ASSESSING THE MAJOR REWORK FACTORS IN TRANSPORT INFRASTRUCTURE PROJECTS IN MALAYSIA

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Quantity Surveying

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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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APPROVAL FOR SUBMISSION

I certify that this project report entitled **"ASSESSING THE MAJOR REWORK FACTORS IN TRANSPORT INFRASTRUCTURE PROJECTS IN MALAYSIA"** was prepared by **LIM ING RHONG** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Quantity Surveying at Universiti Tunku Abdul Rahman.

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ABSTRACT

Development of transport infrastructure projects (TIP) is pivotal as it inaugurates national connectivity and accessibility, also establishes impetus towards the blossoming of the local economies. However, rework seems to be the ubiquitous issue and a deep-rooted dilemma that imperil the TIP's growth and performance. There is substantial lack of attention by the Malaysian construction industry and severe paucity of extant studies investigated into the rework factors of TIP. Thus, this research aims to bridge the knowledge gap by identifying the major rework factors; evaluating the criticality of the major rework factors; and appraising the rework reduction measures within the context of Malaysian TIP. Through a comprehensive literature review, assessment had been accomplished where 40 rework factors and 15 rework reduction measures had been identified. Meanwhile, 108 questionnaire responses were being collected from various industry personnel including client, consultant and contractor. The Importance Index technique shown the five significant factors that provoke reworks are poor communication; noncompliance of task requirements; inappropriate construction method; lack of scope clarity and lack adherence to quality assurance. Furthermore, five underlying factors have been unveiled through factor analysis, namely, inadequacy in construction stage considerations; incompetency of site practitioners; inadequacy in feasibility stage considerations; inappropriate allocation of resources and haphazard information delivery system. Meanwhile, the five most significant reduction measures via Relative Importance Index approach are maintaining effective communication; client's needs and priorities should always be clear; accurate contract documentation and design; implementing constructability strategy and utilising BIM tools. Lastly, the statistical relationship between the factors and potential measures were examined via correlation test. The five most effective and practical measures for the addressed factors are workers should undergo proper training programmes; maintaining effective communication; be conscious and responsive of site conditions; implementing constructability strategy and ensure skilled workforce in carrying out special tasks. Conclusively, this research assessment could be the basis for Malaysian researchers to look into

its implication in the near future while the proposed potential measures should be further investigated to maximise the development of Malaysian TIP.

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LIST OF SYMBOLS / ABBREVIATIONS

α	Cronbach's Alpha
rs	Spearman's Rank Correlation Coefficient
F.I.	Frequency Index
S.I.	Severity Index
IMP.I.	Importance Index
RII	Relative Importance Index Techniques
FA	Factor Analysis
V	Variance

DOSM	Department of Statistics Malaysia
CIDB	Construction Industry Development Board
GDP	Gross Domestic Product
LRT	Light Rail Transit
MRT	Mass Rail Transit
NTP	National Transport Policy 2019-2030
ECRL	East-Coast Rail Link
HSR	High Speed Rail
PMI	Project Management Institute
BIM	Building Information Modelling
WBS	Work Breakdown Structure
CLT	Central Limit Theorem
PCA	Principal Component Analysis
KMO	Kaiser-Meyer-Olkin
SPSS	Statistical Package for Social Sciences
3D	Dirty, Dangerous, Difficult
TOD	Transit-Oriented Development
TIP	Transport Infrastructure Projects

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

This chapter provided the synopsis of the research which encompasses the discussions of the research background, problem statement, research gaps, research aim and objectives, research questions, research scope, research significance and justification, followed by the clarification of chapters' outline for this research.

1.2 Background of Study

Scrutinizing on the statistics published by the Department of Statistics Malaysia (DOSM) (2022a, 2022b), during the fourth quarter of 2021, the construction industry had contributed the least production (RM12.6 billion) towards the national Gross Domestic Product (GDP) as compared to other economic sectors including the manufacturing, services, agriculture, mining and quarrying sectors. In spite of that, the researchers, Khan, Liew and Ghazali (2012; 2014), Zid, et al. (2020), Ibrahim, et al. (2010) and Masrom, et al. (2015) opined that the construction industry is indisputably contemplated as one of the substantial productive contributors in driving national economic development, although the GDP's contribution of Malaysian construction industry merely ranged between 3 to 5 percent over recent decades.

Specifically, since the day of Malaysian Independence, the transport infrastructure developments in part of the construction industry have been proliferated and served as an efficacious instrument manoeuvred by the state and federal Governments in achieving Malaysia as one of the developed countries in Southeast Asia (Masrom, et al., 2015; Khan, Liew and Ghazali, 2014; Ibrahim, et al., 2010). The Malaysian Government had invested a lot of propulsion effort to boost up the Malaysia's economic by building up numerous TIP comprising the construction of road, bridge, tunnel, highway system, railway system, airport system and so forth in order to increase the connectivity across the whole nation. For instance, a comprehensive network of transportation system had been established in Kuala Lumpur and Selangor areas allowing the public transports such as bus, commuter, monorail, Light Rail Transit (LRT) and Mass-Rail Transit (MRT) to be operated and provided the local accessibility to another whole new level as compared to other states.

Generally, the deliverables from the construction of transport infrastructure in Malaysia indeed created a forward linkage as the development of transportation system is capable to grant the pathway in generating consistent revenue from various kind of local business and services (Khadaroo and Seetanah, 2010; Khan, Ghazali and Liew, 2012; 2014). Additionally, throughout the construction process, it required a wide variety of construction raw materials such as concrete, metal, timber, plastic to be manufactured, also not forgetting various machineries and equipment would be required which indirectly empower the mass production from manufacturing sector through the backward linkage (Khan, Ghazali and Liew, 2012; Alaloul, et al., 2021).

Moreover, the contribution of Malaysian TIP cannot simply be neglected especially those mega projects due to the attribute of being such great scale where all the projects are exceptionally labour-extensive, hence directly inaugurate a plethora of employment opportunities. According to Statista (2021), although the construction industry suffering affliction from the Covid-19 pandemic, nevertheless, the industry is still able to supply approximately 1.4 million jobs opportunities in 2020. While the DOSM (2022c) also denoted that the construction industry had secured a relatively high employment rate of 98.2%, about 1.3 million people are actually earning a living from the construction industry in the fourth quarter of 2021. While the recovery conditions are having positive growth in the soon future, declared by the DOSM (2022d).

Based on further detail statistics elaborated (DOSM, 2022e), the civil engineering construction projects are holding up to 36.3% in generating market share value from the overall projects' work done, claimed to be the largest contributors as compared to building construction projects and special trade activities. Essentially, the TIP are postulated to act as the economic development catalysts (Ramli, et al., 2021; Aziz, 2022) that will expedite the momentum for Malaysia to achieve the visions and prospects introduced in the national plans including the Strategic Thrust 6: Regional Inclusion of the Shared Prosperity Vision 2030; the Five Policy Thrusts tailored in the National Transport Policy 2019-2030 (NTP), also the 3rd Policy Enabler gazetted within the 12th Malaysia Plan, 2021-2025. (EPU, 2019; PMO, 2019; RMKE12, 2021). Additionally, a recent study from Yap, Skitmore (2021) also emphasising the urgent need of more dynamic and sustainable transport infrastructure to be established in Malaysia's Klang Valley region so to create impetus in realising the accomplishment of Greater Kuala Lumpur in soon manner.

1.3 Problem Statement

Throughout recent years, the Covid-19 pandemic had ensued critical strikes towards the Malaysian construction industry, while the three consecutive changes of Malaysian governments had also lead to multiple fiscal constraints that indirectly stymied the proceeding of the mega transport infrastructure projects including the MRT3, East-Coast Rail Link (ECRL) and High Speed Rail (HSR) projects in West Malaysia; meanwhile the predicament also affected the proceeding of Pan Borneo highway in East Malaysia (Aziz, 2022; Bunyan, 2021). Nonetheless, apart from these crisis which are beyond the construction personnel's control, the researcher in Malaysia, Tammy, et al. (2021); Durdyev and Ismail (2016) pointed out a chronic problem which should be reasonably monitored by all the construction practitioners – rework. As the ultimate consequence resulting from construction issues such as change order, design error, poor quality of work done, incompetency of human resource capabilities and so forth. Rework is indeed a deep-rooted dilemma for the Malaysian transport infrastructure projects that preventive and mitigative strategies are indispensable needed to be done in a timely manner, nevertheless the investigation and assessment of the relevant rework factors should be executed prior to the actions to be taken (Love, et al., 2010).

According to Ramli, et al. (2021), of all the major transport infrastructure projects within Malaysia, they possess the common significant issue where project schedules were kept on delaying while the underlying factors including lack of experience and skill, ambiguous detailed drawings, change orders, improper construction approach and so on that will eventually lead to erroneous deliverables. Additionally, when more and more construction practitioners tends to overlook the mentioned rework precursors and proceed without further conscious, eventually the accumulation of such inappropriate acts will lead to unfavourable reworks (Li and Taylor, 2014; Yap, Low and Wang, 2017; Zhang, et al., 2018; Safapour and Kermanshachi, 2019; Yap and Tan, 2021; Love, et al., 2022). The major consequences of rework have also been encapsulated within the papers affirming that rework is plaguing the project schedule, causing schedule and construction cost overrun and eventually sabotage the project performance. Researcher from China, Ye, et al. (2014) had also advocated that the trade-off of reworks indeed caused the contract sum to be rising and range between 5% to 20% of the total amount.

According to the research statement established from the most developed country in African region, Khadaroo and Seetanah (2010) asserted that a dynamic and well-established transport infrastructure system is playing a pivotal role especially in the developing countries as the advancement in transportation system will boost up the local economy while also able to attract a lot of foreign investments. In view of this matter, Malaysia as one of the fastest-developing countries within Southeast Asia still has considerably immense room for improvement in the development of transport infrastructure, in order for the transport infrastructure industry to be able to keep up the track in increasing the national connectivity and accessibility, also to align with the national visions aforementioned, it is an urge to deliver the Malaysian TIP in a more efficient manner first by reducing the rework issues and hence shoot up the project performance.

Nonetheless, it is being discovered that the relevant concerns were not being prioritised, emphasized and practised within the construction industry in the Malaysian context. There is still lacking of awareness while relevant research in assessing and analysing the reworks factors and their correspond strategies towards the Malaysian TIP are claimed to be solemly insufficient. Such critical detainment of the Malaysian TIP resulting from severe rework issues cannot be compromised anymore in attaining the vision to be recognised as one of the developed countries.

Most of the extant studies had been done in respect of the rework issues are relating to the building construction projects whereby relevant investigation and analysis that are being done to the rework issues within the civil engineering areas are significantly deficient (Love and Edwards, 2005; Love, et al., 2010; Yap, Low and Wang, 2017; Forcada, et al., 2017; Love, et al., 2018). Throughout the literature review process, it is being discovered that research investigation dedicating to the rework issues specifically for TIP hitherto are solemnly limited and yet to be discovered in the global context (Love, et al., 2022) , not to say within the extent of Malaysian region. Thus, this research tends to provide a holistic view of the pessimist side of Malaysia transport infrastructure development process by assessing the major rework factors that are hijacking the Malaysian TIP and in hope that this research clarification would able to draw the attention from the local construction personnel to confront and take into serious account of the rework factors before any rectification measures can be done.

The prospects for Malaysia to become one of the self-sufficient and prosperous nation in terms of the social development, economic prosperity, quality educational system and political stability would never be attained as long as the rework issues wreck-havoc on the TIP, essentially upon those mega structure projects which will not only deferring the project schedule, but it also impede the positive economic thrive for other economic sectors due to the robust backward and forward linkage generated by the construction industry (Khan, Ghazali and Liew, 2012; Zid, et al., 2020).

Thus, this research was being implemented to fill up and dwindle the literature gaps of the rework factors that have always been influencing the progress and performance of the Malaysian TIP. This research will be emphasising in figuring out the major rework factors within Malaysian TIP framework; whereby suggestions of the predictive solutions or mitigation measures in reducing reworks would be investigate accordingly. Generally, the enhancement of the overall efficiency and productivity of the transport infrastructure development should be implemented in time as it was comtemplated as the national economy-driven instrument to achieve Malaysia as a highly-developed nation’s status.

1.4 Research Aim

This research aims to ameliorate the comprehensive performance of the Malaysian TIP and hence forge the national economic developments to be more mature through the means of assessing the major rework factors in Malaysian transport infrastructure projects and bridging effective measures accordingly.

1.5 Research Objectives

The objectives of this research are:

1. To identify the major rework factors in Malaysian TIP.
2. To evaluate the criticality of the major rework factors upon Malaysian TIP based on the level of occurrence and level of severity.
3. To appraise the measures in reducing major rework factors in Malaysian TIP.

1.6 Research Questions

The research questions for this research are:

1. What are the major rework factors in Malaysian TIP?
2. How significant are the impacts of rework contributed towards Malaysian TIP?
3. What are the effective measures to reduce rework in Malaysian TIP?

1.7 Research Scope

The data collection for this research will inclusive of the perceptions from various kind of construction industry practitioners, favourably to whom that are actively engaged in all kind of TIP in Malaysia including construction of road, railway, expressway, tunnel, bridge and so on. Generally, the respondents will be categorised into three major groups that constitute of clients, consultants and contractors.

1.8 Research Significance and Justification

Through a series of assessment and analysing process, this research intends to affirm and accentuate the major rework factors that substantially influence the Malaysian transport infrastructure projects. Meanwhile, the insights and opinions relating to the preventive or mitigation measures attained from the construction practitioners through this research will be recapitulated as well to promote a more efficient and effective civil construction delivery process. Basically, this research finding could be make acknowledgeable among the construction personnel involved in the transport infrastructure projects in Malaysia, thus creating more awareness that indirectly contributing to the enhancement of project knowledge management. Additionally, this research that was done within the Malaysia context could provide a general framework to those developing countries, enlighten more relevant potential studies to be done for the construction fraternity and thus achieve significant rework reduction in future transport infrastructure development. Conclusively, when more and more relevant study could be done in the context of the developing countries, eventually increasing reliable and effective construction practices and alternatives could be generated and implemented for the on-going or upcoming transport infrastructure projects of the country.

1.9 Outline of the Report

Chapter 1: Introduction

This chapter offered the synopsis and overview of the study. Study background, problem statement and the research gaps related to the rework issues in the Malaysian TIP had been highlighted. Meanwhile, research aim, research objectives, research questions, research scope, research siginification had been generated and justified through this chapter as well.

Chapter 2: Literature Review

A brief introduction of rework definition, rework issues and its impact had been identified in this chapter. After that, analysation and reviewing of a series of literature resources done by previous researchers from both primary and secondary resources data had been carried out to clarifiy and summarize the rework factors and relevant measures that reducing or avoiding rework occurrence.

Chapter 3: Research Methodology

This chapter explained the mechanism and research method that are being employed for the data collection in conducting this research. It encompases the explanation of the research types, research design process, data collection approach and the data analysis techniques.

Chapter 4: Results and Discussions

The data obtained through the collection process will undergo statistical analysis in this chapter. The research results will be discussed in detail and data achieved will be rearranged and demonstrated by figures or tables.

Chapter 5: Conclusions and Recommendations

This chapter will conclude the data analysis results and discussions generated from Chapter 4. Lastly, the research limitation will be established, meanwhile reasonable recommendations in enhancing future relevant research will be prepared within this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter expatiates on the body of literature that have been reviewed which are related to the rework issues. The definitions of rework are being discussed in this chapter. Meanwhile, relevant rework problems in various countries had been analysed and described in detail. Furthermore, the rework factors that are being classified into the extent of developing countries and developed countries had been appraised and explained in the following section. Overall summary for each context of rework factors were being tabulated as in Table 2.2 and Table 2.3. Whilst, the further section of this chapter had also included the literature reviews obtained from previous researchers' studies that are related to the measures in reducing rework issues. The findings were then being summarised and tabulated based on the managerial types as indicated in Table 2.5.

2.2 Definition of Rework

Rework has been asserted to be the innate phenomenon within the construction industry, not only in Malaysia, but also a fundamental issue happening in other countries including Australia, China, Egypt, Singapore, Spain and the United States of America (USA) (Forcada, et al., 2014; Hwang, Zhao and Goh, 2014; Ye, et al., 2014; Yap, Low and Wang, 2017; Love, et al., 2018b; Safapour and Kermanshachi, 2019; Al-Janabi, Abdel-Monem and El-Dash, 2020)

The notion of rework has been developed and identified by various researchers for decades. Several interpretation of the definition of rework had been done based on respective production systems. Researchers from USA, Burati, Farrington and Ledbetter (1992) had examined the degree of quality deviations correlated to the project specifications that rework had been comtemplated as one of the consequences resulting from such failures in conforming the quality requirements or standards. Additionally, the results had reported that the rework cost of quality deviation tasks can range up to

12.4% of oevrall project cost. Meanwhile, in 2004, the studies from Fayek, Dissanayake and Campero advocated that regardless of the initiating percursors, rework is the overall direct cost that are resulting from re-doing tasks. While the researchers Sommerville, Craig and Bowden (2004) and Sommerville (2007) defined the terms rework was the acquired correspond rectifications for the consequence of minor defects and quality lapses.

Several relevant research had been implemented by the Australia researchers as well where they clarified that reworks is posseing synonymous to non-conformance, quality failure and quality deviation (Love, et al., 2010; Love and Smith, 2019). Love and Li (2000) also elaborated that rework is the unnecessary effort derived from non-conformance of work requirements thus acquiring re-doing of the activity or process to rectify what was erroneously done in the first place. Rework has also being interpreted as the works that went through omission, regulation changes or errors which are subject to practical amendments (Taylor and Ford, 2008).

Whilst few studies in relating to rework issues had been carried out by the Nigeria researchers, Oyewobi, et al. (2011) reiterated that rework the non-fulfilment of the contracted project performance in accomplishing the client’s requirements; whilst Eze and Idiake (2018) stated that rework is the unfavourable effort that degrade the overall project performace. Meanwhile, in Malaysia, Yap, Low and Wang (2017); Yap and Tan (2021) encapsulated that rework is an undesired and non-value adding effort given rise from the non-compliance of tasks’ requirements that eventually cause dentrimental effect to the overall project accomplishment. Table 2.1 below indicates definitions of rework by various researchers.

Table 2.1: Summary of Definitions of Rework.

Country	**Year**	**Authors**	**Key Descriptions**
USA	1992	Burati, Farrington and Ledbetter	Nonconformity of quality requirements and standards
	2004	Sommerville, Craig and Bowden	Rectification works for quality defects and lapses
	2007	Sommerville	
	2008	Taylor and Ford	Amendment made to error, omission and change

Country	Year	Authors	Key Descriptions
UK	2004	Fayek, Dissanayake and Campero	Re-doing a process or task
Australia	2000	Love and Li	Unnecessary effort of re-doing an activity or process
	2010 2019	Love, et al. Love and Smith	Non-conformance, quality failure and quality deviation
Nigeria	2011	Oyewobi, et al.	Non-fulfilment of client's expectations
	2018	Eze and Idiake	Unfavourable effort that degrade project performance
Malaysia	2017 2021	Yap, Low and Wang Yap and Tan	Undesired non-value adding effort due to nonconformity of requirements

2.3 Rework Issues in Developing Countries

2.3.1 Egypt

A study relating to rework impacts that was implemented by Okasha, Arafa and Amer (2018) had elucidated that the more the design changes that required rework to take place, the higher the time and cost overruns. The result shown that the additional cost and time provoked from rework is approximately 30% and 33% higher from the original model's cost if more than 60% of design change being imposed on the work done. Whereas two years later, the researchers Al-Janabi, Abdel-Monem and El-Dash (2020) advocated that rework is the prime cause that always jeopardizing the Egypt construction industry, causing every construction project to encounter dreadful cost overruns and schedule delays. The researchers also deduced that the most substantial rework factor is due to the economic conditions of the country such as inflation and instability of currency exchange.

2.3.2 Nigeria

Researchers Oyewobi, et al. (2011) had declared that Nigeria as a developing country is facing a lot of struggling and difficulty in developing better construction services as the development cycle has always been compressed by the client to reduce the total development cost. Nonetheless, due to the severe lack of skilled labour and advancement of technologies being adopted by the industry ultimately the occurrence of reworks has never been reduced. Whilst, a case study executed by Abeku, et al. (2016), deduced that the estimated time and cost overruns resulting from rework were 38% and 12.58% respectively. Two years later, researchers Eze and Idiake (2018) indicated that an average of 7.35% and 3.53% will be incurred from the respective initial estimated project delivery time and initial estimated project cost as the ramifications of rework.

2.3.3 Malaysia

Based on the statistics elucidated by Yap, Low and Wang (2017), the cost of rework within Malaysian construction industry range from 3.1% up to 6% of the overall contract value while the incompetency derived from both the design and construction teams that resulting poor quality project performance was claimed to be the main factors that causing reworks. While another research done in the same year by Yap, Abdul-Rahman and Chen (2017) also strengthen that rework issues had contributed to additional 6% of construction cost and 10% increasing in the project schedule growth. Moreover, few studies was being done years later indicated that reworks not only causing the Malaysian construction projects to suffer undesired time and cost overrun, but it also causing fatigues among the the construction site personnel that give rise to poor productivity and disputes, eventually imperial the construction site safety and promoting various site accidents (Yap, et al., 2020; Yap and Tan, 2021).

