Available online at
http://journal.uitm.edu.my/ojs/index.php/BEJ

e-ISSN: 2637-0395

Built Environment Journal 22(2) 2025, 212 – 232.

Built Environment Journal

Considerations for Decision-Making in Quality Among the Main Contractor in The Construction Industry: A Case Study of The MRT2 Elevated Project Klang Valley

Nurulhayati Md Zin[1], Nurul Nadiah Zainol[1*], Emma Marinie Ahmad Zawawi[2], Mohd Khairul Afzan Mohd Lazi[3], Anwar Mohd Ismail[1]

[1]*School of Real Estate and Building Surveying, College of Built Environment, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*
[2]*School of Construction and Quantity Surveying, College of Built Environment, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia*
[3]*Faculty of Civil Engineering, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia*
[4]*Siemens Mobility Malaysia Sdn Bhd, 50480 Kuala Lumpur, Wilayah Persekutuan Kuala Lumpur, Malaysia*

ARTICLE INFO

Article history:
Received 09 August 2024
Revised 18 January 2025
Accepted 25 February 2025
Online first
Published 01 July 2025

Keywords:
Decision-Making
Quality
Construction Industry
Main Contractor
MRT2 Elevated Project

DOI:
10.24191/bej.v22i2.1255

ABSTRACT

Decision-making is essential for maintaining quality in large infrastructure projects like the MRT2 Elevated Project in Klang Valley, Malaysia. Decision-making involves gathering information, evaluating options, and making choices that affect time, cost, and quality. This research examines challenges faced by main contractors in decision-making related to quality and suggests solutions for better project outcomes. A mixed-method approach was used, including a survey of executive-level contractors and interviews analysed with Atlas.Ti. The research identified twelve key issues under three (3) categories: Top Management, Customer Satisfaction, and Strategic Management Process. It also highlighted eight (8) important factors for effective decision-making: strategic management, clear guidelines, quality assurance and control, regular meetings, effective communication, managing constraints, skilled decision-makers, and continuous training. These findings provide practical solutions to improve quality management, helping.

INTRODUCTION

Various factors and considerations influence decision-making in quality within the construction industry at each stage of the construction process. Construction sectors are driving economic growth, especially in

[1*] Corresponding author. E-mail address: nadiahzainol@uitm.edu.my
https://doi.org/10.24191/bej.v22i2.1255

developing countries (Huzaifah & Haslinda, 2021). Typically, projects move through design, planning, construction, handover, and maintenance phases, managed within constraints of time, cost, and quality, known as the "triple constraint" (Nguyen et al., 2022). This research aims to enhance understanding of decision-making in quality in the construction industry. Specifically, the research aims to investigate the problems associated with decision-making in quality among main contractors in the MRT2 Elevated Project Klang Valley. Additionally, it recommends considerations for improving decision-making in quality for main contractors involved in the same project. By addressing these objectives, this research contributes to the broader understanding of how effective decision-making in quality can be made to meet expectations or requirements and ensure successful project outcomes.

Quality is essential in any project, ensuring adherence to standards and client expectations through planning, control, and assurance processes (Riaz et al., 2022). Quality elements cover compliance with quality standards, stakeholder requirements, risk management, resource allocation, and communication. Decision-making in quality occurs throughout the project lifecycle, affecting time, cost, and overall quality (Abu Oda et al., 2022). Therefore, factors influencing decision-making must address time, cost, and quality issues for realistic outcomes (Nguyen et al., 2022). Compliance with standards and regulations from bodies like SIRIM and CIDB Malaysia is essential as it ensures that construction practises meet industry requirements, legal obligations, and safety standards. Adhering to these regulations helps avoids delays, penalties, ensure worker safety, and promotes the use of high-quality materials and procedures. This alignment with established standards also builds trust with stakeholders and clients, leading to better project outcomes and reducing the likelihood of costly reworks that can caused delays. Effective decision-making meets client needs and ensures high-quality projects (Mohsen Alawag et al., 2022).

Previous research has identified major key causes of construction delays linked to decision-making in quality, including regulatory issues, design changes, poor project management, cost constraints, environmental challenges, labour shortages, unforeseen ground conditions, supply chain disruptions (recently during pandemics), utility conflicts, contractual disputes, and legal issues (Masrom et al., 2015). The listed factors vary in their significance and impact from project to project. Given these challenges, evaluating the decision-making process regarding quality among main contractors in recent large infrastructure projects like Mass Rapid Transit (MRT) is important. Generally, Mass Rapid Transit (MRT) consists of elevated works, underground or tunnelling works, and systems work. This research aims to enhance Malaysia's global competitiveness and assessment, specifically regarding MRT2. The MRT2 project has significantly contributed to Malaysia's economic growth and Gross Domestic Product (GDP). The Fourth Industrial Revolution (IR 4.0) has marked the construction industry's role in Malaysia's journey towards becoming a high-income country.

Overview of Construction Industry

In Malaysia's Fourth Industrial Revolution, organisations faced challenges like project failure, constant changes, and poor decision-making (Rivera et al., 2020). Large infrastructure project complexity poses a critical issue in construction management, as embracing technology aims to enhance productivity and efficiency. The project lifecycle presents dynamic challenges for main contractors and stakeholders, especially in large infrastructure projects like the Mass Rapid Transit (MRT). Quality management is vital for project success, involving multiple parties such as clients, contractors, and suppliers (Talbi & Souad, 2022). Effective decision-making, particularly in quality aspects is crucial to avoid rejections and delays, with leadership playing an important role in project success.

https://doi.org/10.24191/bej.v22i2.1255

Main contractors, entrusted by clients to oversee site work, prioritise decision-making, progress monitoring, and project control (Aaltonen & Kujala, 2010) and (Khoshnava et al., 2020). They ensure quality standards are met through Quality Assurance and Quality Control (QAQC) departments, ultimately enhancing client satisfaction and loyalty (Martin & Benson, 2021). Quality Assessment Systems like QLASSIC are implemented in projects such as the MRT, emphasising compliance with specifications and codes of practice. Effective decision-making in quality involves exploring alternatives and complying with regulations, highlighting the importance of clear communication between contractors and stakeholders (Jaapar et al., 2012). Table 1 shows challenges and issues in decision-making based on previous studies and research.

Table 1. Challenges and Issues in Decision-making

Challenge	Author	Year
In the planning and control of construction projects, three (3) crucial elements to consider are time, cost, and quality. Achieving a harmonious balance among these factors, where project duration and total cost are optimised while quality is maximised plays a defining role in determining the success of the projects	Aaltonen & Kujala, 2010	2010
In construction projects, decision-makers often face complex situations where they must carefully evaluate various options to reach suitable solutions and balance conflicting objectives.	Monghasemi et al., 2015	2015
The existing emergency response demonstrates limited auxiliary decision-making capability, within the context of managing issues and problems relying heavily on predefined work processes outlined in their respective emergency plan and essentially following set implementation procedures	Shi et al., 2022	2022
Neglecting proper analysis of the market needs, engineering aspects, requirements, and regulations or available resources can result in significant flaws in decision-making, ultimately leading to conflicts, chaos and causing project failure	Hu et al., 2022	2022

Source: Authors (2024)

The MRT2 Elevated Project in Klang Valley, being a large infrastructure project is complex due to various factors. Several challenges are implementing new technologies, learning new tasks, meeting client requirements, and integrating scopes of work. Decision-makers are often required to make quick decisions to avoid rejection due to non-compliance. The MRT project follows standard quality management guidelines and procedures, including workflows for main contractors on-site. Implementing quality management guidelines can lead to deliberate decision-making by organising relevant information and defining alternatives. However, main contractors often face challenges such as slow decision-making resulting from compliance issues. Another common challenge involves aligning decisions among main contractors with multiple senior management or stakeholders with conflicting priorities (Wang et al., 2021).

