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Rework causes classification model with liable parties of the contract in construction projects

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Rework is an interesting topic in the contract management of construction projects. An effective way of improving performance on construction projects is to manage rework. However, managing rework is challenging because of the dynamic nature of construction activities. A rational starting point is the identification of the root causes of rework then a framework for its management can be developed for improving construction performance. This paper reviews rework-related studies in the construction industry through a critical review of literature to investigate the main causes of rework in the construction contracts. A content analysis of the previously proposed classification methods for rework revealed that all rework causes could be grouped under various project stages. The causes of rework also could be ascribed to different project parties. However, previous studies have suggested various categories of rework, there is no commonly used classification model for rework causes in construction contracts. The current study proposes a model in three levels to address this gap. The developed model categorised rework causes in five constructs linked to three main stages of the project under two liable contract parties. The study findings show that the procurement stage has fewer categories of rework causes than design and construction. The result also reveals that the involvement level of contract parties in rework occurrence can be investigated in contract documents. Thus, this paper suggests further research in procurement stage to address rework causes in the contract conditions.

KEYWORDS

rework, construction, contract, defect, classify

1 Introduction

In construction projects, the combination of stakeholders works together to execute a complex and unique product. Rationally, each stakeholder prefers to save more benefits, so motivation to work collaboratively is low (Liu et al., 2020). Such an attitude has steered projects to split the main work into smaller packages to be accomplished by distinct organizations individually. Thus, the stages of design, procurement, and construction of projects have been performed separately for a long period. This breakup of the project's main stages has degraded construction success indicators such as performance, productivity, and competitiveness (Ye et al., 2015). Novel contracting strategies have emerged over the last few years to coordinate the relationship between contractors and clients to achieve better performance. The cost of construction projects is effectively reduced if the main stages of the project life cycle are taken into consideration (Bao et al., 2018) under rework events. Rework is an issue that appears across various stages of the project and has cross-functional

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TABLE 1 An overview on the classification methods used in the reviewed papers in this study.

Number of occurence		18	2	10	8	1	2	21	2	5	5	9	7	5	4	1	1	2	1	6	7
[35]	Nigeria	~	~	~	~	~	~	√	~	~	~	~	~	~	~	~	~	~	~	~	~
[34]	Saudi Arabia	~	~	~	~	~	~	~	~	√	~	~	~	~	~	~	~	~	~	~	~
[33]	China	√	~	~	√	~	~	√	√	~	√	~	~	~	√	~	~	~	~	√	~
[32]	USA	~	~	~	~	~	√	~	~	~	√	√	~	~	~	~	~	~	~	~	~
[31]	Singapore	√	~	√	~	√	~	√	~	~	~	~	~	~	√	~	~	~	~	~	~
[30]	Ukrine	√	~	√	~	~	~	√	~	~	~	~	~	~	~	~	~	~	~	~	~
[29]	Nigeria	√	~	√	~	~	~	√	~	~	~	~	~	~	~	~	~	~	~	√	~
[28]	Nigeria	√	√	√	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
[27]	Malaysia	~	~	~	~	~	~	√	~	~	√	√	~	√	~	~	~	~	~	~	~
[26]	Nigeria	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	√
[25]	South Africa	~	~	~	~	~	~	√	~	~	~	~	√	~	~	~	~	√	~	~	~
[24]	Palestine	√	~	√	~	~	~	√	~	√	~	√	~	√	~	~	~	~	~	√	~
[23]	Nigeria	~	~	~	~	~	~	√	~	~	~	~	~	~	~	~	~	~	~	~	~
[22]	Nigeria	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	√
[21]	India	√	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~
[20]	India	~	~	√	~	~	~	√	~	√	~	√	~	√	~	~	~	~	~	√	~
[19]	Palestine	√	√	√	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	√	~
[18]	Nigeria	√	~	√	~	~	~	√	~	~	~	~	~	~	~	~	~	~	~	~	~
[17]	Nigeria	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	√
[16]	Iran	√	~	~	√	~	~	√	~	~	~	~	~	~	~	~	~	~	~	~	~
[15]	China	√	~	√	√	~	~	√	√	~	√	~	~	~	√	~	~	~	~	√	~
[14]	Spain	~	~	~	~	~	√	~	~	~	√	√	~	~	~	~	~	~	~	~	~
[13]	Singapore	√	~	~	~	~	~		~	~	~	~	~	~	~	~	~	~	~	~	~
[12]	Hong Kong	√	~	~	√	~	~	√	~	~	~	~	√	~	~	~	~	~	~	~	~
[11]	Nigeria	√	~	√	~	~	~	√	~	~	~	~	~	~	~	~	~	~	~	~	~
[10]	Canada	~	~	~	~	~	~	~	~	~	~	√	~	~	√	~	~	~	~	~	~
[9]	Australai	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	√

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TABLE 1 (*Continued*) An overview on the classification methods used in the reviewed papers in this study.

Number of occurence		18	2	10	8	1	2	21	2	5	5	9	7	5	4	1	1	2	1	6	7
[8]	Nigera	~	~	~	~	~	~	~	~	~	~	√	~	~	~	√	~	~	√	~	~
[7]	Australia	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	~	√
[6]	Hong Kong	√	~	~	√	~	~	√	~	~	~	~	√	~	~	~	~	~	~	~	√
[5]	Hong Kong	√	~	~	√	~	~	√	~	~	~	~	√	~	~	~	~	~	~	~	√
[4]	Hong Kong	~	~	~	√	~	~	√	~	√	~	~	√	~	~	~	~	~	~	~	~
[3]	Canada	~	~	~	~	~	~	√	~	~	~	√	~	√	~	~	√	√	~	~	~
[2]	Australia	√	~	~	√	~	~	√	~	√	~	~	√	~	~	~	~	~	~	~	~
[1]	Sweden	√	~	~	~	~	~	√	~	~	~	√	√	√	~	~	~	~	~	~	~
References	Country / Category	Client	Consultant	Contractor	Subcontractor	Vendor/Supplier	Organizational factors	Design/Engineering review	Contract Management	Construction	Project	Workmanship/People/Human Resources	Site Management/Productopn/Operation	Material and equipment/Machine	Process/Change/Error/Ommision	Technical	Leadership and Communications	Planning and Scheduling	Quality Management	External/Environmental aspects	No classification/General
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

[1] Josephson et al. (2002); [2] Love and Smith (2003); [3] Robinson et al. (2004); [4] Palaneeswaran et al. (2005); [5] Palaneeswaran (2006); [6] Palaneeswaran et al. (2008); [7] Love et. (2009); [8] Oyewobi and Ogunsemi (2010); [9] Love et. (2010b); [10] Zhang et al. (2012); [11] Aiyetan (2013); [12] Palaneeswaran et al. (2014); [13] Hwang et al. (2014); [14] Forcada et al. (2014); [15] Ye et al. (2015); [16] Miri and Khaksefidi (2015); [17] Ajayi and Oyeyipo (2015); [18] Aiyetan and Das (2015); [19] Mahamid (2016); [20] Shah et al. (2016); [21] Ahmed and Naik (2016); [22] Oyewobi et al. (2016); [23] Wilson and Odesola (2017); [24] Enshassi et al. (2017); [25] Ndwandwa et al. (2017); [26] Ajayi (2017); [27] Yap et al. (2017); [28] Eze et al. (2018b); [29] Eze et al. (2018a); [30] Trach et al. (2019); [31] Hwang et al. (2019); [32] Safapour et al. (2019); [33] Liu et al. (2020); [34] Mahamid (2020); [35] Salihu and Babarinde (2020).

impacts on the construction industry (Zhang et al., 2018). Identifying rework causes at the main stages of a project is required to facilitate construction projects' success and to provide solutions for managing rework. Therefore, implementing a life cycle philosophy for rework management is critical due to the integrated activities of the construction contracts.

In the study area of construction rework, available literature mostly has focused on general trends of rework topics. Identified causes of rework from previous studies have generally been classified in various methods based on research scopes (Love and Smith, 2003; Robinson et al., 2004; Liu et al., 2020). Literature on this topic lacks systematic analysis of rework causes from a perspective that covers various stages of projects and liable contract parties (Taggart et al., 2014). The various categories of rework causes in the literature show that there is no unify used classification method for categorizing causes of rework in construction contracts (Love and Li, 2000; Zhang et al., 2012; Safapour and Kermanshachi, 2019). The variety of uses of different classification methods is presented in Table 1. The lack of systematic literature review on rework causes will require further investigation to unify all identified causes in a model that refers to the contract parties under various project stages (Ye et al., 2015; Asadi et al., 2021b). As such, a classification model is needed to be designed and proposed to address rework causes under the contract party's liability. Furthermore, there is no detailed analysis and systematic review of the identified rework causes link to the contract documents, while the other aspects such as change orders, payments, safety issues, conflicts and disputes have been studied in detail (El-adaway et al., 2016; El-adaway et al.,2017; Abdul Nabi et al., 2020; Saseendran et al., 2020). Therefore, the lack of addressing rework causes in the construction contracts under the project's main stages is considered a knowledge gap. Rework can be addressed in the contract documents, and to find an appropriate guideline for mapping rework in the contract (Asadi et al., 2023), firstly, causes of rework need to be identified and classified (Hwang et al., 2009) with the liable contract parties.

