

# Investigating Rework: Insights from the Malaysian Construction Industry

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Construction practitioners recognise that rework is undesirable due to the detrimental effects. While rework literature has examined rework causation factors in construction projects, the problem continues to plague the industry resulting in poor delivery performance. To better understand this phenomenon and given the scarcity of Malaysian-based rework study, a questionnaire survey involving 130 Malaysian construction practitioners (consultants, contractors and clients) were undertaken to obtain feedback about nature, implications, causes and solutions for rework. Data were analysed using descriptive statistical techniques to prioritise the variables studied. From the analyses, rework is a causal factor for delays and cost overruns, higher wastage and productivity inhibitor. The findings revealed the leading causes of rework are poor quality management, improper planning, lack of communication, design changes and poor subcontractor management. Some practical rework minimisation approaches are also suggested to better manage and prevent rework towards enhanced project performance.

**Keywords:** rework; construction industry; project management; schedule delay; cost overrun; Malaysia

## I. INTRODUCTION

Rework remains a chronic problem undermining construction performance globally (Love *et al.*, 2020; Palaneeswaran *et al.*, 2014; Yap *et al.*, 2017, 2020; Ye *et al.*, 2014). Previous research has indicated rework as a critical factor that can directly cause delays and cost overruns (Hwang & Yang 2014; Hwang *et al.*, 2009; Josephson *et al.*, 2002). According to Hwang *et al.* (2009), the cost of construction is often raised by 5% due to rework alone. In another study in Australia, Love and Edwards (2005) reported the mean direct and indirect cost of rework in relation to contract sum accounted for 6.7% and 5.9%, respectively. In Singapore, Hwang and Yang (2014) observed rework as the primary factor of schedule growth. In this connection, frequent changes that result in additional work or simply rework much contributed to low labour productivity in India (Thomas & Sudhakumar 2015). Given that 55% of Malaysian projects suffered from cost overruns (Shehu *et al.*, 2014) and rework is a significant inhibitor

factor for time and cost control, the persistence of the problem warrants more research efforts to gain more comprehensive understanding so practical rework minimisation strategies can be formulated.

There have been limited studies on rework causation and attributing rework to time-cost overruns in the Malaysian context. In this light, the first sensible step in improving project performance is to recognise the nature of rework and the negative implications to project outcomes. After determining the implications of rework, the second step is to assess the rework causation factors most relevant to the local construction so that some effective rework prevention approaches can be recommended, ultimately allowing the industry to improve overall construction performance. With this background, the aim of this paper will be achieved through the following objectives:

- i. To investigate the nature and implications of rework;
- ii. To identify and rank the causes of rework;
- iii. To compare the Malaysian situation with some other selected countries; and

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- iv. To examine the significance of potential rework reduction measures.

To achieve these objectives, a systematic review on rework was conducted to appreciate the interpretations, determinants of rework and some practical remedies. These salient rework issues were then appraised through a broad survey of Malaysian construction practitioners to provide much-needed insights to understand and address rework problems in the Malaysian construction industry and beyond.

## II. REWORK BACKGROUND

A summary of the keywords used by various authors is presented in Table 1. Burati *et al.* (1992) associated rework with quality deviation factors while Love *et al.* (2015) deliberated non-conformances. Common predicaments associated with rework are defects (Sommerville, 2007), quality failures (Barber *et al.*, 2002) and incompetency (Yap *et al.*, 2019). It can be observed from Table 1 that rework involves doing the same thing more than once, which is considered non-value adding activity. It is worth to underscore that rework demands additional resources (i.e. time, cost, labour, materials, machinery) for abortive work that jeopardises project success. As such, doing it right the first time is the precursor for not reworking.

Table 1. Rework in construction

Keywords	Authors							
	(Eze & Idiake, 2018)	(Love <i>et al.</i> , 1999)	(Josephson <i>et al.</i> , 2002)	(Ashford, 1992)	(Oyewobi <i>et al.</i> , 2011)	(Abdul-Rahman <i>et al.</i> , 2016)	(Palaneeswaran <i>et al.</i> , 2008)	(Kakitahi <i>et al.</i> , 2016)
Undesired and unnecessary effort	✓	✓				✓	✓	✓
Redoing a process or activity		✓				✓	✓	✓
Degrades the total project performance	✓		✓		✓	✓	✓	✓
Non-conformance to client's requirement and expectation				✓	✓			✓
Correction to the failure work		✓		✓			✓	✓