This research on the main contractor's decision-making in quality aspects consists of the need to weigh advantages and disadvantages to align decisions with project goals. Regardless of project size, decision-making in quality aspects will occur throughout its lifecycle, addressing various issues and situations. Addressing these issues involves selecting, ranking, or classifying alternatives based on multiple criteria and standards. Decision-making in quality involves choosing the right solution without compromising standards. Management and stakeholders should have sufficient time, resources, and logistics for decision-

https://doi.org/10.24191/bej.v22i2.1255

making. Experience plays a significant role in speed and efficient decisions. Well-defined roles and responsibilities are crucial for effective decision-making. Failure to make timely decisions can lead to task delays, quality issues, and cost overruns. Insufficient consideration of technical or engineering aspects linked to quality requirements among main contractors can result in an organisation's reputation and project failure (Hu et al., 2022). Successful project delivery hinges on timely completion within budget and meeting quality standards (Zong et al., 2022).

Current Scenario of Construction Industry in Malaysia

The construction industry in Malaysia is a contributor to the nation's economic growth, enhancing the quality of life for its citizens through various infrastructure projects (Masrom et al., 2015). Divided into public and private sectors, it encompasses activities ranging from building construction to transportation system development (Kwan et al., 2017). Major projects like the Electrified Double Track Project, the East Coast Expressway, and the Mass Rapid Transit Sungai Buloh Line and Mass Rapid Transit Putrajaya Line play a crucial role in improving socio-economic infrastructure (Manzolli et al., 2021). Despite the benefits, challenges related to environmental, social, and governance aspects persist, necessitating efficient decision-making processes and stakeholder engagement.

Environmental concerns such as carbon emissions and resource sustainability increasingly influence project planning and implementation. Social challenges, including ensuring equitable community benefits and minimising disruptions to local populations, demand more inclusive approaches. Governance issues, such as transparency and compliance with regulatory workflow, further complicate decision-making in quality. Additionally, digitalisation is transforming the sector, with technologies like Building Information Modelling (BIM) and real-time data analytics enabling smarter, more informed decisions while transitioning to new skills and systems. These factors collectively shape the strategies accepted by stakeholders to navigate complexities and achieve project objectives. Table 2 shows the criteria for Public Construction and Private Construction.

Table 2. Public Construction and Private Construction

Category	Regulations	Project Scope	Bidding Process	Time Frame
Public Construction	Subject to government regulations	Usually, large-scale projects such as highways, railways, etc	Award through a competitive bidding process	Usually, longer timelines (regulatory and approval process)
Private Construction	Subject to fewer regulations than public projects	Small-scale large projects such as shopping malls or office buildings	It may not necessarily require a bidding process; the owner may choose their preferred contractor	May have shorter timelines, as there are subject to new regulations and approvals

Source: Authors (2024)

The industry’s transition towards digitalisation, aligned with the Fourth Industrial Revolution (IR 4.0), holds promise for enhancing productivity and efficiency. However, issues like slow decision-making could lead to project cost overruns, highlighting the need for streamlined processes in large infrastructure projects. For example, in Malaysia’s MRT2 project, delays in decision-making regarding design changes led to extended project timelines and increased costs (Zhong et al., 2022). Such delays required additional resources and adjustments to schedules, ultimately impacting the project’s overall budget and completion date. Despite challenges, the construction sector continues to drive Malaysia’s economic development and

https://doi.org/10.24191/bej.v22i2.1255

growth towards becoming a developed nation. By adopting digital tools and technologies, the industry can reduce decision-making delays, improve communication, and ensure better project outcomes (Manzolli et al., 2021)

LITERATURE REVIEW

The concept of decision-making in the construction industry, particularly among main contractors, holds significant importance in ensuring project success and quality outcomes. Various studies have emphasised the complexities involved in decision-making processes within construction projects, highlighting the need for considerations in quality aspects. Main contractors often face multifaceted decision-making challenges impacting project success and quality outcomes. One (1) key issue is the need to navigate complex decision landscapes, especially in large-scale infrastructure projects. The multidimensional nature of decisions often involves trade-offs between time, cost, and quality benchmarks (Nguyen et al., 2022). Balancing these competing objectives while ensuring project success and meeting stakeholder expectations can lead to decision-making issues, including delays, cost overruns, and quality deficiencies. This underscores the necessity for main contractors to navigate through intricate decision landscapes, especially in large-scale infrastructure projects like the MRT1 and MRT2 Elevated Project in Klang Valley.

Main contractors involved in the MRT project encounter several critical issues in decision-making regarding material selection, subcontractor management, quality assurance process, compliance with regulations and standards, and stakeholder engagement and communication (Govindan et al., 2016). Material selection poses a significant challenge as contractors must choose materials that ensure durability, safety, and compliance with quality standards. Issues may arise if materials fail to meet project specifications or withstand environmental conditions, potentially leading to safety hazards to the public. Subcontractor management is crucial, yet challenging, as contractors must oversee specialised tasks executed by subcontractors (Yap et al., 2021). Challenges such as negligence, lack of supervision, or poor communication may result in quality issues, delays, and rework (Zhong et al., 2022). Effective implementation of quality assurance processes is essential to maintain standards throughout the project lifecycle (Aaltonen & Kujala, 2010). Main contractors must establish robust quality control measures and address non-conformance promptly to prevent defects and compromised project quality. Compliance with regulations and standards is paramount to avoid legal penalties, project delays, and reputational damage. Failure to adhere to safety, environmental, and building code regulations may result in non-compliance issues. Effective stakeholder engagement and communication are vital for project success. Contractors must address stakeholder concerns, provide regular updates, and resolve conflicts promptly to prevent disruptions and delays. Issues may arise from a lack of transparency, miscommunication, or conflict among stakeholders, highlighting the importance of proactive engagement and communication strategies.

Quality considerations in decision-making within the construction industry have been a focal point in a large-scale infrastructure project. Researchers such as Pamucar and Riaz (2022) stress the importance of integrating quality management principles into decision-making processes to achieve desired project outcomes (Pamucar et al., 2022) and (Riaz et al., 2022). According to them, effective decision-making entails not only addressing technical specifications but also considering broader quality dimensions. Effective decision-making in the construction industry requires careful consideration of various factors, particularly in quality aspects. Main contractors must not only address technical specifications but also consider broader quality dimensions, such as public safety and infrastructure integrity, especially in projects like the MRT where these aspects are paramount. Understanding the basic concept of decision-making in quality is essential for main contractors to navigate through diverse stakeholder interests and project

https://doi.org/10.24191/bej.v22i2.1255

dynamics successfully. Implementation of the basic concept of decision-making in quality is essential for main contractors to make informed decisions and mitigate risks associated with project execution.

Considering contextual factors such as project complexity, organisational culture, and stakeholder dynamics (Lei et al., 2017). Each project presents unique challenges that require careful evaluation and strategic decision-making. Overall, understanding the basic concept of decision-making in quality holds immense significance for enhancing project outcomes and ensuring the delivery of safe and high-quality infrastructure. Main contractors must navigate through intricate decision landscapes, prioritise quality considerations, and leverage appropriate strategies to achieve project success while meeting stakeholder expectations.

Decision-making and Quality

In the construction industry, time, cost, and quality are key benchmarks. The goal is to achieve high-quality outcomes at lower costs and within project timelines. According to (Nguyen et al., 2022) a builder's ability to optimise project duration, cost, and overall quality defines project success. Swift decision-making regarding quality throughout the project is crucial to ensure compliance and avoid delays or rejection. Decision-making involves selecting the best option from available alternatives, often involving issue-framing, intelligence-gathering, and learning from past project experiences. Decision-making principles emphasise proportionate actions, consultation, respect for human rights, transparency, and considerations of equality and diversity.

