

# Analysis of Rework Causes in Infrastructure Projects in Pulau Pinang

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**Abstract** Construction industry plays an important role in the Malaysia economy. One of the factors that contribute to this industry is infrastructure projects. Rework in infrastructure projects can cause the collapse of the Malaysian economy since it is detrimental to project outcomes. However, less attention was given regarding rework within the Malaysian construction industry especially in infrastructure projects. The purpose of this paper is to investigate the rework causes in the infrastructure project at Pulau Pinang. To acquire opinion of professionals from the construction industry about rework causes in infrastructure projects, questionnaires were distributed via Google form and received 52 responses. Data was analysed through SPSS 25.0 and ranked according to the level of importance. From this research, the results revealed that subcontractor factors and design related factors are the major categories that contribute to rework causes. In addition, the study showed that communication effectiveness within owners and changes made at request of the client are the main rework causes which considerably influenced infrastructure projects performance.

**Keywords** Rework, Infrastructure, Construction Project, Causes of Rework

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## 1. Introduction

The construction industry plays a vital role in economic growth. It is an important industry and it contributes a substantial boost in overall Gross Domestic Product (GDP) of a country [1]. In construction and engineering projects, rework is a chronic problem [2], which means that the rework triggers future rework reduction mitigation approaches for building projects in Malaysia. In particular, rework harms projects triggering time and cost overruns. When the root causes of the rework were not given much attention, it tends to be a global phenomenon [3]. It has an adverse effect on performance of projects which contributes to the schedule overrun and expenditure in construction projects [4-6]. In the long term, the reputation of a construction company and its ability to attract new businesses can also be affected by rework. However, in Malaysia, there was not much research carried out on identifying rework causes especially in infrastructure projects and rework remains an innate problem as a result due to little being known about the background. Therefore, a list of rework causes in infrastructure projects need to be determined to reduce rework from previous studies.

## 2. Materials and Methods

### 2.1. Literature Review

Through literature review, all causes regarding rework in infrastructure project that has been stated from previous studies were listed out. Rework will not occur without any reason, there must be some causes which contribute to rework. Most of the rework occurred due to design changes as per client request, unclear project management process, improper construction technology, and handling machinery and equipment. Nowadays, a systemic rework model has been developed to give a better explanation of the causes of rework so that solutions could be generated. A review of the literature indicates that finding the cause for reworks at construction sites has been the passion of many researchers over the world.

A better knowledge and a clear overview of the reworking structure can be provided through rework models. By the models, the character traits of rework and rework consideration can be determined. In this section, specific rework models were shown. Figure 1 shows the conceptual model of rework that was suggested by Love [7]. Based on this model, project management practices, organizational management practices, and project characteristics are the factors that directly and indirectly cause rework, and they were also divided into more particular elements which were productive and related to project performance.

This study conducted by Ye et al., [8] found some rework factors in other countries or regions as shown in

Table 1. A thorough literature review was first carried out by Ye et al., [8] to determine the preliminary list of rework causes and after conducting a semi structured interviews with 13 experts, an initial list of 47 rework causes were found.

Following consolidation, 39 causes of rework were identified according to its ranking based on mean value from questionnaire survey, as summarized in Table 2. Results gained from the questionnaire survey are that most causes have an average score of 3.0, which in the rating scale is considered significant. An uncertain and ambiguous project management process, poor building technology and the use of poor building materials, each with a mean value of over 3.70, is most significant. The most significant factor is an uncertain and ambiguous project management process. Some activities are inadequately prepared to begin construction due to an urgent timetable or unreasonable decision-making involving client's ego or image issues. This results in much needless rework that could be avoided by the introduction of more sensible methods of project management. The standard of building technology plays a key role in building construction. Because the construction industry is still traditionally labour-intensive and makes little use of high technology, building quality is difficult to control, often resulting in considerable rework. Therefore, improving building technologies will help considerably in minimising rework. The poor quality of building materials is also a significant reason for rework.