## III. RESEARCH METHOD

A detailed literature review was used to identify the nature of rework in construction and the implications of rework as well as a list of 20 most frequently cited causes of rework and nine potential approaches to minimise rework. A structured questionnaire was further developed based on the variables emerged and drafted in plain and simple language to seek the respondents' judgement on the variables. The questionnaire contained four parts: first, respondent's background information; second, an overview of rework in construction; third, rework causes and forth, seeming solutions for rework minimisation. A 5-item Likert scale was adopted to gauge the extent of agreement, with 1 being "strongly disagree" to 5 being "strongly agree". A total of 1005 e-survey forms were disseminated to construction practitioners nationwide. Of these, 130 valid responses were returned; reaching response rate of 12.94% where it is not uncommon for studies seeking feedback from the Malaysian construction industry. This is in accordance with Yong and Mustaffa (2013) and Abdul-Aziz (2012) recorded a low response rate of 9.83% and 10.33% respectively in which they attributed to busy work environment and apathy towards research in the local construction industry. Nonetheless, the sample size of 130, which is greater than 100 is adequate for satisfactory statistical analysis and inference (Fellows & Liu 2015; Yap *et al.*, 2019). SPSS Statistics V23.0 statistical analysis software was used to analyse the data and prioritise the hypothesised variables accordingly.

### A. Respondent's Characteristics

Table 2 provides detailed background information about the 130 respondents. The respondents included representatives from three primary construction stakeholders, viz. consultant (45.4%), contractor (30.0%) and client (24.6%) to ensure capturing the perspectives of different project roles. Of the respondents, all had undergone tertiary education. Additionally, almost 30% hold managerial or higher designations while 38.6% had more than 10 years of experience in the construction industry which indicated that the respondents had appropriate qualification and experience to offer sound judgement on the questionnaire.

Table 2. Respondents' profile

Parameter	Category	Response	Frequency (%)
Role	Consultant	59	45.4
	Contractor	39	30.0
	Client	32	24.6
Working experience	< 5 years	57	43.8
	6 - 10 years	23	17.7
	11 - 15 years	20	15.4
	16 – 20 years	13	10.0
	> 20 years	17	13.1
Highest education	High school	0	0
	Diploma	19	14.6
	Degree	83	63.8
	Master	21	16.2
	PhD	7	5.4
Job position	Junior executive	51	39.2
	Senior executive	42	32.3
	Supervisor/manager	26	20.0
	Director	11	8.5

### B. Data Reliability

The internal consistency of questionnaire items was tested using Cronbach's  $\alpha$  to ensure metric reliability. The computed  $\alpha$  coefficient values were 0.863 for perceptions towards rework (5 items), 0.769 for impacts of rework (7 items), 0.886 for rework causes (20 items) and 0.854 for potential rework minimisation approaches (9 items); all were found to be greater than 0.70 whereby the data can be regarded as reliable (Yan *et al.*, 2019; Yap *et al.*, 2019).

## IV. RESULTS AND DISCUSSION

### A. Perceived Rework Problems and Impacts

Table 3 shows the mean and standard deviation for the understanding of rework in construction. The majority of the respondents agreed that rework is associated with non-value adding activity where the three most perceived rework problems are related to "redoing a process or activity", "correction to the failure work" and "non-conformance to client's requirement and expectation". These findings are consistent with the definition of rework, as discussed above.

Table 3. Nature of rework

Nature	Mean	SD	Rank
Redoing a process or activity	4.008	0.821	1

Correction to the failure work	3.854	0.957	2
Non-conformance to client's requirement and expectation	3.739	0.894	3
Degrades the total project performance	3.477	0.950	4
Undesired and unnecessary work	3.477	0.950	5

Regarding the impacts of rework, Table 4 indicates the ratings provided by the respondents. Global studies have elucidated rework as an endemic phenomenon that can significantly undermine project success and team morale (Kakitahi *et al.*, 2016; Love *et al.*, 2009; Ye *et al.*, 2014). A closer examination of Table 4 reveals the three most detrimental implications to Malaysian projects include "time and cost overruns", "contribute to construction waste" and "low productivity". According to Yap *et al.* (2017) Malaysian-based study, rework raises construction cost by up to 6% and delays schedule by practically 5-10%. In Ugandan public projects, rework impacted project budget and schedule by nearly 4.5% and 8.4%, respectively (Kakitahi *et al.*, 2016). Additionally, rework negatively impact organisational performance. The need to rework degrades workers' morale, disturb work rhythm, increase stress level and can cause high absenteeism (Hanna *et al.*, 2005; Yap *et al.*, 2018). Thus, labour productivity is adversely impacted.