Quality refers to the degree of excellence and satisfaction of specified attributes or requirements. Low-quality results in inefficiency, wasted time and materials, increased costs, and safety hazards for users (Juhari & Arifin, 2020). Safety improvements are tied to the quality of materials and equipment, serving as preventive measures against future accidents. In construction projects, ‘quality’ refers to the degree to which a project meets its specified standards, such as design requirements, regulatory compliance, and client expectations. It is typically measured through key performance indicators (KPIs) such as defect rates, adherence to safety standards, and compliance with schedules and budgets. Hence, ‘decision-making in quality’ involves evaluating these metrics and making them throughout the project lifecycle, balancing time, cost, and quality factors (Abu Oda et al., 2022).

Decision-making in Construction

Decision-making in the construction industry is a critical process involving the selection of the best option among various alternatives (Kineber et al., 2021). This process entails identifying issues, gathering information, and evaluating alternative resolutions to solve problems across project planning, design, procurement, resource allocation, risk management, and quality assurance. Factors such as project constraints, stakeholder requirements, regulatory compliance, cost savings, and project goals influence decision-making. Understanding the principles, methodologies, and tools of quality management is essential for effective decision-making (Aaltonen & Kujala, 2010).

Decisions made by construction professionals influence project outcomes and must be justified and evaluated regularly. Decision-makers often face stress, pressure, and complexity due to the frequent need to make decisions throughout the project lifecycle (Zong et al., 2022). The construction phase, including pre-construction, construction, handover, and post-construction phases, involves a series of decisions that impact subsequent phases and overall project timelines. As a firm grows and becomes more structured,

https://doi.org/10.24191/bej.v22i2.1255

decision-making processes become more complex, requiring clear identification of problems, variables, alternatives, and participants (Aaltonen & Kujala, 2010).

Quality in the construction industry is deliberate and results from adherence to agreed guidelines and procedures within the project scope (Riaz et al., 2022). It is essential for project success and must be intentionally managed and implemented by construction personnel. Decision-making regarding quality involves evaluating various alternatives logically, utilising available resources, and employing quantitative methods. The decision-making process involves framing issues, gathering intelligence, making choices, and receiving feedback (Mohsen Alawag et al., 2022). Feedback from decisions helps improve main contractor and stakeholder identification, acceptance, and personalised understanding of project outcomes, enhancing the decision-making process overall. Effective decision-making and maintaining quality are crucial for competitive excellence and achieving project success in the construction industry.

Problem Associated with Decision-making in Quality

Large infrastructure projects like the Mass Rapid Transit (MRT) project involve numerous stakeholders, complex supply chains, and strict regulatory requirements, which dd to the challenges of quality decision-making. These factors make coordination difficult, causing main contractors to struggle with maintaining consistent adherence to quality standards across project. Another significant challenge lies in managing time, cost, and quality trade-offs inherent in large-scale construction projects (Nguyen et al., 2022). The Mass Rapid Transit (MRT) project, like many others of its scale, faces relentless pressures to meet tight deadlines and budget constraints while maintaining quality standards.

The problems are closely tied to top management, customer satisfaction, and strategic management (Talbi & Souad, 2022). The involvement and direction of top management significantly impact decision-making in quality. Lack of clear leadership or support from top management can result in inadequate allocation of resources and insufficient emphasis on quality standards. Main contractors need strong leadership and commitment from top management to prioritise quality throughout the project lifecycle (Aaltonen & Kujala, 2010).

At the same time meeting customer expectations and ensuring satisfaction are paramount in the construction industry (Zhong et al., 2022). However, balancing customer demands with project constraints of time, cost, and quality poses a challenge. Failure to effectively manage customer expectations can lead to dissatisfaction and jeopardise the success of the project. Main contractors must prioritise customer satisfaction while navigating the complexities of large-scale infrastructure projects.

Strategic decision-making is essential for addressing the inherent complexities of large infrastructure projects (Paton & Andrew, 2019). Main contractors must carefully consider the trade-offs between time, cost, and quality to achieve project objectives. Strategic management involves developing robust risk management strategies and making informed decisions that align with the project goals. The complexity of large-scale infrastructure projects like the Mass Rapid Transit (MRT) project further complicates these decision-making processes, emphasising the need for effective communication, collaboration, and stakeholder engagement to mitigate risks and enhance project outcomes (Martin & Benson, 2021).

Considerations in Decision-making

Decision-making in quality encompasses a multitude of considerations, ranging from regulatory compliance and technical specification to stakeholder expectations and project constraints (Abu Oda et al.,

https://doi.org/10.24191/bej.v22i2.1255

2022). Central to this process is the need for main contractors to meticulously evaluate and prioritise various quality considerations to ensure the successful execution of construction projects. Through the lens of the Mass Rapid Transit (MRT) project, it portrays that decision-making in quality involves some elements that necessitate careful analysis and strategic alignment to achieve desired outcomes.

Potentially, the critical consideration in decision-making in quality is due to the establishment of clear and measurable quality objectives. In the context of the Mass Rapid Transit (MRT) project, main contractors must define precise quality metrics and performance indicators that align with the project requirements and stakeholder expectations (Manzolli et al., 2021). These objectives serve as guiding principles for decision-making processes, enabling main contractors to assess project progress, identify areas of improvement, and mitigate quality-related risks effectively. Moreover, clear quality objectives facilitate communication and collaboration among project teams, fostering a shared understanding of quality expectations and driving collective efforts toward achieving project excellence (Yang et al., 2021).

Another consideration in decision-making in quality revolves around the integration of quality management practices into project planning and execution processes (Martin & Benson, 2021). Main contractors must proactively embed quality considerations into every stage of the construction lifecycle, from design and procurement to construction and commissioning (Aaltonen & Kujala, 2010). This entails implementing robust quality assurance and control mechanisms, conducting regular inspections and audits, and fostering a culture of continuous improvement throughout the organisation. By incorporating quality management as a fundamental aspect of project management, main contractors can streamline decision-making processes, enhance operational efficiency, and uphold quality standards across diverse project scopes and complexities.

Furthermore, decision-making in quality necessitates a comprehensive understanding of factors or implications on project outcomes. Main contractors must conduct an assessment to identify potential threats to quality, safety, and project timelines. By anticipating and mitigating the potential risks early in the project lifecycle, the main contractor can proactively address quality-related challenges, minimise costly rework, and ensure timely project delivery (Mu et al., 2014). Additionally, effective risk management strategies enable main contractors to make informed decisions regarding resource allocation, technology adoption, and subcontractor selection, thereby optimising project performance and maximising stakeholder value.

CASE STUDY

Overview of Mass Rapid Transit Project

As Malaysia progresses economically, infrastructure development, particularly in transportation, serves as a key indicator of the nation's advancement. The Malaysian government has prioritised the Mass Rapid Transit (MRT) project within the transportation sector to provide affordable, efficient, and reliable public transportation while easing traffic congestion in urban areas. The Mass Rapid Transit (MRT) project consists of three (3) lines in the Klang Valley, with the Sungai Buloh Line (MRT1) and the Putrajaya Line (MRT2) both completed, while the Circle Line (MRT3) not started.

The stakeholders are, Suruhanjaya Pengangkutan Awam Darat (SPAD) as Supervising Agency, Mass Rapid Transit Corporation Sdn Bhd (MRTC) as Project Owner and MMC-Gamuda Joint Venture Sdn Bhd originally appointed as Project Delivery Partner. The project aims to integrate with existing rail systems

https://doi.org/10.24191/bej.v22i2.1255

and enhance public transportation networks to accommodate the region's growing population. Table 3 shows facts about the Mass Rapid Transit (MRT) project.