2.4 Rework Issues in Developed Countries

2.4.1 Australia

According to the case study accomplished by Love and Li (2000), the direct cost of reworks was asserted to be incurred up to 3.15% of the overall contract sum which is slightly lower as compared to the developing countries that could surge up between 3% to 10% of the entire contruction cost. However, Love (2002) also stated that the rework’s indirect consequence that inclusive of the increasing conflicts, loss of business relation, compression of profit margin cannot be neglected as it may attain a maximum effect up to six times of the direct rework costs. Whereas, a study that was specifically adopted for Australia's civil infrastructure projects deduced that rework can evolve an additional 10% of the construction contract value when the projects possess excessive changes and ambiguity cases, also, abortive utilisation of information technologies (Love, et al., 2010).

2.4.2 Sweden

A Swedish case study of seven building construction projects that was being done by Josephson and Hammarlund (1999) also discovered that the associated costs in rectifying the defects works had recorded up to 2.3% to 9.3% of the construction's production cost which tends to be similar to that of developing countries. Meanwhile, another case study had been carried out by Josephson, Larsson and Li (2002) to study the rework costs in seven construction projects in Sweden and the research finding claimed that about 4.4% of rework costs being incurred on the construction values, while the time spent in relevant rectification works had took up to 7.1% of the total construction period.

2.4.3 Canada

The Canada researchers Fayek, Dissanayake and Campero (2003) had made effort and developed a classification model or a fishbone model, namely Ishikawa diagram to better identify various kind of rework factors. However, the rework issues do not seem to be ameliorated through decade. In 2013, an integrated research had been done by Mendis, Hewage and Wrzesniewski (2013) that investigating into the rework issues within Canada. The researchers asserted that the huge generation of up to 30% municipal solid waste (MSW) was largely due to the rework issues within Canadian construction industry; they had further clarified that such tempestuous rework issue was due to the ambiguity and failure in diversify the rework risks among the construction stakeholders. This is mainly because the standard construction contract in Canada denoted that consultants are the one to inspect and approve for the works' quality conformance, nonetheless as the actual rework costs will be bear by the contractors which in turn creating a space for the employer to take as granted in making specification changes.

2.5 Rework Factors in Developing Countries

2.5.1 Malaysia

According to the literature reviews within the Malaysian construction industry context, it is being discovered that throughout the five years of studies from 2017 to 2021, the most substantial rework factors that were being mentioned by previous researchers are due to the poor project planning and coordination which had been categorised as in Table 2.2 under the Project Management issues. While the subsequent factors that were being repeatedly asserted to be critical and continue to generate abundant rework issues in Malaysia are claimed to be the change orders and design changes initiated by Client or Consultant. The dismally poor communication among the construction stakeholders throughout the entire project development process are also asserted to be an vital reason that will cause rework. Whereas the rework issues arise from the implementation of ineffective site supervision that incorporated with the non-compliance of task requirement by the main contractors and sub-contractors are also being declared to be the significant aspects among the critical precursors that will eventually lead to rework (Yap, Low and Wang, 2017; Yap, et al., 2018; 2020; Yap, Chow and Shavarebi, 2019; Yap and Tan, 2021). Briefly, the Malaysian researchers opined that the most perilous major rework factors are arised from the improper project planning and coordination, insufficient communication, change orders, changing design, ineffective site inspection and also the dissatisfied task-fulfilment of work done by the main contractors and sub-contractors.

The research done by Yap, Low and Wang (2017) by employing the factor analysis approach deduced that the most crucial factors that spur to rework are the Project Coordination Management which is coincided to the summarisation done previously. The incompetence in dealing with project coordination had been affirmed by the stated researchers as it recorded the highest percentage, approximately 15.40% had been derived from the total variance. The researchers stressing that an effective project coordination should be done in the first place – the design stage. Nonetheless, the Malaysian construction projects are mostly still adopting the conventional construction approach where the main contractor is absent in the design phase.

They would not participate in the pre-construction stage with the client and consultants, subsequently this separation gaps leading to the result where they tends to be more focusing on generating own interest in this stage (Love, 2002b).

Basically, all the construction stakeholders including the Client, Consultants and Contractors should be actively engaged during the design stage so to improve the clarifications of the project delivery system regarding the project's procurement method, thus reducing the uncertainty and dispute that may arise due to the lapse of information during later stage (Love, 2002b; Hwang and Yang, 2014; Oyewobi, Abiola-Falemu and Ibironke, 2016; Yap, Chow and Shavarebi (2019) also justified that a strategic planning during the earlier phase is exceptionally essential to minimize possible changes initiated in the implementing stage and ended up rework is being acquired to rectify the problems (Safapour and Kermanshachi, 2019).

Besides, design change and change orders are frequently wreck hovoc on project cost and schedule, highlighted by Yap, Low and Wang, (2017), Yap, et al. (2018) and Yap and Tan (2021). The researchers urge the need for the construction practitioners to realise that understanding of the client's requirements and project specifications are crucial to be done in the design phase in order to hamper the consequence of errorneous in design. Subsequently, the design changes will affected the work done and thus causing rework. At the same time, the flow of the stated project information and any later design changes should always be adequately conveyed and shared among the construction stakeholders in a timely manner. Nonetheless, most of the construction projects are extensively employing the sub-contracting exercise that eventually creating a bureaucratic practice and diminish the completeness of project information flow (Yap, Low and Wang, 2017; Yap, et al., 2018; Hwang and Yang, 2014).

The poor intensity of workmanship consolidated with the lack of site inspection will eventually lead to severe rework issues (Yap, Low and Wang, 2017; Yap, et al., 2018; 2020). The researchers pointed out that Malaysian construction industry are still employing a huge quantum of foreign labour who are not only possess difficulty in interpreting instructions, but they are also mostly unskilled that prone to conduct incorrect construction approach hence not able to perform as the standards when there is increasing complexity of project’s tasks. This statement is further justified through the studies done in Australia (Love, et al., 2009) and Sweden(Josephson, Larsson and Li, 2002) asserted that poor quality of workmanship tends to contribute largely in rework issues.

In Yap, et al. (2018) paper, the factor analysis executed had found that the site constraints had accounted for about 10.5% of the overall variance elucidated. They affirmed that the most significant rework factors are mostly the consequence from various kind of site issues encompassing the unforeseeable site conditions and restrictions. Thus, prior to this site issues, sufficient site visits and site inspections have to be done by the consultant teams in order to attain the completeness of site information and reducing the practice of design change in later construction stage (Mohamad, Nekooie and Al-Harthy, 2012). Additionally, it is indispensable to implement adequate site inspections no matter it is design or construction process, especially for the mega transport infrastructure project that are usually large in scale and occupied a substantial areas of different sites with more uncertainties and risks tend to arise as compared to the building construction projects (Eldash and Abdel-Monem, 2004).

2.5.2 China

A study done through the factor analaysis method by Ye, et al. (2014) in China denoted that the most problematic rework causes are the ambiguity and unclear project management activities, inadequate utilisation of high specification building technologies and the faulty building material’s quality. Within this research, Ye, et al. (2014) also established the terms of “active rework”, describing that some reasonable reworks that are made as earlier as possible are comtemplated to be able to reduce the construction cost and period by making amendment or changes to the complex design or expensive materials adopted in the first place (Yap, et al., 2018). Nonetheless, the researchers further clarified that most of the construction projects in China are having tight project schedule and being classified as the three-way projects, bringing the definition for projects which are being appraised, designed and implemented at the same time. Additionally, different from the

Joint Venture culture or Public-Private Projects initiated as in Malaysia, most of the civil engineering projects in China are imposing that Government is the sole ownership for the projects, hence the construction players in China are actually receiving less experience and knowledge in managing and practising the mistakes deduce from the rework cases.

Another case study regarding rework management was done four years later by Zhang, et al. (2018), the researchers had investigated into three different construction projects and analysed the factors of rework by grouping them into four major root causes comprising of the design management failure, ineffective communication, construction management failure and poor material management practice. Similar to the explaination mentioned in subsection of Malaysia and Singapore, this case study indicated that the most frequent rework cause is derived from the poor design management and the consolidation of communication failure among the construction stakeholders. Based on the research findings, it was notable that the contract management should be accounted in a more serious manner during the initial development stage, clients are encourage to provide as comprehensive as possible regarding the project requirements and scope so to ensure there is no ambiguity in the interpretation of contract terms and conditions when negotiate with the contractors. Meanwhile, ineffective communication among the construction practitioners during the design stage may lead to some misunderstandings and disputes during execution stage (Ye, et al., 2014; Zhang, et al., 2018).

Apart from that, both of the studies had been emphasising on the rework factors of poor material quality. The researchers urge the need for the construction authorities to enforce the site supervisor or administrative staff to undergo proper training programs that are related to the management of materials and machinery on site. For instance, the site administrative staff may acknowledge the measures in handling and protecting the resources on site hence achieved a sustainable material and machinery quality and performance.

2.5.3 Egypt

According to the survey implemented to 67 construction professionals in Egypt of nineteen construction projects (Al-Janabi, Abdel-Monem and El-Dash, 2020), the major critical rework factors are quite different as compared to the context of other developing countries explained in previous sections, the five most substantial causes of reworks in Egypt are due to the country's economic conditions, the compression of project schedule, design changes and specification changes made by client and insufficient feasibility survey. The researchers had employed the importance index approach and listed out a total of 87 reworks problems and further categorised the entire problems into ten major rework factor groups comprising of the areas of client, contract, design, contractor and subcontractor, supervisory, construction, site, labours, material and equipment, lastly the external issues.

The Egypt researchers opined that the policy decisions made by the Egypt's Central Bank was the main contributors to the severe rework issues for Egypt's construction projects. Specifically, the fluctuation in Egypt's currency exchange will impose significant increase in the material price, equipment rates, so does the labour wages. The researchers further advocated that such inflation was substantially hijacking the construction industry which in retun the project stakeholders tends to impose changes on the material types, project design and project specifications in order to curb the loss of profit margin due to inflation.

Apart from this, further study in 2021 by Yousry Akal and Metwally El-Kholy (2021) asserted that the compressed and tight project schedule was the most frustrating factors that inducing reworks while design omissions or errors due to the limited time frame during design stage was ranked as the 5th rework factors in this research (Abeku, et al., 2016). The intermediate rework factos are the delay payment of contractual fees, poor quality assurance due to the tendering policy in selecting the most lowest bid and the poor labour skill level due to inadequate vocational education. Generally, the acceleration and compression of project schedule was the most agreeable rework factors based on the integrated review done to the aforementioned research. The researchers, Yousry Akal and Metwally El-Kholy (2021) further elaborated that the Egyptian project sponsors are always setting an unrealistic time frame for the construction projects in achieving each progress milestone along with the compression of project budget. Therefore, such situations are compelling the contractors and sub-contractors to initiate for design change by substituting the original material with a cheaper alternative. Ultimately, the completed scopes are not accepted by the project owner as the failure in adhering with the project requirements and specifications contributed to the poor quality deliverables that required rework (Yousry Akal and Metwally El-Kholy, 2021).

2.5.4 Summary of Rework Factors in Developing Countries

Table 2.2 denoted the rework factors unfold within the developing countries context based on the literature contributions done by various previous authors including Malaysia (1-5), China (6-7) and Egypt (8-9). According to Table 2.2, it can be concluded that within the developing countries' context, "F2 - change orders" is the most critical rework factors in the Clients-related issues; meanwhile, "F9 - design change", "F8 - design deficiency" and "F5 - poor investigation on site conditions" contributed as the most crucial rework factors in Design-related issues; whereas, "F17 - poor coordination", "F18 - poor communication" and "F20 - ineffective site inspection" are the main factors in the Project Management issues; while "F28 - lack adherence of quality assurance", "F27 - noncompliance of task requirements" and "F33 - inappropriate construction method" are remarked as the significant factors in Contractor and Sub-contractors related rework; lastly, "F38 - dangerous site conditions" are also being considered as the vital rework factors within the category of External Factors.

Table 2.2: Major Rework Factors in Developing Countries.

Rework Factors	**ID**	**Malaysia**					**China**		**Egypt**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Client-related Factors	**FA**									
Limited fund / financial instability	F1								✓	
Change Orders	F2	✓	✓	✓		✓		✓	✓	✓
Lack of scope clarity	F3						✓			
Tight schedule assigned	F4						✓		✓	✓

		1	2	3	4	5	6	7	8	9
Consultant-related Factors	**FB**									
Poor investigation of site condition	F5		✓				✓		✓	
Inaccurate initial budget estimation	F6	✓								
Design Error	F7		✓							✓
Design deficiency	F8	✓	✓				✓		✓	
Design changes	F9	✓	✓	✓		✓			✓	
Complexity of design	F10						✓			
Poor contractual arrangement	F11						✓			
Time limitation in design	F12	✓							✓	
Inadequate utilisation of Information Technologies	F13	✓		✓			✓			
Deferring information about the site	F14		✓		✓					
Wrong material chosen	F15	✓								
Project Management Factors	**FC**									
Limited time for site investigation	F16		✓						✓	
Poor Coordination	F17	✓	✓	✓	✓	✓	✓			
Poor Communication	F18	✓		✓	✓	✓		✓		
Slips or lapses of attention	F19									
Ineffective site supervision	F20	✓	✓	✓	✓			✓		
Poor consciousness of the site condition	F21	✓		✓						
Machine breakdown or defects	F22				✓					
Contractor/ Subcontractor-related Factors	**FD**									
Misunderstanding of drawing	F23	✓								

		1	2	3	4	5	6	7	8	9
Erroneous workmanship	F24	✓								
Omission errors	F25									
Inproper handling of equipment/ machineries	F26	✓			✓					
Noncompliance of task requirements	F27	✓	✓		✓	✓				✓
Lack adherence of quality assurance	F28	✓				✓	✓	✓		✓
Inexperienced Personnel	F29	✓				✓				
Low labour skills' level	F30	✓	✓							✓
Poor material quality	F31		✓				✓			✓
Faulty material handling	F32	✓			✓					
Inappropriate construction method	F33	✓			✓			✓		
Poor site management	F34						✓	✓		
Change of construction method for constructability improvement	F35						✓			
Excessive overtime and fatigue	F36		✓	✓						
External Factors	**FE**									
Adverse weather conditions	F37		✓							
Dangerous site condition	F38		✓	✓	✓					
Unforeseeable site condition	F39									
Political Issues	F40								✓	

Notes to Table 2.2: (Authors)

1 - (Yap, Low and Wang, 2017); 2 - (Yap, et al., 2018); 3 - (Yap, Chow and Shavarebi, 2019); 4 - (Yap, et al., 2020); 5 - (Yap and Tan, 2021); 6 - (Ye, et al., 2014); 7 - (Zhang, et al., 2018); 8 - (Al-Janabi, Abdel-Monem and El-Dash, 2020); 9 - (Yousry Akal and Metwally El-Kholy, 2021).

2.6 Rework Factors in Developed Countries

2.6.1 USA

A study done by collecting and analysing data from 44 construction proiects in USA by Safapour and Kermanshachi (2019) deduced that the incompetency of project management team in planning the design, maintaining and effective team and controlling the development process are the main indicators that eventually lead to rework. To be specified, the researchers stated that the lack of experience of Project Manager in the construction stage is the most critical precursor while the inadeaquate project management staff on site to carry out field inspection and supervision is weighed as the second significant factors as the failure to comply with the quality requirements ultimately revealed the process into rework. The third reason that causing excessive reworks is due to the ineffective planning by the Project Manager during design stage especially within the context of project buildability or constructability issues.

Generally, the well-coordination and effective communication during the design phase is the utmost pivotal aspect. The project management process should include the execution of constructability reviews by coordinating the design team and construction team. Li and Taylor (2014) advocated that most of the inexperience consultants are prone to make a plethora design errors that are actually having constructability issues and it is difficult for the design team itself to discover the underlying risk, therefore, the reviews from the construction teams should be took place in order to sufficiently justify the design errors before the works are being constructed, hence reducing the rework issues. This preventive measures are deemed to be suit to address and resolve the design error issues from previous studies (Love, 2002b; Yap, Low and Wang, 2017).

Furthermore, the research implemented by Safapour, et al. (2022) asserted, the most perilous rework factors are inclusive of the inefficiency of design, poor communication, and poor level of workers' skills and experience. The researchers claimed that the inefficiency or inappropriate design is weighed as the most significant rework factors that are frequently arising in the USA construction projects. Meanwhile, the poor communication among the construction professionals also evolved to the insufficient of scope definition, as consequence, rework tends to happen during the construction phase due to the non-compliance and deviation of the project goals. The poor workmanship is basically due to the lack of site supervision conducted by the management (Asadi, Wilkinson and Rotimi, 2021).

2.6.2 Australia

The Australia researchers Love and Smith (2019), and Love, Matthews and Fang (2020) advoacated that the precursors to reworks are including of some major issues that are developed throughout the entire construction process, such as errors and changes, slips and lapses of attention or execution either intentionally or unintentionally, lastly the poor decision making or judgement made (Love and Li, 2000; Love, et al., 2009).

The researchers highlighted that human nature tends to create mistakes, therefore, the significant contributors to reworks are usually oriented from the errors and changes made by the consultants and contractors within the context of design and construction phase. For instance, the Architect tends to change the design or materials procured in order to enhance the aesthetically appearance and functionability of the deliverable so to align with the client's expectations (Love and Li, 2000). Love and Li (2000) also stressing that effective and completeness of exchanging information through communication is the core attribute during design stage to reduce the deviation and errors done by the consultants to prevent changes initiated in implementing stage and causing rework (Love, Matthews and Fang, 2020). The contractors will also make construction mistakes that are probably due to the site conditions issues (Love and Li, 2000; Trach, Pawluk and Lendo-Siwicka, 2019; Asadi, Wilkinson and Rotimi, 2021).

Moreover, the rework required to be conducted by the contractors or sub-contractors during the construction period are usually derived from the lapses or slips of project specifications and standards. The researchers mentioned that most of the rework problems are due to the lapses in following the project specified standards and scope, thus the lack of adherence towards such requirement subsequently affected the project quality performance, even worse causing various safety concerns to be arisen (Love, et al., 2018b; Trach, Pawluk and Lendo-Siwicka, 2019; Love, et al., 2022).

Apart from that, poor judgement or decision made by consultants including the incorrect construction procurement method, wrong sub-contractor selection, improper material selections and other relevant inappropriate resourcing approaches also committed a huge portion in contributing to rework issues (Love and Smith, 2019).

2.6.3 Spain

According to the study done by Forcada, et al. (2014), the major rework factors were identified and the results indicated that the changes in scope initiated by the employer (Hwang, et al., 2009; Hwang, Zhao and Goh, 2014), high complexity of project features, poor labour's skill level and unforeseeable underground conditions are the most critical apects. Meanwhile, another reseach developed by Forcada, et al. (2017) also emphasized that the project attributes, the organization managerial culture and the contractual agreement are the most crucial particular that causing rework. Based on the case study executed to eight Spanish highway projects (Forcada, et al., 2014), seven out of the eight projects are likely to possess the insufficient of site inspections and supervisions. Consequently, cases like lapses of attention by the project management teams regarding the quality and standards of tasks will eventually cause the dissatisfaction of the project owner and the risk of reworks are most likely to be bear by the contractors themselves (Forcada, et al., 2014; Love and Smith, 2019; Love, Matthews and Fang, 2020).

Both of the Spanish research revealed that the project attributes or characteristics are the leading factors that prone to have rework issues especially for the civil infrastructure projects where the uncertainties are higher as compared to the building construction projects due to the project complexity and technical requirements (Love, et al., 2010; Forcada, et al., 2014; 2017). For instance, the unexpected site conditions such as the heavy traffic and underground running services. Besides, the contractual arrangement system for Spanish private construction companies are usually employing the design-bid-construct approach which the absence of contractor involvement during the design stage is most likely to generate a higher portion of risks and uncertainties due to the errors, omissions and inconsistencies made by the design consultants (Forcada, et al., 2017; Yap, Low and Wang, 2017).

2.6.4 New Zealand

A research was done by Asadi, Wilkinson and Rotimi (2021) that investigating into the common rework causes within New Zealand and a list of 22 significant rework factors had been listed out. The results elucidated that the most important rework cause is the errors derived during design and construction stage including the design errors, drawings errors, specification mistakes and errors happen during constructing. Such errors subsequently lead to change orders to the contractor where frequent disputes and contractual conflicts are prone to arise and impair the relationships among the construction practitioners (Love and Smith, 2019; Hansen, Rostiyanti and Rif'at, 2020).

The next dominant factor of rework in New Zealand is dedicated to the deficiency in designing and construction stage omission. The incomplete designs during the initial tender stage may cause to the subsequent omission during the impleting stage. Again, change orders might be initiated by the client and additional cost for various resources will be required that not only increasing the project cost, but also deferring the project schedule (Hwang and Yang, 2014; Mahamid, 2016). Meanwhile, the researchers also highlighted the third ranking rework factor, the poor contractual arrangement and documentation process within the New Zealand construction industry. Most of the surveyed construction profesionnals opined that the contract documents are having severe deficiencies with many ambiguous contractual areas. Ultimately, such deficiencies may cause the misunderstanding or misinterpretation of the contract documents and hence rising the occurrence of errors that eventually lead to rework. Lastly, Al-Janabi, Abdel-Monem and El-Dash (2020) also mentioning the significant rework factor due to the unclear information or incomplete requirement during the design stage by the project owner.