Several definitions for rework can be found in the literature (Josephson et al., 2002; Hwang et al., 2019; Liu et al., 2020), and under each definition, rework prevention or reduction requires both contract parties' attention and effort. In this study, rework is considered an activity that needs to be redone due to non-compliance with the contract. Since the impact of rework does not vary significantly with different procurement methods used (Love, 2002), this paper has reviewed all rework causes regardless of various procurement routes to avoid missing any items related to different contract types. Procurement is the key element of a project that plays a vital role in the success of the construction industry (Aiyetan, 2013). Contract as the main output of the procurement stage has been studied under different situations (Mendis et al., 2015; El-adaway et al., 2016). Non-etheless, the assessment of rework in contract documents needs further investigation as literature shows the lack of addressing rework in the contracts, which results in contractual claims and disputes (Wang et al., 2019; Asadi et al., 2021a). Thus, identifying the main causes of rework in construction contracts is considered as the key objective for this study followed by proposing a classification model.

2 Literature review

2.1 List of rework root causes under projects' main stages

The investigation into the sources of rework has taken more attention than the other study area of rework such as rework impacts, proposed strategies, implemented theories, reduction models and other solutions (Asadi et al., 2021b). Identifying the root causes of rework has always been an essential part of research around rework as it is the first step towards rework management either through reduction or prevention (Hwang et al., 2009; Ye et al., 2015; Ndwandwa et al., 2017). Rework identification is a necessity in construction projects as the consequences of rework lead to cost overruns and delay, poor organizational performance, and contractual claims (Love and Smith, 2003; Kim and Skibniewski, 2020). Cost and the other effects of rework are reduced when the causal structure of rework causes is understood (Love et al., 2010a). Various research have attempted to identify causes of rework in different types of construction projects including residential and commercial buildings, (Oyewobi and Ogunsemi, 2010; Hwang ans Yang, 2014; Ajayi and Oyeyipo, 2015; Yap et al., 2017; Liu et al., 2020; Mahamid, 2020), civil and infrastructure projects (Palaneeswaran et al., 2008; Love et al., 2010b; Zhang et al., 2012; Palaneeswaran et al., 2014; Enshassi et al., 2017; Hwang et al., 2019), and industrial plants.

The primary sources of rework are deviation from quality or non-conformance, changes, failures, defects, damages, errors, and omissions (Palaneeswaran et al., 2005). Numerous rework causes have been identified in different research by implementing various methods of benchmarking, cause and effect, regression, system dynamic, artificial neural networks, and fuzzy set theory based (Love and Smith, 2003; Robinson et al., 2004; Palaneeswaran et al., 2008; Love et al., 2010b; Aiyetan and Das, 2015; Hwang et al., 2019). The first list of rework causes with six categories (Josephson et al., 2002) was presented as a benchmark rework cost in the Swedish construction industry. In 2004, a full list of rework root causes under five categories was developed in Canada to measure and classify construction field rework using a fishbone diagram of cause and effects (Robinson et al., 2004). The identified causes of rework through the literature have been used for different purposes, for example, providing a framework to monitor rework in building projects (Palaneeswaran et al., 2005) or to determine the cost of rework in civil and infrastructure projects (Love and Li, 2000; Love et al., 2010b; Miri and Khaksefidi, 2015; Mahamid, 2016).

The causal structure of rework causes must be identified to understand the overall influence of rework on project performance (Love et al., 2010a). Thus, the list of rework root causes has evolved through empirical research and case studies worldwide. In some studies, the list of rework causes was identified and tested over construction projects, and in some others, it has been used for proposing a classification model or developing a framework of rework management (Love and Edwards, 2004; Love et al., 2009; Forcada et al., 2014; Aiyetan and Das, 2015; Zhang et al., 2018). Part of the reviewed papers focused on the identification of rework causes from the perspective of their impacts on project performance through measuring contractual claims, time, cost, quality and safety indicators (Palaneeswaran et al., 2008). Previous studies

also have provided or used the list of rework root causes for various purposes such as investigating client-related factors (Hwang et al., 2014), minimizing the effects of rework to achieve more effective construction (Shah et al., 2016), reducing design-related causes (Wilson and Odesola, 2017; Salihu and Babarinde, 2020), examining the perception of professionals on the factors that trigger the occurrence of rework (Eze et al., 2018a), prioritizing rework indicators (Balouchi et al., 2019; Safapour et al., 2019), and evaluating the relationship between material waste and rework (Mahamid, 2020). Overall, it is required to be noted that rework occurs at various stages of a project. Non-etheless, when the emphasis is given to managing rework at the early stages, the impacts of rework will be reduced in the following steps (Ma et al., 2019). Thus, rework management at the design and procurement stages may result in fewer numbers of rework in downstream phases such as construction (Hossain and Chua, 2013).

Despite all efforts to investigate the causes of rework in different projects worldwide (Ye et al., 2015), the literature lacks a list of rework root causes to cover the main stages of a project under two parties of the contract. In the literature review, identified rework causes were largely from one and, to a lesser extent, from two project stages. Rework generally originates from the design stage, while it may occur in the other project stages (Love et al., 2010a). The focus of this paper is to identify and classify causes that result in rework in construction projects. Thus, it covers all causes that may appear in the process, starting from design to construction completion. Rework may also occur after construction work during the operation stage of the project (Kakitahi et al., 2013). Rework after practical completion, including the defect liability period till the end of the operation stage, is called failure and latent defect (Love and Smith, 2018) or defective work (Yap et al., 2017). Rework at this project stage is the result of causes initiated from previous project stages such as ineffective communication, inadequate design information, non-complaint building material, and insufficient works supervision (Kakitahi et al., 2013). The literature review showed no classified rework causes under the operation stage as there is no practical work after construction. Therefore, all the identified and classified causes are analysed under three main stages of design, procurement and construction; however, they may result in rework after the practical completion and during the defect liability period.

2.2 Background of the rework classification methods

The classification of rework causes is an essential part of the rework management process (Robinson et al., 2004; Zhang et al., 2012). The root causes of rework are traceable when a classifying method is employed. The classification provides referencing for future rework management and strategies (Love and Edwards, 2013). The literature review shows that most previous studies had classified the causes of rework based on their research aims. For example, in the study (Love and Li, 2000), the adopted classification system comprised two design and construction categories with five causes, including changes, errors, omissions, and damage. Literature indicates that the root causes of rework are categorized into various groups, including a) stakeholders, b) project stages, c) organizational factors and activities, and d) other miscellaneous aspects. Most of studies have classified rework causes based on the initial sources of rework from stakeholders "client, contractor, consultant and subcontractors" (Aiyetan, 2013; Palaneeswaran et al., 2014). Classification based on the occurrence of rework at different stages of the project (design, contracting management and construction) was the second-most used method in the literature (Zhang et al., 2012; Wilson and Odesola, 2017). The rest of the papers have added some other categories or used a combination of stakeholders and projects stages in their classified methods. A lesser proportion of the papers have not adopted a specific classification method and simply listed the causes of rework (Oyewobi et al., 2016). Table 1 presents the rework classification methods used in previous studies. All category names of rework causes used in the classification methods are listed in Table 1. The most used category names among the classification methods are design (21 studies), client (18 studies) and contractor (10 studies).

Detailed analysis of previous classification methods show that the list of rework causes under each category varies among different studies. The lists of rework root causes in most of the studies were adopted based on the research needs, project types and stakeholders' requirements. Therefore, the existing classified groups do not cover a wide range of rework causes liable to the contract parties. Furthermore, the same identified causes are found in different categories from different levels. For example, lack of communication is identified in the category of client (Mahamid, 2016; Eze and Idiake, 2018; Trach et al., 2019), contractor (Hwang et al., 2019), and subcontractor (Ye et al., 2015; Liu et al., 2020). Lack of communication also is found under various project stages such as design (Wilson and Odesola, 2017; Liu et al., 2020), construction (Mahamid, 2020), or other categories (Oyewobi et al., 2016; Enshassi et al., 2017). A single cause may occur in each project stages liable to different stakeholders, thus available categories in the literature may unable to show the accurate roots of rework causes. Lack of knowledge and training is another example that can occur in the design or construction stages (Eze et al., 2018b; Eze and Idiake, 2018; Hwang et al., 2019; Trach et al., 2019) and can be linked to both sides of the contract, either client or contractor. It also had been classified in the grouping of human resources in some other studies (Zhang et al., 2012; Shah et al., 2016).