Table 3. The Mass Rapid Transit (MRT) Project Facts

Details	MRT1	MRT2
Alignment	Kwasa Damansara - Kajang	Sungai Buloh - Putrajaya
Total Length	47 km	57.7 km
Total Stations	29 & 3 reserved Stations	36 Stations
Ridership	Estimate 400,000 daily	daily
Line Opening	Phase 1 on 16 December 2016 Phase 2 on 17 July 2017	Phase 1 on 16 June 2022 Phase 2 on 16 March 2023

Source: Authors (2024)

The context of the Mass Rapid Transit (MRT) project underscores the urgent need for enhanced public transportation to alleviate severe traffic congestion in high-density urban areas like the Greater Kuala Lumpur region, also known as the Klang Valley. The MRT system, characterised by elevated viaducts, stations, systems, and tunnel works, serves as the backbone of the city's public transportation network, to cater to a large number of passengers and facilitates seamless connectivity. The project's quality policy emphasises safety, convenience, and reliability, fulfilling the stakeholder focus, commitment to quality, risk-based thinking, knowledge sharing, and continual improvement. Figure 1 shows the Integrated Line for MRT1 and MRT2

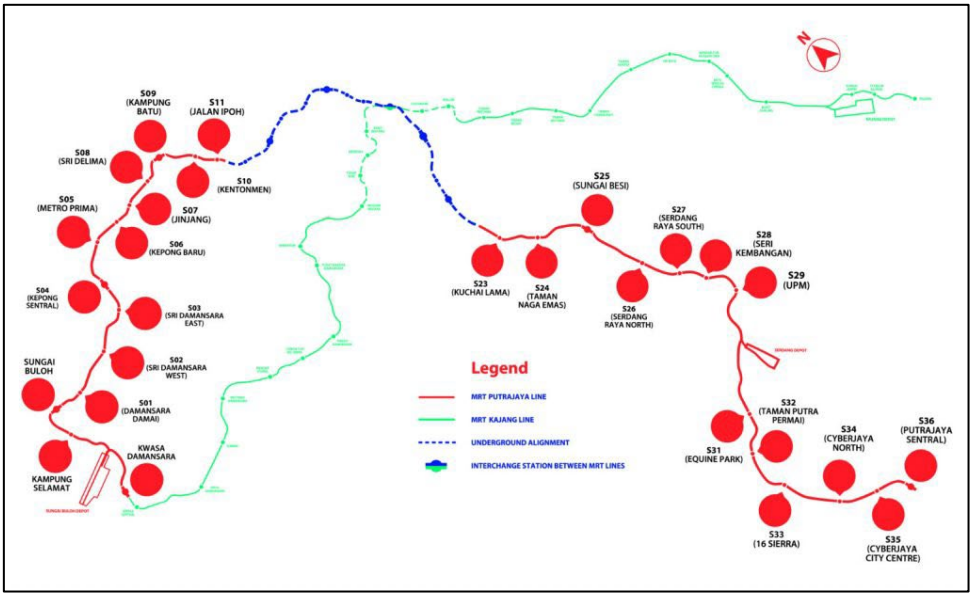

Fig. 1. The Integrated Line

Source: MMC-Gamuda (2023)

https://doi.org/10.24191/bej.v22i2.1255

The Mass Rapid Transit (MRT) project's significance lies in its ability to improve quality of life, safety, health, and security by offering convenient and sustainable urban transportation solutions. With its complexity, the decision-making process in quality among main contractors is crucial to managing challenges such as quality issues, traffic congestion, utility relocation, and traffic diversion effectively. Divided into multiple phases and sections, including elevated and underground packages, the MRT project is designed to accommodate a ridership of 104,000 passengers upon completion, with underground alignment built using a tunnel boring machine and the cut-and-cover method. The project's success improves transportation and contributes to environmental sustainability and urban development in Malaysia's growing metropolitan areas.

METHODOLOGY

The MRT2 Elevated Project Klang Valley was awarded to ten (10) main contractors. The Main Contractor is known as the Work Package Contractor (WPC) in MRT2 Elevated Project Klang Valley. They are also sub-contractors appointed to execute station works for the elevated sections. The approach to quality management in the MRT2 Elevated Project Klang Valley blends Malaysian traditional practices with current international standards, emphasising effective Quality Control (QC) by main contractors, manufacturers, suppliers, and independent Quality Assurance (QA). Through verification processes and detailed reports, the project ensures compliance with ISO 9001:2015 standards, requiring each entity involved to develop and implement quality systems meeting ISO 9001 requirements. The Malaysian government's focus on developing integrated public transport systems, particularly the Mass Rapid Transit (MRT) project, aims to elevate Malaysia into a high-income nation and revive the construction industry amid economic slowdowns and the post-pandemic era. Despite challenges posed by the pandemic, the government's initiatives, including Movement Control Orders (MCOs) and support for infrastructure projects, have facilitated the construction industry's recovery and operational continuity.

The emphasis on quality in construction is paramount to minimising construction risk, as it reflects the industry’s image and influences client confidence, future marketability, and investor attraction (Moshood et al., 2020). Recognising this, the Construction Industry Development Board (CIDB) introduced the Quality Assessment System in Construction (QLASSIC) in 2007 to assess workmanship and final products according to industry standards. By implementing QLASSIC assessment during project development and construction stages, quality across construction projects can be objectively compared, helping the main contractor to expedite the decision-making process, and ensuring client and stakeholder satisfaction. For instance, the recent ISO 9001:2015 certification obtained by the Mass Rapid Transit (MRT) project reflects its commitment to quality management, reinforcing its reputation and receiving international quality awards.

A triangulation process is employed to integrate quantitative and qualitative data. This approach ensures that findings from numerical data, such as quality assessment scores, are cross-referenced with qualitative insights, like the interviews, to provide a comprehensive understanding of quality decision-making.

Research Method

The literature review for the research was conducted by analysing existing research on decision-making in the construction industry, with a specific focus on main contractors. The review highlighted the complexities involved in decision-making processes within construction projects, emphasising the need for

https://doi.org/10.24191/bej.v22i2.1255

consideration of quality aspects. Main contractors face multifaceted challenges in decision-making, particularly in large-scale infrastructure projects like the MRT2 Elevated Project Klang Valley. These challenges include navigating complex decision landscapes, balancing competing objectives of tie, cost, and quality, and ensuring stakeholder satisfaction.

Several critical issues regarding decision-making in quality within the construction industry were identified. Main contractors involved in projects like the MRT2 Elevated Project face challenges such as material selection, subcontractor management, quality assurance processes, compliance with regulations and standards, and stakeholder engagement and communication. These challenges can lead to safety hazards, delays, cost overruns, and quality deficiencies if not managed effectively. The review also emphasised the importance of integrating quality management principles into decision-making processes and considering broader quality dimensions beyond technical specifications.

The review underscores the significance of establishing clear and measurable quality objectives, integrating quality management practices into project planning and execution, and conducting comprehensive risk assessments to inform decision-making processes. Through the lens of the MRT2 Elevated Project and similar large-scale infrastructure endeavors, the literature review provides insights into the challenges and considerations associated with quality decision-making among main contractors, highlighting the need for proactive strategies and holistic approaches to address this challenge effectively.

This research employed quantitative and qualitative methods to achieve its objectives. The questions were designed in two (2) sets: Part A closed-ended questions and Part B open-ended questions. The introduction of the survey discusses the researcher's background of research and explains the purpose of the research.

The quantitative research component aimed to investigate problems associated with decision-making in quality among main contractors in MRT2 Elevated Project Klang Valley. This involved distributing closed-ended questionnaires to a minimum of twenty professionals with executive-level experience in railway construction, particularly in Mass Rapid Transit (MRT) or construction sectors such as main contractors. The data were then analysed using descriptive analysis, helping to discern critical factors based on mean values.

The qualitative research component was used to recommend considerations for decision-making in quality main contractors in the MRT2 Elevated Project, Klang Valley. Open-ended questions were distributed to a minimum of twenty professionals with executive-level experience in railway construction, focusing on Mass Rapid Transit (MRT) or construction sectors like main contractors. Responses were analysed using Atlas.ti software through thematic analysis, involving the identification of patterns and themes within the data. This research specifically focused on the elevated section of the MRT2 Project in the Klang Valley, situated in an area known for its high population density.