Table 4. Ranking of impacts of rework

Implications	Mean	SD	Rank
Time and cost overrun	4.454	0.648	1
Contributed to construction waste	4.231	0.753	2
Low productivity	4.146	0.808	3
Quality deviation	4.092	0.782	4
Disputes	4.077	0.700	5
Delay in progress payment	3.954	0.870	6
Poor safety	3.569	0.797	7

### B. Rework Causes in Construction

Ranked in descending order, Table 5 presents the significance score for each cause. When two or more causes obtained the same mean score, the cause that obtained a smaller standard deviation is regarded as more significant (Yap *et al.*, 2018). Twelve of the causes obtained high mean scores greater than 4.0, which are considered as very significant in the rating

scale whereas the other eight causes are also rated as significant with mean scores of higher than 3.0. The leading causes of rework are poor quality management (mean=4.300), improper planning (mean=4.292), lack of communication (mean=4.246), design changes (mean=4.246) and poor subcontractor management (mean=4.192). Similarly, Love *et al.* (2009) investigated rework using data from 260 completed building and infrastructure projects in Australia to observe that inadequate emphasis on quality management mechanism contributed to higher rework costs in the projects sampled. The other contributors to rework costs are related to changes instructed by the client, site and subcontractor-related issues and flawed project communications. In a Swedish study, Josephson *et al.* (2002) grouped rework causes according to client, design, workmanship, material, machines and production management. Associating rework and schedule performance, Hwang and Yang (2014) reported that design-related changes, deficient design coordination and improper site management as major factors undermining schedule performance. Additionally, high fragmentation of the construction industry contributes to an adversarial culture that also provokes frequent changes due to miscommunication and improper coordination, and ultimately continual rework (Yap *et al.*, 2018).

Table 5. Ranking of rework causes

Causes	Mean	SD	Rank
Poor quality management	4.300	0.552	1
Improper planning	4.292	0.549	2
Lack of communication	4.246	0.671	3
Design changes	4.246	0.727	4
Poor subcontractor management	4.192	0.636	5
Poor and inefficient site management	4.185	0.680	6
Lack of clarity in project scope	4.177	0.628	7
Lack of data	4.169	0.661	8
Poor site coordination	4.146	0.779	9
Lack of commitment	4.092	0.652	10
Variation order	4.069	0.673	11

Design error	4.062	0.775	12
Poor contract documentation	3.985	0.816	13
Improper handling of machinery and equipment	3.915	0.845	14
Poor human resources management	3.892	0.780	15
Improper handling of materials and delivery	3.854	0.836	16
Loss of biorhythm	3.823	0.731	17
Slips and lapses of attention	3.815	0.691	18
Time limitation	3.669	0.893	19
Lack of motivation	3.377	0.828	20

The major rework causes identified in this study are also comparable with the primary delay factors in Malaysian and Indian construction industry as observed by Sambasivan and Soon (2007) and Doloi *et al.* (2012), respectively. In another Malaysian study, Yap *et al.* (2019) opined that the primary underlying reasons for schedule delays are uncontrolled design changes, project communication breakdown and incompetency of team members. Thus, it is sensible to infer that rework causation and construction time-cost overruns factors are reciprocal. With this in mind, generic strategies for reducing rework occurrences will lead to improved project performance.

A comparison of the five most important causes of rework among some selected countries is provided in Table 6. The selected studies give a better understanding of the common rework causes in other countries and triangulate the findings of this current study in Malaysia. According to Olawale and Sun (2010), construction projects worldwide share some common characteristics but some issues may be country-specific. Nonetheless, the major causes of rework cited in Table 6 are associated with poor project management practices in relation to planning, monitoring and control aspects. Additionally, lack of knowledge and expertise of the designers and site personnel often result in design and construction deficiencies. In light of this, rework causation is significantly influenced by the competency and experience of project personnel and workmanship of tradesmen.

Table 6. Comparison with selected countries

Location of study (Author)	Major causes				
	1	2	3	4	5
Malaysia (This study, 2020)	Poor quality management	Improper planning	Lack of communication	Design changes	Poor subcontractor management
Nigeria (Oyewobi <i>et al.</i> , 2016)	Design errors	Design omissions	Construction errors	Construction omissions	Quality deviation
China (Ye <i>et al.</i> , 2014)	Unclear and ambiguous project process management	Poor quality of construction technologies used	Use of poor construction materials	Active rework made by the contractors to improve quality	Design error/omission because of too many design tasks and time boxing
Singapore (Hwang & Yang, 2014)	Design-related change orders	Poor design coordination between design members	Poor site management systems	Poor workmanship/lack of technical skills	Design errors and omission
Canada (Fayek <i>et al.</i> , 2003)	Consistency not ensured before issued for construction	Poor workmanship of the prefabricated material	Lack of inspection	Original design/specification was incorrect	Inadequate discipline coordination
Sweden (Josephson <i>et al.</i> , 2002)	Erroneous workmanship	Unsuitable or faulty design	Lack of coordination	Late deliveries	Mistakes in planning

### C. Potential Rework Minimisation Approaches

Table 7 presents the ranking of potential solutions to reduce rework in construction projects. A close examination of Table 7 reveals that all the recommended solutions except for design scope freezing are perceived as very significant with mean scores of higher than 4.0. Improve communication (mean=4.245), building information modelling (BIM) (mean=4.215) and flexibility in project management (mean=4.185) are seen as the three most effective measures; all relating to effective coordination processes for collective multi-stakeholders engagement.

