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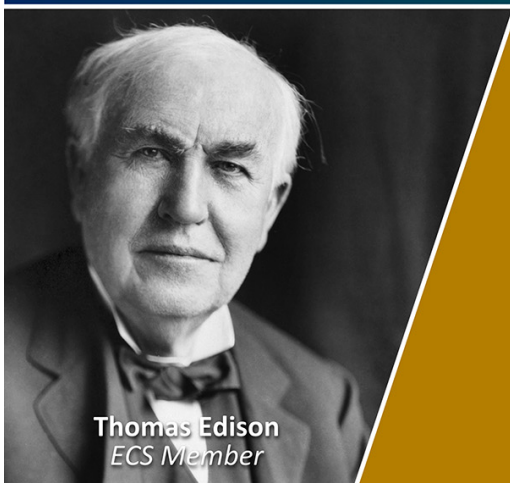
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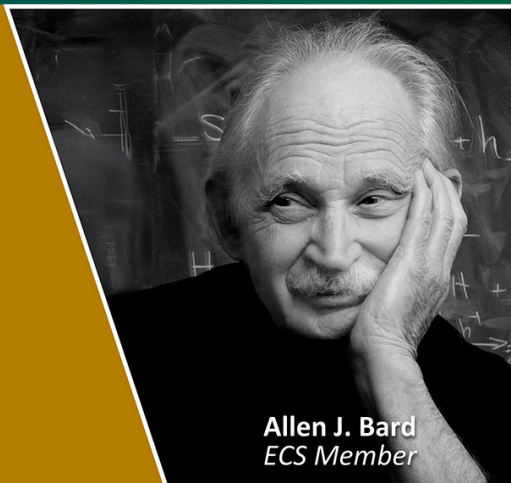
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Classification of rework root causes in the design stage of projects for contract assessment

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Abstract. Rework is one of the leading causes of cost and time overruns that primarily affect project performance. The performance of construction projects can be elevated with the implementation of rework moderation strategies. Identifying rework root causes is the first step of rework management followed by a mitigation approach, reducing or preventing strategy. As the contract is the core connection between clients and contractors, using a rework management approach in the contracting process allows participants to be aware of rework impacts before the project's commencement. Selecting the best approach for rework mitigation depends on rework causes and their classified roots. Thus, the paper classifies rework root causes in the design stage of projects to provide a platform for contract documents assessment. The method used to classify the identified rework causes into five categories was designed on the literature. Results from collecting secondary data indicated all categories in the design stage, consisting of technical, human resources, process, material/equipment, and other general factors. The next step of the study is to assess contract documents through a questionnaire based on these classified factors in search of a connection between rework, contractual claims, and clauses of the contract. The paper recommends that assessing contract documents can be used as a new approach for rework management.

Keywords

Classification system, construction performance, contract documents, design, rework causes.

1. Introduction

The construction industry has been criticized widely for poor performance and inefficient output as it has faced significant problems of unappropriated financial performance. The other main construction problems are the high cost of project delivery and the inability to complete projects on time. One of the major factors contributing to these problems is reworking. Rework has been identified as a significant factor contributing to poor project performance by construction professionals [1]. An appropriate strategy for reducing the impacts of rework cannot be effectively implemented with little familiarity with the rework background. Rework can remain a fundamental problem when there is not enough knowledge about the causes of rework [2]. Thus, a full understanding of the contributing factors in rework occurrence will be an essential part of rework management studies.



However, rework occurs for different reasons and affects construction projects; few industry standards exist for defining, quantifying, and classifying rework root causes. Selecting and specifying a general preventing measure by comparing the results of previous rework studies is not an easy decision [3]. There is no uniformity of collecting data in previous studies [4] and their interpretations are almost different [5], so collecting data on rework is usually difficult. To understand more about the causes of rework, various type of rework needs to be classified first. Previous studies have designed and applied several classification systems at different levels based on their research needs as follows.