Research Methodology Phases

The research is structured into four (4) distinct phases aimed at addressing a defined research problem related to decision-making factors in quality within the context of railway construction, particularly focusing on the Mass Rapid Transit (MRT) project or construction sector, with a specific emphasis on the MRT2 Elevated Project in Klang Valley. This research focuses specifically on the Klang Valley MRT2 Elevated Project, which covers its unique project-specific context.

https://doi.org/10.24191/bej.v22i2.1255

Phase 1 involves defining the research problem by conducting a thorough review of relevant literature. This literature review helps identify critical factors influencing decision-making in quality, drawing from previous studies. Additionally, discussions and consultations with supervisors and industry experts are conducted to pinpoint gaps in existing research, refine the focus, and create a potential question for the research.

Phase 2 revolves around method and data collection. The research employs both quantitative and qualitative data collection methods. Questionnaires are designed based on factors identified in the literature review. The questionnaire design is refined through discussions with supervisors and industry experts. A pilot survey involving seven (7) participants ensures the relevance and scope of the questions.

For quantitative data collection, the questionnaire is divided into two (2) sections with twenty (22) questions. The closed-ended questions are utilised and distributed to a minimum of twenty-four (24) professionals in the railway construction sector at the executive level or higher, with at least five (5) years of relevant experience. SPSS software is employed for data analysis, focusing on descriptive statistics to identify and investigate problems associated with decision-making in quality.

Qualitative data collection involves open-ended questions that contain thirteen (13) questions distributed to a minimum of twelve (12 professionals in the railway construction sector, with a focus on those involved in the Mass Rapid Transit (MRT) project or construction sector at an executive level or higher and possessing at least five (5) years of relevant experience. These questions aim to gather nuanced insights into recommendations for consideration for decision-making in quality within the specific context of the MRT2 Elevated Project in Klang Valley. Atlas.ti software aids in analysing the qualitative data, enabling to identification of patterns, themes, and emerging trends from the responses provided by the participants, thus enriching the understanding of the qualitative aspects of decision-making processes in quality within the railway construction domain in Phase 3.

Finally, Phase 4 involves drawing conclusions and making recommendations based on the outcomes of the research. This phase synthesises findings from the entire research process, offering insights into problems associated with decision-making in quality within railway construction, and suitable considerations to be in place, particularly in the context of the MRT2 Elevated Project in Klang Valley. Figure 2 shows the Research Methodology Process for this research, where the findings are grounded in this project, insights gained may offer valuable lessons for the other large-scale infrastructure projects, particularly in regions with similar construction practices and quality management challenges.

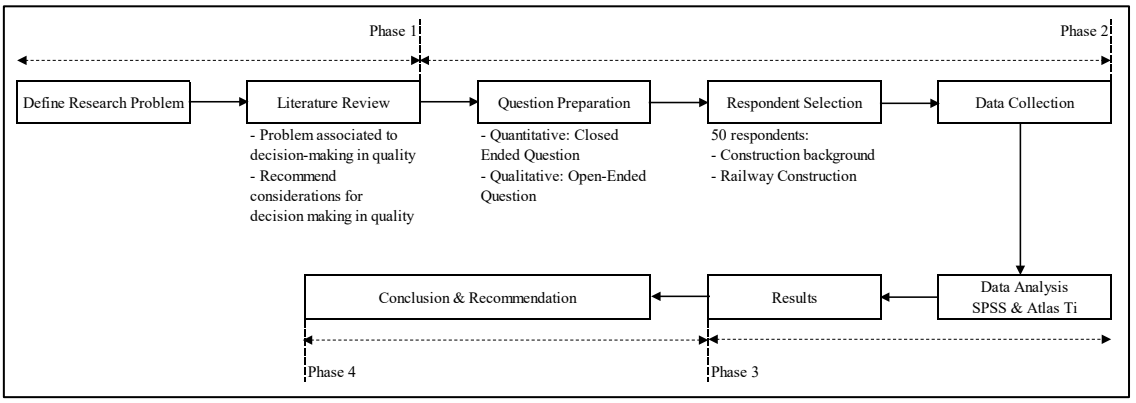

Fig. 2. Research Methodology Process

https://doi.org/10.24191/bej.v22i2.1255

Source: Authors (2024)

RESULTS

Data Collection for Closed-ended Questions

Closed-ended Question Section 1: Demographic Information of Respondent

Fifty (50) respondents participated in the data collection. Among them, 58% (29 respondents) were male, while 42% (21 respondents) were female, indicating male dominance in the construction industry. The majority of respondents, 72% (36 respondents), fell within the 31-40 age group, followed by 14% (7 respondents) in the 41-50 age group, 10% (5 respondents) in the 23-30 age group, and 4% (2 respondents) above 50 years old. Regarding academic qualifications, 62% (31 respondents) held degrees, 31% (16 respondents) had master's degrees, 4% (2 respondents) had diplomas, and only 2% (1 respondent) had a Doctorate PhD.

Additionally, 96% (48 respondents) worked in the private sector, with an average of two (2) respondents per contractor from MRT projects. The majority of respondents, 66% (33 respondents), were from contractor organisations, 20% (10 respondents) from consultants, 10% (5 respondents) from developer companies, and 4% (2 respondents) from clients. Job designations varied, with 46% (23 respondents) being engineers, 30% (15 respondents) holding managerial positions, and others represented by 13 respondents each. Most respondents had over 5 years of working experience (92%), with only 8% (4 respondents) having 6-10 years, 16% (8 respondents) had over 20 years, and 6% (3 respondents) had 16-20 years, primarily in railway engineering within the construction industry. Therefore, this research successfully met the criteria for the majority of target respondents.

Closed-ended Question Section 2: To Investigate Problems Associated with Decision-Making in Quality Among Main Contractors in MRT2 Elevated Project Klang Valley

The findings from the data collection for Section 2 are to investigate problems associated with decision-making in quality among the main contractors involved in the MRT2 Elevated Project in the Klang Valley. The results reveal three (3) categories of problems associated with decision-making in quality among main contractors in MRT2 Elevated Project Klang Valley. The results indicate the following rank from higher to lower: a) Top Management, b) Customer Satisfaction, and c) Strategic Management Process.

The results suggest that the primary challenge in decision-making in quality stems from "Top Management" within the railway construction sector, particularly concerning the Mass Rapid Transit (MRT) project or construction projects such as the MRT2 Elevated Project in the Klang Valley. Based on the mean value of 4.200 and a standard deviation of 0.904, which were attributed to the lack of internal communication regards to quality concerns, these findings emphasise a crucial area of improvement, indicating that issues related to decision-making processes, resource allocation, or strategic direction may originate from top-level leadership. Understanding and addressing these concerns are pivotal for enhancing the overall quality management framework within the sector, potentially leading to more effective project outcomes and better alignment with stakeholders' expectations.

In the realm of "Customer Satisfaction", the highest scores, with a mean of 3.920 and a standard deviation of 0.986, were a result of slow responses to clients' needs and issues effectively and promptly.

https://doi.org/10.24191/bej.v22i2.1255

These common situations may lead to dissatisfaction and frustration. It also indicates a critical area for improvement in addressing client concerns promptly and efficiently to enhance overall satisfaction levels. Meanwhile, in the domain of "Strategic Management Process", the highest scores, with a mean of 4.120 and a standard deviation of 0.895, stemmed from a slow decision-making process among various parties, such as clients and subcontractors, which hindered efficient operations and strategic initiatives. Addressing these delays and streamlining decision-making procedures across stakeholders is essential to ensure organisational agility and effectiveness in executing strategic initiatives. Results are shown in Table 4.