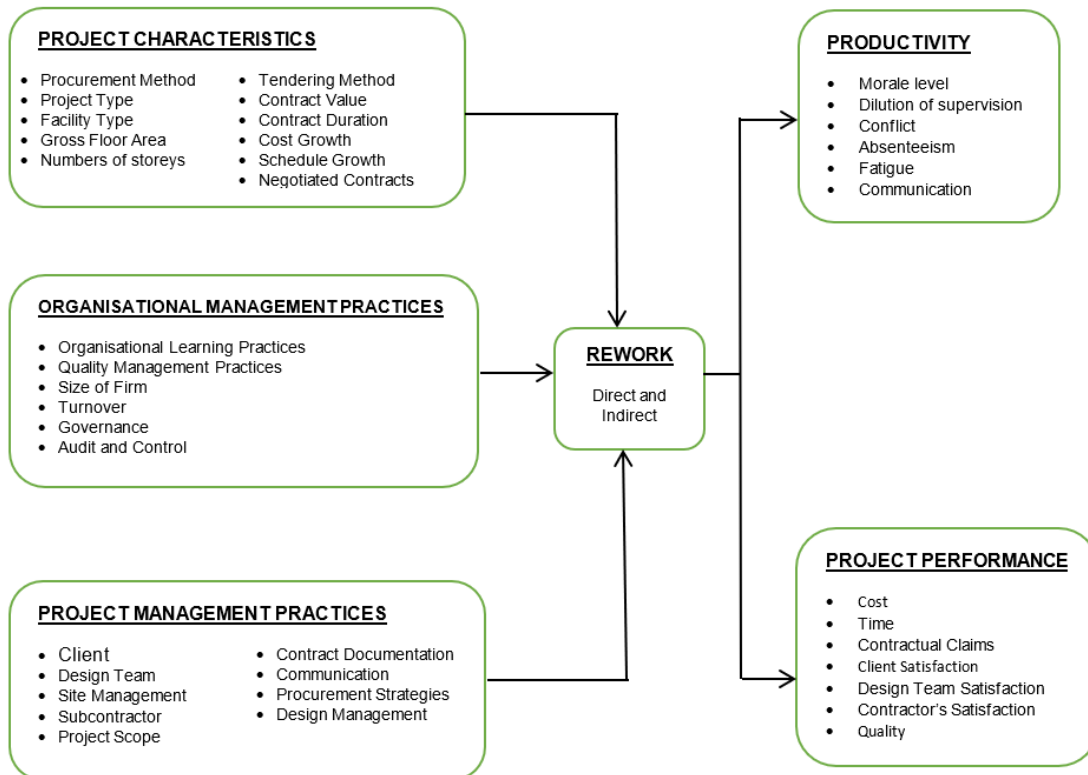


Figure 1. The Conceptual Model of Rework Notes/Sources: Love & Edwards, (2004)

**Table 1.** Rework Factors in Other Countries/Regions

Rework Cause	China	Sweden	Canada	United Kingdom	Netherlands	Hong Kong	Australia
	Current study	Josephson and Hammarlund (1998) Josephson et al. (2002)	Favek et al. (2003)	Hwang et al. (2010)	Mastenbrock (2010)	Palaneeswaran et al. (2008)	Love et. Al (2002)
F1	Field management	X	X	-	X	X	X
F2	External environment	-	-	-	X	-	-
F3	Contract Management	-	-	-	-	-	-
F4	Subcontractor management	-	-	-	-	X	-
F5	Design management	X	-	X	-	X	X
F6	Project Communication	-	X	-	X	-	-
F7	Plan Changes	X	-	-	X	-	-
F8	Active rework	-	-	-	-	-	-
F9	Owner capability	X	-	X	-	X	X
F10	Scope management	-	-	-	-	-	-
F11	Process management	-	X	-	-	-	-