- Three levels of activities, causes, and rework sources [6]
- Five categories followed by cause & effect diagram [7]
- Three groups of client, design, and contractor [1]
- Four groups of contractors, client, consultant and environmental [8]

There are some differences between design rework and construction rework [9]. Design rework occurs with client changes in scope and specifications, design, and procurement errors, while construction rework results from a lack of implemented techniques and poor construction management policies. More investigation in the literature showed that the causes of rework in each stage of the project are not limited only to these items, and the list of rework causes was completed gradually by searching different types of projects. In line with this progress, this study aims to identify and classify the underlying causes of construction rework in the design stage of the project, and then it explores the relations between contract clauses and rework through an investigation on contract documents. These objectives can be achieved by preparing a comprehensive list of all identified rework root causes and developing a model for classifying them in the design stage of the project. The results of this study are systematically accomplished through literature as described in the methodology section of this paper.

2. Literature Review

2.1. Design Process

The employed design process approach affects construction projects [10] as common delays are mostly linked with drawings and other design deliverables [11]. The design process is a major source of issue for the following stages; as an instance, design changes make construction more complicated, and tender deficiency in the procurement stage rises with design incompetency [12]. Unlike the manufacturing process, design in construction projects is not duplicating, so the applied model in a design project cannot be developed for the other one. In addition, the design process of a project involves various disciplines, activities, and resources in which all design variables are dependent. These dependencies vary for each construction project and are prone to make design errors that reach rework at the end [11]. Rework as an important waste in construction projects is mainly addressed to unclarified and disordered design tasks when the project starts [12]. Process models that enable projects to determine the location of rework causes in design activities will assist in preventing rework occurrence. Dependency relationships of the design activate model is an example that has been examined to minimize the negative effects of the design process [11].

2.2. *Rework in Design Stage of Projects*

The construction of a facility is highly dependent on design; therefore, any error or omission in the design documents can affect the construction process [13]. A suggestion was given for extending the same methodology to the design stage of projects when all objectives of the rework pilot study for field construction have been achieved [7]. This suggestion consented that rework in the design stage of projects can be measured and reduced by modifying and expanding a similar approach. Design-related causes of rework were investigated later with other studies to uncover the causes of rework [14, 15]. Causes such as change requests by the design team and contractor, change orders in design by a client after undertaking work on-site, and design error and omissions originate significant rework in the construction stage [9, 14, 16]. Imposed pressure by clients on design firms to provide design details and an unclear communicated requirement to designers are the main reasons for design error. Also, tight design schedules make incomplete information, leading to design omission [17]. Effective communication between the project team and client can mitigate part of these changes and design errors.

2.3. *Design changes*

Changes are part of the exploratory nature of design as the content and structure of design activities are dynamic [18]. Change in design may continue even after the starting construction stage. Design changes often make unexpected side effects such as delay, defects, and cost overruns, and sometimes it may become a source of project failure. Design changes are often discovered when the practitioners are adjusting or looking for an alternative way of correction, though design change impacts are mostly overlooked. With such an attitude, the consequences of changes cannot be evaluated [18]; however, identifying and analyzing design change consequences on time is essential for a construction project to succeed.

The design change is the most influential factor between the number of causes that make changes in construction projects. All identified causes of design change have been classified into two groups of internal and external. Client, designer, consultant, and contractor are among the internal sources of causes and natural environment, economic, politics, third party and advanced technology are among external sources. Empowering clients in the design process is an effective way of rework reduction [19] as a client has the most influence on the design change occurrences [20]. Less involvement of the client at the design stage is probably caused by the addition or removal of the work from the main contract, which is called scope changes. When scope change happens after completing the work, it may lead to major rework with extra cost whereas, it may consist of lower-cost impacts when it is announced before the commencement of construction [21]. According to Vachara, change issues in the design stage are:

- Scope change by owner,
- Design function change due to client's requirement
- Change due to design errors by designer,
- Change in specifications by designer,
- Change due to poor and incomplete design by designer,
- Design change due to inconsistent site conditions,
- Change in design initiated by a supplier,