2.6.5 Singapore

Slightly different to the sequential significant rework factors denoted by Malaysia, Hwang and Yang (2014) had conducted a study to 32 Singapore construction related companies, the results that have been collected and analysed indicated that the most crucial rework cause is the change orders specifically related to design issues. While the project coordination was listed as the second significant factor followed by claimant of poor site management. Besides, the poor workmanship in related to the quality performance issues had also being highlighted by the researchers.

Meanwhile, another research executed in 2019, Hwang, Zhao and Yang (2019) had further identified the variables within the context of design changes and eventually categorised it into eight variable groups, basically based on the changes, omissions or errors that are being initiated by several construction stakeholders including the employers, design teams, construction teams, manufacturers and suppliers. Again, design-related issues seems to be a salient problems that various risks from the construction parties tends to arise since the project initiation stage until the closing stage. Essentially, changes in specifications and project scope generated by the client are prone to arise in engineering projects, most probably due to the errors in the construction procurement method and design that are inappropriate and encounter buildability issues due to unforeseen circumstances (Hwang and Yang, 2014). Apart from that, the researchers also argued that the poor and insufficient coordination among the consultant member such as the Architects and Engineers could ultimately result in repetitive or overlapping of designs which in turn cause rework to happen on the implementing stage.

Furthermore, Hwang, Zhao and Goh (2014) had also developed a research that are distinctively focusing on the client-related rework concerns. The findings from the aforementioned study are investigating into 51 Singapore construction companies and about 381 projects were being analysed. The studies ascertained that clients are most likely dedicated to the rework problems where by the alternatives in "substituting the original materials specified" and the "changes of scope or plans by client" were ranked to be the most critical rework reasons that impacts severely on the project value and performance.

2.6.6 Summary of Rework Factors in Developed Countries

Table 2.3 denoted the rework factors unfold within the developed countries context based on the literature contributions done by various previous researchers including USA (1-2), Australia (3-5), Spain (6-7) and Nea Zealand (8) and Singapore (9-10). According to Table 2.3, it can be concluded that within the developed countries' extent, "change orders" is the most critical rework factors in the Clients-related issues; meanwhile, "design errors" and "design change" contributed as the most crucial rework factors in Design-related issues; whereas, "poor communication", "slips and lapses of attentions" are the main factors in the Project Management issues; while "omission errors" and "change of construction method" are remarked as the significant factors in Contractor and Sub-contractors related rework; lastly, "dangerous and expected site conditions" are also being considered as the vital rework factors within the category of External Factors.

Table 2.3: Major Rework Factors in Developed Countries.

Rework Factors	**ID**	**USA**		**Australia**			**Spain**		**New Zealand**	**Singapore**	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Client-related Factors	**FA**										
Limited fund for site investigation	F1										✓
Change Orders	F2			✓	✓		✓	✓	✓	✓	✓
Lack of scope clarity	F3					✓			✓		
Tight schedule assigned	F4							✓			

		1	2	3	4	5	6	7	8	9	10
Consultant-related Factors	**FB**										
Poor investigation of site condition	F5	✓								✓	
Inaccurate initial budget estimation	F6									✓	
Design Error	F7	✓	✓	✓	✓				✓	✓	
Design deficiency	F8	✓	✓			✓			✓		
Design changes	F9			✓	✓	✓	✓	✓			✓
Complexity of design	F10						✓	✓			
Poor contractual arrangement	F11			✓	✓			✓	✓		
Time limitation in design	F12										
Inadequate utilisation of Information Technologies	F13							✓			
Deferring information about the site	F14										
Wrong material chosen	F15			✓							
Project Management Factors	**FC**										
Limited time for site investigation	F16							✓			
Poor Coordination	F17	✓							✓	✓	✓
Poor Communication	F18	✓	✓	✓							✓
Slips or lapses of attention	F19			✓	✓	✓					
Ineffective site supervision	F20	✓					✓			✓	✓
Poor consciousness of the site condition	F21										
Machine breakdown or defects	F22										
Contractor/ Subcontractor-related Factors	**FD**										
Misunderstanding of drawing	F23										
Erroneous workmanship	F24			✓	✓				✓		✓

		1	2	3	4	5	6	7	8	9	10
Omission errors	F25			✓	✓	✓			✓		✓
Inproper handling of equipment/ machineries	F26										
Noncompliance of task requirements	F27	✓		✓	✓						
Lack adherence of quality assurance	F28	✓		✓	✓					✓	
Inexperienced Personnel	F29	✓	✓						✓		
Low labour skills' level	F30		✓				✓			✓	
Poor material quality	F31										
Faulty material handling	F32										
Inappropriate construction method	F33	✓		✓		✓				✓	✓
Poor site management	F34										
Change of construction method for constructability improvement	F35				✓		✓	✓	✓		
Excessive overtime and fatigue	F36										
External Factors	**FE**										
Adverse weather conditions	F37									✓	
Dangerous site condition	F38				✓						
Unforeseeable site condition	F39						✓				
Political Issues	F40										

Notes to Table 2.3: (Authors)

1 - (Safapour and Kermanshachi, 2019); 2 - (Safapour, et al., 2022); 3 - (Love and Smith, 2019); 4 - (Love, Matthews and Fang, 2020); 5 - (Love and Li, 2000); 6 - (Forcada, et al., 2014); 7 - (Forcada, et al., 2017); 8 - (Asadi, Wilkinson and Rotimi, 2021); 9 - (Hwang and Yang, 2014); 10 - (Hwang, Zhao and Yang, 2019).

2.7 Comparison of Major Rework Factors between Developing and Developed Countries

Based on the literature review done in previous sections explicitly in the contexts of the developing countries and developed countries, the consolidated reviews had been concluded and depicted as in Table 2.4. It summarised up the frequency of the rework factors being mentioned by various researchers, thus to observe the correlation of such critical factors that impart to the rework catastrophe within both kind of countries' development status. In vein of this statement, Malaysia could harness the insights obtained via this research by reffering to the context of developing countries, it could be inaugurated as an awareness to the local construction practitioners so to pay more attentions towards each rework factor that come with higher frequency. Besides, the similarities of insights between both developing and developed countries also allow the relevant researchers to have more understanding of which rework factors tend to possess higher criticality where the developed countries are having difficulties in handling such factors as well. Meanwhile, the differences of opinions between each national status also allow the researchers to have more exposure and awareness towards those underlying potential rework factors.

Table 2.4: Summary of Comparison of Major Rework Factors between Developing and Developed Countries.

Major Rework Factors	ID	Developing Countries				ID	Developed Countries					
		1	2	3	Freq.		4	5	6	7	8	Freq.
FA (F1-F4)	**F2**	4	1	2	**7**	**F2**		2	2	1	2	**7**
	F4		1	2	**3**	**F3**		1		1		**2**
	F3		1		**1**	**F1**					1	**1**
	F1			1	**1**	**F4**			1			**1**
FB (F5-F15)	**F9**	4		1	**5**	**F9**		3	2		1	**6**
	F8	2	1	1	**4**	**F7**	2	2		1	1	**6**
	F5	1	1	1	**3**	**F8**	2	1		1		**4**
	F13	2	1		**3**	**F11**	0	2	1	1		**4**
	F7	1		1	**2**	**F5**	1				1	**2**
	F12	1		1	**2**	**F10**			2			**2**
	F14	2			**2**	**F6**					1	**1**
	F6	1			**1**	**F13**			1			**1**
	F10		1		**1**	**F15**		1				**1**
	F11		1		**1**	**F12**						**0**
	F15	1			**1**	**F14**						**0**
FC (F16-F22)	**F17**	5	1		**6**	**F17**	1			1	2	**4**
	F18	4	1		**5**	**F18**	2	1			1	**4**
	F20	4	1		**5**	**F20**	1		1		2	**4**
	F16	1		1	**2**	**F19**		3				**3**
	F21	2			**2**	**F16**			1			**1**
	F22	1			**1**	**F21**						**0**
	F19				**0**	**F22**						**0**
FD (F23-F36)	**F27**	4		1	**5**	**F25**		3		1	1	**5**
	F28	2	2	1	**5**	**F33**	1	2			2	**5**
	F30	2		1	**3**	**F24**		2		1	1	**4**
	F31	1	1	1	**3**	**F28**	1	2			1	**4**
	F33	2	1		**3**	**F35**		1	2	1		**4**
	F26	2			**2**	**F27**	1	2				**3**
	F29	2			**2**	**F29**	2			1		**3**
	F32	2			**2**	**F30**	1		1		1	**3**
	F34		2		**2**	**F26**						**0**
	F36	2			**2**	**F31**						**0**
	F23	1			**1**	**F32**						**0**
	F24	1			**1**	**F34**						**0**
	F35		1		**1**	**F36**						**0**
	F25				**0**	**F23**						**0**
FE (F37-F40)	**F38**	3			**3**	**F37**					1	**1**
	F37	1			**1**	**F38**		1				**1**
	F40			1	**1**	**F39**			1			**1**
	F39				**0**	**F40**						**0**

Notes to Table 2.4: (Countries)

1 – (Malaysia); 2 – (China); 3 – (Egypt); 4 – (USA); 5 – (Australia); 6 – (Spain); 7 – (New Zealand); 8 – (Singapore).

2.7.1 FA: Client-related Factors

For the first category of rework factor, Client-related factors, researchers from both developing and developed countries opined that the ‘F2 - Change orders by Client’ is the most condemning rework precursor. Whilst developing countries contemplate ‘F4 - Tight schedule assigned by the Client’ is the following crucial precursor that lead to rework issue, nevertheless developed countries profound that the ‘F3 - Lack of scope clarity’ is more apparent forerunner in contrast to the ‘F4 - Tight schedule assigned’.

2.7.2 FB: Consultant-related Factors

Furthermore, for Consultant-related factors, ‘F9 – Design Changes’, ‘F8 – Design Deficiency’, ‘F7 – Design Error’ and ‘F5 – Poor investigation of site condition’ are deduced within the Top Five perilous rework factors while ‘F9 – Design Changes’ possess as the highest frequency variable in the context of both developing and developed countries. Meanwhile, according to Table 2.4, the literature discovery distinguished that within the interpretation of the developing countries, ‘F13 – Inadequate utilisation of Information Technologies’ had been construed as one of the substantial factors that contributed to rework issues. Concurrently, the factor of ‘F11 – Poor Contractual Arrangement’ is deemed as one of the momentous rework determinant, nonetheless, there is still lacking of alertness in light of this rework factor within the circumstances of the developing countries.

2.7.3 FC: Project Management Factors

Rework issues in terms of Project Management factors from both researchers’ perspectives of developing and developed countries are similar whereby ‘F17 – Poor Coordination’, ‘F18 – Poor Communication’ and ‘F20 – Ineffective site supervision’ had been denoted to be the top three most prevailing rework precursors. On the other hand, in conforming to the research done by one of the developed countries – Australia, it is being unveiled that the ‘F19 – Slips or lapses of attention' is reiterated to be the key dominating factor that eventually lead to construction reworks. According to Love, et al. (2008), this is because the construction designers tends to reutilize the design details and specifications so to mitigate the design workload especially for those projects that are made prone to fast-tracking. The chain effect subjected to this kind of design slips and lapses will ultimately cause the project information and the procedural steps to become ambiguous and thus the chance of committing omission errors become even more susceptible.

2.7.4 FD: Contractor/ Subcontractor-related Factors

In light of the slips or lapses of attention aforementioned, the rework factor 'F25 – Omission errors' had been contemplated as the most significant cause that dedicated to rework in the developed countries (Love, et al., 2008; Love and Smith, 2019). Whereas, in the context of developing countries, it can be examined that the lacking of adherence in the manner of task requirements (F27); quality assurance (F28); poor level of resources in terms of workmanship (F30) and material (F31); and inappropriate construction method (F33) had been deemed to be the dominant aspects that give rise to rework.

2.7.5 FE: External Factors

Rework precursors that are subjected to external factors for both developing and developed coutries are congruent which 'F-37 – Adverse weather conditions' and 'F38 – Dangerous site condition' are the paramount factors that spark off rework in construction projects.

2.8 Measures in Reducing Reworks

2.8.1 Project Management

Within the context of project management, the adoption of Building Information Modelling are claimed to be one of the significant strategies to minimising rework (Zhang, et al., 2018; Hwang, Zhao and Yang, 2019). Based on the study done in Singapore, the researched ascertained that the projects that embrace the utilisation of BIM indeed prone to have lower magnitude of rework occurrence and impacts (Hwang, Zhao and Yang, 2019). According to the research findings, the infrastructure project that utilising BIM have lower rework rate as compared the project without BIM usage, a significant difference can be perceived where the rework rates are 58.1% and 90.3% respectively. Besides, the BIM environment promote collaboration among the construction stakeholders as any information and changes can be seamlessly shared to other stakeholders for acknowledgement within the shared common database (Hwang and Yang, 2014). Additionally, the utilisation of BIM also advocated to be essential to detect and identify the clashes, overlapping and inappropriate building elements during design stage as it provide the construction stakeholders with visualisation technology (Zhang, et al., 2018).

Furthermore, maintaining and ensuring a good communication system is comtemplated as one of the utmost matters to avoid rework from occurring (Hwang and Yang, 2014; Yap, Low and Wang, 2017; Eze and Idiake, 2018; Yap and Tan, 2021). A previous research done in Malaysia advocated that the exchange and flow of project information through an effective communication channel allow the completeness of project requirements to stream among every construction professional synchronously especially during the design stage. Morever, it also inculcates better relationship between the construction stakeholders by strenghthen the trust among them through the active participations in conducting collective decision-making process even during the initial design phase (Yap, Low and Wang, 2017; Yap and Tan, 2021). For instance, adequate communication during the inception stage especially between the contractor and consultant is very crucial for the designers to be be alert of the consequences if any changes made to specified scope (Hwang and Yang, 2014).

Apart from that, proper resources planning is crucial in assuring a quality management system to be delivered (Yap, Low and Wang, 2017). For instance, effective resources planning on site can help to prevent overlapping of tasks that could induce additional cost for re-doing the task. Meanwhile, client's requirements and priorities should be clarified clearly and comprehensively during the design stage thus able to provide scope that are understandable by both the design and construction teams (Eze and Idiake, 2018; Yap, et al., 2018).

2.8.2 Error and Change Management

As design-related changes are asserted to be one of the critical rework factors, therefore, it is very predominant for the project manager to leveraging the expertise and experience in possessing strong adaptability and analytical problem-solving capabilities to response for various changing circumstances throughout the entire construction process (Hwang and Yang, 2014; Love and Smith, 2016; Yap, et al., 2018; Zhang, et al., 2018). It is also suggested that a well-established and structured change management system to be executed since the project's inception phase so to govern and monitor changes initiated throughout various phase of progress (Hwang and Yang, 2014).

Love, et al. (2016) opined that constructability reviews and inputs should be made applicable during the planning stage and enhancement of such constructability concerns should be made in time. The management team should encourage the involvement of the experienced contractor and sub-contractors to engender responsibility by carry out construction review and generating inputs for the refining and enhancement of scope's standard specifications based on their expert judgement (Eze and Idiake, 2018).

2.8.3 Quality Management

The assignation of the right people in executing the right task is one of the important measures to ensure the particular construction personnel is qualified to carry out the specified task that require certain level of technical skills (Hwang and Yang, 2014; Yap, Low and Wang, 2017). Besides, enforcing the workers to undergo and pass the standardised or proper training programmes is a effective measures to assure project deliverebles' quality as to make sure the stated construction professionals are adequately skilled to implement the tasks especially those required high technical level. Basically, proper training programmes for the site labours are able to ensure the implementation of quality management in satisfying the requirements and expectations regarding time, cost and quality (Love and Edwards, 2004a; Balouchi, Gholhaki and Niousha, 2019).

Apart from that, quality control process such as the three-level training approach mentioned in Ye, et al. (2014) and the four-level inspections process highlighted in Safapour, et al. (2022). The three level training are being adopted to enhance the management aptitude and technical capabilities of the construction professionals covering the three organisation level, namely construction team training, project department training and enterprise-level training. While the four-level inspections are employed to examine the resources' quality thus able to assure a quality delivery process, the inspections should be covering the warehouse inspection, inspection before use, materials and machinery inspection and finally the safety and maintenance inspection.

2.8.4 Risk Management

As the client-oriented changes and design changes are argued to be the most significant factors that lead to rework (Hwang and Yang, 2014; Zhang, et al., 2018), thus accurate contract documentation and design should be made applicable during design stage (Palaneeswaran, Love and Kim, 2014; Hansen, Rostiyanti and Rif'at, 2020). Besides,(Love, et al., 2016) stated that proper contract documentation is necessary for each construction personnel not only to acknowledge their obligations, but also to always record and register any risks or change orders that are prone to happen frequently on site. The researchers also urge the need for the organisation or project team member to act ethically by facilitate a healthy reporting culture. Apart from that, it is vital for the management team to implement adequate and effective site inspection so to identify the possible tasks that are provoked to reworks. This action can be further improve by the creation of a visual symbol on site to indicate the risks of rework, thus the construction site practitioners could be more alert in implementing the particular task.

Design scope freezing (Love and Edwards, 2004b) or rigid contractual agreement should be initiated and agreed during the design stage (Eze and Idiake, 2018). For instance, the claims for additional change order on specified tasks should be clearly clarified thus able to reduce the probability of rework from occurring. A rigid and fixed contract documentation will also cut off the gray areas that could be take for granted by any parties and capable to induce the construction stakeholders to conduct their obligations in a more vigilant manner.

2.8.5 Knowledge and Heath Management

Repeating mistakes tend to happen when the failure never being learnt and understood. Knowledgement management is comtemplated as a proactive learning process that can be implemented in two manner where the lesson learnt from the mistakes should be assimilated not only to the extent of organisational aspect but also to the project implemention process itself. Critical and comprehensive reflection on the failure done will enhance the experience and knowledge of the relevant authorities and hence errors tend to be reduce in the future projects undertaken (Love, et al., 2018a; Zhang, et al., 2018; Yap and Tan, 2021).

The China researchers Zhang, et al. (2018) also further emphasising that an integral learning process should be implemented for every project. Firstly, gathering and collection of lessons and experiences from each construction personnel should be done through a brainstorming session during the project closing stage or a kick-off meeting. Followed by the reviewing session, whereby all the construction professionals are encourage to actively discuss either to uncover some rework issues, or investigate the factors for the relevant issues, or even to conclude some tacit knowledge attained from the failure due to rework. While it is important that the concluded lesson to be disseminated among the teams so to improve future practices (Love, et al., 2015).

Love, et al. (2018c) highlighted the importance of knowledge, safety and health management and asserted that these practice should be assimilate into three forms, namely the people, project and the organisation. The researchers stressing that the managerial system play a major role in reducing rework. Project manager should be experience and expertise to be committed in both design and construction stage. Instead of blaming any of the construction team member for the failures, forgiveness should be foster and encouragement of individual's opinions should be made priorities so to cultivate a learning climate within the organisation. For instance, such ethical leadership skill promotes the balanced processing of information from different perspectives derived by each specialised-technical personnel. Therefore, any mistakes or errors can be foreseen and identified in the first place hence able to reduce and eliminate the potential and magnitude of rework's occurrence. Love, et al. (2016) also advocated that the site workers should undergo proper training to acquire relevant safety issues knowledge thus able to acknowledge the hazardous impacts that would be cause by reworks.

2.8.6 Summary of Measures in Reducing Reworks based on different Managerial Types

Table 2.5 below depicted the measures in reducing rework factors based on five different managerial types. The classification of each measures into different managerial types allow an inclusive perspective for the researchers to understand which managerial area should be emphasized. Based on the indicated frequency in Table 2.5 below, it shows that it is essential to draw more attention and effort for improvement in terms of the project management; quality management; and risk management.

Table 2.5: Measures in Reducing Rework Factors based on different Managerial Types.

Managerial Types	ID	Actions	Authors								Freq.
			1	2	3	4	5	6	7	8	
Project Management	M1	Maintaining effective communication	✓	✓	✓		✓	✓	✓	✓	7
	M2	Proper planning of resources	✓					✓	✓	✓	4
	M3	Be conscious and responsive of the site conditions	✓		✓		✓			✓	4
	M4	Utilizing building information modelling (BIM)		✓		✓					2
	M5	Regular meeting among consultants, between consultants and client, consultants and contractors					✓				1
	M6	Client's needs and priorities should always be clear				✓					1
Error and Change Management	M7	Implementing constructability strategy					✓	✓			2
	M8	Using tools such as work breakdown structure (WBS) during the inception stage			✓						1
Quality Management	M9	Workers should undergo proper training programme	✓				✓		✓	✓	4
	M10	Ensure skilled workforce in carrying out special tasks	✓		✓			✓		✓	4
	M11	Proper field inspection							✓	✓	2
Risk Management	M12	Accurate contract documentation and design	✓			✓	✓	✓			4
Knowledge and Health Management	M13	Implement critical reflection on failures		✓		✓	✓				3
	M14	Kick off meetings before working on site				✓	✓				2
	M15	Enforce workers to attend safety and health training programmes					✓				1

Notes to Table 2.3: (Authors)

1 - (Yap, Low and Wang, 2017); 2 - (Yap and Tan, 2021); 3 - (Hwang and Yang, 2014); 4 - (Zhang, et al., 2018); 5 - (Love, et al., 2016); 6 - (Eze and Idiake, 2018); 7 - (Balouchi, Gholhaki and Niousha, 2019); (Safapour, et al., 2022).