By referring to above evidence and despite all the efforts to identify rework causes, there is a lack of a standard classification model to cover three project stages in conjunction with liable contract parties. A structured classification model including a list of rework root causes removes such limitations and summarizes the long list of identified causes from previous studies. Such a structured classification model effectively facilitates long-term solutions for eliminating or reducing rework issues (Taggart et al., 2014). The list of rework causes can be used and modified by project parties at initiation steps of the construction projects and assists practitioners to manage impacts of rework in later steps. As a result, the provided list is used to further investigate rework issues in the contracts by addressing rework causes in the contract terms and conditions. Addressing rework causes in the contract conditions results in fewer claims and disputes (Ndwandwa et al., 2017; Kim and Skibniewski, 2020; Asadi et al., 2022). Thus, the identified and classified rework causes in this study contributes to the body of knowledge in construction contracts.

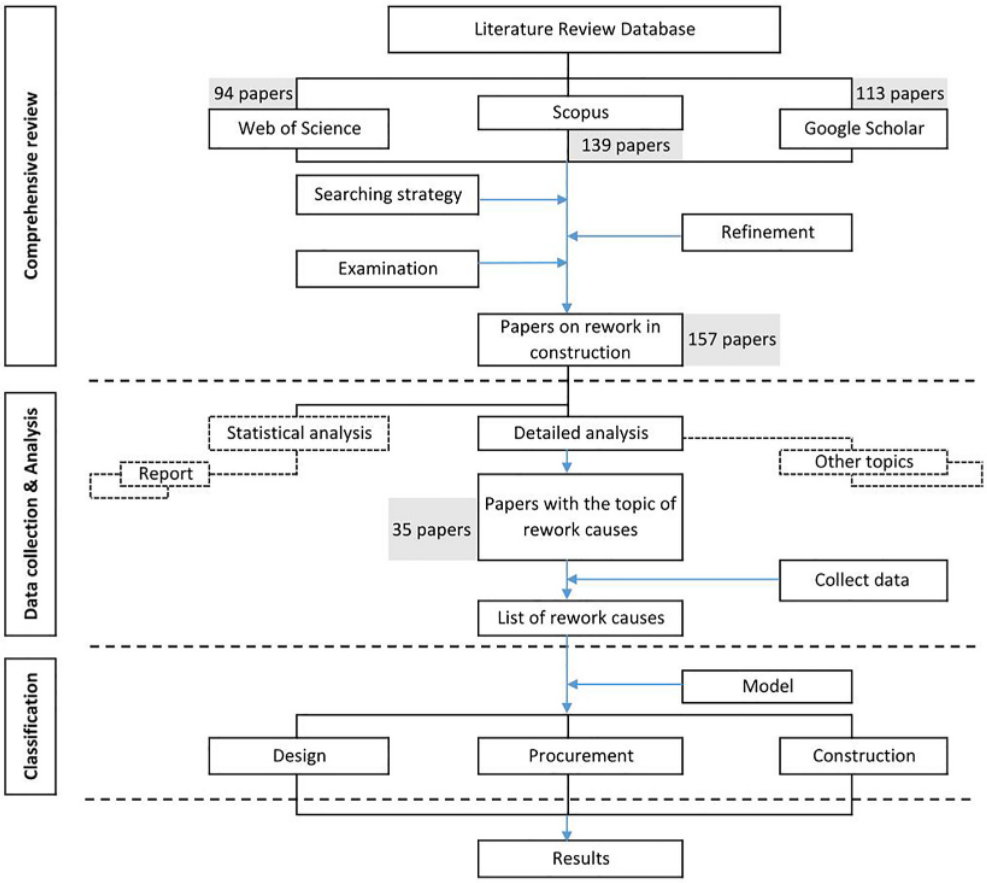

FIGURE 1
The process of research methodology.

3 Methodology

This paper is part of a research study that explores rework management in construction contracts. Poor contract management and scope ambiguity in the contract documents creates contractual claims and change orders and leads to rework occurrence (Palaneeswaran, 2006; Al-jababi et al., 2020). Thus, identifying the causes of rework is the key priority of this study, as previous research has recommended further investigation of the contract documents under rework circumstances (Forcada et al., 2014). One way to provide a list of identified rework root causes is through searching the published articles on rework in the construction sector. An effective way to identify knowledge gaps and pave the way for future studies is through literature review. Published papers on the topic of rework from 1990 to 2021 were obtained through the following systematic literature review steps. The reason for the selected period is that rework research has started expanding after the first official definition of rework by Construction Industry Development Agency in 1995 (Love et al., 2018). A systematic literature review as a scientific activity is more often used for management practices. An extensive literature review on rework causes identifies gaps in each stage of the project and provides the opportunity for further recommendations to address rework issues. The sequences of implementing this comprehensive review consist of identifying research by generating a strategy, selecting criteria to include and exclude studies, collecting relevant articles, quality assessment of the collected documents, data extraction, and result summarization (Park and Tucker, 2017). This review was initiated to answer this question of what the root causes of rework in construction projects are? Rework is a term widely used in many research fields and is interchangeable with several other words (Love and Smith, 2003). Such similar words may cause interferences in the search result and since the paper aimed to identify the causes of rework in contracts, the scope of searching publications was confined only to the keyword of "rework" in the paper's title considering all stages of the project. The search was further limited only to construction projects with the document type of article and conference papers. Other published papers under the broad categories of editorial, book review, forum, discussions/closures, letters to the editor, articles in the press, index, foreword, introduction, conference/seminar report, briefing sheet, and comment were excluded from the search analysis.

Following the commonly used method in previous studies, suitable search engines of Scopus, Web of Science "WoS," and

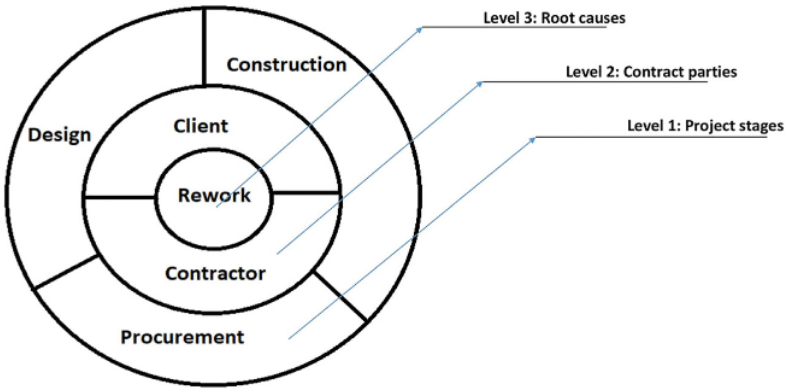

FIGURE 2
Conceptual structure for rework root causes classification.

Google Scholar were employed for searching (Bao et al., 2018; Habibi and Kermanshachi, 2018; Wang et al., 2020). The study began by a) searching for the rework topics in the Scopus followed by two complementary searching engines, b) selecting relevant papers and c) clustering them based on the subtopics, and then d) detailed analysis of rework causes in three stages of design, procurement and construction. In the first search round, Scopus was utilized as it is widely used for reviewing construction literature (Park and Tucker, 2017). The search was then completed using the Web of Science and Google Scholar search engines (Chan et al., 2020). Using the second and third search engines ensured that no relevant document is missed. The supplementary search engines cover the potential limitations of each other. The following algorithm has been considered to meet the systematic literature review criteria, as described in Figure 1.

3.1 Comprehensive literature review

The critical part of each research finding can be acquired and shared through publications for further advancement in a specific area (Bao et al., 2018). The publications provide a wider perspective of the topics and accordingly researchers can build a new idea by continuing the work of others. As a result, a comprehensive review of published papers identifies the current status and would help researchers to investigate future required research (Ke et al., 2009). The review process of finding relevant journal and conference papers is started when the research requirements are adopted based on the scope of the study (Safapour et al., 2019; Malek and Desai, 2020). The afore-mentioned requirements then are divided into three main steps: defining a search strategy, refining documents for inclusion in and exclusion from the papers, and examining of the documents to ensure that only selected papers are in the study's scope and are not duplicated. The search for rework in three search engines was conducted in June 2021 with the following codes:

- (TITLE (rework) AND ALL (construction)) AND DOCTYPE (ar OR cp) AND PUBYEAR > 1989 AND (LIMIT-TO (LANGUAGE , "English")) in the Scopus search engine,
- (TITLE: (rework) AND TOPIC: (construction), Timespan: 1990-2021. Databases: WOS, BIOABS, CABI, CCC, FSTA, KJD, MEDLINE, RSCI, SCIELO. Search language=English) in the Web of Science search engine and,
- (with all of the words (rework) AND (construction) in the title of the article, Return articles dated between, 1990–2021, excluding citations AND search English pages)) in the Google Scholar search engine.

The search then resulted in 139 papers in Scopus, 94 papers in Web of Science, and 113 papers in Goggle Scholar. A total of 346 papers were then reviewed to remove the irrelevant documents and duplicated papers among three search engines. The selection of more relevant papers will lead to more accurate results. Thus, initially, all paper titles were reviewed carefully to check whether they meet the research scope or not. The papers with titles out of the research scope were removed. Following that, the abstract of all remaining documents was scanned to segregate the relevant papers according to research scope. Besides, all papers with the same titles were identified to avoid duplications. The outcome of this process resulted in 93 papers in Scopus, 12 papers in Web of Science, and 52 papers in Google Scholar. In total, 157 papers remained for further analysis.