2.4. *Design errors*

Errors due to human limitations may occur independently of the skill, education, and experiences, even sometimes the most detrimental error happens by highly trained and the most capable person [22]. The direct cost of design error is about 6.85, and indirect is about 7.36 percent of contract value [23]. Rework occurrence is inevitable when there is an error in design, so errors often involve rework that requires extra time and resources and finally affects project performance. Errors in the design are prioritized amongst top sources of construction rework [9]. Findings show that design error causes up to 79 percent of rework cost [24]; however, the extent of rework is highly dependent on when it happens within the project life cycle. Some factors such as inefficient quality assurance, design team poor integration, inadequate training, and ineffective coordination strongly make errors in design [25]. Findings of research done in construction to address causes of design errors show that the cost of design errors has not been recorded as much as change orders and claims so, little is known about design error costs as firms rarely measure their actual costs [23].

Errors in design can delay the project schedule and put pressure. This pressure will transmit the negative impacts of such errors to construction activities, even those indirectly linked. Underestimating these negative impacts will enable practitioners to count errors number precisely. A study on the process of design documentation to understand how the design error occurs in construction projects showed that short term strategies such as recruiting external resources and paying low salaries to designers are not effective practice and take an appropriate method of design review, audit and verification are required in the long run [22, 26].

2.5. *Design and Construction Interface*

Three main problems associated with design management are design quality, design standard, and constructability [27]. Design and construction are dependent on each other, and their dependencies also differ from project to project. Attentions to the design process management have been raised as a design-related factor such as lack of coordination among specialists, mistakes in drawings or specifications, and less knowledge of construction have increased the number of difficulties in construction [24]. The model of the feedback mechanism between design and construction showed that hidden rework in the design stage would reduce the quality of construction work as they are revealed during the execution of the project [30].

Constructability is the only interface of design and construction. Constructability is detected during construction without design details or even after the task has been accomplished. Lack of constructability would result in higher costs and a longer delivery period [27]. It has been claimed that this challenge in the construction industry is getting more complicated due to the increase of participants and their relations [48]. When the project is segmented, each participant tries to maximize its interests, so project managers receive different information from different sources [29]. These complex interconnections have been the core of the research studies. Thus, some solutions have been proposed to maximize the constructability of projects.

2.6. *Design Management Strategies on Rework*

Rework is time-consuming and costly, and any balance between the delayed time and total amount of rework cost depends on project priorities and the competitive market [24]. Rework causes are mostly associated with design development. Choosing an appropriate strategy to

manage rework in the project's design stage practically depends on the complexity of construction, project size, and the number of involved entities. The priority for selecting a strategy can be altered based on where the most design problems are raised. Poor design management is due mainly to lack of coordination, design complexity, inefficient information flow, and obtaining compliance permissions. Research findings indicate that design-related rework can be minimized by implementing the following strategies.

When design error and changes originated from a lack of coordination creates a higher rate of rework, moving towards a workable mechanism to bring all participants together is the best choice [27]. Otherwise, involving the contractor at the early design stage to reduce error and mistakes would be encouraging. This can be achieved through a quality assurance system that enhances the project's buildability and elevates the compliance rate. When errors and changes are originated from complex design or poor information flow, applying information modeling techniques such as BIM to reduce waste is recommended [12, 28].

2.7. *Collaboration of design and construction*

Generally, construction is started the following design, and each part is executed separately by different team members. This Method lengthens the overall time of project completion [24]. On-time completion of projects in the construction industry is an important criterion in assessing contractors' qualifications. To achieve this aim, design disciplines and construction activities are integrated. Working with contractors, owners, designers, and other parties for many years together is evidence of this integration to gain the project goals [29]. Integrating design and construction is assumed to be a solution and achieving this integration would be possible by adopting several methods [24]. However, the strength of this integration has not been evaluated yet [30]. To get reasonable performance in collaborating with design and construction, strong communication between contractors and designers plays a critical role, and trusted relationships among participants pushed it to the ultimate rate. Nonetheless, entities are unwilling to do that because of their financial benefits and leadership [29].

