of experience and practical knowledge.	○	○	○	○	○
Aging workers perceive safety risks more seriously due to their experience with past site hazards and accidents.	○	○	○	○	○

Aging workers help prevent fatal injuries by applying lessons learned from past incidents and guiding younger workers.	○	○	○	○	○
Aging workers are better at managing workplace conflicts due to their emotional regulation and experience.	○	○	○	○	○
Aging workers are dependable and committed, contributing to greater workforce stability and productivity	○	○	○	○	○
Aging workers are less productive at work due to age-related physical limitations	○	○	○	○	○
Aging workers are at greater risk of fatal injuries due to slower physical responses.	○	○	○	○	○
The retirement of aging workers increases skilled labor shortages due to the loss of experience without adequate replacement.	○	○	○	○	○
Aging workers face challenges in learning new skills due to cognitive decline and reduced adaptability to change.	○	○	○	○	○
Aging workers are more likely to face discrimination based on assumptions of declining capability.	○	○	○	○	○
Aging workers have difficulty adapting to intelligent construction technologies due to limited digital literacy.	○	○	○	○	○

Section C: The Challenges Faced by Construction Companies Due to an Aging Workforce

This section explores the challenges faced by construction companies due to an aging workforce. Based on your current working experience, please indicate the extent to which you agree or disagree with the following statements.

[Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5]

Challenges Faced by Construction Companies	1	2	3	4	5
Construction companies must promote workplace health to address aging workers' higher risk of illness and injury.	○	○	○	○	○
Construction companies need to adjust the working environment for aging workers (e.g., ergonomic tools, lighter workloads).	○	○	○	○	○
Suitable human resource practices have to be adapted to suit aging workers (e.g., flexible work schedules).	○	○	○	○	○
Retaining aging workers may limit job opportunities for younger professionals entering the construction industry.	○	○	○	○	○
An aging workforce can lead to an unbalanced workforce structure (e.g., more aging workers than young recruits).	○	○	○	○	○
There are noticeable communication or work style differences between aging and younger workers (e.g., aging workers may prefer face-to-face instructions, while younger workers rely more on digital communication).	○	○	○	○	○
Aging workers may be less inclined to adopt new technologies or innovative work methods (e.g., relying on manual cost estimation rather than using software tools)	○	○	○	○	○
Aging workers may lack up-to-date technical skills (e.g., using digital tools or software)	○	○	○	○	○

Aging workers often withdraw early or absent from employment due to health issues or physical fatigue.	○	○	○	○	○
Aging workers are expected to mentor younger staff while also managing their own workload.	○	○	○	○	○

Section D: The Strategies for construction companies to adapt to an aging workforce.

This section explores the strategies for construction companies to adapt to an aging workforce. Based on your current working experience, please indicate the extent to which you agree or disagree with the following statements.

[Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5]

Strategies for Construction Companies	1	2	3	4	5
Provide mentor programs help aging workers transfer and retain their expertise among younger employees.	○	○	○	○	○
Implement job redesign to enable aging workers to remain productive in less physically demanding roles (e.g., shifting aging workers from heavy labor to supervisory positions).	○	○	○	○	○
Provide flexible work arrangements to improve job satisfaction and retention among aging workers. (e.g., shorter work hours or part-time positions)	○	○	○	○	○
Hire younger or foreign workers supporting workforce capacity and reduce the physical burden on aging workers.	○	○	○	○	○
Provide wellness and health programs help aging workers maintain their fitness	○	○	○	○	○

and continue working safely (e.g., on-site health checks).					
Implement targeted safety measures reducing the risk of injury for aging workers on construction sites (e.g., anti-slip walkways, adjustable scaffolding).	○	○	○	○	○
Provide assistive technologies minimizing physical strain and support aging workers in performing their tasks (e.g., lifting aids, wearable monitoring devices)	○	○	○	○	○
Implement age-inclusive policies promote a supportive and discrimination-free work environment for aging workers.	○	○	○	○	○
Provide skill development opportunities allowing aging workers to stay updated with current tools and construction methods (e.g., BIM training).	○	○	○	○	○
Review benefits plans encourage aging workers to remain in employment longer before retiring. (e.g., extended medical coverage)	○	○	○	○	○

This concludes the questionnaire.

Thank you for taking the time to complete this questionnaire. Your responses are greatly appreciated and will contribute to the success of this research. Have a wonderful day!