Table 7. Rework minimisation measures

Potential solutions	Mean	SD	Rank
Improve communication	4.254	0.686	1
Building information modelling (BIM)	4.215	0.610	2

Flexibility in project management	4.185	0.785	3
Total quality management (TQM)	4.185	0.795	4
Implementing error management	4.177	0.687	5
Implementing preventive maintenance	4.131	0.652	6
Value management	4.131	0.719	7
Training	4.008	0.858	8
Design scope freezing	3.746	0.901	9

Stakeholder alignment at early phases of the project such as planning stage alleviates the likelihood of design changes at the latter part of the project (Aldhaheri *et al.*, 2018). In this vein, project effectiveness can be achieved with proper synchronisation through timely and effective communication among project parties from differing background and

expertise. Conversely, lack of communication hampers much-needed coordination among various stakeholders, resulting in mistakes, omissions, conflicts and constructability predicaments which then demand further adjustments (rework). On another note, enhancing communication engenders collaboration needed to promote trust, collective decision-making and effective participation; leading to fewer changes in design and construction, ensuring compliance and quality of deliverables and enhancing project control (*Yap et al.*, 2019). It is worth noting that communication, trust and knowledge sharing are intertwined; affecting shared learning among team members within and across projects. In this connection, the factors critical to project success include competence, strong commitment and effective communication (Yong & Mustaffa, 2013).

In a recent Singapore-based study, Hwang *et al.* (2019) reported that projects that used building information modelling (BIM) tend to experience lower incidence, magnitude and impact of rework as compared to non-BIM projects. Moreover, information can be openly shared using BIM environment to support collaboration and change management (Matthews *et al.*, 2018). However, the adoption of BIM is still lacklustre in the global construction industry attributable to reasons such as lack of relevant knowledge and expertise, technical issues and data ownership issues (Zhao *et al.*, 2017). There are no one-size fits all approach for construction project management, particularly dealing with rework. As such, flexible and adaptable thinking, and situational problem-solving aptitudes are crucial due to dynamic products and processes in construction projects (Teerajetgul & Chareonngam, 2008) to address the factors that may inflate rework incidence. Leveraging on reusable project knowledge and collective organisational learning, Yap and Skitmore (2020) emphasise continuously exploit best practices such as proven construction techniques and management processes to contain rework and enhance project performance.

## V. CONCLUSIONS

Rework remains a pervasive and perennial problem in construction; demanding additional resources to perform non-value adding activities and leading to poor project performance. From a literature review, pertinent issues

concerning rework in construction projects were identified. The opinions of construction practitioners about rework were obtained through a broad questionnaire survey. This study has identified the critical issues arising from rework. Poor quality management, improper planning, lack of communication, design changes and poor subcontractor management were listed as the top five most significant causes of rework. A comparison with some selected countries pointed out analogous rework causation factors, mostly attributed to persistent managerial problems. This study has also determined the most effective rework minimisation measures comprise improving communication, building information modelling (BIM) and flexibility in project management.

From these results, critical reflection about existing practices is needed to reduce rework. In this vein, the failure to learn and improve organisational and project performance is regarded as “functional stupidity” (Love *et al.*, 2018), which results in recurring rework and project failures. Drawing on Pareto’s 80/20 rule, addressing the five major causes of rework identified in this study can contain rework to a considerable extent. Thus, the findings could help construction fraternity to gain better insights about the criticality and root causes of rework in their present and future projects. Recognising the nature, impacts and most probable causes for rework will induce the construction industry to devise strategies to manage and prevent rework towards improved project performance. The proactive control measures prescribed are useful for preventing rework incidence in practice.

While this research makes several contributions to recognise rework as an unnecessary abortive activity that can adversely affect time, cost, quality and productivity performance as well as resulting in higher wastage, some limitations should be noted. The majority of the respondents are from consultant organisations which may skew the results towards the consultant’s perspective. The low response rate and relatively small sample size restrict generalisation but can support the indicative quantitative observation. Additionally, data collection was facilitated using a single approach via a questionnaire survey. Therefore, future research can include a more balanced representation of construction professionals with enlarged sample size. The use

of qualitative approaches such as case studies and in-depth interviews allow participants to provide more detailed explanation through story-telling about rework-related issues in the projects that they involved. The richness of the data enables mapping of the interdependent cause-and-effect relationships beyond single-cause identification. As

suggested by Yap *et al.* (2019), deepened mental models about phenomenon causation using retrospective sensemaking and systemic thinking approaches are likely to increase the ability to learn and influence current practices towards the construction industry transformation agenda.

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