2.9 Summary of Chapter

A comprehensive literature review regarding rework issues had been completed in terms of the developing countries and developed countries. The comparison of rework factors and rework reduction measures among these two groups of countries had been analysed and tabulated to provide further understanding for the readers.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Welman, et al. (2005) contended that 'Research' is a process that entails collecting scientific knowledge through numerous objective methodology and procedures. The data collection and data analysis approaches and techniques that were being adopted throughout this research process in gathering and processing relevant information will be explained and justified accordingly. The research problem was studied at foremost, whereby prudent research aim and objectives had been formulated while comprehensive literature review had been conducted. Within this chapter, the flow of the further research progress is illustrated as Figure 3.1 below including the detailed description of each methodology being employed and the rationale behind the selections.

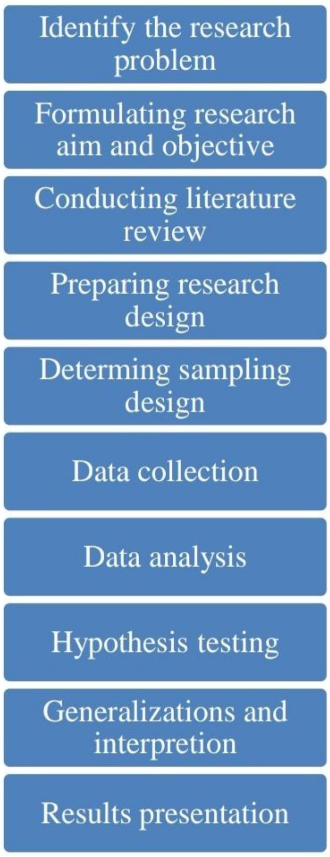

Figure 3.1: Systematic research process (Adopted from Bist, 2015)

3.2 Research Strategy

Research strategy or research methodology is a scientific and systematic approach in analysing and answering research questions or research problems. Basically, it is a series of planned actions in developing and conceptualising the research (Kumar, 2011). Generally, research method are categorised into two methods, namely qualitative and quantitative research. Some researchers may employ both method in conducting one study which is known as a mixed-method research. Each method possess own strengths and weaknesses. For this research, quantitative research approach was being adopted where further justification had been discussed in the following sub-section.

3.2.1 Qualitative Research Approach

Qualitative research approach is appropriate to be applied when encounter with certain research areas that comprehend with random or limited knowledge area and theories. Basically, it is emphasising on the in-depth understanding and knowledge through the exploration of feeling, perception, description, meaning, quality and experiences. Usually, interviews with open-ended questions will be adopted for the respondents to encourage more perspectives and ideas. Nevertheless, the amount of interview respondents are limited as compared to the quantitative approach (Kumar, 2011; Goundar, 2012).

3.2.2 Quantitative Research Approach

According to Kumar (2011) and Goundar (2012), quantitative research approach is applicable to circumstances where theoretical framework existed. The research hypotheses could be analysed through multiple mathematically-based method being employed. This approach had been employed for the conduction of this research as the utilisation of questionnaire in conducting the research is very prevalent. The formulation of questionnaire survey is rigid, structured, besides it allows the evaluation of larger sample size within a shorter time as compared to the qualitative approach. Generally, the rationale for employing such approach for this research enables the research hypotheses tends to have high reliability level by implementing statistical comparison among the huge number of sample groups as the data obtained could be generalised and easy to be quantifiabled.

3.3 Sampling Design

Before conducting the data collection process, sample selection process shall be implemented. For this research, due to the constraints of time and budget, sampling design is exceptionally vital to determine the targeted respondents as it is impracticable and unrealistic to collect data from the entire population (Kothari, 2011).

For this research, one of the non-probability sampling method namely convenience sampling are employed to determine the sample respondents. Subsequently, three distinct strata, namely developer (client), consultant and contractor are being chosen due to their availability and conveniency (Kothari, 2003; VanderStoep and Johnston, 2009). The justifications for choosing this sampling method are due the the effectiveness where the respondents could be easily approached and possess the capability to avoid selection bias of the sample respondents (Kumar, 2011). Meanwhile, another non-probability sampling approach entitled as the snowball sampling was adopted in order to attain a reasonably sound sample size (Darko, et al. 2018). The chosen respondents for the survey were requested to disseminate the questionnaire through their social network and sharing the information to more construction industry practitioners that are equipped with adequate knowledge and experiences regarding rework issues, specifically for transport infrastructure projects.

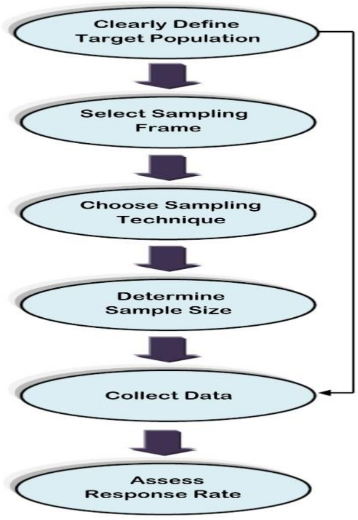

Figure 3.2: Sampling design procedures. (Adopted from Taherdoost, 2017)

3.4 Sampling Size Determination

According to Yap, Low and Wang (2017), sample portion of greater than 30 and lesser than 500 are adequate to be adopted for most research. Since the research background is dedicated to the entire construction practitioners that comprising of clients, consultants, and contractors in Malaysia, the targeted respondents population are deemed to be considerably huge and it is practically unfeasible to collect data from the entire population. Thus, the Central Limit Theorem (CLT) had been employed to enumerate the sample size for this research. Fundamentally, this sample size determination strategy required the selection of various respondent categories to be equally or having the same probability distribution, also known as the normal distribution approach whereby the variance is limited (Chihara and Hesterberg, 2019). Generally, the questionnaire developed shall be in accordance with the research objectives while the planned sample size is determined to be approximate 100 to 120 respondents, specifically a minimum of 30 respondents from each stratum will be engaged for this research. Based on Chassan (1979), each sample group that range from 20 to 25 is deemed to be an absolute minimum size in order to obtain for a reasonable probability of detecting the differences of opinions among the respondents; while due to the time constraint, this research had obtained approximate 35 respondents for each sample group.

3.5 Data Collection

There are two forms of data sources in collecting data, either through the primary form of interviews or questionnaire survey or through the secondary sources such as published books, journals, articles, gazetted government documents or any other reliable online resources (Kumar, 2011). In the conduction of this research, both data collection approaches had been adopted, where primary source had been applied by designing and developing the research's questionnaire survey, whilst the secondary form of sources had been utilised to acquire for more understanding and broad perspective regarding the major rework factors and the relevant reducing measures. Briefly, the secondary sources are crucial in formulating the questions for the questionnaire survey. The mechanism harness in admistrating the questionnaire survey is known as self-administered computer methods, where the questionnaire survey had been generated via Google Form and the link shall be disseminated to the chosen respondents via social media such as LinkedIn, Twitter, Email, Whatsapps and so forth. Briefly, the respondents will be completing the questionnaire electronically by utilising any electronic devices (Bowling, 2005).

3.5.1 Questionnaire Design

Collection of questionnaire is asserted to be the the most prevalent and popular approach as it is affirmed to be the most cost-effective manner in collecting relevant information from multiple kinds of perspectives, attitudes and behaviours (Garvetter and Forzano, 2012; Chan, 2012). Questionnaire developed should be clear and brief so to avoid unreliable and invalid information due to fatigued respondents. Thus, at the inception for the questionnaire, a brief instruction and research objectives are being provided to the respondents for their acknowledgement and understanding of the research purpose.

The prepared questions are classified into four sections whereby the foremost section will be acquiring the respondent's general background information such as gender, age, years of experience within the industry, represented parties and types of projects engaged. While the second and third sections, respondents are requested to rate the frequency of occurrence and the severity effects based on various rework factors. Next, the last section will require the respondents to rate the effectiveness of measures in reducing rework. Generally, five-point Likert Scales was applied in the questionnaire for the respondents to ease the expression of their perspectives in the matters of rework issues in Malaysian transport infrastructure projects.

3.5.2 Questionnaire Pre-testing

After the questionnaire being formulated and developed, prior to the distribution of questionnaire, it is essential and and prudent for the researcher to carry out questionnaire pre-testing as the questionnaire designed might subject to modicum knowledge where errors are prone to be happened and the researcher tends to be difficult in realising his own mistakes (Hague, 1987).

The researcher should seek for experienced interviewers oriented from different sub-categories that are beyond the research parameter to run through and administer the questionnaire design. The pre-testing interviewers would able to refine and point out the mistakes and ambiguous parts made by the researcher in the questionnaire. The sample size of pre-testing is usually small, subjected from five to ten respondents. As for this research, five potential respondents had been chosen for pre-testing, comprising of two academic personnel and three professional industry personnel. After the questionnaire being reviewed by the aforementioned personnel, specified amendment had been made to the questionnaire by the researcher as requested by the pre-testing respondents. Next, it had been pass to the respondents again for another pre-testing to ensure there is no other new faults while the amendments made are align with the expectations of the questionnaire (Reynolds, Diamantopoulos and Schlegelmilch, 1993).

3.6 Data Analysis

Once the distributed finalised-questionnaire achieved the required amount of responds, checking of the collected data should be implemented at once to ensure the questionnaire responses are adequate and without discrepancies (Tsai, Mom and Hsieh, 2014). Several statistical analysing methods were applied according to the facts. Meanwhile, the execution of data analysing process was incorporated with the utilisation of the software, namely Statistical Package for Social Sciences (SPSS). Besides, there were a total of five statistical analysis method being adopted for this research, listed as below:

a) Cronbach’s Alpha Reliability Test.
b) Importance Index Analysis.
c) Relative Importance Index.
d) Spearman’s Correlation Coefficient.
e) Factor Analysis.

3.6.1 Cronbach’s Alpha Reliability Test

Cronbach’s alpha reliability test was employed as a technique to determine the internal consistency or the degree of reliability of the research collected data attained from the questionnaire. By examine each item’s score and the overall score of all items from the questionnaire, this analysis technique is capable for the researcher to ascertain the level of reliability and consistency of the sample data (Hong, et al., 2018).

As for this research, the five-point Likert Scales employed for the questionnaire was applied for this test to have more accurate estimation of the sample reliability level. The Cronbach’s alpha formula is indicated as below:

$$\alpha = \frac{n}{n-1}\left(\frac{1-\sum Vi}{Vtest}\right)$$

where,

n = numbers of items;

Vi = variance of the scores for each component;

V = total variance of the overall scores upon the entire test.

The alpha values are ranging between 0 and 1, basically higher alpha value denoted for higher reliability and consistency. An overall alpha value greater than 0.70 for the sample indicates that the questionnaire designated content is consistent. Table 3.1 indicates the ranking of internal consistency according to various Cronbach’s alpha coefficient’s ranges.

Table 3.1: Cronbach's Alpha Reliability Coefficient ranging scale.

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

3.6.2 Importance Index Analysis

For the subsequent continuous sections after the respondent's background information, importance index analysis was being utilised to analyse and evaluate every rework causes within the context of Malaysian transport infrastructure projects where this statistical analysis approach was developed by Bagaya and Song (2016). Regarding the rework factors concern, there will be two kinds of questions prepared for the respondents including:

i) How frequent is the occurrence of the these rework factors throughout the construction process of Malaysian transport infrastructure projects?

ii) How much is the degree of severity of such issues affecting the Malaysian transport infrastructure projects?

Both frequency and severity degree of the rework factors were being quantified and measured based on the five-point Likert Scales. Table 3.2 denoted the Likert Scales measurement for the Frequency and Severity Index.

Table 3.2: Likert Scales Measurement.

Category of Question	**Likert Scale**				
	1	**2**	**3**	**4**	**5**
Frequency of occurrence	Never Happened	Rarely Happened	Sometimes	Often Happened	Always Happens
Distinguished Impact	Not Severe	Little	Moderate	Very Severe	Extremely Severe

Frequency index (F.I.): This index will denote how often is the occurrence of the rework issues within the transport infrastructure projects and the responses collected from the questionnaire's respondents could be ranked accordingly using this approach. The formula for Frequency Index refer to below:

$$F.I. = \frac{\sum_0^5 a_i n_i}{4N}$$

where,

a = Constant indicating weighting given to each response;

n = Frequency for each response;

N = Sum of the responses.

Severity index (S.I.): This index will show the degree of severity of the rework factors contributed to the transport infrastructure projects and the responses attained from the questionnaire's respondents could be ranked accordingly using this technique. The formular for Severity Index is shown as below:

$$S.I. = \frac{\sum_0^5 a_i n_i}{4N}$$

where,

a = Constant indicating weighting given to each response;

n = Frequency for each response;

N = Sum of the responses.

Important Index (IMP.I.): This index indicates the overview of a factor according to both frequency and severity indices. The formula of Important Index is shown as below:

$$IMP.I. = F.I. \times S.I.$$

3.6.3 Relative Importance Index

Relative Importance Index (RII) was adopted to examine the the results achieved for the third objective of this research. It is designed for the fourth section of the questionnaire that is to evaluate the effectiveness of the measures in reducing reworks for transport infrastructure project.

The question concerning the measures in reducing the rework issues will be generated as follow:

i) How effective are these measures in reducing rework in a transport infrastructure project?

Meanwhile, engagement of the 5-score likert scale measurement for this method was depicted as in Table 3.3 below.

Table 3.3: Likert Scale Measurement for Relative Importance Index Method.

Category of Question	**Likert Scale**				
	1	**2**	**3**	**4**	**5**
Measures Effectiveness	Ineffective	Slightly Effective	Effective	Very Effective	Extremely Effective

Relative Importance Index (R.I.I.): This index will show the degree of effectiveness of the measures in reducing reworks regarding to the transport infrastructure projects and the responses established from the questionnaire's respondents could be ranked accordingly using this technique. The formular for Relative Importance Index is portrayed as below:

$$RII = \frac{\sum W}{AN}$$

where

W = Weight given to each factor by the respondents (ranging from 1 to 5);

A = Highest weight (for this scenario = 5);

N = Total sum of the respondents.

Generally, the higher the index attained for a measures' criterion, the more significant it is in reducing the rework issues (Muhwezi, Acai and Otim, 2014).

3.6.4 Spearman's Correlation Coefficient

Spearman's correlation coefficient (rs) is employed for this research to examine the degree of association or endorsement between the paired data. For this research, Spearman's correlation will be engaged to study the correlation between rework factors and measures in reducing reworks. The ranges of the correlation coefficient is between -1 to 1. Based on Table 3.4, it can be deduced that the value -1 indicated a total negative relationship (disagreement), whereas +1 denotes a total positive relationship (disagreement). The strength of correlation with the categorisation of interpreted ranges are indicated as in Table 3.4.

Table 3.4: Correlation Strength among paired variables.

Correlation Size / Strength	**Interpretations**
0.90 to 1.00 (-0.90 to -1.00)	Very high positive (negative) correlation
0.70 to 0.90 (-0.70 to -0.90)	High positive (negative) correlation
0.50 to 0.70 (-0.50 to -0.70)	Moderate positive (negative) correlation
0.30 to 0.50 (-0.30 to -0.50)	Low positive (negative) correlation
0.00 to 0.30 (0.00 to -0.30)	Negligible correlation

Within this research context, the Spearman's correlation coefficient will be adopted for various aspects. First by referring to the computed Frequency Index, Severity Index and Important Index, this correlation coefficient test will be run on the 20 major rework factors that are suffered by the Malaysian transport infrastructure projects based on the perspectives from each respondents group, namely, clients, contractors and consultants. Next, this correlation test will be executed upon the computed responses in order to analyse the statistical relationship of the rework factors against the measures in reducing rework.

The formula in calculating the Spearman's correlation is indicated as below:

$$rs = 1 - \frac{6\sum d^2}{N(N^2 - 1)}$$

where,

rs = Spearman correlation;

d = the difference between the ranks of the corresponding variables;

N = total number of variables.

3.6.5 Factor Analysis

This analysis technique was employed in the circumstances to compress or decompose the large amount of observable variables into fewer manageable number of variables (Yap, Low and Wang, 2017; Yong and Peare, 2013).

Generally, there are two kinds of variables within this research study, namely, the observable variables and the latent or underlying variables (factors).

Factor analysis was applied to examine the underlying relationships among multiple variables in a complicated manner. It is very prevalent to be utilised for the study which containing a large amount of variables that are deemed to be difficult to investigate and analyse directly. Therefore, by employing this approach, it allows the discovering of the latent patern underneath. By referring to the common variance computed from this method, it allows reseachers to have clarification on the large number of variables and decompose the factors into few manageable minor group where the underlying factors could be interpreted in a more precise and consistent manner.

Furthermore, factor analysis required a large sample size to be performed, thus this research study with a sample size range from 100 to 120 is appropriate to be applied in categorising and ease the assessment of the major rework factors within the Malaysian transport infrastructure projects. However, prior to the implementation of the factor analysis, the suitability of data must be assured first through the proceeding of the Kaiser-Meyer-Olkin (KMO) matrix and the Barlett’s Test of Sphericity. Generally, the data suitability have to comply to the aforementioned tests before the factor analysis can take place.

For the KMO matrix, the sampling adequacy is tested whereby the adequacy values are ranged between 0 and 1. The tested value that are near to 1 is contemplated as the best result. The minimum requirement to pass the KMO matrix is 0.6, any value below that simply indicates the factor analysis may not suit to your study. After that, for the Barlett’s Test of Sphericity, a significance of 1.00 elucidates that the correlation matrix is an identity matrix.

3.7 Summary of Chapter

As this research was implemented in a quantitative mechanism, thus the questionnaire survey had been adopted and designed as the data collection instrument. Generally, the questionnaire delineated was divided into four sections where three main categories of construction practitioners that consists of clients, consultants and contractors were being chosen to solicit for their expert assistance and pragmatic perspectives through their professionalism and knowledge of the construction industry in realising this research study. The insights of frequency of occurrence and severity of rework factors as well as the effective measures in reducing reworks were required from the targeted respondents. Meanwhile, five types of statistical analysis strategies were being incorporated to analyse the research result including the Cronbach's Alpha Reliability Test, Importance Index Technique, Factor Analysis, Relative Importance Index Technique and Spearman's Correlation Coefficient.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

In essence, this chapter entails and represents on the analysed data. The collected questionnaire data were examined, evaluated and analysed by employing the research techniques established in the preceding chapter. Both Microsoft Excel and the Statistical Package for the Social Sciences (SPSS) were being utilised to interpret the questionnaire data for this research project. Subsequently, the obtained information was then being consolidated, reorganised ,summarised, calibrated and tabulated for ease of discussion within this chapter. Briefly, the discussion was intended to address the research aims and objectives stipulated in Chapter 1.

4.2 Questionnaire Response Rate

The acquired data collected pertaining to this research was principally through the virtual dissemination via social media, specifically majority of the respondents are derived from the Klang Valley area. A total of 350 questionnaires were being disseminated online to various construction disciplines in addition with the snowball approach being adopted, 108 sets of questionnaires were being collected successfully within 4 weeks approximately. The data collection through online platform was asserted to be quite convenient and efficient, nevertheless, majority of the respondents are limited to whom the author was connected to. Whereby, repeating gentle reminders for the respondents to answer the questionnaire survey is required in order to achieved higher rate of responses. Briefly, the response rate potrayed from this research is around 30.86% which is deemed to be optimistic as it is close to the average online response rate – 39.6% set out by Basa-Martinez, et al. (2018).

4.3 Profile of Questionnaire Respondents

The demographic profile of the questionnaire respondents was summarised and outlined as in Table 4.1. In terms of the types of organisation, there are about 35 (32.4%) Clients, 39 (36.1%) Consultants and 34 (31.5%) Contractor among the 108 sets of questionnaire collected. Meanwhile, across all the respondents, approximately 65.7% are holding position as an Executive, 19.5% are possessing as Manager position, 11.1% are in Senior Manager position while only 3.7% are oriented from Director or Top Management position. On the other hand, plurality of the respondents (51.9%) are possessing less than 5 years of working experience within the construction industry, meanwhile, follow by 22.2%, 19.4%, 4.6% and 1.9% of the respondents are having working experience range between 5 to 10 years, 11 to 15 years, 16 to 20 years and over 20 years respectively.

Besides, the questionnaire had also designed to figure out which types of transport infrastructure projects had been engaged by the respondents in assessing the relevant major rework factors. According to Table 4.1, it depicted that most of the respondents (95%) are engaged in the construction of Roads, following with 75% and 48% of respondents being involved in Railways and Highways construction respectively. Lastly, Table 4.1 also explicitly demonstrated that majority of the respondents (94.5%) are Bachelor's Degree holder with a total number of 102 out of the 108 respondents.

Table 4.1: Demographic Profile of Questionnaire Respondents.

Parameter	**Category**	**Total (N=108)**	**Frequency (%)**
Type of Organisation	Client	35	32.4
	Consultant	39	36.1
	Contractor	34	31.5
Position in Organisation	Executive	71	65.7
	Manager	21	19.5
	Senior Manager	12	11.1
	Director / Top Management	4	3.7
Years of Working Experience	< 5 years	56	51.9
	5-10 years	24	22.2
	11-15 years	21	19.4
	16-20 years	5	4.6
	Over 20 years	2	1.9

Types of Transport Infrastructure Project Involved	Roads	95	88.0
	Bridges	15	13.9
	Tunnels	5	4.6
	Highways / Expressways	48	44.4
	Railways	75	69.4
Academic Qualification	Postgraduate Degree	5	4.6
	Bachelor's Degree	102	94.5
	Diploma, Certificate	1	0.9
	High School	0	0

Conclusively, the respondents participated in this survey were considered to be evenly composed from the designation of Client, Consultant and Contractor with plurality of them are involved in the transport infrastructure construction of Roads, Railways and Highways. Nevertheless, majority of the respondents are possessing as Executive where most of them are Bachelor's Degree holder with approximately working experience that range between one to five years.