3.2 Data collection and analysis

All 157 papers were studied to take out the required data around the causes of rework and provide a list of rework root causes that covers both liable parties of the contract under three project stages. The following strategy was developed to generate a report on the extracted data. The main criteria for selecting papers were mainly based on discussing the causes and sources of rework. Thus, all papers that contain the list of rework causes were clustered in a separate group for further analysis and providing a report. Of 157 publications, the total number of 35 papers had provided a list of rework causes. Since the paper aimed to unify the identified causes and classify them, all identified lists, including their classification methods, were transferred to an Excel file for

further analysis. Different categories appeared from the extracted data of the collected classification methods. The Excel file also revealed that the number of cases in each study varied and ranged between a minimum of seven items (Hwang et al., 2014) and a maximum of 77 items (Oyewobi and Ogunsemi, 2010). The Findings and Discussion sections of the paper contain more details about the analysis of rework causes and their categories.

3.3 Classifying the results

Despite the various points of view on classifying rework root causes, having a model for managing rework consequences is essential when rework causes are identified (Hwang et al., 2009). As shown in Table 1, various rework classification methods have been used in the construction industry for categorizing identified rework causes and measuring their impacts. The identified rework causes from the literature can be categorized into different groups based on their similarity and differences. A flexible model for various construction projects can cover all identified rework causes and provide possible solutions or recommendations. Since this research aims to assess rework in contracts across the main stages of projects, the model needs to contain design, procurement, and construction with liability to the contract parties. The classified causes of rework will be used for further studying of the contract (Al-Jababi et al., 2020), so the liable contract parties would need to be included in the classification model. For this purpose, a classification system at three levels in Figure 2 is adopted to address all reviewed and analyzed rework root causes. The novelty of this research is to propose a structure to address rework causes under project stages with their liable contract parties.

3.4 Proposing a rework classification model

Providing a systematic approach for classifying the causes of rework will improve the rework management consequences (Miri and Khaksefidi, 2015). Rework causes can be grouped based on their sources, impacts, occurrence in project stages, and involved parties. However, rework is found at many project stages, such as inspection, construction, after handover, or even during defect liability period and project maintenance, the causes of rework are generally investigated and linked to the operational stages (Taggart et al., 2014). The primary purpose of this research is to investigate rework issues in construction contracts. The standard form of contract in the construction industry is involved two parties overall. Thus, this study has focused on these two main parts—The client and the contractor. The client-side of the contract generally encompasses consultants and the contractor side covers subcontractors and their suppliers. Depending on the contract types, both parties are involved from the initiation stage of a project. Therefore, both client and contractor may contribute to rework occurrences at each project stage. The stage of project shows when rework occurs, during the contract period. The contract's liable parties indicate where the causes of rework originate. Lastly, root causes of rework may sit under each of the stages and liable contract parties to explain how they may be initiated. The proposed model in this study covers rework causes either from various sources or at different project stages. The proposed model has incorporated contract parties and various project stages at two separate levels to tackle these contradictions. As a result, six clusters appear in the model, namely, design-client (cluster 1), design-contractor (cluster 2), procurement-client (cluster 3), procurement-contractor (cluster 4), construction-client (cluster 5), and construction-contractor (cluster 6). Assessing rework causes under these six clusters is the novelty of the research, which has not yet been examined in the literature. The proposed model in three levels describes when, where, and how rework occurs. These three questions are the critical points to address rework in the contract documents.

The employed concepts and terminologies in Table 1 are used as the basis of the proposed model in this paper. The concept and criteria applied in previous studies have been considered in the proposed model to avoid missing or duplicating any of the identified causes. The identified rework root causes from the literature then are grouped into five constructs under each of the clusters. Grouping the similar rework root causes is necessary to understand the interdependency of causes and avoid duplications (Siraj and Robinson, 2019). The selected five categories in this paper are align with five group of rework causes in previous studies (Asadi et al., 2021a; Asadi et al., 2022). The category names in the proposed model were adjusted precisely to cover all identified categories in Table 1. In the case where a category name is found with other similar terms, the more inclusive name has been chosen. For example, the category name of "Contract Management" is used to cover "Procurement" and the category name of "Construction" covers both "Site Management" and "Construction". Furthermore, "Process" is selected over "Change/Error/Omission" as it covers all the interchangeable names, and "Human Resources" is selected over the other terms of "People and Workmanship" (Yap et al., 2017). Overall, the proposed classification model clearly shows the various groups of rework causes with their liable contract parties in three main stages of a project as described below.

3.4.1 Level 1: Project stages

According to PMI "Project Management Institute," the life cycle of a project consists of developed sequences from initiation to closing. This definition in the construction industry in overall, consists of three main stages of design, procurement and construction (Habibi et al., 2018), which are sometimes called EPC in megaprojects. The design stage covers items from previously identified and classified rework causes in Table 1 under design/engineering reviews category. The procurement stage covers rework causes from previous contracting management categories (Coleman et al., 2020), and the construction stage covers previous categories of site management and construction (Palaneeswaran et al., 2005). Rework causes in the category of "Project" are distributed among all stages depending on the nature of the items.

3.4.2 Level 2: Contract liable parties

Since contract documents in construction projects are signed off between the client and contractor, this paper has classified rework causes into these two main groups as described in introduction section. The client parts cover two previous categories of client and consultants. The contractor parts cover three categories of contractor, subcontractor and supplier from previous

classification methods (Assaad et al., 2020). Rework causes under "Organizational factor" are distributed among both parties depending on the nature of the items. The study conducted by Taggart et al., (2014) showed that rework root causes are identified when a more collaborative approach is adopted among the supply chain stakeholders. Rework may also contribute to other parties such as consultants, suppliers and subcontractors. This study investigates rework issues between two main sides of the contract as the client and contractor and that is another limitation to the study which can be covered by further research considering other parts involved in the project.

3.4.3 Level 3: Root causes

Continuance to the afore-mentioned levels; this paper has categorized the root causes of rework under five distinct constructs: process, human resources, material and equipment, technical, and general/external factors. The group of process-related factors covers the items from the previously classified category with the same title (Zhang et al., 2012). Human resources-related factors cover the previous categories under the names of workmanship, people, and human resources (Robinson et al., 2004; Forcada et al., 2014; Yap et al., 2017). The material and equipment related factors cover the same category in previous models plus the machine's category (Josephson et al., 2002; Enshassi et al., 2017). The technical-related factors cover the following categories of planning and scheduling, leadership and communication, technical and quality management (Robinson et al., 2004; Oyewobi and Ogunsemi, 2010; Ndwandwa et al., 2017). The last group of general/external factors covers the previous categories of environmental/external, and other related factors (Ye et al., 2015; Mahamid, 2016; Eze et al., 2018b; Liu et al., 2020). In this way, all identified causes of rework throughout the literature are allocated to the proposed model.

Figure 3 presents a diagram of the proposed model in which the horizontal line has divided it into two similar patterns that may occur on both sides of the contract. The upper section addresses the client and the lower section is for the contractor. This line also has been considered as the border between the two and can be treated as the contract. The contract documents are signed at the end of the procurement stage, while before and after that point are known as pre-contract and post-contract, respectively (Love et al., 2009; Kakitahi et al., 2014). It also shows how a project evolves from design on the left side of the diagram towards the end of construction on the right side. Each of the five constructs has been placed on both sides and three stages to check the probability of rework occurrence in the entire process. Each box in the diagram contains numbers of rework root causes, as described in Tables 2–7. Three abbreviations based on the three-level classification system have been allocated for coding of each boxes. The first character of the code shows the project's stage, and includes "D" for design, "*P*" for procurement, and "C" for construction. The second character shows the liable contract parties in which "E" is used for the client and "S" for the contractor. The third character shows the relevant category of root causes as "*P*" for the process, "H" for human resources, "M" for material and equipment, "T" for technical, and "G" for general/external related factors. For example, DST means technical related factors that originated by contractor at the design stage and may comprise more than one root cause that will be demonstrated as DST1, DST2, and more. Each identified rework cause places in one of these boxes. The diagram has been developed based on the proposed model, and it is part of the study's novelty. All identified rework causes were then placed in the adopted classification model to provide a list of rework causes that can be utilized in construction contracts throughout various project stages. Allocating rework root causes to the diagram facilitates the preparation of the list of rework causes from various studies. It contributes to the body of knowledge by generating a matrix that addresses rework management gaps in construction projects, as shown in Table 8.