**Table 2.** Mean Score and Ranking of Causes of Rework

Overall Ranking	Causes of rework in construction projects	Mean	Standard deviation
1	Unclear of project process management	3.834	1.275
2	Project scope change after work had been undertaken or completed	3.794	0.999
3	Revisions and modifications of project function initiated by the owner	3.729	1.095
4	Budget compression or escalation	3.69	1.092
5	Schedule acceleration	3.643	1.003
6	Replacement of materials/equipment during construction	3.632	0.964
7	Inappropriate/contradictory project constructions initiated by manager	3.617	1.049
8	Poor communication path of project instructions	3.57	1.08
9	Poor communication/coordination between owner/end-user	3.567	1.139
10	Delay in providing site conditions, such as water and electricity to the contractor	3.495	1.079
11	Payment of low contract fees or delay in paying contract fees	3.495	1.147
12	Ambiguity of items from contract documentation	3.484	1.115
13	Lack of clear definition of contract documentation for working content	3.44	0.997
14	Poor contract execution	3.44	1.087
15	Active rework made by the contractors to improve quality	3.415	1.112
16	Active rework made by the designers to improve quality	3.365	1.06
17	Lack of constructability because of separation between design achievements and construction conditions	3.361	1.158
18	Poor coordination of design team members	3.357	0.996
19	Design error/omission because of too many design tasks and time boxing	3.307	1.03
20	Poor quality of construction technology	3.307	1.092
21	Use of poor construction materials	3.249	1.173
22	Lack of use of advanced mechanical equipment	3.209	1.07
23	Poor quality of construction procedure	3.181	1.068
24	Ineffective use of construction management standard	3.137	1.051
25	Construction errors caused by incomplete understanding of the intent of design	3.13	1.122
26	Poor communication of construction managers	3.123	1.222
27	Poor site conditions, such as water, electricity, and telephone	3.116	1.05
28	Changes made by quite difficult construction methods	3.112	1.138
29	Poor coordination of subcontractor between upstream and downstream	3.076	1.188
30	Poor communication of construction team members	3.022	1.116
31	Failure to provide protection to the completed works	3.011	1.105
32	Poor supervision of admission materials/equipment	3.004	1.124
33	New request made by the end-users to improve standards during construction	2.993	1.06
34	New request made by the end-users during the final inspection and certification stage	2.939	1.186
35	Adverse natural conditions, such as hot weather, rain, cold, earthquakes and floods	2.935	1.088
36	Changes in government regulations, laws, and policy	2.928	1.094
37	Shortage of construction materials/equipment in market	2.91	1.134
38	Lack of strictly fulfilled for project process management	2.892	1.187
39	Effect of social and cultural factors rework	2.57	1.26

## 2.2. Methodology

Factor analysis is a statistical technique to explain the difference between measured variables as a possible lower number of variables or factors that have not been measured. In this paper, the underlying classes of the 39 causes are discussed by factor analysis. 11 factors are produced by the principal component analysis (PCA). The final rotated part matrix is shown in Table 3. By combining the definitions of these variables with maximal cross-factor loads, each factor can be interpreted and named. This study discusses the situation of construction professionals and identifies 11 primary rework variables, comprising design management, communications management, field management, project scope

management, project management, project process management, successful reworks, project plan adjustment, sub-contractor management, owner capacity [8].

From the studies, it is found that rework causes can be divided to client related factors [9-14], design-related factor [10-11, 14, 16-17], subcontractor [9-11, 18-19] and site management [6, 10-11, 14, 16, 19]. All listed causes were then used in the questionnaire survey in order to know the causes of rework in infrastructure project in Pulau Pinang. In order to assess mean value and standard deviation, SPSS 25.0 are used in ranking analysis. The data was classified specifically using mean value, standard deviation, overall mean and overall standard deviation for all the attributes for causes related to rework in infrastructure projects.

**Table 3.** Factor Profile in infrastructure project in Pulau Pinang

Details of the factors and causes reworks	
	<b>Management of contractor</b>
<b>Factor 1:</b>	Poor quality of construction technology and procedure
	Lack of use of advanced mechanical equipment
	Ineffective use of construction management standard
	Construction errors
	Use of poor construction materials
	<b>External environment</b>
	Poor site conditions
<b>Factor 2:</b>	Change made by quite difficult construction methods
	New request from end-users to improve standards during construction or during final inspection and certification stage
	Adverse natural conditions, e.g., extreme weather, earthquake, and floods
	Changes in government regulations, laws, and policy
	Shortage of construction materials/equipment in market
	<b>Management of contract</b>
<b>Factor 3:</b>	Low contract fees or delay in payment
	Ambiguity of items from the contract documentation
	Lack of clear definition of contract documentation for working content
	<b>Management of subcontractor</b>
<b>Factor 4:</b>	Poor communication of construction managers, team members and subcontractor
	Failure to protect the completed works
	<b>Management of design</b>
<b>Factor 5:</b>	Lack of design management because of separation between design and construction conditions
	Poor coordination of design team members
	<b>Management of communication</b>
<b>Factor 6:</b>	Inappropriate/contradictory project instructions initiated by managers
	Poor communication path of project instructions
	<b>Changes of project plan</b>
<b>Factor 7:</b>	Compression to increasing the budget
	Accelerating time to shortening the schedule
	Replacement of materials/equipment during construction
	<b>Changes in quality improvement</b>
<b>Factor 8:</b>	Changes made by the designers or contractor to improve quality
	<b>Management of client</b>
<b>Factor 9:</b>	Poor communication/coordination between owner and end-users
	Delay in providing the site conditions, such as water and electricity, to the contractor
	<b>Management of project scope</b>
<b>Factor 10:</b>	Project scope was changed after work had been undertaken/completed
	Revisions and modifications of the project function initiated by the owner/end-user
	<b>Management of project process</b>
<b>Factor 11:</b>	Unclear of project process management
	Lack of strictly fulfilled for project process management