4.4 Reliability of Results

In order to ascertain the internal consistency and reliability of the data collected for the three sections from the questionnaire survey, Cronbach's alpha realibility test was implemented with the utilisation of SPSS. Subsequent results was computed and tabulated as in Table 4.2 where the coefficient alpha values are 0.866, 0.801 and 0.739 referring to the frequency of occurrence of rework factors (20 items), severity of the rework factors (20 items) and effectiveness of the measures in reducing the rework factors (15 items). Since the acceptable alpha values are ranging from 0.70 to 0.95 (Bland and Altman, 1997), thus it can be affirmed that the research findings are deemed to be reliable.

Table 4.2: Cronbach's Coefficient α Values.

Category of Variables	**Number of Items**	**Cronbach's α**
Frequency of occurrence of the rework factors	20	0.866
Severity of the rework factors	20	0.801
Effectiveness of measures in reducing major rework factors	15	0.739

4.5 Rework Factors in Malaysian Transport Infrastructure Projects

4.5.1 Ranking of Rework Factors in terms of Occurrence

The frequency of occurrence for the twenty rework factors in Malaysian Transport Infrastructure Project had been deduced and indicated as per Table 4.3. The table had presented the overall ranking of rework factors frequency of occurrence in an ascending order in conformity with the index for each factor. Whereas, the three distinct parties namely, Client, Consultant, and Contractor's ranking regarding the frequency rework factors had been included as well for the comparison of their perspectives. In accordance with Table 4.3 that are summarised based on the results attained from frequency index approach (F.I.), it can be concluded that the five most substantial rework factors that occur frequently in Malaysian Transport Infrastructure Projects are poor communication ($F.I._{factors}$= 0.970); noncompliance of task requirements ($F.I._{factors}$= 0.943); inappropriate construction method ($F.I._{factors}$= 0.915); lack of scope clarity ($F.I._{factors}$= 0.913); and lack adherence of quality assurance ($F.I._{factors}$= 0.913).

Based on Client's viewpoints, the five most frequent rework factors within the parameter of the Malaysian Transport Infrastructure Projects are poor communication; inaccurate initial budget estimation; ineffective site supervision; inappropriate construction method; and lack of scope clarity. On the other hand, scrutinizing to the Consultant's perspectives, the five most critical rework factors dedicated to Malaysian Transport Infrastructure Project are noncompliance of task requirements; poor communication; inappropriate construction method; lack of scope clarity and tight schedule assigned by the Client. Meanwhile, according to the Contractor's opinions, the top five factors that lead to rework of the Transport Infrastructure Projects in Malaysia are poor communication; noncompliance of task requirements; change orders by Client; design changes by Consultants; and lack adherence of quality assurance.

4.5.2 Ranking of Rework Factors in terms of Severity

The degree of severity for the twenty rework factors within the context of Malaysian Transport Infrastructure Project had been tabulated and depicted as in Table 4.4. The table had portrayed the overall ranking in terms of the degree of severity of rework factors in an ascending manner by referring to the each respective factor's index. Whereas, the three distinct parties namely, Client, Consultant, and Contractor's ranking regarding the severity of rework factors had been included as well for the comparison of their perspectives. Table 4.4 had summarised the results achieved from severity index methodology (S.I.), it can be deduced that the five most severe rework factors that happen in Malaysian Transport Infrastructure Projects are due to poor communication ($S.I._{factors}$= 0.965); noncompliance of task requirements ($S.I._{factors}$= 0.948); inappropriate construction method ($S.I._{factors}$= 0.943); lack of scope clarity ($S.I._{factors}$= 0.935); and ineffective site supervision ($S.I._{factors}$= 0.920).

According to Client's standpoints, the five most acute rework factors within the parameter of the Malaysian Transport Infrastructure Projects are consisting of inaccurate initial budget estimation; inappropriate construction method; ineffective site supervision; poor communication and lack of scope clarity. On the other hand, scrutinizing to the Consultant's perspectives, the five most drastic rework factors contributing to the Malaysian Transport Infrastructure Project are noncompliance of task requirements; poor communication; lack of scope clarity; inappropriate construction method; and lack adherence of quality assurance. Meanwhile, based on the Contractor's opinions, the top five rework factors that possess horrendous impact to the Malaysian Transport Infrastructure Projects are change orders by Client; poor communication; design deficiency; lack adherence of quality assurance; and erroneous workmanship.

4.5.3 Ranking of Rework Factors in terms of Importance

Table 4.5 delineates the overall score obtained for the Importance Index technique (IMP.I.). The rework factors had been computed and ranked accordingly based on the index score examined from the comparison of various perspectives derived from the multidisciplinary industry practitioners including the clients, consultants and contractors. Basically, the Importance Index (IMP.I.) is the outcome yielded from the product of Frequency Index (F.I.) and Severity Index (S.I.). Hence, there shall be no significant ranking disparities between the IMP.I. and the aforementioned indices that are being employed for this research.

Poor communication ($IMP.I._{factors}$= 0.936) was being ranked as the most essential factor among the twenty rework precursors. Similarly, it is being rated as the first place for both the $F.I._{factors}$ and $S.I._{factors}$. Although it ranked as the first place based on the Contractor's perspectives, nevertheless, when comparing three of the major groups of construction personnel, the Consultants suffer higher degree of effects from this factor as it indicates a IMP.I. of 0.964 as compared to that of Clients ($IMP.I._{factors}$= 0.916) and Contractor ($IMP.I._{factors}$= 0.924). Poor communication arised among the design consultants is one of the major contributing factors that amplify the risks of reworks, asserted by researchers from Nigeria and Australia (Eze, et al., 2018b; Palaneeswaran, et al. 2014). Meanwhile, researcher from Australia (Lopez, et al., 2010) opined that the preceding factor for poor communication is due to the absence of common language among the construction personnel. As the Contractor ranked poor communication as the first critical rework factor, it was corresponding to the statement highlighted by the researcher from Sri Lanka (Priyadarshani, et al, 2013) where the rework risk may increase if one person is unable to understand language.

Noncompliance of task requirements ($IMP.I._{factors}$= 0.894) was being ranked as second significant rework factor within the context of Malaysian Transport Infrastructure Projects. Meanwhile, inappropriate construction method ($IMP.I._{factors}$= 0.863) was being ranked as the third most critical rework factor. Yap, et al. (2018) such inadequacy of team competency are mainly due to the fast track development nowadays where most of the projects design stage are overlapping with the construction stage, alternatively, most of the later design changes initiated in addition with the lack of communication and coordination will eventually lead to defective designs and thus contributing to serious discrepancies during the later construction stage which task requirements could not be fulfilled while impertinent construction procurement method may be carried out.

In terms of the significant rework factors for Malaysian Transport Infrastructure Projects, lack of scope clarity and lack adherence of quality assurance were ranked fourth and fifth with index value of ($IMP.I._{factors}$= 0.854) and ($IMP.I._{factors}$= 0.837) respectively. According to Yap, Low and Wang (2017), the poor communication among design consultants will eventually lead to ambiguity in detailed drawings where the lack of scope clarity will ultimately escalate the risks to rework. The mentioned researcher also pointed out that the Contractors in Malaysia are still consider not competent enough as most of the Contractors tends to implement rework on site in order to recover the lacking of adherence to the required quality assurance.

Be referring to Table 4.5, the ranking of the following rework factors had been unveiled where ineffective site supervision ($IMP.I._{factors}$= 0.834); design deficiency ($IMP.I._{factors}$= 0.804); inaccurate initial budget estimation ($IMP.I._{factors}$= 0.798); poor investigation of site condition ($IMP.I._{factors}$= 0.788); poor coordination by Project Manager ($IMP.I._{factors}$= 0.787); tight schedule assigned by Client ($IMP.I._{factors}$= 0.762); design error ($IMP.I._{factors}$= 0.749); change orders by Client ($IMP.I._{factors}$= 0.739); erroneous workmanship ($IMP.I._{factors}$= 0.732); design changes by Consultants ($IMP.I._{factors}$= 0.720); and inexperience personnel ($IMP.I._{factors}$= 0.700) were ranked from sixth to sixteenth among the overall of twenty rework factors.

Subsequently, there are four remaining rework factors that possess lower IMP.I value lower than 0.7 and being considered as the least significant factors that lead to rework in this research. The mentioned factors are low labour skills level; poor material quality; inadequate utilisation of Information Technologies and dangerous site condition.

In conformity to the Client's point of view, the five most critical rework factors that are impacting the Malaysian Transport Infrastructure Projects are inaccurate initial budget estimation; poor communication;

inappropriate construction method; ineffective site supervision; and lack of scope clarity. Whereas based on the Consultant’s opinions, the five most drastic rework factors for this research are noncompliance of task requirements; poor communication; lack of scope clarity; inappropriate construction method; and lack adherence of quality assurance. While according to the Contractor’s perspectives, the top five critical rework factors are change orders by Client; poor communication; design deficiency; lack adherence of quality assurance; and design changes by Consultants.

Table 4.3: Frequency Index and Ranking of Rework Factors.

Factors	Overall (N=108)		Client (N=35)		Consultant (N=39)		Contractor (N=34)	
	F.I.	**Rank**	**F.I.**	**Rank**	**F.I.**	**Rank**	**F.I.**	**Rank**
Poor Communication	0.970	1	0.960	1	0.974	2	0.976	1
Noncompliance of task requirements	0.943	2	0.897	7	0.995	1	0.929	2
Inappropriate construction method	0.915	3	0.943	3	0.949	3	0.847	11
Lack of scope clarity	0.913	4	0.931	5	0.939	4	0.865	10
Lack adherence of quality assurance	0.913	4	0.909	6	0.928	6	0.900	4
Ineffective site supervision	0.906	6	0.943	3	0.882	9	0.894	7
Design deficiency	0.889	7	0.891	9	0.877	10	0.900	4
Inaccurate initial budget estimation	0.881	8	0.949	2	0.892	8	0.800	17
Poor investigation of site condition	0.880	9	0.897	7	0.897	7	0.841	12
Tight Schedule assigned by Client	0.876	10	0.874	11	0.933	5	0.812	16
Poor Coordination by Project Manager	0.874	11	0.880	10	0.872	12	0.871	8
Erroneous workmanship	0.848	12	0.840	14	0.877	10	0.824	13
Design error	0.841	13	0.874	11	0.785	16	0.871	8
Design changes by Consultants	0.841	13	0.846	13	0.785	16	0.900	4
Inexperience personnel	0.828	15	0.811	16	0.851	13	0.818	14
Change orders by Client	0.817	16	0.794	19	0.749	20	0.918	3
Low labour skills level	0.807	17	0.800	17	0.805	14	0.818	14
Inadequate utilisation of Information Technologies	0.800	18	0.834	15	0.795	15	0.771	19
Poor material quality	0.793	19	0.800	17	0.785	16	0.794	18
Dangerous site condition	0.733	20	0.760	20	0.779	19	0.653	20

Table 4.4: Severity Index and Ranking of Rework Factors.

Factors	**Overall (N=108)**		**Client (N=35)**		**Consultant (N=39)**		**Contractor (N=34)**	
	S.I.	**Rank**	**S.I.**	**Rank**	**S.I.**	**Rank**	**S.I.**	**Rank**
Poor Communication	0.965	1	0.954	4	0.990	2	0.947	2
Noncompliance of task requirements	0.948	2	0.926	7	0.995	1	0.918	6
Inappropriate construction method	0.943	3	0.971	2	0.944	4	0.912	8
Lack of scope clarity	0.935	4	0.954	4	0.979	3	0.865	12
Ineffective site supervision	0.920	5	0.971	2	0.892	8	0.900	10
Lack adherence of quality assurance	0.917	6	0.914	11	0.908	5	0.929	4
Inaccurate initial budget estimation	0.906	7	0.977	1	0.908	5	0.829	16
Change orders by Client	0.904	8	0.954	4	0.800	16	0.971	1
Design deficiency	0.904	8	0.903	12	0.872	11	0.941	3
Poor Coordination by Project Manager	0.900	10	0.923	8	0.867	12	0.912	8
Poor investigation of site condition	0.896	11	0.920	9	0.892	8	0.876	11
Design error	0.891	12	0.920	9	0.841	13	0.918	6
Tight Schedule assigned by Client	0.870	13	0.891	13	0.897	7	0.818	17
Erroneous workmanship	0.863	14	0.857	17	0.887	10	0.841	13
Design changes by Consultants	0.856	15	0.863	15	0.790	19	0.924	5
Inexperience personnel	0.846	16	0.880	14	0.821	14	0.841	13
Low labour skills level	0.815	17	0.823	18	0.805	15	0.818	17
Poor material quality	0.813	18	0.806	19	0.800	16	0.835	15
Inadequate utilisation of Information Technologies	0.806	19	0.863	15	0.779	20	0.776	19
Dangerous site condition	0.744	20	0.794	20	0.795	18	0.635	20

Table 4.5: Importance Index and Ranking of Rework Factors.

Factors	Overall (N=108)		Client (N=35)		Consultant (N=39)		Contractor (N=34)	
	IMP.I	Rank	IMP.I	Rank	IMP.I	Rank	IMP.I	Rank
Poor Communication	0.936	1	0.916	2	0.964	2	0.924	1
Noncompliance of task requirements	0.894	2	0.831	6	0.990	1	0.853	3
Inappropriate construction method	0.863	3	0.916	2	0.896	4	0.772	10
Lack of scope clarity	0.854	4	0.888	5	0.919	3	0.748	11
Lack adherence of quality assurance	0.837	5	0.831	6	0.843	5	0.836	5
Ineffective site supervision	0.834	6	0.916	2	0.787	9	0.805	7
Design deficiency	0.804	7	0.805	10	0.765	10	0.847	4
Inaccurate initial budget estimation	0.798	8	0.927	1	0.810	7	0.663	17
Poor investigation of site condition	0.788	9	0.825	8	0.800	8	0.737	12
Poor Coordination by Project Manager	0.787	10	0.812	9	0.756	12	0.794	9
Tight Schedule assigned by Client	0.762	11	0.779	12	0.837	6	0.664	16
Design error	0.749	12	0.804	11	0.660	14	0.800	8
Change orders by Client	0.739	13	0.757	13	0.599	20	0.891	2
Erroneous workmanship	0.732	14	0.720	15	0.778	11	0.693	13
Design changes by Consultants	0.720	15	0.730	14	0.620	17	0.832	6
Inexperience personnel	0.700	16	0.714	17	0.699	13	0.688	14
Low labour skills level	0.658	17	0.658	18	0.648	15	0.669	15
Poor material quality	0.645	18	0.645	19	0.628	16	0.663	17
Inadequate utilisation of Information Technologies	0.645	18	0.720	16	0.619	18	0.598	19
Dangerous site condition	0.545	20	0.603	20	0.619	18	0.415	20

4.6 Factor Analysis

4.6.1 Analysis Considerations

Generally, Factor Analysis is a summarisation or data reduction approach where it often being employed to observe the relationship between a huge number of variables that are notably correlated and reduce such variables into several manageable level of variable group based on the common variance obtained from the results (Yong and Pearce, 2013; Yap, et al., 2018). Regarding this research study that are within the context of Malaysian Transport Infrastructure Projects, this Factor Analysis technique had been utilised for the reclassification of the twenty major rework factors into limited categories of variables in conformity to the shared variance. Preceding to the implementation of such technique, it is pivotal to interrogate the adequancy of the collected data. Hence, there shall be the employment of the Kaisen-Meyer-Olkin (KMO) test and Barlett's test of sphericity to kick start this analysis process (Doloi, et al., 2012).

Table 4.6: Results of KMO and Barlett's Tests.

Parameter	**Value**
Kaiser-Meyer-Olkin measure of sampling adequacy	0.801
Bartlett's test of sphericity	
Approximate chi-square value	880.648
Degree of freedom	190
Significance	0.000

In accordance to the value demonstrated in Table 4.6, a significance value of 0.000 is being achieved for the Barlett's test of sphericity. In order to assure that the proposed variables are possessing a patterned and structured correlation, Yong and Pearce (2013) asserted that significant level of p should be less than 0.05 so to be contemplated as acceptable result. Meanwhile, based on Field (2013), the KMO value shall be greater than 0.50 as a prerequisite condition that the result are deemed to be satisfied. The KMO value could be ranging from 0 to 1 where any value lesser than 0.5 depicting that the factor analysis is questionable to generate distinct and reliable outcomes. In this case, the analysis applied to the twenty rework factors had shown the KMO value was deduced to be 0.801. Since both of the

KMO and Barlett's tests' requirements had been fulfilled, it permits the proceeding for the application of factor analysis as the research data is reliable.

According to Yong and Pearce (2013), the variables that are worth conducting discussions are solely subjected to those being extracted and rotated values. Through the adoption of the principal component analysis (PCA), the underlying factors were identified and extracted successfully. The scree plot of the twenty factors had been shown portrayed in Figure 4.1.

Based on Table 4.7, there are five underlying root factors being generated from the extraction of the overall twenty rework factors with the eigenvalues that are greater than 1 were presented. Besides, by referring to Table 4.7, the captured five underlying root factors are accounted for 63.18% of rework issues in Malaysian Transport Infrastructure Projects, thus satisfied the total variance requirement of 60% to be proved the data are to construct validity (Yap, et al., 2019). Moreover, Yap, et al. (2019) also affirmed that the loading values for the variables that are greater than 0.5 shall be deemed practically significant. Table 4.8 depicted the variables that have loading values greater than 0.5 and had been gone through the final rotated compoenent matrix. The extracted root factors are named as follow:

(i) Inadequacy in Construction Stage Considerations as *F1*;
(ii) Incompetency of Site Practitioners as *F2*;
(iii) Inadequacy in Feasibility Stage Considerations as *F3*;
(iv) Inappropriate Allocation of Resources as *F4*;
(v) Haphazard Information Delivery System as *F5*.

Table 4.7: Total Variance Explained.

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	**Percentage of Variance**	**Cumulative (%)**	**Total**	**Percentage of Variance**	**Cumulative (%)**
F1	6.277	31.383	31.383	2.902	14.508	14.508
F2	2.149	10.747	42.130	2.879	14.396	28.904
F3	1.731	8.653	50.783	2.788	13.938	42.842
F4	1.367	6.836	57.618	2.086	10.431	53.273
F5	1.113	5.565	63.183	1.982	9.909	63.183

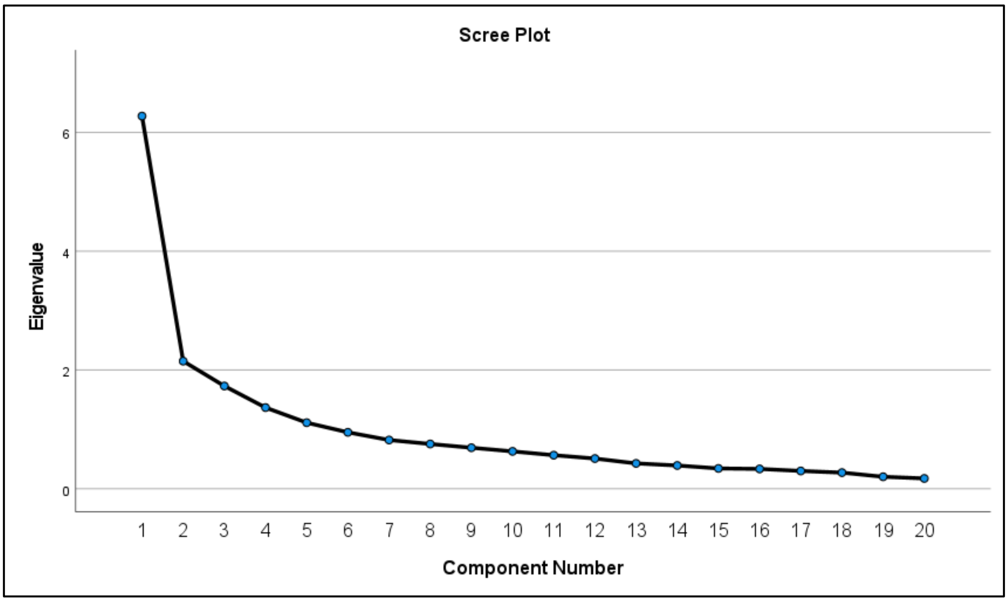

Figure 4.1: Scree Plot of Factors.

Table 4.8: Factor Analysis Loading Results for Rework Factors.

Infrastructure Project Rework Factors	**Factor Loading**	**Variance explained (%)**
Factor 1: Inadequacy of Construction Stage Considerations		14.508
Dangerous site condition	0.755	
Poor investigation of site condition	0.663	
Inappropriate construction method	0.573	
Lack adherence to quality assurance	0.571	
Poor material quality	0.557	
Noncompliance of task requirements	0.553	
Ineffective site supervision	0.495	
Erroneous workmanship	0.410	
Factor 2: Incompetency of Site Practitioners		14.396
Low labour skills level	0.803	
Inexperience personnel	0.729	
Poor Coordination by Project Manager	0.573	
Factor 3: Inadequacy of Feasibility Stage Considerations		13.938
Change orders by Client	0.813	
Design error	0.794	
Design deficiency	0.663	
Design changes by Consultants	0.651	
Factor 4: Inappropriate Allocation of Resources		10.431
Inaccurate initial budget estimation	0.827	
Inadequate utilisation of Information Technologies	0.674	
Tight Schedule assigned by Client	0.654	
Factor 5: Haphazard Information Delivery System		9.909
Poor Communication	0.851	
Lack of scope clarity	0.588	

Note:
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 9 iterations.
a: loading less than 0.4

4.6.2 Extraction of Underlying Root Factors

Based on Table 4.8, the respondents perceived that the five most critical rework factors that carried the highest index of factor loading which is seriously jeopardizing Malaysian TIP had included poor communication (0.851); inaccurate initial budget estimation (0.827); change orders by client (0.813); low labour skills level (0.803); and design error by consultant (0.794). Meanwhile, there were five root factors being extracted and unveiled in this research, namely, inadequacy in construction stage considerations (F1); incompetency of site practitioners (F2); inadequacy in feasibility stage considerations (F3); inappropriate allocation of resources (F4); and haphazard information delivery system (F5).