Table 4. Descriptive Statistics of Problems Associated to Decision-making

		No of Sample	**Minimum Score**	**Maximum Score**	**Mean**	**Std Deviation**
Top Management	Lack of clear quality vision and mission statement that reflects goal and values of the project	50	2	5	4.00	0.926
	Lack of internal communication regards to quality concerns	50	2	5	4.20	0.904
	Unwilling to seek external expertise such as quality assurance consultant or relevant professional	50	2	5	3.92	0.966
	Hasn't establish quality metrics and indicators to measure the progress	50	1	5	3.92	1.007
Customer Satisfaction	Inappropriate mechanism and technique to reach the quality standard according to requirements	50	1	5	3.90	0.995
	Lack of regular meeting or discussion to define workflow to complete the task	50	1	5	3.66	1.042
	Lack of adopting the quality-oriented strategy	50	1	5	3.88	0.961
	Slow respond to client's need and issue effectively in timely manner	50	1	5	3.92	0.986
Strategic Management Process	Slow decision-making process of among various parties (e.g. : clients, sub-contractors etc)	50	2	5	4.12	0.895
	Inadequate planning and scheduling, integrating, monitoring and reporting the work progress during construction	50	2	5	4.10	0.974
	Lack of practise good performance analysis and rating to ensure the quality as per requirements	50	2	5	4.02	0.915
	Lack of communication and timely process to address issues related to quality	50	1	5	4.10	0.995
	Valid N (listwise)	50				

Source: Authors (2024)

https://doi.org/10.24191/bej.v22i2.1255

Data Collection for Open-ended Questions

Open-ended Question Section 1: Demographic Information of Respondent

The result from quantitative data collection for Part B Section 1, represents demographic characteristics of the population. For Section 1, a total of 34 respondents participated, exceeding the minimum target of twelve (12) participants. The table shows that 64.7% (22 respondents) of them were male and 35.3% (12 respondents) of them were female participants. Which shows the respondents dominated by males instead of females.

The majority age group is between 31-40 years old 73.5% (25 respondents), followed by age 23-30 years old 14.7% (5 respondents), and age 41-50 years old 11.8% (4 respondents). The respondents' academic qualification is from Masters and Degree holders only with Degree holders 73.5% (25 respondents) and Masters holders 26.5% (9 respondents).

Open-ended Question Section 2: To Recommend Considerations for Decision-Making in Quality Among Main Contractor in MRT2 Elevated Project Klang Valley

Question 1 aims to identify common problems that may arise during the decision-making process. The results provided outline five (5) major problems encountered among main contractors in the MRT2 Elevated Project Klang Valley. These problems include a) Strategic Management Process, b) "Triple Constraints" (Time, Cost, Quality), c) Insufficient Information, d) Communication, and e) Top Management. Refer to Figure 3.

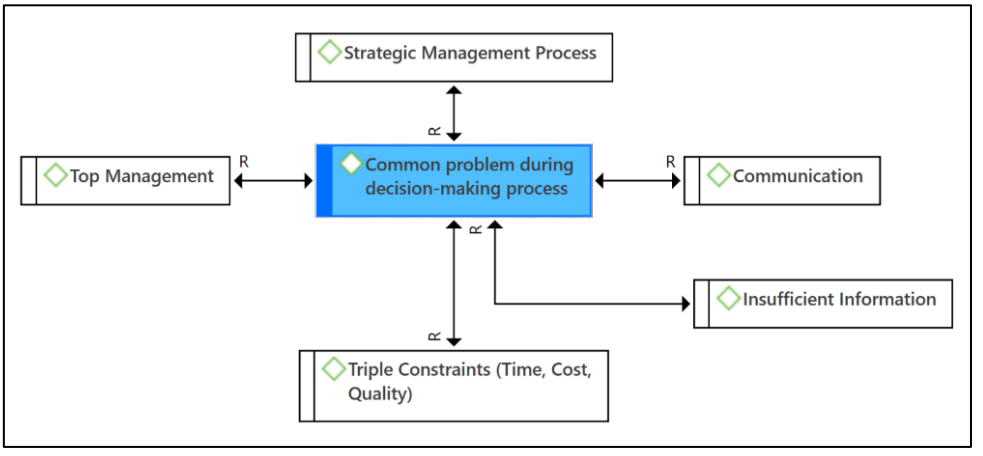

Fig. 3. Common Problem During Decision-making Process

Source: Authors (2024)

Question 2 seeks to determine the most effective approach for main contractors to enhance the decision-making process in quality, thereby minimising delays and losses. The results provided figure outline eleven (11) approaches identified for main contractors in MRT2 Elevated Project Klang Valley to consider. These approaches include: a) Establishing procedures and guidelines to meet quality requirements, b) Implementing effective communication among stakeholders, c) Ensuring decision-makers possess the

https://doi.org/10.24191/bej.v22i2.1255

necessary capabilities, d) Conducting regular meetings and discussions for updated and information exchange, e) Utilising strategic management processes within the organisation, f) Emphasising continuous improvement and training initiatives, g) Employing reporting tools and dashboards for timely and accurate information, h) Ensuring compliance with regulations and requirements, i) Engaging top management in strategic vision and resource allocation, j) Conducting performance reviews to promote accountability and collaboration, and k) Implementing risk management strategies for identifying and mitigating potential threats and challenges. Refer to Figure 4.

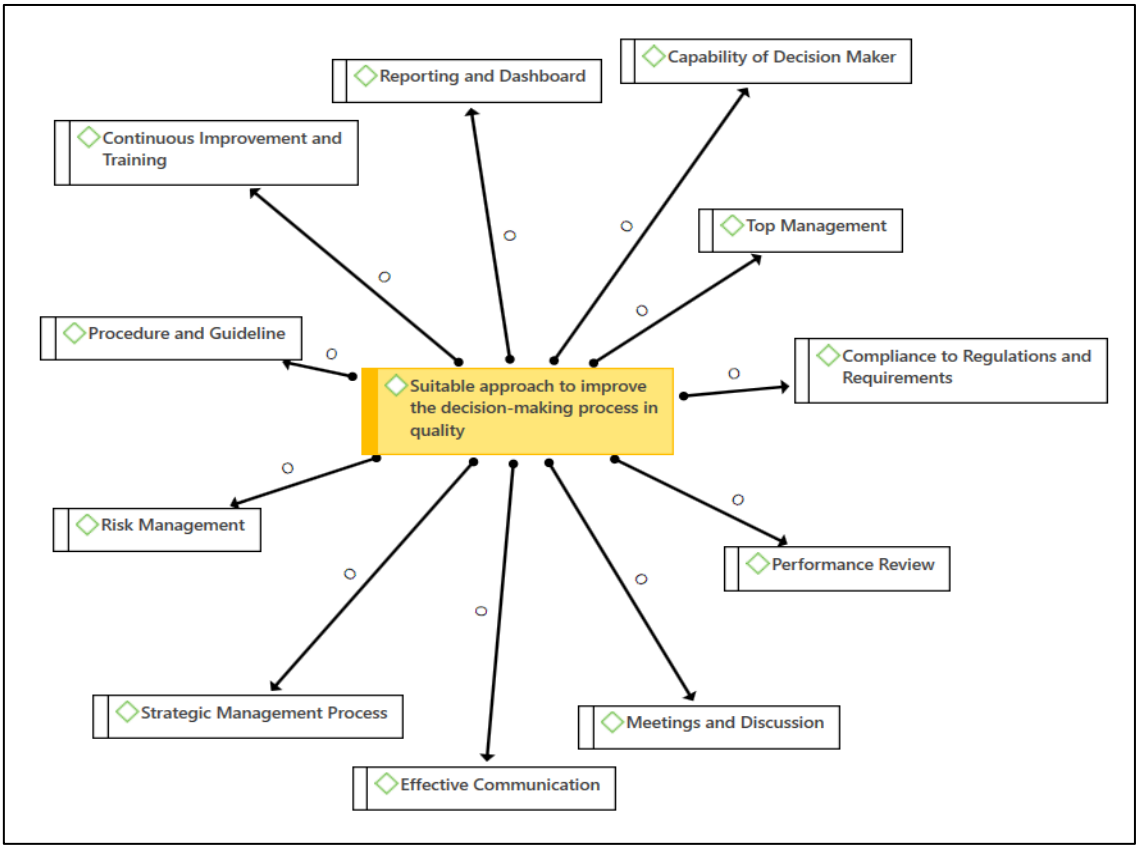

Fig. 4. Suitable Approach to Improve the Decision-making Process in Quality

Source: Authors (2024)