2.2.1. Questionnaire survey

Question survey was adopted in this research as the quantitative method to identify the main causes of rework in infrastructure projects. This questionnaire survey was found to be effective because of the relative ease of obtaining standard data appropriate to achieve the objectives. To identify rework causes, surveys were conducted within 6 categories of companies related to construction industries especially in infrastructure projects. They were from Architecture firms, Consulting Engineers, Project Management firms, Contractor and sub-contractors, also from others firms including developers and surveyors. All those companies were selected based on their previous project performance especially in infrastructure surrounding Pulau Pinang. The questionnaires were sent via Google form through an e-mail and at the end of the questionnaire survey period, data had been collected from 52 respondents.

The finalized questionnaire contains 2 parts. The first part was intended to gather the company category, respondents job position in that company and work experience. Last part involves the rating of 4 categories of rework causes which are client related factor, design related factors, site management and subcontractor. Each category consists of a list of rework causes giving a total of 32 causes overall. A five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = uncertain, 4 = agree, 5 = strongly agree) was adopted in order to analyse the importance of each cause [8, 20-21]

3. Result and Discussion

3.1. Descriptive Statistics

The respondents completing the questionnaire were from different companies: Architect (4%), Consulting Engineer (26%), Project Manager (46%), Contractor (15%), and Other, including developer and surveyor (9%). However, Quantity Surveyors were not involved in answering this questionnaire. The percentage of company categories involved with this questionnaire were presented in Figure 2(a) and the job position of respondents in each company are shown in Figure 2(b). The majority of respondents were construction officers (including civil engineers, safety directors etc.) with 46.15%, followed by construction managers (including project manager, superintended officers, resident engineers etc.) with 25%. However, Figure 3 shows the working experience of all the respondents in the company. 71.15% of the respondents have experience of more than 10 years in the construction industry.