Rework in construction projects can be eliminated if the design process is improved and all involved entities are well coordinated [31]. This refers to the design and construction links as any disconnection will be the root of consequent problems in the construction industry [32]. Projects operate more effectively due to the accuracy of transferring information at the time of collaborating between design and construction. A collaboration between these two stages of the project will be more effective when the knowledge and values of the project are defined precisely by the client or end-users [33]. One way to achieve such collaboration is by inviting construction expertise in the early design stage to improve constructability concepts [24]. To involve construction in the design stage, BIM as a technological tool can be employed. Building information modeling works by sharing information across the participants to make better decisions, remove rework and reduce unnecessary wastes in the process, whereas design and construction firms do not need to make a significant change in their organizations. However, evidence shows that BIM is not a perfect option to integrate design and construction; it can be used partially to achieve collaboration [29].

2.8. *Overlapping design and construction activities*

Due to the high demand for shorter completion of projects, various methods of schedule compression have emerged, such as overlapping phases of projects and acceleration of schedule. Overlapping is a well-known technique to complete construction projects faster.

Other terminologies such as concurrent engineering, parallel engineering, and phased construction have been used in the literature as the replacement word for overlapping [34]. The project management body of knowledge (PMBOK) has called this technique fast-tracking. In the overlapping technique, some activities that normally are performed by a sequence can be performed in parallel. This technique is used for large-scale projects in which construction starts before completing the design stage. However, this technique shortens the completion of projects, and it has some disadvantages. It probably makes rework in construction activities, specifically when the final design differs from the early design. In addition, feedback from construction cannot be addressed to design activities [24] so, implementing this technique needs to be considered with care.

Pena Mora's study on overlapping in construction projects in 2001 was among the most contributing research on this topic. The evolution of upstream tasks and the sensitivity of downstream tasks were selected as the study's main concepts to generate a framework for construction activities. The framework was applicable for any type of overlapping to minimize rework risk [34]. The other approach of minimizing re-design in downstream activities was applied on overlapping later, and then the provided framework was completed through characterizing downstream tasks [35] to address part of activities. Scheduling model of overlapped design activates based on information dependency made progress in the field; however, none of the studies was able to propose an optimum way of overlapping as all just have considered one dependency between upstream design tasks and downstream construction activities [24].

Since overlapping performs with the expense of rework, it increases the cost of the project. An optimum overlapping strategy needs to be found to make a balance between the time saving on one side and rework cost on the other side [36]. In search of an optimal overlapping strategy, the dependencies between rework probability and overlapped activities were assessed with two assumptions, predefining costs to minimize time and vice versa. Then cost and time impacts of overlapping on the project performance were quantified. Results showed that the reduction of both impacts of time and rework's cost is closely correlated to the accuracy of early information. In other words, rework will be reduced with provided accurate information at the early design stage. The other dependency was construction sensitivity to change. The higher sensitivity of construction activities will increase the rework amount. Moreover, unplanned overlapping may result in unexpected design and construction rework as well [24].

2.9. *Design and Technology*

Lack of modern technology implementation may result in project inefficiencies such as imperfect communication and poor transmitting of information [37]. Adapting technology in the construction industry lagged far behind others [9]. Technology, people, and process are the three main components of a successful collaboration in any context [29]. People and process effects on project collaboration will be less in the absence of the third component. The construction industry tends to keep working with traditional approaches, but improvement can be seen by the emergence and use of information technology in all stages of projects [38]. Up to 80 percent of construction problems at the site can be attributed to delayed and missed information [39], so employing technology to facilitate timely information delivery is an essential part of decision making [40].

Research results have shown that inefficient use of information technology in the design

stage of projects contributes to rework [25]. Design documentation processes, design checks, and reviews are managed more accessible when information technology is used. Implementing BIM in the collaboration of design and construction context to find the effects of technology is an example that has been set as a core in recent studies [37, 41, 42]. Evidence indicates that rework is reduced in the vision of BIM even though the source of information between design and construction is the same [29].

3. Research Methodology

To achieve the research aims, a four-step methodology has been considered and implemented in this paper.