Question 3 aims to explore recommendations for improving the decision-making process among main contractors in quality aspects. The results provided eight (8) recommendations for consideration in the decision-making process among main contractors in MRT2 Elevated Project Klang Valley. These recommendations include: a) Implementing a strategic management process, b) Establishing standard procedures and guidelines for the project, c) Prioritising quality assurance and quality control, d) Conducting regular meetings and discussions, e) Implementing effective communication strategies, f) Addressing the "triple constraints" of time, cost, and quality, g) Ensuring decision-makers possess the necessary capabilities and h) Emphasising continuous improvement and training initiatives. Refer to Figure 5.

https://doi.org/10.24191/bej.v22i2.1255

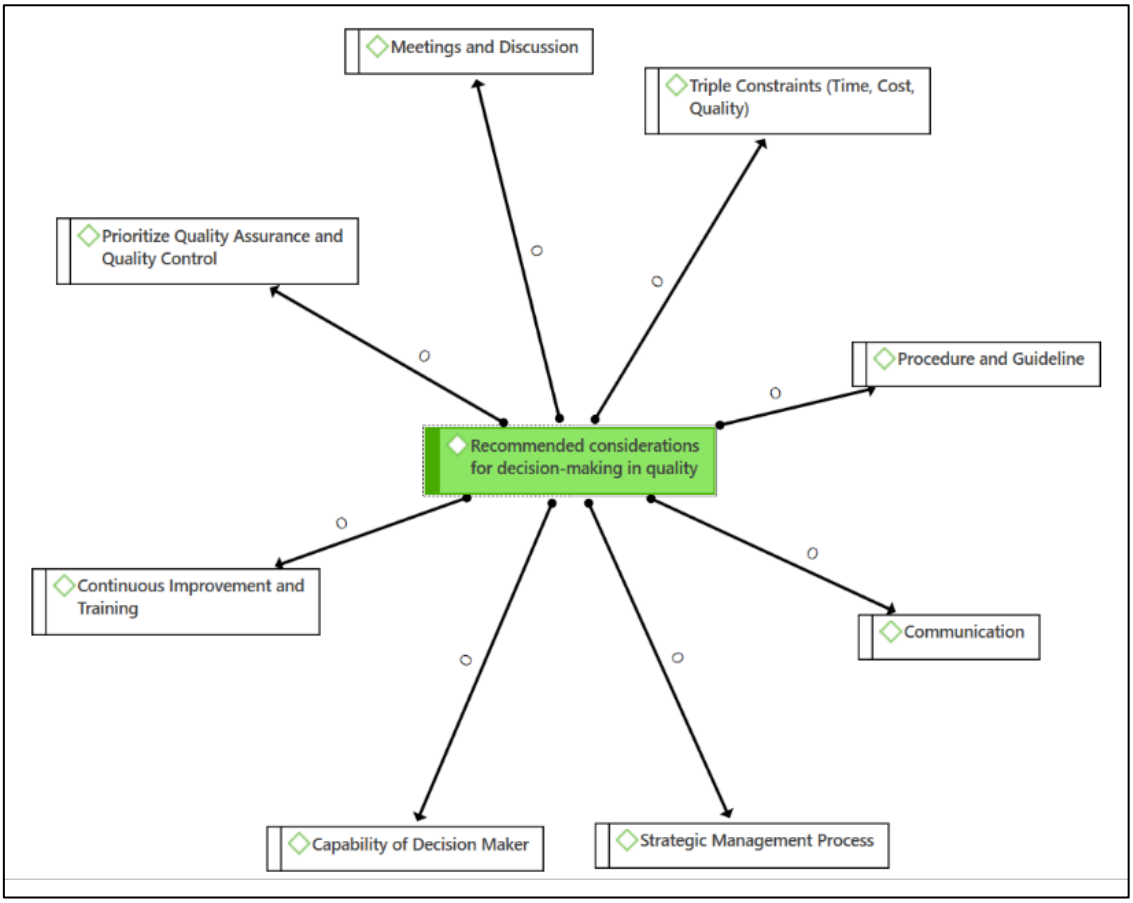

Fig. 5. Recommended Considerations for Decision-making in Quality

Source: Authors (2024)

CONCLUSION

Construction experts engaged in MRT projects within the Klang Valley stress the critical importance of quality-related decision-making for main contractors. Inadequate decisions in this realm can lead to subpar workmanship, jeopardise safety and environmental standards, and cause time inefficiencies and cost overruns. The decision-making process plays an important role in ensuring projects adhere to correct procedures, meet required standards, and achieve set goals. This research aims to identify problems related to decision-making processes and enable to assess considerations for decision-making in quality among main contractors in MRT projects. Key findings highlight the importance of decision-maker proficiency, strategic planning, time management, cost considerations, adherence to quality benchmarks, and organisational structure.

Proficiency in decision-makers directly influences project quality. Skilled decision-makers can understand complex project needs, anticipate potential challenges, and provide effective solutions. Strategic

https://doi.org/10.24191/bej.v22i2.1255

planning ensures resources are allocated appropriately, timelines are adhered to, and risks are mitigated, which will supporting the achievement of project goals. Also, an effective organisational structure enhances communication and collaboration among team members, enabling smooth decision-making processes.

Main contractors must set minimum requirements when hiring key player positions which are decision-makers, ensuring they possess the necessary expertise and resources for informed decision-making. Internal disputes, top management dynamics, and customer satisfaction are identified as major issues affecting quality-related decision-making among main contractors. Recommendations for improving decision-making in quality include strategic management processes, the establishment of procedures and guidelines, effective communication, prioritising of quality assurance and quality control, and regular meetings. Specific objectives, risk management, continuous improvement, and compliance are deemed essential considerations for enhancing decision-making in quality within the construction industry, particularly in large infrastructure projects like MRT endeavours.

The findings of research can also be applied to other infrastructure and construction sectors, such as highway developments, water treatment facilities, and airport construction projects, where decision-making quality plays a critical role in project success. Timely delivery of high-quality projects is crucial for project success, ensuring adherence to standards and meeting stakeholder expectations.

Future studies may explore the impact of digital tools on decision-making process, such as Building Information Modelling (BIM) or project management tools, which can enhance efficiency and accuracy. Additionally, examining how cultural differences in leadership styles affect quality management in international construction projects could provide valuable insights. By addressing these potential research gaps, future studies can contribute to a deeper understanding of decision-making in quality among main contractors in the construction industry and provide valuable insights for practitioners and researchers alike.

ACKNOWLEDGEMENTS

The publication is an author's research work at Universiti Teknologi Mara (UiTM). Acknowledgments are given to Universiti Teknologi Mara (UiTM), Shah Alam, Selangor, Malaysia for providing the facilities for this research.

CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial, or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Nurulhayati Md Zin conducted the research, developed the methodology, strategised data collection, and drafted and revised the manuscript. Nurul Nadiah Zainol conceptualised the core research idea, established the theoretical framework, and supervised the research process. Emma Marinie Ahmad Zawawi led the manuscript review, provided critical revisions, and approved the final submission. Mohd Khairul Afzan Mohd Lazi contributed to the academic review of the manuscript and refinement of its content. Anwar Mohd Ismail provided insights as an industry expert and contributed to the validation of practical relevance.

https://doi.org/10.24191/bej.v22i2.1255

REFERENCES

Aaltonen, K., & Kujala, J. (2010). A project lifecycle perspective on stakeholder influence strategies in global projects. *Scandinavian Journal of Management,* 26(4), 381–397. https://doi.org/10.1016/j.scaman.2010.09.001

Abu Oda, M. M. A., Tayeh, B. A., Alhammadi, S. A., & Abu Aisheh, Y. I. (2022). Key indicators for evaluating the performance of construction companies from the perspective of owners and consultants. Results in Engineering, 15(May), 100596. https://doi.org/10.1016/j.rineng.2022.100596

Govindan, K., Madan Shankar, K., & Kannan, D. (2016). Sustainable material selection for construction industry - A hybrid multi criteria decision making approach. Renewable and Sustainable Energy Reviews, 55, 1274–1288. https://doi.org/10.1016/j.rser.2015.07.100

Hu, W., Dong, J., Hwang, B. G., Ren, R., & Chen, Z. (2022). Is mass rapid transit applicable for deep integration of freight-passenger transport? A multi-perspective analysis from urban China. Transportation Research Part A: Policy and Practice, 165(October), 490–510. https://doi.org/10.1016/j.tra.2022.10.001

Huzaifah, A., & Haslinda, N. (2021). The Practices of Occupational Safety and Health Management in Construction Industry : Case Studies of High Rise Building Projects. 1, 10–17. https://doi.org/10.30880/jsmbe.2021.01.01.002

Jaapar, A., Zawawi, M., Bari, N. A. A., & Ahmad, N. (2012). Value Management in the Malaysian Construction Industry: Addressing a Theory and Practice Gap. Procedia - Social and Behavioral Sciences, 35(December 2011), 757–763. https://doi.org/10.1016/j.sbspro.2012.02.146

Juhari, M. L., & Arifin, K. (2020). Validating measurement structure of materials and equipment factors model in the MRT construction industry using Confirmatory Factor Analysis. Safety Science, 131(June), 104905. https://doi.org/10.1016/j.ssci.2020.104905

Khoshnava, S. M., Rostami, R., Zin, R. M., Mishra, A. R., Rani, P., Mardani, A., & Alrasheedi, M. (2020). Assessing the impact of construction industry stakeholders on workers' unsafe behaviours using extended decision making approach. Automation in Construction, 118(February), 103162. https://doi.org/10.1016/j.autcon.2020.103162

Kineber, A. F., Othman, I., Oke, A. E., Chileshe, N., & Zayed, T. (2021). Exploring the value management critical success factors for sustainable residential building – A structural equation modelling approach. Journal of Cleaner Production, 293, 126115. https://doi.org/10.1016/j.jclepro.2021.126115

Kwan, S. C., Tainio, M., Woodcock, J., Sutan, R., & Hashim, J. H. (2017). The carbon savings and health co-benefits from the introduction of mass rapid transit system in Greater Kuala Lumpur, Malaysia. Journal of Transport and Health, 6(January), 187–200. https://doi.org/10.1016/j.jth.2017.06.006

Lei, Z., Tang, W., Duffield, C., Zhang, L., & Hui, F. K. P. (2017). The impact of technical standards on international project performance: Chinese contractors' experience. International Journal of Project Management, 35(8), 1597–1607. https://doi.org/10.1016/j.ijproman.2017.09.002

Manzolli, J. A., Trovão, J. P., & Henggeler Antunes, C. (2021). Scenario-Based Multi-criteria decision analysis for rapid transit systems implementation in an urban context. ETransportation, 7. https://doi.org/10.1016/j.etran.2020.100101

Martin, L., & Benson, L. (2021). Relationship quality in construction projects: A subcontractor perspective of principal contractor relationships. International Journal of Project Management, 39(6), 633–645. https://doi.org/10.1016/j.ijproman.2021.05.002

Masrom, M. A. N., Rahim, M. H. I. A., Mohamed, S., Chen, G. K., & Yunus, R. (2015). Successful criteria for large infrastructure projects in Malaysia. Procedia Engineering, 125, 143–149. https://doi.org/10.1016/j.proeng.2015.11.021

Mohsen Alawag, A., Salah Alaloul, W., Liew, M. S., Ali Musarat, M., Baarimah, A. O., Saad, S., & Ammad, S. (2022). Total quality management in industrialised building system: Implementation and benefits in construction projects. Ain Shams Engineering Journal, 14(2), 101877. https://doi.org/10.1016/j.asej.2022.101877

Moshood, T. D., Adeleke, A. Q., Nawanir, G., & Mahmud, F. (2020). Ranking of human factors affecting contractors' risk attitudes in the Malaysian construction industry. Social Sciences & Humanities Open, 2(1), 100064. https://doi.org/10.1016/j.ssaho.2020.100064

Mu, S., Cheng, H., Chohr, M., & Peng, W. (2014). Assessing risk management capability of contractors in subway projects in mainland China. International Journal of Project Management, 32(3), 452–460. https://doi.org/10.1016/j.ijproman.2013.08.007

Nguyen, D. T., Le-Hoai, L., Basenda Tarigan, P., & Tran, D. H. (2022). Tradeoff time cost quality in repetitive construction project using fuzzy logic approach and symbiotic organism search algorithm. Alexandria Engineering Journal, 61(2), 1499–1518. https://doi.org/10.1016/j.aej.2021.06.058

Pamucar, D., Macura, D., Tavana, M., Božanić, D., & Knežević, N. (2022). An integrated rough group multicriteria decision-making model for the ex-ante prioritisation of infrastructure projects: The Serbian Railways case. Socio-Economic Planning Sciences, 79(October 2020). https://doi.org/10.1016/j.seps.2021.101098

Paton, S., & Andrew, B. (2019). The role of the Project Management Office (PMO) in product lifecycle management: A case study in the defence industry. International Journal of Production Economics, 208(November 2018), 43–52. https://doi.org/10.1016/j.ijpe.2018.11.002

Riaz, H., Iqbal Ahmad Khan, K., Ullah, F., Bilal Tahir, M., Alqurashi, M., & Badr Alsulami, T. (2022). Key factors for implementation of total quality management in construction Sector: A system dynamics approach. Ain Shams Engineering Journal, 14(3), 101903. https://doi.org/10.1016/j.asej.2022.101903

Rivera, F. M. La, Hermosilla, P., Delgadillo, J., & Echeverría, D. (2020). The sustainable development goals (SDGs) as a basis for innovation skills for engineers in the industry 4.0 context. Sustainability (Switzerland), 12(16). https://doi.org/10.3390/su12166622

Talbi, A., & Souad, S. B. (2022). Industry 4.0 in construction organisation of a mega projects: a bibliometric analysis. Procedia Computer Science, 204, 524–531. https://doi.org/10.1016/j.procs.2022.08.064

Wang, T. K., Wu, Z., & Luo, C. (2021). Multi-participant construction waste demolition and transportation decision-making system. Resources, Conservation and Recycling, 170(March), 105575. https://doi.org/10.1016/j.resconrec.2021.105575

Yang, L., Eom, S., & Suzuki, T. (2021). Measuring railway network performance considering accessibility levels in cities worldwide. Journal of Transport Geography, 96(January). https://doi.org/10.1016/j.jtrangeo.2021.103211

Yap, J. B. H., Goay, P. L., Woon, Y. B., & Skitmore, M. (2021). Revisiting critical delay factors for construction: Analysing projects in Malaysia. Alexandria Engineering Journal, 60(1), 1717–1729. https://doi.org/10.1016/j.aej.2020.11.021

Zhong, S., Elhegazy, H., & Elzarka, H. (2022). Key factors affecting the decision-making process for buildings projects in Egypt. Ain Shams Engineering Journal, 13(3), 101597. https://doi.org/10.1016/j.asej.2021.09.024

Zong, C., Margesin, M., Staudt, J., Deghim, F., & Lang, W. (2022). Decision-making under uncertainty in the early phase of building façade design based on multi-objective stochastic optimisation. Building and Environment, 226(August), 109729. https://doi.org/10.1016/j.buildenv.2022.109729