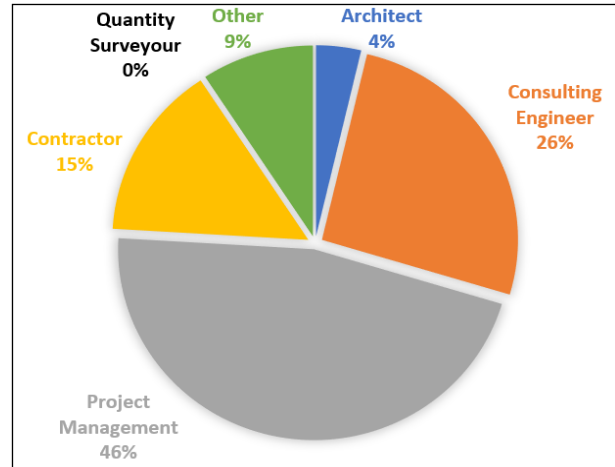


Figure 2(a). Company category of respondents in infrastructure projects

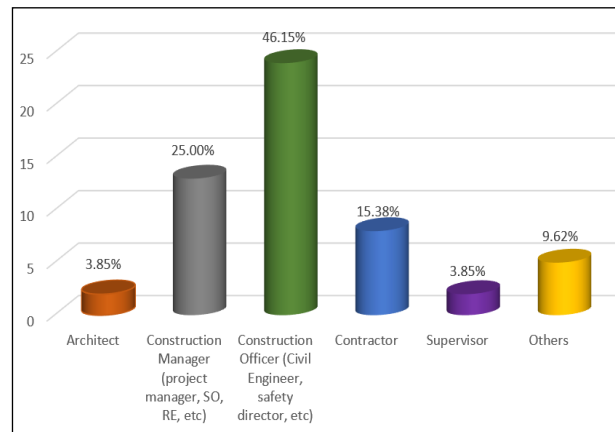


Figure 2(b). Job position of respondents in infrastructure projects

The respondents were mostly construction officers and construction managers with work experience of more than 10 years, competent with infrastructure projects and have qualified knowledge related to engineering. Therefore, it can help produce more reliable results towards the finding of the research study since the majority of respondents are very well versed about rework in infrastructure projects.

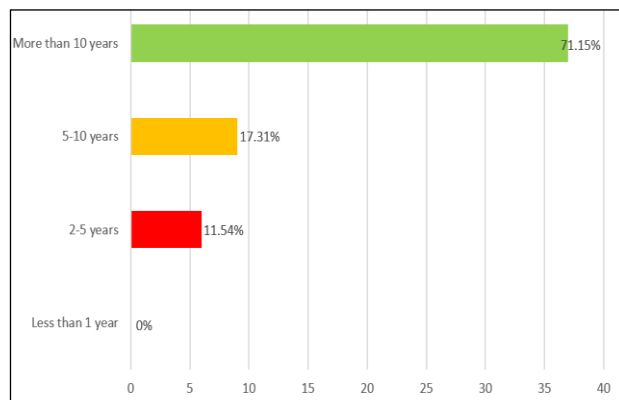


Figure 3. Work Experience of Respondents in Infrastructure Projects

### 3.2. Causes of Rework in Infrastructure Projects

Literature analysis has been used to determine the key causes of reworking in infrastructure programs. From the literature review, it is found that four classes can be grouped into the triggers of rework in the infrastructure project, which were: client-related factor, design-related factor, site management and subcontractor. In the infrastructure project, ranking analysis by mean, standard deviation and Relative Importance Index (RII) are used to classify the key causes attributes of rework causes. In ranking analysis, scales from rank 1 to 5 are used to denote the attributes of rework in infrastructure projects that are most important to the least critical key causes.

#### 3.2.1. Client-related factors

The results ranking of the client related rework triggers group in the infrastructure project are shown in Table 4. Most respondents believe that communication efficiency among owners is the most important cause of client related factor rework attributes in the infrastructure project and has the highest RII value of 77.31%. Lack of communication between client and design team may contribute to documentation errors. Simpeh [10] stressed that client together with members of the project team shall collaborate in order for the project to be carried on or ahead of production time. In management practice, good communication and congruent cooperation are a shared point of view for successful project execution and key to alleviating documentation errors and omissions. [20].

Next, change in plans or scope is the second cause of rework for client related in infrastructure projects with RII value of 74.62%. This is due to the owners or client may not have a clear opinion on the project structure and appearance of the project before authorizing it. Inadequate organisation among client, owners and end-user is the third ranking for rework causes due to client related factors with RII value of 73.85%.

#### 3.2.2. Design-related factors

As for the design-related rework causes, factors in the infrastructure project are shown in Table 5. Most respondents accept that changes made by the client's request are the key causes leading to the rework of 77.31% of the highest RII value for design-related factors in the infrastructure project. Ekambaram [12] stated that design and construction related factors are client-based rework symptoms such as client request for design changes and construction related changes insisted by clients.

The second ranking of rework causes contribute to design related would be design consistency with RII value of 73.85% because there was no consistency in the design with the original demand of the project.

Insufficient time for design stage would be the third rank of rework causes for design related in infrastructure project with RII value of 73.08%. This includes incomplete design at the time of the tender as well as insufficient time to prepare contract documentation.