3.1. *Comprehensive Review*

In the first step, a comprehensive review was carried out on rework literature in construction projects to select relevant sources that were published in journals and conferences. Through conducting a literature review based on an in-depth assessment of the available articles on rework only in the construction industry, this research was able to find more than 80 sources with the keyword of rework in their titles. All selected papers were then analyzed in detail, considering the following content. The investigation of rework-related factors has been attempted worldwide, and many variables as rework root causes have been identified. Since identified items in previous research were repeated in different ways, this study constrained the next step for collecting more reliable data. It follows PRISMA main steps of identification, screening, eligibility and included documents.

3.2. *Refinement from literature*

For the second step, the most recent rework studies in various regions of the world that contained a list of identified rework causes and covered at least one of the stages of the project life cycle have been chosen to explore all possible root causes of rework and make a comprehensive list without missing any items from the previous step. After several refinements in search of the first step, it was clear that all identified rework causes could be found in the following sources as listed here:

- [A]: Divergence or Congruence? A Path Model of Rework for Building and Civil Engineering Projects, Peter E. D. Love, David J. Edwards, Jim Smith and Derek H. T. Walker, 2009, [25]
- [B]: Factors influencing rework occurrence in construction, L.O. Oyewobi and D.R. Ogunsemi, 2010, [32]
- [C]: Construction small projects rework reduction for capital facilities, Di Zhang, Carl T. Haas, Paul M. Goodrum, Carlos H. Caldas and Robin Granger, 2012, [43]
- [D]: Using system dynamics principles for conceptual modelling to resolve causes of rework in construction projects, Olatunji Ayodeji Aiyetan and Dillip Das, 2014, [44]
- [E]: Analyzing causes for reworks in construction projects in China, Gui Ye, Zhigang Jin, Bo Xia, and Martin Skitmore, 2014, [45]
- [F]: Analysis of rework in residential building projects in Palestine, Ibrahim Mahamid, 2016, [8]
- [G]: Factors Contributing to Rework and their Impact on Construction Projects Performance, Adnan Enshassi, Matthias Sundermeier, and Mohamed Abo Zeiter, 2017, [46]

Analysis of these articles resulted in preparing a list of 316 identified rework root causes with details of; 42 items from source [A] in the direction of the client and contractor related

items with a focus on design, 77 items from source [B] mostly oriented on technical and human resource in all stages of a project, 18 items from source [C] with processing evaluation in all stages of a project, 39 items from source [D] on both client and contractor side in design and construction stages of a project, 39 items from source [E] covering all stages of a project with no order, 43 items from source [F] considering consultants and environmental factors in the construction stage and 58 items from source [G] both client and contractor side assessing different internal and external factors.

3.3. *Categorizing of Rework*

In the third step, a model for the classification of all identified rework root causes has been designed. It is used to categorize and simplify the list of causes based on the needs of this research. Previous criteria and concepts used by other researchers were considered in the proposed classification model to avoid missing or duplicating identified factors. Identified rework root causes are distributed between two major parts of the contract as client and contractor in this model. To simplify this matrix, all other organizations that work with the client have been merged on the client-side. The same approach is considered for the contractor side. More details of this step are the same as the applied model for studying of Procurement "tendering" stage of the project [47].

3.4. *Classification of root causes*

In the last step, all identified rework root causes were entered into the matrix with three dimensions of contract sides, project stages, and rework root categories. Depending on the defined scope for each identified item, one or more matrix spaces can be allocated. Distributing of identified rework root causes within the designed classification model is used as the base for the results of this paper. More details on the obtained result can be found in the finding and conclusion sections.

4. Findings and Discussion

However, the overall research covers all stages of the project life cycle; this section presents only the result of the project's design stage. The second step of methodology in the presence of rework showed 102 items that attribute to design activities [47]. Allocating 102 items into the distribution matrix in the third step of methodology raises this figure to 136 for both contract sides. In other words, there are 34 common items between client and contractor that have been repeated among different sources of literature. Providing a descriptive list of allocated items in each matrix line indicated that some of the causes are the same content, and some can be considered the same as their terminology almost transmits the same meaning. For example, modification, revision, and change in spec and scope for any reason can be classified in one general item, as can be seen in the table.