4 Findings

4.1 Rework causes classification and ranking in the project stages

Several research efforts have attempted to identify and classify the causes of rework and quantify its overall extent (Aiyetan, 2013), and each study's outcomes show different results. Engineering and reviews such as unsuitable or faulty design and lack of coordination in the design stage were known as the most significant causes of rework at the design stage (Josephson et al., 2002; Robinson et al., 2004). According to Love et al. (2000), the main source of rework is documentation that is basically used for construction activities. In other studies, human resources capability, and rework factors related to the contractors were prioritized as the major rework categories that affect the projects' performance (Enshassi et al., 2017; Eze and Idiake, 2018). The top five rework factors were identified as error and omission, labour skills, inadequate supervision, scope changes, and NCR to the specifications and requirements of the project (Mahamid, 2020). The importance and frequency of these causes vary from one study to another depending on the project type and locations.

Distribution of the identified rework root causes within the proposed classification model is presented in Tables 2–7. Each table presents a list of classified rework causes in a project stage that is linked to one side of the contract. The identified causes under each study are analyzed separately to bring together the same items under each table. The frequency of repeating an item over the studies is indicated in the last column of the tables. This indicator is for sorting the causes and does not make any priority in terms of severity or probability of rework occurrences. It only reflects the high interest of previous researchers on the identified cause and explains how it was commonly used among previous studies. The severity or probability of occurrence is generally used to measure the impacts (Robinson et al., 2004; Love et al., 2011). However, such measurement is not in the scope of this research as this study focuses on identifying the causes of rework regardless of their severity or occurrence probability. Thus, the number of citations in previous studies is considered an indicator for sorting the identified causes. For making the list of causes in each project stage, the following process take place to maximize the accuracy of referencing from the literature (Chan et al., 2020).

- Provide a list of rework causes under each author name to define the interrelations between causes

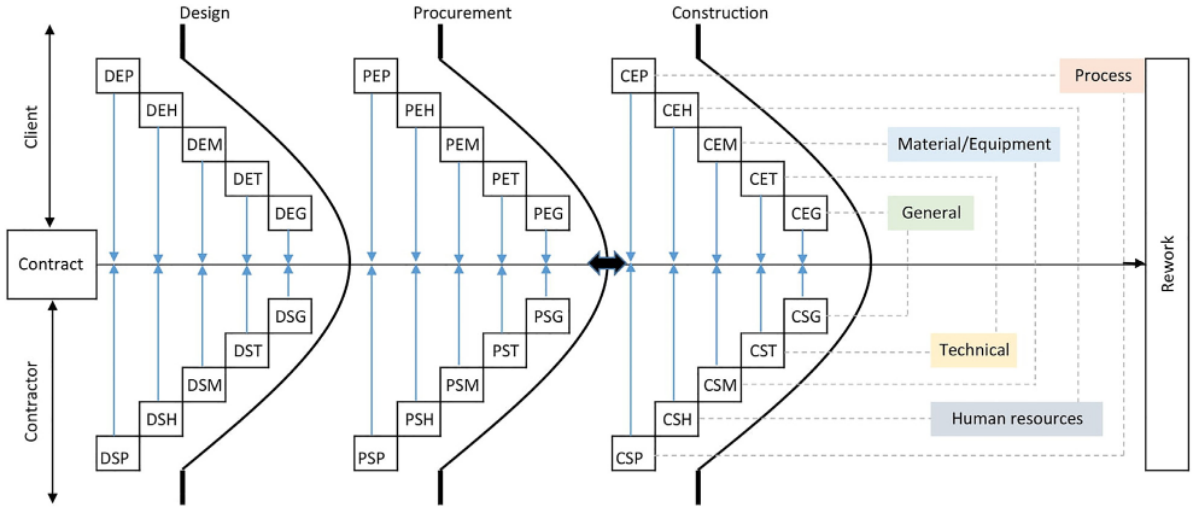

FIGURE 3
Classification model for rework root causes in life cycle of project with liable parties of the contract.

- Review the identified cause regarding the relevant paper's title as precisely as possible
- Ensure that categorizations of causes are uniform by comparing the provided lists
- Match the retrieved information with the details of the project stage
- Optimize the results through merging the same items in each stage separately

This processing confirms that all causes have been grouped in the most relevant and correct places. It also reduces the variety of views in providing more general causes that will incorporate easily into the more overall frameworks. Moreover, it would help the identification of more effective response strategies that can be allocated to the appropriate contract party. It finally generates a list of rework causes that can be adopted for different projects with two liable contract parts. Below are details of rework causes under three main project stages.

4.1.1 Design stage

The design stage consists of two main parts: pre-design/conceptual design and detailed design (Yeo and Ning, 2002). Error and incomplete information in the design stage generate rework (Love and Li, 2000). The development of this stage has been identified as the most important activity in a project's life cycle (Habibi et al., 2018) as the initial concept of the client's requirement consolidates into reality within this stage. During the design process, naturally, errors occur and sometimes lead to change and, consequently, rework (Love et al., 2010a). All items under this category from previous research studies were carefully reviewed to combine altogether and make a single list of causes in the design stage. Table 2 comprises 24 root causes of rework from the client-side of the contract concerning their code number, references and numbers of citations over various studies.

The findings suggest that rework causes in the design stage of a project have appeared in all five factors. However, the distribution of root causes among the categories is not in balance for both sides of the contract. The most frequent category in the design stage is human resources related factors, on both sides following the technical related factors. The low number of design errors brings more reputation to the firm and presents a better image of the designers (Love et al., 2000). Overall, the total number of rework root causes at this stage of the project is more likely to slope towards the client rather than the contractor with 24 items against 21. Table 3 comprises 21 root causes of rework from the contractor side of the contract concerning their code number, references and numbers of citations over various studies.

The most cited cause in both contract sides is a poor communication system with a frequency of more than 20 times from 35 publications. This particular cause was reported as one of the most severe causes of rework (Mahamid, 2016) in residential buildings that frequently trigger the need for rework management (Eze et al., 2018a). An acceptable logic for that is because communication provides channels for exchanging information between involved parties (Ye et al., 2015). Design error is another common cause of rework that can be reduced when participants follow integrated mechanisms to manage documentation in the design process (Love et al., 2000).

4.1.2 Procurement stage

The procurement stage plays a critical role in the success of construction projects as the project's cost and time are affected by different procurement strategies (Love et al., 2000). The errors that appear in the design stage affect the procurement process and reduce the project performance (Love et al., 2010a). Procurement is a stage between design and construction and generally overlaps with both stages. The overlapping of procurement with design and construction stages creates higher uncertainties during contract preparation (Yeo and Ning, 2002). Since procurement follows the

TABLE 2 Rework causes classification in design stage—liable to the client-side of the contract.

	Rework root causes	Code	Covered by references	Sum
1	Poor communication system	DET1	[2,5,6,7,9,10,11,12,15,16,17,18,19,21,24,27,28,29,30,33]	20
2	Changes, modification, and revisions	DEP1	[1,2,3,4,7,8,9,10,11,13,15,18,19,22,24,25,30,31,33]	19
3	Financial issues and lack of funding	DEG1	[2,5,6,7,9,11,12,13,16,17,18,19,21,24,28,29,30,31]	18
4	Conflicting and incomplete information	DET2	[1,3,5,6,9,11,14,15,16,17,18,19,22,23,24,26]	16
5	Lack of client involvement	DEG2	[2,5,6,7,8,9,12,16,17,19,21,25,26,28,29,30]	16
6	Lack of experiences and personal expertise	DEH1	[2,5,6,7,8,9,12,14,16,18,19,21,28,29,30]	15
7	Lack of education and poor knowledge of team	DEH2	[2,5,6,7,8,9,10,12,16,19,21,28,29,30,32]	15
8	Time pressure to complete design tasks	DEG3	[2,7,8,9,11,12,14,18,19,21,23,28,29,30]	14
9	Inefficient management	DET3	[8,10,11,13,17,18,24,31]	8
10	Inadequate planning and poor scheduling of workload	DET4	[7,8,9,10,11,14,18,19]	8
11	Lack of skill	DEH3	[3,8,10,14,17,21,24]	7
12	Defective material, non-adherence to material spec	DEM1	[1,3,10,13,14,20]	6
13	Ineffective use of quality management practices and deviation or failure due to poor monitoring	DET5	[7,8,9,11,14,18]	6
14	Incomplete design, omission in design, drawings, spec	DEP2	[3,7,8,9,10,19]	6
15	Lack of documents control	DEP3	[3,10,18,23,32]	5
16	Inadequate supervision staff	DEH4	[3,9,14,19,27]	5
17	Error in design, drawings and specifications	DEP4	[7,8,9,15,19]	5
18	Poor technology application and lack of IT use	DET6	[7,8,9,17,18]	5
19	Conflict of interest	DEH5	[11,20,24,31]	4
20	Inappropriate personal attitude	DEH6	[8,10,24]	3
21	Lack of employee motivation and rewards	DEH7	[8,10,24]	3
22	Unclear line of authority	DEG4	[20,24]	2
23	The absence of job security and other safety rules	DEH8	[20,24]	2
24	Unanticipated consequences of change	DEG5	[8]	1

design stage of the project, it sometimes is called post design. In some other studies, procurement has been referenced as the pre-construction stage (Love and Sing, 2013). During the procurement stage, documents from design stage are collated to perform tenders till contract awards. In the construction industry, procuring the required equipment and material is part of the contractor's main responsibility (Habibi et al., 2018). Thus, the procurement stage in some projects involves supplying materials and equipment. All relevant items from previous research studies were carefully reviewed and analysed, then placed in a single list. Table 4 comprises seven root causes of rework from the client-side of the contract concerning their code number, references and numbers of citations over various studies.