**Table 4.** RII and Rank of Rework Causes for Client-related Factors in Infrastructure Projects

Causes of Rework in Infrastructure Project at Construction Site	Level of significant quoted by 52 respondents					Weightage	Mean	Std. Deviation	RII %	Rank	Overall Std. Deviation	Overall RII %	Overall Rank
	1	2	3	4	5								
<b>Client-related factors</b>													
Change in plans or scope	0	8	5	32	7	194	3.7308	0.8882	74.62	2			10
Inadequate project objectives	0	23	10	19	0	152	2.9231	0.9042	58.46	11			39
Change in specification	0	12	8	30	2	178	3.4231	0.8932	68.46	7			29
Impediment in prompting decision making	1	3	12	32	4	191	3.6731	0.7852	73.46	4			13
Replacement of materials	1	3	29	18	1	171	3.2885	0.6955	65.77	9			33
Client's financial problems	1	5	23	18	5	177	3.4038	0.8691	68.08	8			30
Communication effectiveness within owners	0	2	7	39	4	201	3.8654	0.5950	77.31	1	0.4411	69.48	1
Poor coordination between client and end-user	1	5	6	37	3	192	3.6923	0.8053	73.85	3			11
Lack of experience and knowledge of the design process	0	9	26	14	3	167	3.2115	0.8004	64.23	10			34
Lack of experience and knowledge of the construction process	1	10	12	22	7	180	3.4615	1.0187	69.23	6			28
Lack of funding allocated for site supervision	1	10	7	28	6	184	3.5385	0.9992	70.77	5			22

**Table 5.** RII and Rank of Rework Causes for Design-related Factors in Infrastructure Projects

Causes of Rework in Infrastructure Project at Construction Site	Level of significant quoted by 52 respondents					Weightage	Mean	Std. Deviation	RII %	Rank	Overall Std. Deviation	Overall RII %	Overall Rank
	1	2	3	4	5								
<b>Design-related factors</b>													
Design consistencies	0	6	6	38	2	192	3.6923	0.7286	73.85	2			11
Changes made at the request of the client	0	3	9	32	8	201	3.8654	0.7417	77.31	1			2
Changes made by the contractor during construction	0	13	5	29	5	182	3.4808	0.9800	70.00	8			25
Errors made in the contract documentation	0	10	26	14	2	164	3.1538	0.7767	63.08	14			37
Omissions of items from the contract documentation	0	5	26	20	1	173	3.3654	0.6868	66.54	12			32
Ineffective use of quality management practices	0	9	14	25	4	180	3.4423	0.8725	69.23	11			28
Difficulty in system design	0	7	30	14	1	165	3.1923	0.6871	63.46	13	0.4540	70.14	36
Poor design coordination/ communication/ integration	0	7	10	31	4	188	3.5962	0.8227	72.31	4			16
Poor contract administration and documentation	0	10	7	32	3	184	3.5385	0.8736	70.77	7			21
Lack of effective communication between client and design team	0	6	11	33	2	187	3.5962	0.7478	71.92	5			18
Poor planning of workload	0	9	7	33	3	186	3.5769	0.8482	71.54	6			19
Insufficient time for design stage	0	8	8	30	6	190	3.6538	0.8831	73.08	3			15
Permanent equipment quality issue	0	8	12	31	1	181	3.4808	0.7794	69.62	9			26
Wrongly identified initial budget	0	12	9	26	5	180	3.4615	0.9592	69.23	10			27

**Table 6.** RII and Rank of Rework Causes for Site Management Factors in Infrastructure Projects

Causes of Rework in Infrastructure Project at Construction Site	Level of significant quoted by 52 respondents					Weightage	Mean	Std. Deviation	RII %	Rank	Overall Std. Deviation	Overall RII %	Overall Rank
	1	2	3	4	5								
	<b>Site Management</b>												
Ineffective use of quality management practices	0	9	6	37	0	184	3.5385	0.7787	70.77	4			20
Lack of training and experience	0	7	14	27	4	184	3.5385	0.8275	70.77	6			24
Setting-out errors	0	10	25	14	3	166	3.1923	0.8174	63.85	8			35
Constructability problems	0	6	4	39	3	195	3.7500	0.7376	75.00	1			8
Poor planning of resources	2	4	14	24	8	188	3.5962	0.9754	72.31	3			17
Poor coordination of resources (e.g. Subcontractor)	1	3	13	29	6	192	3.7115	0.8245	73.85	2	0.5871	69.70	12
Failure to provide protection to constructed works	1	6	23	15	7	177	3.3846	0.9321	68.08	7			31
Lack of safety	1	6	13	28	4	184	3.5385	0.8736	70.77	5			23
Excessive overtime	0	10	30	9	3	161	3.0962	0.7736	61.92	9			38