Factor 1: Inadequacy in Construction Stage Considerations

The total variance accounted for Factor 1 is the highest among other groups of underlying rework factors which is approximately 14.51% of the total variation of 63.18%. Besides, it accommodates most number of the rework factors which is up to eight variables that constituted of dangerous site condition; poor investigation of site condition; inappropriate construction method; lack adherence to quality assurance; poor material quality; noncompliance of task requirements; ineffective site supervision and erroneous workmanship. In accordance with the variables aforementioned, it can be deduced that such inadequacy of site management during construction stage are mainly due to the incompetency of the contractor himself. Researcher Le-Hoai, et al. (2008) contended that poor site management and coordination are principally as the consequence of the incapabilities of the appointed contractor. Therefore, for the selection of tenderer during the tendering stage, it is prudent to always be emphasizing on the tenderer's profiles where technical competency and management skills of the tenderer shall be evaluated thoroughly before awarding the contract instead of merely considering of the lowest bidder that is offering attractive initial price (Frimpong, Oluwoye and Crawford, 2003).

Factor 2: Incompetency of Site Practitioners

Factor 2 is accountable to possess slightly lower variance (14.40%) as compared to Factor 1. However, the rework factors lied within this category are contemplated to be significant where the low labour skills level; inexperience personnel; and poor coordination by the Project Manager are encapsulated to be the contributing reasons of rework. Firstly, due to the stagmatised 3D phenomenon (dirty, dangerous and difficult) of the construction industry, it is hard to retain any local hired construction site workers. Additionally, with the attractive cheaper rate offered by the foreign workers and their willingness to work beneath the extreme environment on site, most of the employers tend to hire foreign workers in resolving the manpower shortage issue (Najib, et al., 2019). In fact, Malaysian construction industry is heavily rely upon the foreign workforce, therefore it is important to acknowledge the reason that always lead to undesirable rework issues on site. Since most of the foreign workers are having limited knowledge, experience and skills, even worse most of them are only able to understand their own dialect in the workplace, hence plaguing the project progression and performance as the foreign workers are unable to ascertain the hidden hazards on site, unable to catch up the safety programmes, as the consequence, they might not only be performing a poor quality of work, but also possessing lower productivity (Marhani, et al., 2012; Priyadarshani, et al., 2013; Najib, et al., 2019). On the other hand, the competency of managing and coordinating resources is the baselines to examine the project's credibility and to satisfied client's expectations, it is basically depends on the hardskills or the technical competencies of a Project Manager (Zhang, et al., 2013; Tripathi and Jha, 2018; Safapour and Kermanshachi, 2019). However, the competency of the Project Manager in terms of soft skills should not be neglected too as it is proved that such capabilities could lead to higher and enhanced project performance. It is crucial that the project coordinator could provide necessary training to the workers and able to make sound decision by assigning the exact people for the particular task (Abbas, et al, 2018).

Factor 3: Inadequacy in Feasibility Stage Considerations

Factor 3 is accountable for up to 13.94% of the entire variance presented. It mainly consists of the causes that are initiated by the Clients and Consultants during the feasibility stage which including the change orders by Client; design error, design deficiency, and design changes by the Consultants. A project's plausibility is rely on the competencies of the construction project stakeholders (Yong and Mustaffa, 2013). It is essential that every parties of construction stakeholders acknowledge each of their roles in realising the smooth development of the project and to abate or eliminate risks that might lead to project failure (Doloi, 2013). To put forward, during the pre-construction stage, the stakeholders specifically the Client and the design team Consultant should always coordinate effectively among themselves as early as possible, this is because change orders during design stage will incur much minimum cost as compared to any later change during the construction stage (Safapour and Kermanshachi, 2019). Additionally, lack of experience and familiarity in managing change orders or reworks, especially with the incessantly complexity of modern construction projects nowadays, it will eventually lead to drastic schedule delay and even worst budget bursting (Alnuaimi, et al., 2010).

Factor 4: Inappropriate Allocation of Resources

Factor 4 makes up about 10.43% of the total variance presented where there are three rework factors being classified within this area of study, namely, inaccurate initial budget estimation; inadequate utilisation of information technologies; and tight schedule assigned by Client. Appropriate planning of project productions is such crucial in order to well-organized the resources and time required to accomplished a project delivery. Generally, a project is deemed successful if it is able to be delivered within the allocated budget, timeframe and the required standard of quality. Therefore, if there is any unreasonable tight schedule being assigned by Client or any event that delay the project critical path, the subsequent overtime induced upon the construction workers would eventually cause fatigue among them, and this is where the intentional shortcut being employed by the workers in order to catch up the progress which turns out might not meet the project fundamental requirements in terms of both performance and quality (Han, et al. 2014; Mohammadi, et al., 2018). Apart from that, limited time box assigned might as well trigger the design-related rework due to the incomplete detailed drawing and design procedures (Hwang and Yang, 2014; Yap, et al., 2017).

Factor 5: Haphazard Information Delivery System

Factor 5 is accounted for 9.91% of the total variance explained, comprising only two rework factors which are poor communication; and lack of scope clarity. The deficiency in delivering information through consistent communication will eventually contributed to the occurrence of construction errors such as misunderstanding of the design and forming of ambiguous project management process. Ye, et al. (2014) deduced that the most critical rework factor in China was due to the ambiguity possess in the project management procedure. Therefore, the appointed Project Manager shall be proactive in initiating and facilitating an efficient communication platform or system among the key construction stakeholders, also, to kick start the project planning with pertinent project management tools and techiniques in order to ensure there shall be no grey area or uncertainties within the project parameter that might ultimately lead to unnecessary rework at last (Yap, Low and Wang, 2017). Meanwhile, in terms of aligning the understanding of project development procedures between the consultants and the contractors, it is appropriate to implement the constructability strategy as outlined within this research regarding the recommended effective measures in reducing rework. Generally, during the earlier stage of a project, it is crucial to set up the communication channel where the contractor could participate in reviewing the constructability aspects of the detailed design established by the consultants. Such efficient communication and coordination will hence significantly impede the risks of rework during the later construction stage due to any unrealistic construction issues (Hwang and Yang, 2014; Yap, Low and Wang, 2017).

4.7 Effective Measures in Reducing Reworks

After the identification and assessment of rework factors that may cause severe affliction towards the performance of the Malaysian Transport Infrastructure Projects, relevant measures in reducing the rework factors had been provided to the respondents and acquiring for their insights by rating the effectiveness of the measures in resolving the critical rework problems. The collected results were discussed in the following section.

4.7.1 Ranking of Effective Measures in Reducing Reworks

The ranking and comparison of perspectives among the three distinct groups of construction professional including Cliens, Consultants, and Contractors in terms of the effective measures in reducing rework factors for Malaysian Transport Infrastructure Projects are demonstrated in Table 4.9 with the application of Relative Importance Index techniques (RII). Based on Table 4.9, ‘Maintaining effective communication’ was being ranked as the foremost effective measures in reducing rework with a RII index of 0.974.

Apart from that, the measure that was being ranked second for this exploratory procedure was found to be the ‘Client’s needs and priorities should always be clear’ with a RII index value of 0.959. ‘Accurate contract documentation and design’ was being one of the crucial measures in reducing reworks as well since it was ranked as third for this research. Meanwhile, the urge of ‘Implementing constructability strategy’ and ‘Utilising Building Information Modelling (BIM) tools’ were prevailed since these two variables were being ranked as fourth and fifth places in the vein of the measures in reducing rework factors for the Malaysian Transport Infrastructure Projects with RII index values of 0.924 and 0.922 respectively.

Likewise, the RII for the remaining measures for reducing reworks were examined to be able to obtain index score of more than 0.70, consequently implying that all the remaining measures are crucial mechanism to eliminate or reduce rework thus enhance the project performance in terms of schedule, cost and quality. The ten remaining measures in reducing rework factors in Malaysian Transport Infrastructure Projects are ranked as follow, started with ‘Proper field inspection (RII=0.909)’; ‘Proper planning of resources (RII=0.898)’; ‘Ensure skilled workforce in carrying out special tasks (RII=0.893)'; 'Kick off meetings before working on site (RII=0.891)'; 'Regular meeting among construction stakeholders (RII=0.885)'; 'Implement crtical reflection on failures (RII=0.883)'; 'Be conscious and responsive of the site conditions (RII=0.881)'; 'Workers should undergo proper training programmes (RII=0.852)'; 'Using tools such as Work Breakdown Structure (WBS) during the inception stage (RII=0.807)'; and 'Enforce workers to attend safety and health training programmes (RII=0.765)'.

According to the perspectives of Clients, the most effective measure in reducing reworks are dedicated to the implementation of accurate contract documentation and design. Essentially, the urge of utilising Building Information Modelling (BIM) tools in reducing rework for Malaysian Transport Infrastructure Project was also being ranked as the first places among the Client's respondents. Furthermore, the Clients also held that it is crucial to maintain effective communication throughout the entire development process in order to mitigate the risks of misunderstanding project requirements or suffering loss of information. Besides, the measures that were being ranked as the fourth and fifth places in terms of effectiveness in reducing rework are to ensure Client's needs and priorities should always be clear; concurrently, proper planning of resources shall always be prioritised.

On the other hand, based on the standpoints of the Consultants, there are several similar insights with the preceding respondent group which the Consultants opined the top three effective measure in reducing reworks are maintaining effective communication; accurate contract documentation and design; and to ensure Client's needs and priorities should always be clear. However, the following fourth and fifth ranking of the variables are asserted to be implementing constructability strategy and to carry out proper field inspection in order to reduce the rework issues of the transport infrastructure projects.

In the meantime, according to Table 4.9, the Contractors hold the correspond opinion with the consultant, deduced that the utmost important measure in reducing rework is to maintain an effective communication. While the subsequent measure which is to ensure the Client's needs and priorities should always be clear is fundamentally could be achieved by making sure the preceding measure in maintaining effective communication is accomplished without any hesitation among all the construction practitioners. Meanwhile, the needs to have kick off meetings before working on site and regular meetings among construction stakeholders were postulated and ranked by the Contractor as the third ranking place. Lastly, the Contractors also possess the thought that by ensuring skilled workforce in carrying out the specified tasks could directly assist to reduce the occurrence of any rework issues for the transport infrastructure projects.

Table 4.9: Relative Importance Index and Ranking.

Measures in Reducing Rework	Overall		Client		Consultant		Contractor	
	RII	**Rank**	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**
Maintaining effective communication	0.974	1	0.977	3	0.979	1	0.965	1
Client's needs and priorities should always be clear	0.959	2	0.960	4	0.969	3	0.947	2
Accurate contract documentation and design	0.950	3	0.983	1	0.974	2	0.888	8
Implementing constructability strategy	0.924	4	0.909	7	0.964	4	0.894	6
Utilising Building Information Modelling (BIM) tools	0.922	5	0.983	1	0.928	6	0.853	12
Proper field inspection	0.909	6	0.926	6	0.949	5	0.847	13
Proper planning of resources	0.898	7	0.937	5	0.867	10	0.894	6
Ensure skilled workforce in carrying out special tasks	0.893	8	0.909	7	0.851	12	0.924	5
Kick off meetings before working on site	0.891	9	0.851	13	0.892	7	0.929	3
Regular meeting among construction stakeholders	0.885	10	0.863	12	0.867	10	0.929	3
Implement critical reflection on failures	0.883	11	0.909	7	0.872	9	0.871	9
Be conscious and responsive of the site conditions	0.881	12	0.886	10	0.887	8	0.871	9
Workers should undergo proper training programmes	0.852	13	0.874	11	0.815	13	0.871	9
Using tools such as Work Breakdown Structure (WBS) during the inception stage	0.807	14	0.823	14	0.805	14	0.794	14
Enforce workers to attend safety and health training programmes	0.765	15	0.794	15	0.790	15	0.706	15

4.7.2 Spearman's Correlation Coefficient

Spearman's correlation coefficient test was being implemented to examined the statistical relationship between the rework factors and the measures in reducing rework. In the meantime, the measures that are having greater number of significant correlation could be determined as the most practical and effective solutions to reduce or eliminate the occurrence of the rework factors. Table 4.10 indicates the findings obtained through the spearman's correlation coefficient test that run upon the frequency of occurrence of rework factors with the proposed rework reduction measures. Based on the outcomes, all the measures have a correlation with more than one rework factors.

Whereas, Table 4.11 depicts the outcomes achieved from the testing of spearman's correlation coefficient between the degree of severity of the rework factors with the proposed rework reduction measures. Similarly, scrutinizing to the results, it can be concluded that all the rework factors are considered to have at least one measures to be significantly correlated with.

Subsequently, Table 4.12 shows the multiple product outcomes generated from both the frequency and severity of the total significant correlation relationship. According to Table 4.12, the tabulated findings unveil the five most practical and effective measures in reducing rework which including of, the workers should undergo proper training programmes (12,12); maintaining effective communication (13,11); be conscious and responsive of the site conditions (11,9); implementing constructability strategy (10,9); and ensure skilled workforce in carrying out special tasks (9,9).

By comparing the spearman's correlation coefficient results with the relative importance index (RII) outcomes derived from previous section, there are two measures being ranked correspondingly among the five most effective rework reduction measures for both of the data analysis techniques, namely, maintaining effective communication and implementing constructability strategy. Nevertheless, there are three contradict findings where the urge for utilisation of BIM tools was ranked as the tenth place via the spearman's rank correlation coefficient test while the stated method was actually ranked as fifth place based on the RII results. However, there are still several studies strengthening the utilisation of BIM. For instance, research Kwon, et al. (2014) had incorporated BIM with image-matching and augmented reality towards a defect management software for the purpose to identifying and omitting defects automatically. Nonetheless, the aforementioned developed technologies were only evaluated in experiments but not in real-world projects. Other than detecting defects, Jin, et al. (2017) had accomplished a study towards the Chinese BIM perspectives whereby the findings deduced that the utilisation of BIM could substantially reduce the design errors that are the major consequence of construction reworks. Although some might argue on the software-related issues of the adoption of BIM, however, according to Bryde, et al. (2013), the pros of employing BIM in terms of time saving and cost control are still override the negative side of using BIM.

In essence, for the RII methodology, the deduced results tend to emphasize more on the measures to be implemented during design stage such as to ensure accurate contract documentation and design; and to always make clear the Client’s needs and priorities, so does the remaining ranking order as per Table 4.9. Whilst based on Table 4.10, the effective measures concluded from the spearman’s correlation coefficient was mainly elucidated on the mitigation strategies to be carried out specifically during the construction stage such as to enforce workers to undergo proper training programmes; to ensure skilled workforce in carrying out special tasks; to be conscious and responsive of the site conditions and so forth. Generally, both of the ranking for the effective rework reduction measures could be asserted to be appropriate depends on which particular stage of development process you are going to emphasize and implement such mitigation measures.

Other than that, according to Table 4.5 where the results stated the ranking of major rework factors could hence be addressed within this section, most of the extant studies are focusing on ameliorate the circumstances of the project development process or system either during design or construction stage, nevertheless, it is crucial to acknowledge that the findings from this research within the context of Malaysian Transport Infrastructure Projects deduced that the improvement in terms of knowledge management, specifically the potential effective communication approach shall be emphasized from now on. The process of gathering, capturing, preserving, accessing, sharing learning of the knowledge or information was affirmed to be the utmost fundamental aspect to be acclimatize to every construction profession before making any judgement or decision. Basically, maintaining effective communication among the entire project teams indeed enable the cohesiveness and competency of the team member as the consistent information delivery system had amplified the virtues of experiences, so does the suppression of the learning curve (Yap and Skitmore, 2020). Thus able to ensure future projects could be delivered in a more effective and efficient manner.

Table 4.10: Correlation between Factors and Measures for Frequency Index.

Spearman's Correlation for Frequency															
Factors \ Measures	FM1	FM2	FM3	FM4	FM5	FM6	FM7	FM8	FM9	FM10	FM11	FM12	FM13	FM14	FM15
F1		0.413**			0.258**					0.213*	0.363**				-0.246*
F2			0.224*		0.343**		0.311**					0.191*			
F3							0.275**			-0.215*	-0.235*	0.197*	0.201*		
F4			0.200*	0.380**	0.338**	0.423**			0.292**	0.394**	0.246*	0.339**			
F5			0.226*									0.286**	0.200*		0.290**
F6		0.274**		0.233*	0.201*					0.227*	0.412**				
F7		0.288**				0.208*				0.325**	0.328**				-0.260**
F8		0.304**			-0.233*						0.195*				
F9							0.222*								
F10	0.323**			0.237*	0.336**	0.189*	0.309**	0.192*					0.297**		-0.273**
F11					0.423**	0.265**	0.224*								-0.190*
F12			0.232*	0.414**	0.277**	0.261**		0.231*		0.315**	0.301**			-.306**	-0.233*
F13					0.302**	0.355**	0.230*				0.278**	0.255**			
F14		0.292**			0.299**	0.348**	0.196*		0.213*	0.286**	0.197*				-0.254**
F15		0.362**	0.199*	0.360**	0.343**	0.328**		0.234*	0.266**	0.238*	0.343**	0.243*			-0.264**
F16			0.255**	0.230*		0.230*				0.241*					-0.198*
F17		0.204*		0.277**			0.238*	0.315**			0.263**		0.333**		-0.275**
F18	0.206*	0.256**			0.288**	0.251**	0.323**	0.428**			0.252**		0.335**		-0.305**
F19	0.219*		0.227*	0.212*	0.267**	0.269**								-0.204*	
F20			0.192*				-0.207*		0.231*					-0.223*	
Total number of significant correlations	3	6	8	8	13	11	10	5	4	9	12	6	5	3	11

Table 4.11: Correlation between Factors and Measures for Severity Index.

	Spearman's Correlation for Severity														
Factors \ Measures	SM1	SM2	SM3	SM4	SM5	SM6	SM7	SM8	SM9	SM10	SM11	SM12	SM13	SM14	SM15
S1		0.234*		0.405**			-0.207*			0.390**	0.413**				-0.242*
S2			0.331**		0.225*	0.231*	0.198*		0.230*			0.371**			
S3		-0.207*					0.300**			-0.327**	-0.260**		0.319**		
S4				0.408**	0.266**	0.411**			0.218*	0.317**	0.346**	0.431**			
S5			0.412**		0.216*							0.322**			
S6				0.250**	0.277**	0.194*	-0.212*			0.313**	0.443**				-0.328**
S7		0.264**		0.258**	0.225*	0.202*				0.422**	0.326**				-0.304**
S8	0.200*	0.317**									0.236*				-0.272**
S9							0.309**	0.341**					0.248**		
S10	0.202*	0.207*			0.191*		0.463**	0.204*					0.379**		
S11	0.371**				0.379**		0.365**			-0.215*			0.202*		
S12			0.239*	0.322**	0.371**	0.252**		0.219*		0.233*	0.347**	0.190*	0.255**		-0.210*
S13												0.282**			
S14		0.259**			0.245*	0.331**			0.366**			0.263**			
S15		0.286**		0.245*		0.238*				0.277**	0.371**	0.242*			
S16			0.204*	0.330**				0.283**	0.192*	0.256**	0.425**			-0.226*	
S17		0.215*	0.325**		0.285**		0.313**	0.359**			0.225*		0.221*		
S18		0.196*				0.250**		0.387**			0.278**		0.276**		
S19	0.378**	0.207*	0.224*		0.273**	0.253**			0.218*		0.207*	0.194*			
S20				0.226*			0.331**		0.367**			0.205*	-0.244*	-0.281**	0.350**
Total number of significant correlations	4	10	6	8	11	9	9	6	6	9	12	9	8	2	6

***. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).*

Table 4.12: Summary of Correlation Findings and Ranking for Effective Measures.

Item	Measure	Frequency	Severity	*(F x S)*/100	*F x S*
		Total number of significant correlations			Ranking
FM11	Workers should undergo proper training programmes	12	12	1.44	1
FM5	Maintaining effective communication	13	11	1.43	2
FM6	Be conscious and responsive of the site conditions	11	9	0.99	3
FM7	Implementing constructability strategy	10	9	0.90	4
FM10	Ensure skilled workforce in carrying out special tasks	9	9	0.81	5
FM15	Enforce workers to attend safety and health training programmes	11	6	0.66	6
FM4	Proper planning of resources	8	8	0.64	7
FM2	Regular meetings among construction stakeholders	6	10	0.60	8
FM12	Accurate contract documentation and design	6	9	0.54	9
FM3	Utilising Building Information Modelling (BIM) tools	8	6	0.48	10
FM13	Implement critical reflection on failures	5	8	0.40	11
FM8	Using tools such as Work Breakdown Structure (WBS) during the inception stage	5	6	0.30	12
FM9	Proper field inspection	4	6	0.24	13
FM1	Client's needs and priorities should always be clear	3	4	0.12	14
FM14	Kick off meetings before working on site	3	2	0.06	15

Table 4.13: Summary of Indications for Correlation’s Table.