The procurement method is the primary element of the project that is influenced by rework causes (Love et al., 2010a). The evidence of rework root causes at this stage revealed that only the three categories of process, technical, and general/external related factors appeared in both sides of the contract, and there is no evidence of studying the other two categories in previous research. An investigation into the categories of human resources and material/equipment from the procurement perspective in the future would benefit the projects. As such, further studying of the following items will contribute to the body of knowledge: lack of manpower, staff motivation, inadequate knowledge and experience from the category of human resources factors, lack of information technology use and lack of attention to quality from the category of technical factors in addition to political effects from the category of general/external related factors. Similar to the design stage, the total number of rework root causes from the client-side of the contract is higher than the contractor side. Table 5 comprises five root causes of rework from the contractor side concerning their code number, references and numbers of citations over various studies.

Poor contract documentation and omission of items in the contract are the highly-cited causes of rework under the client-

TABLE 3 Rework causes classification in design stage—liable to the contractor-side of the contract.

	Rework root causes	Code	Covered by references	Sum
1	Poor communication system	DST1	[1,2,5,6,7,8,9,10,11,14,15,18,22,23,24,25,26,28,29,30,31,32,33,35]	24
2	Inadequate planning and poor scheduling of design resources	DST2	[1,2,3,5,6,7,8,9,10,12,14,16,20,23,25,28,29,35]	18
3	Design changes in any form	DSP1	[3,4,7,8,9,10,11,15,18,20,22,23,25,28,29,30,31]	17
4	Time pressure to complete design tasks	DSG1	[3,5,6,7,8,9,11,12,14,16,23,24,27,28,29,35]	16
5	Poor technology application and lack of information technology use	DST3	[2,5,6,7,8,9,11,12,16,17,18,23,28,29,30,35]	16
6	Ineffective use of quality management practices and deviation or failure due to poor monitoring	DST4	[2,5,6,7,8,9,10,11,12,14,16,23,27,29,35]	15
7	Design errors in any form	DSP2	[3,7,8,9,10,11,15,22,23,24,25,28,29,31]	14
8	Inefficient management and ineffective coordination	DST5	[8,10,12,15,16,17,24,27,28,29,32]	11
9	Omission in design process and incomplete design information	DSP3	[1,3,8,10,11,15,22,23,24,25,31]	11
10	Lack of experiences and personal expertise	DSH1	[7,8,9,11,14,17,18,23,25,26,32]	11
11	Lack of skill	DSH2	[3,8,9,10,23,24,26,28,29,30,32]	11
12	Lack of education and poor knowledge of team	DSH3	[7,8,9,10,14,17,20,23,24,26]	10
13	Inadequate manpower to complete the task	DSH4	[2,5,6,7,8,9,12,16,25,35]	10
14	Labor reallocation, alteration and staff turnover	DSH5	[2,5,6,7,8,9,12,16,35]	9
15	Lack of document control	DSP4	[3,10,14,22,23,32]	6
16	Poor project documentations	DST6	[10,20,22,23,24]	5
17	Financial issues and lack of funding, cost pressure	DSG2	[17,20,24,25,26]	5
18	Lack of employee motivation and rewards	DSH6	[8,10,20,24,32]	5
19	The absence of job security and other safety rules	DSH7	[8,20,22,24,32]	5
20	Non-attention to constructability problems raised at early stages	DSG3	[5,6,15,23]	4
21	Inappropriate personal attitude	DSH8	[8,10,24]	3

TABLE 4 Rework causes classification in procurement stage—liable to the client-side of the contract.

	Rework root causes	Code	Covered by references	Sum
1	Poor contract documentations, missing documents	PET1	[2,4,7,8,9,11,12,16,17,18,19,23,25,26,27,28,29,30,31,33]	20
2	Time pressure, insufficient time to prepare contract documentation	PEG1	[2,5,6,7,8,9,12,17,19,25,26,28,29,30,35]	15
3	Incomplete design at the time of tender	PEP1	[2,5,6,7,9,12,19,25,26,28,29,30]	12
4	Financial issues such as low fees for preparing contract documents	PEG2	[2,9,12,21,28,29,30]	7
5	Improper contractor selection	PEP2	[8,11,12,21,22]	5
6	Errors made in the contract documentation	PEP3	[2,4,7,9,30]	5
7	Incomplete information at the time of award	PET2	[5,6,8,11]	4

procurement cluster with the frequency of 20 times over publications. Under the cluster of contractor-procurement, two other causes, namely "ambiguity in contract due to conflicting and incomplete information" and "improper subcontractor selection," were prevalent as the most studied items over 10 publications. Ambiguous scope in the contract documents results in poor contract management and leads to rework (Ye et al., 2015). Employing qualified contractors has been pointed out as the key contributing factor of the industry's success (Chan et al., 2020).

4.1.3 Construction stage

However, many research studies have emphasized the importance of the design stage in the process of construction

TABLE 5 Rework causes classification in procurement stage—liable to the contractor-side of the contract.

	Rework root causes	Code	Covered by references	Sum
1	Conflicting and incomplete information, ambiguity of items from contract documentation	PST1	[5,6,14,15,17,28,29,30,33,35]	10
2	Improper subcontractor selection	PSP1	[4,5,6,8,11,12,19,22,25,34]	10
3	Poor project documents	PST2	[5,6,15,23,28,29,30,33]	8
4	Inadequate procurement method, poor contract execution	PSP2	[8,11,15,22,23,24,31]	7
5	Financial issues such as low contract fees	PSG1	[7,9,15,33]	4

TABLE 6 Rework causes classification in construction stage—liable to the client-side of the contract.

	Rework root causes	Code	Covered by references	Sum
1	Lack of knowledge of construction	CEH1	[2,5,6,7,8,9,10,12,14,16,19,20,21,24,26,28,29,30]	18
2	Lack of experience and personal expertise	CEH2	[2,5,6,7,8,9,10,12,14,16,17,19,21,26,28,29,30]	17
3	Financial issues and cost pressure	CEG1	[2,3,7,8,9,11,12,13,15,18,24,26,33]	13
4	Changes or modification in the construction process or after completed work	CEP1	[1,3,4,7,8,9,11,13,18,22,24,34]	12
5	Lack of client involvement	CEG2	[2,5,6,7,8,9,11,17,25,26,28,29]	12
6	Lack of constructability	CEG3	[3,5,6,15,17,20,24,26,28,29,31]	11
7	Inadequate construction planning and poor planning of workload	CET1	[3,7,8,9,10,11,12,14,17,18,24]	11
8	Ineffective management practice	CET2	[8,11,13,14,18,22,24,31]	8
9	Conflicting and incomplete information	CET3	[1,8,11,14,15,18,22,24]	8
10	Defective materials	CEM1	[1,8,10,13,14,20,32]	7
11	Ineffective use of quality management practices and deviation or failure due to poor monitoring	CET4	[7,8,9,11,14,18,24]	7
12	Poor technology application and lack of IT use	CET5	[7,8,9,12,17,26]	6
13	Changes in government regulations, laws, and policies	CEG4	[15,20,24,31]	4
14	Unpredictable factors from different sources	CEG5	[8,15]	2

projects, yet most problems such as delay, and cost overruns were raised from rework within the construction stage. Construction commencement before design completion affects the project's performance as the overlapping of these two stages transfers the impact of design errors to the job site thus, increasing the time and cost of the project (Habibi et al., 2018). The previous classification systems of rework under construction group included contractor-related factors, site management, and subcontractor factors (Palaneeswaran et al., 2005). In this study, all previously identified items under these categories and other related factors were compared to provide the following single list of rework root causes at the construction stage. Table 6 consists of 14 root causes from the client side of the contract concerning their code number, references and numbers of citations over various studies.

The findings of rework root causes in the construction stage of a project revealed that, as with the design stage, all categories of causes are in existence in both contract sides. The highest number of rework causes in this stage has fallen in the technical category following by the general/external related factors. The other most frequent cause of rework in this stage is human resources in the contractor side; however, the number of causes in this category from the client-side is deficient. In contrast to the pre-mentioned stages, the total number of rework root causes from the contractor side is higher than the client-side. This evidence implies that previous studies have mostly focused on the contractor side as they have been more involved in this project stage. Reducing the causes of rework in the construction stage improves the performance of construction firms by cost saving (Love and Li, 2000). Table 7 comprises 27 root causes of rework from the contractor side of the contract concerning their code number, references and numbers of citations over various studies.