### 3.2.3. Site management factors

Love et al. [7] stated that in order to plan the work that need to be done, site management team must work with subcontractors. Table 3 indicates the result ranking for site management factors of rework cause in infrastructure project. From the table, constructability problem is the main cause of rework for site management factors with RII value of 75%. Poor coordination of resources in example subcontractors come in second ranking with RII value of 73.85% and the third ranking is poor planning of resources with RII value of 72.31%. As for the fourth, fifth and sixth ranking, we can see that the RII value were the same which is 70.77%. According to Vilasini, Gamage, Kahangamage, & N [22] if equal relative importance indices of the individual factors obtain it will be ranked according to the percentage of respondents scoring 4 or more. Due to that, even though all causes have same RII value the percentage of respondents scoring 4 or more is what makes the ranking different. Constructability problems are the fourth ranking for rework causes in site management factor. Setting out errors is the first rank with the highest mean value followed by lack of skills and expertise and weak management of resources as most important rework causes for site supervision factor in South Africa [10]

### 3.2.4. Subcontractor factors

Subcontractor related factors were scrutinized and Table 7 reveals the findings. After ranking the RII value of the responses, shortage of skilled supervisors was rated as most predominant rework causes for subcontractor factor in infrastructure projects with RII value 76.54% subsequently unclear instruction to workers on second ranking, inadequate supervisors, foreman or tradesmen ratios on third-ranking and defective workmanship on the fourth-ranking. All three factors had the same RII value which is 75.77% but with different percentages of respondents scoring 4 or more.

Comparing the data result with a study conducted by Simpeh [10], non-compliance with the specification is the predominant rework causes for subcontractor factor followed by poor workers level of expertise, lack of trained workers and shortage of skilled supervisors and defective workmanship. Simpeh [10] also points out that factors attributable to the construction-related source of rework cost are damages caused by a subcontractor.

However, a study conducted by Trach et al. [13] stated that excessive workload and market conditions are external factors that contribute to the level of rework in the construction project. Restrictions on access for eligible skilled and knowledgeable subcontractors and employees cause increased defects and poor workmanship.



**Table 7.** RII and Rank of Rework Causes for Subcontractor Factors in Infrastructure Projects

Causes of Rework in Infrastructure Project at Construction Site	Level of significant quoted by 52 respondents					Weightage	Mean	Std. Deviation	RII %	Rank	Overall Std. Deviation	Overall RII %	Overall Rank
	1	2	3	4	5								
<b>Subcontractor</b>													
Unclear instruction to workers	0	3	9	36	4	197	3.7885	0.6668	75.77	2			4
Non-compliance with specification	0	6	7	33	6	195	3.7115	0.8480	75.00	6			9
Shortage of skilled supervisors	1	3	7	34	7	199	3.8269	0.8098	76.54	1			3
Shortage of skilled labour	1	4	12	28	7	192	3.6538	0.9050	73.85	7			12
Low labour skill level	0	4	13	26	9	196	3.7308	0.8658	75.38	5	0.6465	75.14	7
Inadequate Supervisor/Foreman/Tradesmen ratios	0	3	12	30	7	197	3.7500	0.7890	75.77	3			5
Defective workmanship	0	2	15	27	8	197	3.7885	0.7498	75.77	4			6
Damage to other trades work due to carelessness	0	7	7	35	3	190	3.6154	0.8202	73.08	8			14

3.2.5. Rework causes category in infrastructure projects

Determination of rework causes analysis was performed using SPSS 25.0 through mean, standard deviation and Relative Importance Index (RII). Based on the analysis in Table 8, it is shown that the ranking of each rework causes category and it is found that subcontractor factor was ranked first with highest RII 75.14%. That reflects that the involvement of subcontractors is important in reducing rework in infrastructure projects. This result is in line with study conducted by Love and Edwards [7], Simpeh [10], Enshassi et al. [14] and Palaneeswaran [15]. Design-related factors was ranked second with RII (10.14%) followed by site management with RII (69.70%) and lastly client-related factors with RII (69.48%).