Table 1. Classification of rework root causes in design stage of project

Part	Process related factors	[A]	[B]	[C]	[D]	[E]	[F]	[G]
Client	1 Changes, modification, and revisions in design "spec, scope and construction method" in any order to improve in quality, constructability, etc. and late design change	3*	3*	*	2*	3*	2*	-
	2 Error in design, drawings and specifications by consultant due to complexity and time boxing	-	*	-	*	*	2*	-
	3 An omission in design, drawings, spec by consultant due to incomplete design or lack of attention to details	-	*	2*	-	-	*	-
	4 Lack of documents control such as inadequacies in contract documentation	-	-	*	-	-	*	-
Contractor	5 Design changes in any form	6*	*	*	-	*	-	*
	6 Design errors in any form	-	*	*	-	-	-	*
	7 Any omission in design process due to incomplete information for design	-	*	*	-	-	-	*
	8 Lack of document control including subcontractor's documents	-	-	*	-	-	-	-
Part	Human resources related factors	[A]	[B]	[C]	[D]	[E]	[F]	[G]
Client	9 Lack of experiences and personal expertise in design team members of consultant	*	-	-	*	-	2*	-
	10 Inadequate supervision staff due to manpower turnover	-	-	-	-	-	2*	-
	11 Insufficient skilled level manpower for specific design	-	-	*	-	-	-	*
	12 Lack of education and poor knowledge due to nonsufficient personal training	*	-	2*	-	-	-	*
	13 Lack of employee motivation and rewards	-	-	*	-	-	-	*
	14 The absence of job security and other safety rules	-	-	-	-	-	-	2*
	15 Conflict of interest	-	-	-	-	-	-	*
16 An inappropriate personal attitude such as unfollowing work instructions or failure to the adhesive to policies due to disturbances in personal planning	-	-	*	-	-	-	2*	
Contractor	17 Lack of experiences and personal expertise in design team members	*	-	-	-	-	-	*
	18 Insufficient skilled level manpower	-	-	*	-	-	-	*
	19 Lack of education and poor knowledge due to deficiencies in personal training	*	-	2*	-	-	-	*
	20 Lack of employee motivation and rewards	-	-	*	-	-	-	*
	21 An inappropriate personal attitude such as unfollowing work instructions or failure to the adhesive to policies due to disturbances in personal planning	-	-	*	-	-	-	2*
	22 The absence of job security and other safety rules	-	-	-	-	-	-	2*
23 Inadequate manpower due to staff turnover or reallocation to other projects	*	-	-	-	-	-	-	
Part	Material and Equipment related factors	[A]	[B]	[C]	[D]	[E]	[F]	[G]
Client	24 Non-adherence to material specifications or non-compliance to standards	-	-	-	*	-	-	-
Part	Technical related factors	[A]	[B]	[C]	[D]	[E]	[F]	[G]
Client	25 Ineffective use of quality management practices and lack of attention to quality	*	*	-	-	-	-	-
	26 Deviation and failure due to poor monitoring, control, and quality inspection or non-compliance to the standards/specification and project requirements	-	4*	*	-	-	-	-
	27 Ineffective or lack of information technology and poor technology application use	*	*	-	2*	-	-	-
	28 Poor communication system and ineffective coordination and integration between different design team members and consultant	*	-	*	*	-	2*	2*
	29 Inefficient management and decision-making due to poor information and poor contractual relations	-	*	*	-	-	-	*
	30 Poor planning of workload and poor scheduling of construction resources	-	-	2*	-	-	*	-
	31 Inability in development of realistic work procedures due to constraint in carrying out activities and ambiguous instructions	-	2*	-	*	-	-	-
	32 Inadequate brief to prepare detailed documentation and deficiencies in forecasting field conditions	*	-	*	-	-	-	*
Contractor	33 Ineffective use of quality management practices and lack of attention to quality	-	*	-	-	-	-	-
	34 Deviation and failure due to poor monitoring, control, and quality inspection or non-compliance to the standards/specification and project requirements	-	4*	*	-	-	-	-
	35 Ineffective or lack of information technology and poor technology application use	-	2*	-	-	-	-	-
	36 Poor communication system and ineffective coordination and integration between different design team members	*	-	*	-	-	-	-