Under the cluster of client-construction, lack of knowledge was the most identified cause by 18 publications. Lack of client knowledge has been introduced as the root causes of many problems in construction projects (Trach et al., 2019). The used of skilled and experienced professionals by both contract parties throughout different project stages also had been recommended to achieve free rework construction (Eze et al., 2018b). Ineffective use of quality management with 25 citations is listed first under the cluster of construction-contractor as well as the highest frequency

TABLE 7 Rework causes classification in construction stage—liable to the contractor-side of the contract.

	Rework root causes	Code	Covered by references	Sum
1	Ineffective use of quality management practices and deviation or failure due to poor monitoring	CST1	[2,3,4,5,6,7,8,9,10,11,12,14,15,18,19,20,22,24,25,27,28,29,31,32,33]	25
2	Inadequate construction planning and poor planning of workload	CST2	[1,2,3,4,5,6,7,8,9,10,12,14,17,20,22,24,25,26,28,29,30,33]	22
3	Lack of skills in both labour and supervisory levels	CSH1	[2,3,4,5,6,8,10,12,16,17,19,20,22,24,25,27,28,29,30,32,34]	21
4	Damage, defect or deviation of products due to carelessness and poor safety consideration	CSG1	[2,4,5,6,7,8,9,11,12,15,16,17,18,19,22,26,28,29,31,34]	20
5	Use of poor-quality material and substandard products	CSM1	[1,2,4,5,6,8,9,11,12,15,16,17,18,19,20,25,26,31,32,33]	20
6	Construction error	CSP1	[2,4,5,6,7,8,9,11,12,15,16,18,19,22,25,28,29,31,34]	19
7	Ineffective management practice and poor site management	CST3	[3,8,11,14,15,16,17,18,19,22,24,25,26,27,28,29,33,34]	18
8	Changes or modification in the construction process or after completed work	CSP2	[2,4,5,6,7,8,9,11,15,16,18,22,28,29,30,31,33,34]	18
9	Poor site condition, environmental conditions	CSG2	[5,6,8,15,17,19,20,22,24,26,27,28,29,31,32,33,34]	17
10	Poor workmanship approach and inappropriate personal attitude	CSH2	[1,5,6,8,10,16,17,18,19,20,24,26,28,29,30,31,34]	17
11	Lack of knowledge, unqualified technical staff due to lack of training	CSH3	[7,8,9,10,14,17,20,22,24,26,28,29,30,31,32]	15
12	Poor communication system	CST4	[7,8,9,10,14,15,17,19,22,24,25,31,32,33,34]	15
13	Labour reallocation, alteration and staff turnover	CSH4	[2,4,5,6,7,8,9,12,17,19,22,26,28,29,34]	15
14	Schedule acceleration, time pressures	CSG3	[3,7,8,9,14,15,17,20,22,24,25,26,28,29]	14
15	The omission of some tasks during construction	CSP3	[2,4,5,6,7,8,9,11,17,22,26,30,31,34]	14
16	Poor technology application and lack of information technology use	CST5	[2,4,5,6,7,8,9,12,15,17,24,26,27]	13
17	Defective or damaged materials	CSM2	[1,3,8,10,11,15,18,20,24,25,27,31]	12
18	Inexperienced personnel	CSH5	[7,8,9,14,17,22,25,26,28,29,32]	11
19	Replacement or misplacement of material	CSM3	[1,10,14,15,20,24,28,29,30,31]	10
20	Use of inefficient equipment	CSM4	[1,10,15,19,20,24,25,27,33,34]	10
21	Financial weakness such as inadequate funding, cost pressure	CSG4	[3,8,15,20,22,24,25,26,32,33]	10
22	Conflicting and incomplete information	CST6	[3,8,14,20,22,25,26,28,29,33]	10
23	Lack of motivation and care, Carelessness	CSH6	[8,10,19,20,22,24,32,34]	8
24	Untimely deliveries of material and equipment	CSM5	[1,3,8,10,20,24,25]	7
25	Lack of manpower to complete the tasks	CSH7	[7,8,9,17,26,31]	6
26	Poor project documents	CST7	[8,20,22,24]	4
27	Unpredictable factors from different sources	CSG5	[8,15]	2

among all identified rework causes throughout the project. This is aligning with the previous research directions that rework is due to the lack of quality focus (Love et al., 1999). However, quality management does not correspond to previous studies' outcomes as none of them have highlighted quality related factors in the list of top rework causes.

5 Discussion

Classification of the identified rework causes is the first required step of rework management (Palaneeswaran et al., 2005). This study presents an extensive literature review of rework causes related to both sides of the contract and the three project stages. Most previously generated classification methods are comparable as they almost follow the same pattern. Thus, achieving a comprehensive categorization scheme for classifying rework causes is implicitly possible. Researchers have used different phrases to present the same rework causes in the literature. This study carefully surveyed each identified item from different sources to bring together the most interrelated concepts of the causes. For example, excessive overtime (Robinson et al., 2004), fixed time for a task (Palaneeswaran, 2006; Miri and Khaksefidi, 2015), time boxing (Love et al., 2010b), schedule pressure (Enshassi et al., 2017), accelerating or shortening the schedule (Ye et al., 2015), and insufficient time for activities (Wilson and Odesola, 2017) are

TABLE 8 List of rework causes in three stages of the project with liable contract parties.

Project stages			Design		Procurement		Construction	
Contract parties			Client	Contractor	Client	Contractor	Client	Contractor
Group factor	Rework root causes	Code	DE	DS	PE	PS	CE	CS
Process	Changes, modification and revisions in design/ construction changes		P1	P1	—	—	P1	P2
	Error in design, drawings and specifications/ construction error		P4	P2	P3	—	—	P1
	Incomplete design, any omission in the design or construction process		P2	P3	P1	—	—	P3
	Inadequate procurement methods/poor contract execution		—	—	—	P2	—	—
	Improper contractor and subcontractor selection		—	—	P2	P1	—	—
	Lack of document control		P3	P4	—	—	—	—
Human Resources	Lack of experience and personal expertise in design and construction		H1	H1	—	—	H2	H5
	Inadequate supervision staff		H4	—	—	—	—	—
	Inadequate manpower to complete the task		—	H4	—	—	—	H7
	Lack of skills		H3	H2	—	—	—	H1
	Poor knowledge of team member, lack of education and training		H2	H3	—	—	H1	H3
	Lack of employee motivation and rewards		H7	H6	—	—	—	H6
	Poor workmanship approach and inappropriate personal attitude		H6	H8	—	—	—	H2
	The absence of job security and other safety rules		H8	H7	-	-	-	-
	Labor reallocation, alteration and staff turnover		—	H5	—	—	—	H4
	Conflict of interests		H5	—	—	—	—	—
Material/Equipment	Defective materials, Non-adherence to material specifications		M1	—	—	—	M1	M2
	Poor-quality material or substandard products/ Prefabrication errors		—	—	—	—	—	M1
	Replacement or misplacement of material		—	—	—	—	—	M3
	Inefficient equipment use		—	—	—	—	—	M4
	Untimely deliveries of material and equipment		—	—	—	—	—	M5
Technical	Ineffective use of quality management practices/ deviation due to poor monitoring		T5	T4	—	—	T4	T1
	Poor technology application and lack of information technology use		T6	T3	—	—	T5	T5
	Poor communication system for coordinating between members		T1	T1	-	-	-	T4
	Inefficient management process, poor site management practice		T3	T5	-	-	T2	T3
	Poor project documents, such as poor contract documents		—	T6	T1	T2	—	T7
	Conflicting and incomplete information		T2	—	T2	T1	T3	T6
	Inadequate planning and poor scheduling of workload		T4	T2	—	—	T1	T2

(Continued on following page)

TABLE 8 (*Continued*) List of rework causes in three stages of the project with liable contract parties.