Factors			**Measures**		
Frequency	**Severity**	**Indication**	**Frequency**	**Severity**	**Indication**
F1	S1	Change orders by Client	FM1	SM1	Client’s needs and priorities should always be clear
F2	S2	Lack of scope clarity	FM2	SM2	Regular meetings among construction stakeholders
F3	S3	Tight Schedule assigned by Client	FM3	SM3	Utilising Building Information Modelling (BIM)
F4	S4	Poor investigation of site condition			tools
F5	S5	Inaccurate initial budget estimation	FM4	SM4	Proper planning of resources
F6	S6	Design error	FM5	SM5	Maintaining effective communication
F7	S7	Design deficiency	FM6	SM6	Be conscious and responsive of the site conditions
F8	S8	Design changes by Consultants	FM7	SM7	Implementing constructability strategy
F9	S9	Inadequate utilisation of Information Technologies	FM8	SM8	Using tools such as Work Breakdown Structure
F10	S10	Poor Coordination by Project Manager			(WBS) during the inception stage
F11	S11	Poor Communication	FM9	SM9	Proper field inspection
F12	S12	Ineffective site supervision	FM10	SM10	Ensure skilled workforce in carrying out special
F13	S13	Erroneous workmanship			tasks
F14	S14	Noncompliance of task requirements	FM11	SM11	Workers should undergo proper training
F15	S15	Lack adherence of quality assurance			programmes
F16	S16	Inexperience personnel	FM12	SM12	Accurate contract documentation and design
F17	S17	Low labour skills level	FM13	SM13	Implement critical reflection on failures
F18	S18	Poor material quality	FM14	SM14	Kick off meetings before working on site
F19	S19	Inappropriate construction method	FM15	SM15	Enforce workers to attend safety and health training
F20	S20	Dangerous site condition			programmes

4.8 Summary of Chapter

The total data collected for this research is derived from 108 construction practitioners in the Malaysian construction industry where the response rate is about 31%. The statistical analysis test conducted for this research were Cronbach's alpha reliability test, Importance Index technique, Relative Importance Index technique, Factor Analysis and Spearman's correlation coefficient. The reliability test had indicated that all the data collected for this research were reliable to be progressed. According to the Importance Index ranking for rework factors, the three most significant rework factors consist of poor communication; noncompliance of task requirements; and inappropriate construction method. Meanwhile, the Factor Analysis test had also revealed that the three most critical rework factors are poor communication; inaccurate initial budget estimation; and change orders by client. Through the same method, the five underlying root factors of rework are 'inadequacy in construction stage considerations'; 'incompetency of site practitioners'; 'inadequacy in feasibility stage considerations'; 'inappropriate allocation of resources'; and 'haphazard information delivery system'. On the other hand, the RII technique shown that the three most effective measures in reducing reworks are 'maintaining effective communication'; 'client's needs and priorities should always be clear'; and 'accurate contract documentation and design'. Lastly, the Spearman's correlation coefficient test demonstrated that the three most efficient rework reduction methods that addressing to the listed rework factors are consist of 'workers should undergo proper training programmes'; 'maintaining effective communication'; and 'be conscious and responsive of the site conditions'.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The research outcomes and conclusions were presented within this chapter conformity with the aims and objectives set forth at the outset of this exploration. Relevant research limitations in realising this research were being addressed and discussed as well. Lastly, a number of recommendations were deduced at the end of this chapter so to foster futher enhancements for future similar studies that are of the corresponding research area.

5.2 Conclusions

Apart from the inevitable strikes brought by varied external factors such as political issues, adverse surroundings and weathers, unforeseeable natural disasters, pandemics, even worse being denounced in a severe state of notoriety of being dirty, dangerous and difficult (3D) sector, the underlying major causes that are afflicting the Malaysian construction industry shall be confronted and sought ways to resolve in a timely manner. The transport infrastructure development projects are encapsulated to be enrolled as a pivotal role that not only contributing significant GDP through its incessantly national connectivity, but also possessing strong backward and forward economical linkage with other major economic sectors.

However, the rework issues that are proved to be the main chronic problem are actually plaguing the growth and advancement of the entire construction industry which shall be addressed in no time as it possess severe affliction towards project quality, schedule and project cost (Fayek, et al., 2003; Ye, et al., 2014; Hwang and Yang, 2014). Nonetheless, there are a severe paucity of studies being accomplished hitherto towards the rework issues, especially referring to the TIP. In light of this literature gap, this research tends to assess the underlying major critical rework factors towards the TIP, specifically in Malaysia, as well as to rectify the exacerbating construction-related issues where most of the precursors are affirmed to be the ultimate consequence of rework. It is accomplished by evaluating the effectiveness of measures in reducing reworks for Malaysian TIP. In order to achieved the aims of this research, there are three objectives being outlined in advanced during the first chapter of this research.

A comprehensive and extensive literature review had been accomplished where 4 major group of rework factors had been identified and a total of 40 numbers of associated rework precursors had been addressed as well. Furthermore, 15 potential effective measures in reducing rework to the transport infrastructure projects had been determined and ranked accordingly through this exploration process. Next, a questionnaire was generated and designed based on the research area in order to be harness as a data collection instrument in gathering information from wide variety of construction disciplines that are comprising of three distinct groups of construction practitioners namely, clients, consultants, and contractors. A total sum of 108 sets of responses were being attained while pertinent statistical methodologies were being adopted to accomplished data analysis for this research. The research objectives were being accomplished by the end of the study and were summarised in the following sections.

5.2.1 First Objective

In the progress of fulfilling the foremost objective of this research, Factor Analysis methodology had been employed to analyse and extract the underlying root factors of rework by examining and testing of the listed twenty rework precursors that are exasperating the Malaysian Transport Infrastructure Projects.

Among the total of twenty rework factors, five rework factors that carried the highest factor loading index had been identified and listed as below:

1) Poor communication - 0.851
2) Inaccurate initial budget estimation - 0.827
3) Change orders by client - 0.813
4) Low labour skills level - 0.803
5) Design error by consultant - 0.794

Meanwhile, there are five major underlying factors being extracted which are accountable for 63.18% of the total accumulative variance explained. The extracted underlying latent rework factors are indicated as follow in a descending order in terms of its accountable variance explained:

1) Factor 1: Inadequacy in Construction Stage Considerations – 14.51%
2) Factor 2: Incompetency of Site Practitioners – 14.40%
3) Factor 3: Inadequacy in Feasibility Stage Considerations – 13.94%
4) Factor 4: Inappropriate Allocation of Resources – 10.43%
5) Factor 5: Haphazard Information Delivery System – 9.91%

5.2.2 Second Objective

In order to accomplish the second objective for this research, the respondents were requested to rank the frequency of occurrence of rework factors in Malaysian Transport Infrastructure Projects via the second section of the questionnaire survey. Subsequently, the Frequency Index (F.I.) approach was then being employed to analyse the collected data. The top five most frequent reasons for rework to occur are listed as follows:

1) Poor communication;
2) Noncompliance of task requirements;
3) Inappropriate construction method;
4) Lack of scope clarity;
5) Lack adherence of quality assurance.

Meanwhile, the respondents were asked to rank the rework factors in terms of its extent of severity towards the Malaysian Transport Infrastructure Projects. The Severity Index (S.I.) was adopted and the computed resultfor the degree of severity of the stated rework factors are presented as follows:

1) Poor Communication;
2) Noncompliance of task requirements;
3) Inappropriate construction method;
4) Lack of scope clarity;
5) Ineffective site supervision.

Lastly, the significance of the factors was generated by obtaining the multiple product of F.I. and S.I. The higher the Importance Index (IMP.I.) attained, the more significant is the factors. The findings through the employment of Importance Index technique had eventually unveil the five most critical rework factors that are afflicting the Malaysian Transport Infrastructure Projects based on the perspectives of the three respondent groups, namely, Clients; Consultants; and Contractors. The results are depicted as below:

1) Poor communication;
2) Noncompliance of task requirments;
3) Inappropriate construction method;
4) Lack of scope clarity;
5) Lack adherence to quality assurance.

5.2.3 Third Objective

In order to attain for the third research objective which is to reduce the occurrence and impact of the rework factors, fifteen measures had been established for this research. Relative Importance Index (RII) data analysis technique had been applied to evaluate and elucidate the ranking of the rework reduction measures based on the perceptions of the three distinct disciplinary within construction industry, namely, Clients; Consultants; and Contractor. The results were analysed and tabulated within Chapter 4 of this research where the overall ranking as well as the separated ranking accomplished by each types of diciplinary in terms of the effectiveness of the measures are indicated accordingly. The top five effective measures ranked by the respondents in reducing rework toward the Malaysian Transport Infrastructure Projects are presented as follows:

1) Maintaining effective communication;
2) Client's needs and priorities should always be clear;
3) Accurate contract documentation and design;
4) Implementing constructability strategy;
5) Utilising Building Information Modelling (BIM) tools.

Concurrently, a spearman's correlation coefficient data analysis technique had been applied as well to observe the relationship between the existing rework factors and the measures in reducing rework. The outcomes shown that all the proposed measures are deemed to be effective and significant to be implemented in resolving the issues of reworks within the context of the Malaysian Transport Infrastructure Projects. Based on the computed results, the five most effective measures in reducing relevant rework issues are indicated as below:

1) Workers should undergo proper training programmes;
2) Maintaining effective communication;
3) Be conscious and responsive of the site conditions;
4) Implementing constructability strategy;
5) Ensure skilled workforce in carrying out special tasks.

5.3 Research Limitations

The interpretation of this research were subjected to several limitations. Firstly, there was paucity of relevant research information accessible from the circumstances of the Malaysian researchers as the research field of the Malaysian TIP is still emerging in a slower pace as compared to other countries. Furthermore, there are also very few countries that had completed research within this TIP field, even those that did were mostly becoming outdated and varied in terms of nation status, making it even more challenging in obtaining relevant information.

Apart from that, although the sample size for each respondent group is deemed to be reliable, nonetheless, there is limited scope for the respondents obtained for this research. This research only included clients, consultants and contractors where in fact, other construction practitioners such as the manufacturers and suppliers might further enlighten the research finding as they possess the closest proximity to the usage of various construction technologies that could reduce rework and enhance the Malaysian TIP performance.

The last and important limitation of this research is subjected to the adoption of structured questionnaire survey as the data gathering instrument.

The questionnaire survey generated were basically in the form of close-ended questions where the chances to attain for extensive and in-depth information are being constrained. In fact, the in-depth perceptions from various construction practitioners could only be attained through a detailed interviews which the research questions shall be generated in the means of various open-ended questions.

5.4 Recommendations for future work

The resulted of this research should be perceived as an exploratory analysis and serve as basis for defining any subsequent empirical research study concerning the similar issues within the construction industry. A more thorough and comprehensive investigation of the relevant similar issues that are impeding the efficiency and effectiveness development of the construction industry is advocated as most of the construction problems are diverse and ubiquitous.

Meanwhile, since the literature reviews and related information were primarily procured from other countries that possess distinct socioeconomic backgrounds and some sources were even out of date, hence, qualitative research approach could be established in the near future to consolidate and accurately reflect the genuine condtion of the Malaysian Construction Industry, particularly the Transport Infrastructure Projects.

Apart from that, the factor analysis technique being employed for this research had identified the underlying variables that essentially reflected the shared attributes that underlie those significant factors. The outcomes of the analysed data may assist the project management professionals to gain a better greater comprehension of such dilemmas. Therefore, the construction professionals may use the most ideal project management techniques or rectification mechanism to tackle the issues at hand. There is a necessity to initiate for further comprehensive research to investigate the addressed problems and hence develop the appropriate project management strategies among the client, consultant and contractor organisations.

To highlight the aforementioned statement, this exploratory study had also identified and determined several efficient methods for resolving some of the existing construction-related problems. Therefore, for any further extended investigation, it could be explored into the challenges and obstacles that are inhibiting the application of such tactics within the Malaysian construction industry context.

REFERENCES

Abbas, M., Sajid, S, and Mumtaz, S., 2018. Personal and contextual antecedents of knowledge sharing and innocative performance among engineers. *Engineering Management Journal,* 30(3),pp.154-164.

Abeku, D.M., Ogunbode, E.B., Salihu, C., Maxwell, S.S. and Kure, M.A., 2016. Projects Management and the effect of Rework on Construction Works: A Case of selected Projects in Abuja Metropolis, Nigeria. *International Journal of Finance and Management in Practice*, 4(1), pp.38–46.

Alaloul, W.S., Musarat, M.A., Rabbani, M.B.A., Iqbal, Q., Maqsoom, A. and Farooq, W., 2021. Construction sector contribution to economic stability: Malaysian gdp distribution. *Sustainability (Switzerland)*, 13(9).

Al-Janabi, A.M., Abdel-Monem, M.S. and El-Dash, K.M., 2020. Factors causing rework and their impact on projects' performance in Egypt. *Journal of Civil Engineering and Management*, 26(7), pp.666–689.

Alnuaimi, A.S., Taha, R.A., Mohsin, M.A. and Al-Harthi, A.S., 2010. Causes, effects, benefits, and remedies of change orders on public construction projects in Oman. *Journal of Construction Engineering and Management,* 136(5), pp.615-622.

Asadi, R., Wilkinson, S. and Rotimi, J.O.B., 2021. The common causes of rework in construction contracts: a diagnostic approach. *Journal of Engineering, Design and Technology*.

Aziz, A., 2022. Cover Story: Construction Industry in the Doldrums. *The Edge Markets*, [online] 17 February. Available at: <https://www.theedgemarkets.com/article/cover-story-construction-industry-doldrums> [Accessed 10 March 2022].

Bagaya, O. and Song, J., 2016. Empitical study of factors influencing schedule delays of public construction projects in Burkina Faso. *Journal of Management in Engineering*, 32(5), p.05016014.

Balouchi, M., Gholhaki, M. and Niousha, A., 2019. Reworks causes and related costs in construction: case of Parand mass housing project in Iran. *International Journal of Quality and Reliability Management*, 36(8), pp.1392–1408.

Basa-Martinez, D.D.F., et al., 2018. An exploration of a respondent pre-qualifying framework to increase response rates in social media initiated online surveys. *Australasian Marketing Journal*, 26(3), pp. 239-261.

Bist, R.B., 2015. Research Procedure: An introduction. *Journal of NELTA Surkhet*, 4, pp.34–40.

Bowling, A., 2005. Mode of Questionnaire Administration can have serious effects on Data Quality. *Journal of Public Health*, 27(3), pp. 281-291.

Bryde, D., Broquetas, M. and Volm, J.M., 2013. The project benefits of building information modelling (BIM). *International Journal of Project Management*, 31(7), pp.971-980.

Bunyan, 2021. KL-Singapore HSR Project cancelled due to Covid-19 impact on economy, says Minister. *Malay Mail*, [online] 4 January. Available at: <https://www.malaymail.com/news/malaysia/2021/01/04/kl-singapore-hsr-project-cancelled-due-to-covid-19-impact-on-economy-says-m/1937126> [Accessed 10 March 2022].

Burati, J.L., Farrington, J.J. and Ledbetter, W.B., 1992. Causes of quality deviations in design and construction. *Journal of Construction Engineering and Management*, 118(1), pp.34–49.

Chan, C.T., 2012. The Principal Factors affecting construction project overhead expenses: and explaratory factor analysis approach. *Construction Management and Economics*, 30(1), pp. 903-914.

Chassan, J.B., 1979. *Research Design in Clinical Psychology and Psychiatry*. 1st ed. New York: Irvington Publishers Inc.

Chihara, L.M. and Hesterberg, T.C., 2019. *Mathematical Statistics with Resampling and R*. 2nd ed. Hoboken: John Wiley & Sons, Inc.

Doloi, H., Sawhney, A., Iyer, K.C. and Rentala, S., 2012. Analysing factors affecting delays in Indian Construction Projects. *Journal of Construction Engineering and Management*, 139(3), pp.267-279.

DOSM, 2022a. *Business Tendency Statistics First Quarter 2022*. [online] Available at: <https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=150&bul_id=bEUyemdLUlU2bmZjT3FQNlJRTXdZUT09&menu_id=YmJrMEFKT0p0WUIxbDl1bzZydW9JQT09> [Accessed 7 March 2022].

DOSM, 2022b. *Malaysia Economic Performance Fourth Quarter 2021*. [online] Available at: <https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=100&bul_id=ckRVWlQrNVF4K2k3M1BWYU8vVTM0Zz09&menu_id=TE5CRUZCblh4ZTZMODZIbmk2aWRRQT09> [Accessed 7 March 2022].

DOSM, 2022c. *Employment Statistics – Fourth Quarter 2021*. [online] Available at: <https://newss.statistics.gov.my/newss-portalx/ep/epFreeDownloadContentSearch.seam?cid=31597> [Accessed 17 February 2022].

DOSM, 2022d. *Key Statistics of Labour Force in Malaysia, Jannuary 2022*. [online] Available at: <https://www.dosm.gov.my/v1/index.php?r=column/cthemeByCat&cat=124&bul_id=UEpPd3dKQkM2ZVRnVFZ3T0w1d1Zrdz

09&menu_id=Tm8zcnRjdVRNWWlpWjRlbmtlaDk1UT09> [Accessed 17 February 2022].

DOSM, 2022e. *Quarterly Construction Statistics – Fourth Quarter 2021*. [online] Available at: <https://newss.statistics.gov.my/newss-portalx/ep/epFreeDownloadContentSearch.seam?cid=31638> [Accessed 17 February 2022].

Durdyev, S. and Ismail, S., 2016. On-site construction productivity in Malaysian infrastructure projects. *Structural Survey*, 34(4–5), pp.446–462.

Eldash, K. and Abdel-Monem, M., 2004. Potential Risks in Civil Infrastructure Projects in Egypt. In: *VIII International Congress on Project Engineering-III IPMA-ICEC International Expert Seminar*. [online] Available at: <https://doi.org/10.13140/2.1.5003.8560> [Accessed 10 March 2022].

EPU, 2019. *Shared Prosperity Vision 2030*. Available through: Malaysia Economic Planning Unit <https://www.epu.gov.my/sites/default/files/2020-02/Shared%20Prosperity%20Vision%202030.pdf> [Accessed 20 February 2022].

Eze, E.C. and Idiake, J.E., 2018a. Analysis of Cost of Rework on Time and Cost Performance of Building Construction Projects in Abuja, Nigeria. *International Journal of Built Environment and Sustainability*, 5(1), pp.56–67.

Eze, E.C., Idiake, J.E. and Ganiyu, B.O., 2018b. Rework risks triggers in the Nigerian construction industry: a view of built environment professionals. *Independent Journal of Management & Production*, 9(2), pp.448.

Fayek, A.R., Dissanayake, M. and Campero, O., 2003. *Measuring and Classifying Construction Field Rework: A Pilot Study*. [online] Available at: <http://www.construction.ualberta.ca/papers.html> [Accessed 3 March 2022].

Fayek, A.R., Dissanayake, M. and Campero, O., 2004. Developing a standard methodology for measuring and classifying construction field rework. *Canadian Journal of Civil Engineering*, 31(6), pp.1077–1089.

Forcada, N., Gangolells, M., Casals, M. and Macarulla, M., 2017. Factors Affecting Rework Costs in Construction. *Journal of Construction Engineering and Management*, 143(8), p.04017032.

Forcada, N., Rusiñol, G., Macarulla, M. and Love, P.E.D., 2014. Rework in highway projects. *Journal of Civil Engineering and Management*, 20(4), pp.445–465.

Frimpong, Y., Oluwoye, J. and Crawford, L., 2003. Causes of delay and cost overruns in construction of groundwater projects in developing countries;

Ghana as a case study. *International Journal of Project Management*, 21(5), pp.321-326.

Garvetter, F.J. and Forzano, L.B., 2012. *Research Methods for the Behavioral Sciences*, 4th ed., Wadsworth, Cengage Learning, Belmont, CA.

Goundar, S., 2012. *Research methodology and research method*. Wellington: Victoria University of Wellington.

Han, S., Saba, F., Lee, S. and Mohamed, Y., 2014. Toward and understanding of the impact of production pressure on safety performance in construction operations. *Accident Analysis and Prevention*, 68, pp.106-116.

Hansen, S., Rostiyanti, S.F. and Rif'at, A., 2020. Causes, Effects, and Mitigations Framework of Contract Change Orders: Lessons Learned from GBK Aquatic Stadium Project. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 12(1), p.05019008.

Hwang, B.-G., Thomas, S.R., Haas, C.T. and Caldas, C.H., 2009. Measuring the Impact of Rework on Construction Cost Performance. *Journal of Construction Engineering and Management*, 135(3), pp.187–198.

Hwang, B.G. and Yang, S., 2014. Rework and schedule performance: A profile of incidence, impact, causes and solutions. *Engineering, Construction and Architectural Management*, 21(2), pp.190–205.

Hwang, B.G., Zhao, X. and Goh, K.J., 2014. Investigating the client-related rework in building projects: The case of Singapore. *International Journal of Project Management*, 32(4), pp.698–708.

Hwang, B.-G., Zhao, X. and Yang, K.W., 2019. Effect of BIM on Rework in Construction Projects in Singapore: Status Quo, Magnitude, Impact, and Strategies. *Journal of Construction Engineering and Management*, 145(2), p.04018125.