	37	Inefficient management and decision-making due to poor information and ambiguous project process	-	*	*	-	*	-	-
	38	Poor planning of workload and poor scheduling of construction resources	-	-	*	-	-	-	-
	39	Inability in development of realistic work procedures due to constraint in carrying out activities and poor project documents such as late design input	-	-	*	-	-	-	*
	40	Deficiencies in forecasting field conditions by contractor	-	-	*	-	-	-	-
Part		Other related factors	[A]	[B]	[C]	[D]	[E]	[F]	[G]
Client	41	Financial issues such as lack of funding allocated by the client for site investigations or inadequate money spent on the briefing process	2*	-	-	-	-	*	-
	42	Low payment fees for design works	-	-	-	-	-	*	-
	43	Lack of client involvement in the project or late user involvement in design process	*	*	-	-	-	*	-
	44	Time pressure due to fixed time for design tasks and lack of time	-	-	-	*	-	*	-
	45	Unanticipated consequences of change	-	*	-	-	-	-	-
	46	Unclear line of authority	-	-	-	-	-	-	*
Contractor	47	Non-attention to constructability problems raised at early stages	-	-	-	-	-	-	*
	48	Competitive or low design fees proposed by contractor	-	-	-	-	-	-	*

Since rework impacts are not measured in this study, the following classified rework root causes have been sorted in no order. Thus, each item has no priority in terms of importance, and the table only shows the number of classified root causes. Results showed that the distribution of causes over the categories is not in balance. Technical-related factors with 16 items are the most frequent category involving rework, followed by human-related factors that contribute to 15 root causes. Process-related factors illustrate eight root causes of rework equal to the total items of the other related factors category. Lastly, material and equipment-related factors were found as the lowest frequent category, with only 1 involving item as a root cause of rework. After fully reviewing and unifying the contents, rework root causes in the project's design stage can be listed as 48 items, as shown in Table 1.

5. Conclusions and Further Research

This study reveals that more efficient rework management can be achieved by packing a series of rework root causes into unified components. The findings suggest that rework causes in the design stage of a project have appeared in all five designated categories; however, human resources and technical-related factors are among the highest number of rework root causes compared to the other categories. In contrast, material and equipment-related factors in this project stage contribute to the lowest number of causes. The results of this paper as rework root causes in the project's design stage can be summarised as the following items.

- Changes in any order, errors, and omission in any form and lack of control documents for both client and contractor are the major items under process-related factors.
- Conflict of interest regarding client staff, manpower experiences, labor shortage, low skilled level, poor knowledge, various personal attitudes, lack of motivation, and the absence of job security for both client and contractor team members are categorized under human resources-related factors.
- Material and equipment related factors just consist of non-compliance to the specifications and standards for the client-side of the contract
- Lack of attention to quality management, deviation and failure, poor technology application use, ineffective communication system, inefficient management and decision

making, weak planning of workload, shortage of work procedures, and the inability of forecasting field conditions are highlighted as technical-related factors in both sides of the contract.

- Financial issues, low payments, lack of involvement, time pressure, unclarity of authority and unanticipated consequences of change from client-side and constructability problems, and low proposed price by contractors are the other related factors that may result in rework.

Based on secondary data from the literature review, the presented model in this paper offers a list of rework root causes as a platform for future studies. Thus, the results of this paper can be used for further studying the relation between rework and contract documents through an evaluation model. The evaluation model reviews all clauses of contract condition and their attachments against the classified rework root causes in search of any relation for rework management. The likelihood of rework occurrences can be managed more effectively when project participants can check the causes of rework at the time of contracting. The classified rework root cause in each stage of the project will provide this opportunity for checking contract documents to assure that possible impacts of rework are covered thoroughly. Rework management through implementing this mechanism will result in more awareness of contract parties, and higher project performance may achieve when both sides of the contract recognize the benefit of this approach.

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