**Table 8.** RII and ranks of rework causes category in infrastructure project at construction site.

Rework causes category	RII%	SD	Rank
Subcontractor	75.14	0.65	1st
Design-related factors	70.14	0.45	2nd
Site Management	69.70	0.59	3rd
Client-related factors	69.48	0.44	4th

3.2.6. Top ten rework causes in infrastructure projects

Table 9 shows ten most important causes that contribute to rework in infrastructure project. The first rank goes to communication effectiveness between owner with RII 77.31% and total respondents scoring more or equal than four (≥ 4) and five (5) are 43. That was how the ranking using RII was obtained. Communication effectiveness causes is commensurate with the study conducted by Ye et al. [8], Muwafaq et al. [9], Palaneeswaran [15], Wilson et al. [22] and Ghannadpour

et al. [23]. They stated that poor communication is an important cause of rework for client related factors. This cause may occur due to the owners who are rarely involved in any project meetings, which does not put an effort into knowing any project matters or due to rules and regulations in decision making and project management. It leads to late design changes, modifications to requirements, product adjustments and adjustments in project management plan, all of which led to rework. Communication barriers between clients and other developers could also result in conflicts and misunderstandings between stakeholders on the requirements for contract documentation. Thus, it affects the process negatively. The findings therefore show the importance of growing cooperation among the contracting parties to ensure a team working environment and a working atmosphere in which everyone involved in the projects meet their targets.

However, the second rank goes to changes made at the request of the client also with RII 77.31% but with total respondents scoring more or equal than four (≥ 4) and five (5) are 40.

According to Vilasini et al. [24] of equal relative importance are the indices of the individual factors obtained and it will be ranked according to the percentage of respondents scoring 4 or more [24]. Changes made at the request of the client is compatible with the study conducted by Wilson et al. [22], Hwang and Yang [20] and Muwafaq et al. [9], which states that design changes made by client is on the top five of rework causes in design related factors. There were 6 causes from subcontractor category in the list of 10 most important rework causes which also indicate why subcontractor category is the first rank of rework causes.

**Table 9.** RII and rank of 10 most important rework causes in infrastructure project at construction site

Causes of Rework in Infrastructure Project at Construction Site	Rework category	Level of significant quoted by 52 respondents					Weightage	RII %	Rank
		1	2	3	4	5			
Communication effectiveness within owners	client-related	0	2	7	39	4	201	77.31	1
Changes made at the request of the client	design-related	0	3	9	32	8	201	77.31	2
Shortage of skilled supervisors	sub-contractor	1	3	7	34	7	199	76.54	3
Unclear instruction to workers	sub-contractor	0	3	9	36	4	197	75.77	4
Inadequate Supervisor/Foreman/ Tradesmen ratios	sub-contractor	0	3	12	30	7	197	75.77	5
Defective workmanship	sub-contractor	0	2	15	27	8	197	75.77	6
Low labour skill level	sub-contractor	0	4	13	26	9	196	75.38	7
Constructability problems	Site management	0	6	4	39	3	195	75.00	8
Non-compliance with specification	sub-contractor	0	6	7	33	6	195	75.00	9
Change in plans or scope	client-related	0	8	5	32	7	194	74.62	10

## 4. Conclusion

The findings of the study are that four (4) essential causes attribute to rework in infrastructure projects are subcontractor as the predominant causes, followed by design-related, site management and client-related. Most of the respondents expressed that the main attributes to rework causes are mostly attributed to subcontractor factors because a majority of subcontractor's sub-causes are in the top 10 overall rework causes. In each category, there were sub-causes to rework in infrastructure project which are lack of trained supervisors, vague instructions and orders for employees, inadequate supervisor / foreman / tradesmen ratios, defective workmanship, low labour skill level and non-compliance with specification. These are some sub-causes of rework which contribute to the predominant rework causes category which is subcontractor category.

However, the top 10 overall rework causes are communication effectiveness within owners, changes made at client's request, lack of trained supervisors, vague instructions and orders for employees, inadequate Supervisor/ Foreman/ Tradesmen ratios, defective workmanship, low labour skill level, constructability problems, non-compliance with specification and change in plans or scope.

An in-depth study should be carried out to study more on rework causes, potential solutions and as well as the impact of rework on infrastructure projects in Malaysia since studies regarding rework in Malaysia are still very limited.

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