Ibrahim, A.R. bin, Roy, M.H., Ahmed, Z. and Imtiaz, G., 2010. An investigation of the status of the Malaysian construction industry. *Benchmarking*, 17(2), pp.294–308.

Jin, R., Hancock, C., Tang, L., Chen, C., Wanatowski, D. and Yang, L., 2017. Empirical study of BIM implementation-based perceptions among Chinese practitioners. *Journal of Management in Engineering*, 33(5), 04017025. doi:10.1061/(ASCE)ME.1943-5479.0000538

Josephson, P.-E. and Hammarlund, Y., 1999. The causes and costs of defects in construction A study of seven building projects. *Automation in Construction*, 8, pp.681–687.

Josephson, P.-E., Larsson, B. and Li, H., 2002. Illustrative Benchmarking Rework and Rework Costs in Swedish Construction Industry. *Journal of Management in Engineering*, 18(2), pp.76–83.

Khadaroo, A.J. and Seetanah, B., 2010. Transport infrastructure and foreign direct investment. *Journal of International Development*, 22(1), pp.103–123.

Khan, R.A., Ghazali, Z. bin and Liew, M.S., 2014. Malaysian Construction Sector and Malaysia Vision 2020: Developed Nation Status. *Procedia - Social and Behavioral Sciences*, 109, pp.507–513.

Khan, R.A., Ghazali, Z.B. and Liew, M.S., 2012. An Empirical Analysis of Linkage between the Construction and Manufacturing Sectors of Malaysia (2000-2010). In: *CHUSER-2012-2012 IEEE Colloquium on Humanities, Sciences and Engineering Research*., pp.678–683.

Kumar, R., 2011. *Research methodology: A step-by-step guide for beginners*. 3rd ed. London: Sage Publication.

Kwon, O.S., Park, C.S. and Lim, C.R., 2014. A defect management system for reinforced concrete work utilizing BIM, image-matching and augmented reality. *Automat. Construction*, 46, pp.74-81.

Le-Hoai, L., Lee, Y.D. and Lee, J.Y., 2008. Delay and cost overruns in Vietnam large construction projects: A comparison with other selected countries. *KSCE journal of civil engineering*, 12(6), pp.367-377.

Li, Y. and Taylor, T.R.B., 2014. Modeling the Impact of Design Rework on Transportation Infrastructure Construction Project Performance. *Journal of Construction Engineering and Management*, 140(9), p.04014044.

Lopez, R., Love, P.E.D., Edwards, D.J. and Davis, P.R., 2010. Design error classification, causation, and prevention in construction engineering. *Journal of Permance of Constructed Facilities*, 24(4), pp.399-408.

Love, P.E.D., and Edwards, D.J., 2004a. Forensic project management: The underlying causes of rework in construction projects. *Civil Engineering and Environmental Systems*, 21(3), pp.207–228.

Love, P.E.D., 2002a. Auditing the indirect consequences of rework in construction: a case based approach. *Managerial Auditing Journal*, 17(3), pp.138–146.

Love, P.E.D., 2002b. Influence of Project Type and Procurement Method on Rework Costs in Building Construction Projects. *Journal of Construction Engineering and Management*, 128(1), pp.18–29.

Love, P.E.D., Ackermann, F., Carey, B., Morrison, J., Ward, M. and Park, A., 2016. Praxis of Rework Mitigation in Construction. *Journal of Management in Engineering*, 32(5), p.05016010.

Love, P.E.D., Ackermann, F., Teo, ; Pauline and Morrison, J., 2015. From Individual to Collective Learning: A Conceptual Learning Framework for Enacting Rework Prevention. *Journal of Construction Engineering and Management*, 141(11), pp.0501500091–0501500910.

Love, P.E.D., David, J.E., Smith, J. and Walker, D.H.T., 2009. Divergence or Congruence? A Path Model of Rework for Building and Civil Engineering Projects. *Journal of Performance of Constructed Facilities*, 23(6), pp.480–488.

Love, P.E.D. and Edwards, D.J., 2004b. Determinants of rework in building construction projects. *Engineering, Construction and Architectural Management*, 11(4), pp. 259–274.

Love, P.E.D. and Edwards, D.J., 2005. Calculating total rework costs in Australian construction projects. *Civil Engineering and Environmental Systems*, 22(1), pp.11–27.

Love, P.E.D., Edwards, D.J., Watson, H. and Davis, P., 2010. Rework in Civil Infrastructure Projects: Determination of Cost Predictors. *Journal of Construction Engineering and Management*, 136(3), pp.275–282.

Love, P.E.D. and Li, H., 2000. Quantifying the causes and costs of rework in construction. *Construction Management and Economics*, 18(4), pp.479–490.

Love, P.E.D., Matthews, J. and Fang, W., 2020. Rework in Construction: A Focus on Error and Violation. *Journal of Construction Engineering and Management*, 146(9), p.06020001.

Love, P.E.D., Matthews, J., Ika, L.A. and Fang, W., 2022. Error culture and its impact on rework: An exploration of norms and practices in a transport mega-project. *Developments in the Built Environment*, 10, p.100067.

Love, P.E.D. and Smith, J., 2016. Toward Error Management in Construction: Moving beyond a Zero Vision. *Journal of Construction Engineering and Management*, 142(11), p.04016058.

Love, P.E.D. and Smith, J., 2019. Unpacking the ambiguity of rework in construction: making sense of the literature. *Civil Engineering and Environmental Systems*, 35(1-4), pp. 180–203.

Love, P.E.D., Smith, J., Ackermann, F. and Irani, Z., 2018a. The praxis of stupidity: an explanation to understand the barriers mitigating rework in construction. *Production Planning and Control*, 29(13), pp.1112–1125.

Love, P.E.D., Smith, J., Ackermann, F., Irani, Z. and Teo, P., 2018b. The costs of rework: insights from construction and opportunities for learning. *Production Planning and Control*, 29(13), pp.1082–1095.

Love, P.E.D., Teo, P., Ackermann, F., Smith, J., Alexander, J., Palaneeswaran, E. and Morrison, J., 2018c. Reduce rework, improve safety: an empirical inquiry into the precursors to error in construction. *Production Planning and Control*, 29(5), pp.353–366.

Love, P.E.D., Davis, P.R., Lopez, R. and Jasper, T., 2008. *It's Not Just About Bricks and Mortar: Procedural Failures in Construction*. In: Association of Researchers in Construction Management (ARCOM) – Proceedings of the 24th Annual Conference. University of Glamorgan Cardiff Wales UK, September 1, 2008.

Mahamid, I., 2016. Analysis of rework in residential building projects in palestine. *Jordan Journal of Civil Engineering*, 10(2), pp.197–208.

Marhani, M.A., et al., 2012. Dependency of foreign workers in Malaysian Construction Industry. *Built Environment Journal*, 9(1), pp.39-50.

Masrom, M.A.N., Rahim, M.H.I.A., Mohamed, S., Chen, G.K. and Yunus, R., 2015. Successful criteria for large infrastructure projects in Malaysia. In: *Procedia Engineering*. Elsevier Ltd.pp.143–149.

Mendis, D., Hewage, K.N. and Wrzesniewski, J., 2013. Reduction of construction wastes by improving construction contract management: A multinational evaluation. *Waste Management and Research*, 31(10), pp.1062–1069.

Mohamad, M.I., Nekooie, M.A. and Al-Harthy, A.B.S., 2012. Design Changes in Residential Reinforced Concrete Buildings: The Causes, Sources, Impacts and Preventive Measures. *Journal of Construction in Developing Countries*, 17(2), pp.23–44.

Mohammadi, A., Tavakolan, M. and Khosravi, Y., 2018. Factors influencing safety performance on construction projects: A review. *Safety Science*, 109(June), pp.382-397.

Muhwezi, L., Acai, J. and Otim, G., 2014. An assessment of the factors causing delays on building construction projects in Uganda. *Construction Engineering and Management*, 3(1), pp.13-23.

Najib, I.Z.M., Nordin, R.M., Ahnuar, E.M. and Sukor, K.M., 2019. Malaysian as the component of labour force for construction industry in Malaysia. *MATEC Web of Conferences*, 266.

Okasha, A., Arafa, A. and Amer, N., 2018. Identifying MajorProject Delay Causes in Egypt and Assessing their Impacts Using System Dynamics. *The International Conference on Civil and Architecture Engineering*, 12(12), pp.1–10.

Oyewobi, L., Ganiyu, B.O., Oyewobi, L.O., Ibironke, O.T., Ganiyu, B.O. and Ola-Awo, A.W., 2011. Evaluating rework cost-A study of selected building projects in Niger State, Nigeria. *Journal of Geography and Regional Planning*, 4(3), pp.147–151.

Oyewobi, L.O., Abiola-Falemu, O. and Ibironke, O.T., 2016. The impact of rework and organisational culture on project delivery. *Journal of Engineering, Design and Technology*, 14(2), pp.214–237.

Palaneeswaran, E., Love, P.E.D. and Kim, J.T., 2014. Role of Design Audits in Reducing Errors and Rework: Lessons from Hong Kong. *Journal of Performance of Constructed Facilities*, 28(3), pp.511–517.

Palaneeswaran, E., Love, P.E.D., Kumaraswamy, M.M. and Ng, T.S.T., 2014. Causal Ascription of Rework in building and civil engineering projects: A multivariate exploration. *Engineering, Construction and Architectural Management*, 21(1), pp.111-126.

PMO, 2019. *National Transport Policy 2019-2030*. Available through: Prime Minister's Office of Malaysia Official Website <https://www.pmo.gov.my/2019/10/national-transport-policy-2019-2030/> [Accessed 20 February 2022].

Priyadarshani, K., Gayani, K. and Jayasuriya, S., 2013. Construction safety assessment framework for developing countries: a case study of Sri Lanka. *Journal of Construction in Developing Countries*, 18(01), pp.33-51.

Ramli, M.Z., Abidin, M.Z.Z., Hamid, N.B., Razman, R. and Noh, N.A.M., 2021. Ranking of railway construction project delay factors in Malaysia by using relative importance index (RII). In: *AIP Conference Proceedings*. American Institute of Physics Inc.

Reynolds, N., Diamantopoulos, A. and Schlegelmilch, B., 1993. Pre-Testing in Questionnaire Design: A Review of the Literature and Suggestions for Further Research. *International Journal of Market Research*, 35(2), pp. 1–11.

RMKE12, 2021. *Twelfth Malaysia Plan*. Available through: Rancangan Malaysia Kedua Belas <https://rmke12.epu.gov.my/en> [Accessed 20 February 2022].

Safapour, E. and Kermanshachi, S., 2019. Identifying Early Indicators of Manageable Rework Causes and Selecting Mitigating Best Practices for Construction. *Journal of Management in Engineering*, 35(2), p.04018060.

Safapour, E., Kermanshachi, S., Taneja, P. and Pamidimukkala, A., 2022. Exploratory Analysis of Human-, Organizational-, and Project-Based Reworks: Challenges and Strategies. *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, 14(1), p. 04521045.

Sommerville, J., 2007. Defects and rework in new build: An analysis of the phenomenon and drivers. *Structural Survey*, 25(5), pp.391–407.

Sommerville, J., Craig, N. and Bowden, S., 2004. The standardisation of construction snagging. *Structural Survey*, 22(5), pp.251–258.

Statista, 2021. Number of People Employed in the Construction industry in Malaysia from 2015 to 2020. [online] Available at: <https://www.statista.com/statistics/809686/annual-employment-in-the-construction-industry-malaysia/#:~:text=In%202020%2C%20approximately%201.4%20million,the%20construction%20industry%20in%20Malaysia.> [Accessed 17 February 2022].

Taherdoost, H, 2017. Sampling methods in research methodology, how to choose a sampling technique for research. *ResearchGate.*

Tammy, N.J., Ismail, I.I., Noor, R.N.H.R.M., Yunus, J.N. and Dollah, Z., 2021. Analysis of rework causes in infrastructure projects in pulau pinang. *Civil Engineering and Architecture*, 9(5), pp.145–156.

Taylor, T.R.B. and Ford, D.N., 2008. Managing Tipping Point Dynamics in Complex Construction Projects. *Journal of Construction Engineering and Management*, 134(6), pp.421–431.

Trach, R., Pawluk, K. and Lendo-Siwicka, M., 2019. Causes of Rework in Construction Projects in Ukraine. *Archives of Civil Engineering*, 65(3), pp.61–74.

Tripathi, K.K., and Jha, K.N., 2018. Determining success factors for a construction organization: A structural equation modelling approach. *Journal of Management Engineering*, 34(1): 04017050.

Welman, J.C., Kruger, F., Mitchell, B. and Huysamen, G.K., 2005. *Research Methodology*. 3rd ed. Cape Town. Oxford: Oxford University Press.

Yap, J.B.H., Abdul-Rahman, H. and Chen, W., 2017. Design Change Dynamics in Building Project: From Literature Review to A Conceptual Framework Formulation. *Journal of Surveying, Construction & Property*, 8(1), pp.13–33.

Yap, J.B.H., Abdul-Rahman, H., Wang, C. and Skitmore, M., 2018. Exploring the underlying factors inducing design changes during building production. *Production Planning and Control*, 29(7), pp.586–601.

Yap, J.B.H. and Skitmore, M., 2020. Amelirating time and cost control with project learning and communication management – Leveraging on reusable knowledge assets. *International Journal of Managing Projects in Businiess*, 13(4), pp.767-792.

Yap, J.B.H., Chong, J.R., Skitmore, M. and Lee, W.P., 2020. Rework Causation that Undermines Safety Performance during Production in Construction. *Journal of Construction Engineering and Management*, 146(9), p.04020106.

Yap, J.B.H., Chow, I.N. and Shavarebi, K., 2019. Criticality of Construction Industry Problems in Developing Countries: Analyzing Malaysian Projects. *Journal of Management in Engineering*, 35(5), p.04019020.

Yap, J.B.H., Low, P.L. and Wang, C., 2017. Rework in Malaysian building construction: impacts, causes and potential solutions. *Journal of Engineering, Design and Technology*, 15(5), pp.591–618.

Yap, J.B.H. and Tan, S.M., 2021. Investigating Rework: Insights from the Malaysian Construction Industry. *ASM Science Journal*, 14, pp.1–9.

Ye, G., Jin, Z., Xia, B. and Skitmore, M., 2014. Analyzing Causes for Reworks in Construction Projects in China. *Journal of Management in Engineering*, 31(6), p.04014097.

Yong, A.G. and Pearce, S., 2013. A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in quantitative methods for psychology*, 9(2), pp.79-94.

Yousry Akal, A. and Metwally El-Kholy, A., 2021. Exploring the critical frequent factors of rework and assigning strategies to mitigate their occurrence in the Egyptian construction projects. *Journal of King Saud University - Engineering Sciences*. [online] ScienceDirect. Available through: University Tunku Abdul Rahman database <https://www.sciencedirect.com/science/article/pii/S1018363921001410> [26 February 2022].

Zhang, F., Zuo, J. and Zillante, G., 2013. Identification and evaluation of the key social competencies for Chinese construction project managers. *International Journal of Project Management*, 31(5), pp.748-759.

Zhang, S., Duan, H., Zhao, X., Xia, B., Feng, Y. and Galvin, S., 2018. Learning on rework management of construction projects: a case study. *International Journal of Construction Management*, 21(3), pp.246–260.

Zid, C., Kasim, N., Raza Soomro, A. and Laidoune, A., 2020. The discrepancy in the construction industry of Malaysia: One of the most contributing industries in Malaysia's economy and the highest contributor of the fatal accidents. In: *IOP Conference Series: Materials Science and Engineering*. Institute of Physics Publishing.

APPENDICES

APPENDIX A: Questionnaire

ASSESSING THE MAJOR REWORK FACTORS IN TRANSPORT INFRASTRUCTURE PROJECTS IN MALAYSIA

Dear Sir/Madam,

Sincere greetings and best regards to you.

My name is Lim Ing Rhong and I am a final year undergraduate student pursuing Bachelor of Science (Honours) Quantity Surveying in University Tunku Abdul Rahman (UTAR). Currently, I am conducting a research for my Final Year Project which is titled as "Assessing the Major Rework Factors in Transport Infrastructure Projects in Malaysia".

It will be much appreciated if you could spend time participating in this survey to contribute your valuable information which is highly imperative to the research and to the development of Malaysian construction industry. This questionnaire consists of four sections and is designed to be completed within 15 minutes. All the information collected through this survey are strictly assured to be kept private and confidential and solely for academic purpose. Should you require any clarification, please do not hesitate to contact me at ingrhong@gmail.com or 012-9785807.

Your precious time and effort in participating the survey are deeply obliged.

Thank you.

Yours faithfully,
Lim Ing Rhong

Section A: Respondent's Background Information

1. Which of the following best classifies your organisation?

☐ Client

☐ Consultant

☐ Contractor

2. What is your position in your organization?

☐ Executive

☐ Manager

☐ Senior Manager

☐ Director / Top Management

3. How many years of working experience do you have in the construction industry?

☐ < 5 years

☐ 5-10 years

☐ 11-15 years

☐ 16-20 years

☐ Over 20 years

4. What is/are the types of transport infrastructure projects you have engaged in throughout your career path?

☐ Roads

☐ Bridges

☐ Tunnels

☐ Highways / Expressways

☐ Railways

5. What is your highest academic qualification?

☐ Postgraduate Degree (PhD, Master’s Degree)

☐ Bachelor’s Degree

☐ Diploma, Certificate

☐ High School

Section B: Frequency of Major Rework Factors that impacting Malaysian Transport Infrastructure Projects
(Choose only one answer per row)

Construction **Reworks** imply the **additional actions** that are required to be carried out in order **to amend, rectify or improve** the works which do not comply with the project requirements and performance.

6. In your opinion, is the practice of Rework a major issue within the context of Malaysian Transport Infrastructure Projects?

Not at all agreed	1	2	3	4	5	Extremely agreed

7. What is the frequency of occurrence for the following rework factors?

Statements	Never Happened	Rarely	Sometimes	Often	Always Happened
Change orders by Client	1	2	3	4	5
Lack of scope clarity	1	2	3	4	5
Tight Schedule assigned by Client	1	2	3	4	5
Poor investigation of site condition	1	2	3	4	5
Inaccurate initial budget estimation	1	2	3	4	5
Design error	1	2	3	4	5
Design deficiency	1	2	3	4	5
Design changes by Consultants	1	2	3	4	5
Inadequate utilisation of Information Technologies	1	2	3	4	5
Poor Coordination by Project Manager	1	2	3	4	5
Poor Communication	1	2	3	4	5
Ineffective site supervision	1	2	3	4	5

Erroneous workmanship	1	2	3	4	5
Noncompliance of task requirements	1	2	3	4	5
Lack adherence of quality assurance	1	2	3	4	5
Inexperience personnel	1	2	3	4	5
Low labour skills level	1	2	3	4	5
Poor material quality	1	2	3	4	5
Inappropriate construction method	1	2	3	4	5
Dangerous site condition	1	2	3	4	5

Section C: Severity of Major Rework Factors that impacting Malaysian Transport Infrastructure Projects
(Choose only one answer per row)

8. What is the degree of severity of the following rework factors?

Statements	Not Severe	Little	Moderate	Very	Extremely Severe
Change orders by Client	1	2	3	4	5
Lack of scope clarity	1	2	3	4	5
Tight Schedule assigned by Client	1	2	3	4	5
Poor investigation of site condition	1	2	3	4	5
Inaccurate initial budget estimation	1	2	3	4	5
Design error	1	2	3	4	5
Design deficiency	1	2	3	4	5
Design changes by Consultants	1	2	3	4	5
Inadequate utilisation of Information Technologies	1	2	3	4	5
Poor Coordination by Project Manager	1	2	3	4	5
Poor Communication	1	2	3	4	5
Ineffective site supervision	1	2	3	4	5
Erroneous workmanship	1	2	3	4	5
Noncompliance of task requirements	1	2	3	4	5
Lack adherence of quality assurance	1	2	3	4	5
Inexperience personnel	1	2	3	4	5
Low labour skills level	1	2	3	4	5
Poor material quality	1	2	3	4	5
Inappropriate construction method	1	2	3	4	5
Dangerous site condition	1	2	3	4	5

Section D: Measures in Reducing Reworks for Malaysian Transport Infrastructure Projects
(Choose only one answer per row)

9. How effective are these measures in reducing rework for a Transport Infrastructure Project?

Statements	Ineffective	Slightly Effective	Effective	Very Effective	Extremely Effective
Client's needs and priorities should always be clear.	1	2	3	4	5
Regular meetings among construction stakeholders.	1	2	3	4	5
Utilising Building Information Modelling (BIM) tools.	1	2	3	4	5
Proper planning of resources.	1	2	3	4	5
Maintaining effective communication.	1	2	3	4	5
Be conscious and responsive of the site conditions.	1	2	3	4	5
Implementing constructability strategy.	1	2	3	4	5
Using tools such as Work Breakdown Structure (WBS) during the inception stage.	1	2	3	4	5
Proper field inspection.	1	2	3	4	5

Ensure skilled workforce in carrying out special tasks.	1	2	3	4	5
Workers should undergo proper training programmes.	1	2	3	4	5
Accurate contract documentation and design.	1	2	3	4	5
Implement critical reflection on failures.	1	2	3	4	5
Kick off meetings before working on site.	1	2	3	4	5
Enforce workers to attend safety and health training programmes.	1	2	3	4	5

End of Questionnaire Survey.
Thank you very much for participating in this survey.