Project stages			Design		Procurement		Construction	
Contract parties			Client	Contractor	Client	Contractor	Client	Contractor
Group factor	Rework root causes	Code	DE	DS	PE	PS	CE	CS
General/External	Financial issues such as lack of funding, low contract or payment fee, delay in payment and cost pressure		G1	G2	G2	G1	G1	G4
	Lack of client involvement		G2	-	-	-	G2	-
	Unclear line of authority		G4		—	—	—	—
	Time pressure, schedule acceleration to finish the task, insufficient time to prepare contract documentation		G3	G1	G1	—	—	G3
	Lack of constructability		—	G3	—	—	G3	—
	Damage/defects/deviations in the product due to poor handling and safety considerations		—	—	—	—	—	G1
	Governmental regulations and policies		—	—	—	—	G4	—
	Environmental conditions		—	—	—	—	—	G2
	Unpredictable factors from different sources		G5	—	—	—	G5	G5

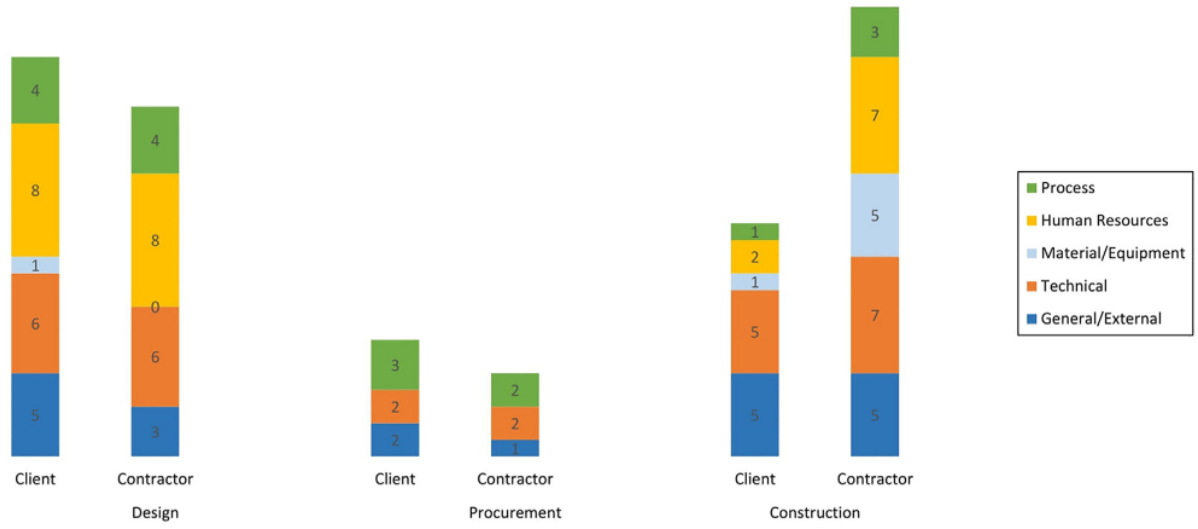

FIGURE 4
Distribution of rework factors in three stages of project.

recorded as one identified cause under the time related concerns. Tables 2–7 show classified rework causes based on collected data from previous studies, and Figure 4 has summarized the number of causes based on the proposed classification model. As shown in Figure 4, interest for studying causes of rework under the construction stage of a project was slightly higher than at the design stage. Both construction and design were constantly studied more than the procurement stage.

Following the proposed classification model, all identified causes of rework are clustered throughout the project stages. An overview of all identified rework causes in each project stage has been displayed in Table 8. This table comprises a list of 37 collected rework causes which are categorized into five primary constructs. The process related factor is involved with the projects' main activities. The human resources related factor deals with the human attributes. The material/equipment related factor supplies the project requirement. The

technical related factor contributes to the supporting project activities, and the general/external related factor covers outsource items or causes that cannot be categorized under the four previously stated constructs. Referring to the nature of each construct, six causes were classified under process, 10 under human resources, five under material/equipment, seven under technical, and nine under the general/external category. Each category's underlying causes in the three project stages were placed under liable contract parties with the same reference code from Tables 2 to 7. Therefore, coding numbers in each cause does not show an in-order pattern. For example, in the process category, changes are listed first under the cluster of design-client with reference code of DEP1, while under the cluster of construction-contractor, errors are listed first with reference code of CSP1. The listing of rework causes in each category is based on the citation frequencies, and simultaneously it is assumed as an index for sorting the identified causes. Obviously, the higher number of citations does not indicate higher occurrence probability but depicts higher research interests.

In the design stage, the number of identified causes of rework in the client side of the contract is higher than contractor side and it is not surprising because the client involvement during design has been known as the primary contributor (Love et al., 2010b; Forcada et al., 2016; Mahamid, 2016; Yap et al., 2017; Eze et al., 2018b). The distribution of rework causes in both sides of the contract under this stage in Table 8 shows a total number of 28 out of 37 identified causes. Nearly all five categories under the cluster of client-design were cited as highly relevant, while the material/equipment related factor under the cluster of contractor-design seemed to be absent in previous studies.

Procurement is the other important stage that affects project performance thereby contributing to rework occurrence (Forcada et al., 2017). In the procurement stage, two categories of human resources and material/equipment were undeniably missed in previous studies. The reasons for lack of research in this area needs to be investigated, whether due to the selected procurement strategy by the projects or redundancy. Research interests for assessing rework causes under the procurement stage in Table 8 have identified eight items out of 37 causes. Most of them deal with contract management in different ways (Ye et al., 2015). Who accepts the responsibility of rework is defined fundamentally in the contract (Love et al., 2006). The lower number of studies on rework causes in this stage is probably linked to the defined delivery system of projects that mostly merges two stages of design and construction together. This was aggravated by improper implementation of procurement strategies that have not been adopted widely at the design stage (Salihu and Babarinde, 2020). Even though the procurement stage is listed with low citation frequencies, the underlying causes in both clusters under procurement are very critical in rework management (Al-jababi et al., 2020). More collaboration between contract parties results in early identification of rework causes and provides better solutions to prevent reoccurrence of rework (Taggart et al., 2014) at this stage.

Construction as the other stage of a project presents different results. However, it encompasses 30 identified causes over 37 listed items; distribution of the causes in both contract sides is not equally balanced. While the contractor has more contribution to the causes of rework, the other side takes half of the causes in terms of quantity. It is because the contractor plays the main role at this stage. However, the three categories of process, human resources, and material/equipment, present a small number of causes under the client's side of the contract, they become more predominant at the other side.

6 Conclusion

The study aimed to identify and classify rework root causes in the main stages of a project to facilitate a better understanding of rework with liable parties of the construction contracts. To achieve the study's aim, a comprehensive review of the literature on the sources of rework was conducted. Reduction of the rework impacts has received extensive attention over the years but rework nonetheless continues to exist (Hwang et al., 2009; Love et al., 2015) probably because the effects of rework have not been integrated in the main stages of a project (Xue et al., 2010). Although interest in reviewing the topic of rework has increased in recent years, a systematic review on rework root causes under three main stages of a project with liable sides of the contract remained undiscovered. Based on the structured method used in this study, a total of 157 papers were identified directly relevant to rework in construction projects. The aggregated publications then were systematically reviewed. The causes of rework were identified through a detailed analysis of selected publications from academic journals and conference. This paper presented a list of 37 rework root causes that have been integrated into a structured classification model. The proposed classification model was applicable to three stages of a project and two liable contract parties.

The summarized result in Table 8 is the main contribution of this study and it illustrates a diversity of rework root causes in a wider perspective. The proposed model shows a full picture of rework root causes in six clusters generated from three project stages and two contract sides. Thus, it alleviates the combination of different levels used in previous classified methods. The proposed model adds value to the existing knowledge as it shows the area of rework studies which has not been explored yet. Compared with previous methods, this model shows rework causes under each project stage linked to the liable contract parties. The result contributes to the theory by proposing a model and classified list of causes. This list will be used to investigate rework in the construction contracts that bridges the existing knowledge gap by addressing rework causes in the contract conditions. Thus, finding of this study contributes to the contract management body of knowledge. The classified rework causes from this study will be used as a platform for further investigation of the contract to improve contractual terms and conditions by addressing rework issues. Improving contract conditions of construction projects prevents rework issues and will result in fewer contractual claims and disputes. The classified causes of rework will also be used as a guideline for construction projects to regulate and adopt more reliable strategies on rework management. It displays the distribution of causes in both sides of the contract and offers opportunities for further practical research.

The topmost frequently cited rework causes in the reviewed papers include, but are not limited to, ineffective use of quality management practices, poor communication systems, inadequate construction planning, insufficient skills in both labour and supervisory levels, damage, defect or deviation of products due

to carelessness and poor safety consideration, use of poor-quality material, and poor contract documentations. The comparison between categories reflected that all stages of a project had not been covered thoroughly with the identified causes. Rework at the construction stage includes the most frequent causes, whereas procurement shows fewer identified causes. However, the result of critical analysis has adequate evidence in each project stages, more focus on studying of the procurement stage is recommended. Since the proposed model needs validation in various contexts, the next step of research will investigate this purpose through a questionnaire survey that examines the effects of rework on contractual claims. Contract documents as the main output of the procurement stage define parties' authorities. Incorrect contract information is presumed to lead rework occurrence (Kakitahi et al., 2014). Searching the relationship between contract clauses and rework within various project stages would benefit future models of rework management by developing a framework that is capable to evaluate contracts in terms of identified rework causes (Mendis et al., 2015; Asadi et al., 2022). Identifying rework from a contract party's perspective will result in higher awareness of client and contractor by recognizing the root causes of rework at the time of contract preparation.

In this paper, the review is limited to the identified causes of rework and does not cover the other aspects of measuring rework impacts. Future research on the identified gaps is recommended to provide a framework for more practical experiments and develop rework management trends. The result inspires further investigations specifically on the categories that have received less attention previously, such as the following areas of study:

- The material/equipment related factor of both sides of the contract at the design stage and the client-side of the contract at the construction stage.
- Human resources and material/equipment related factors of both sides of the contract at the procurement stage.

This paper has some other limitations as the approach used was on the matters related to the causes of rework to be investigated in the contracts. Contracts are the outcome of procurement, and various procurement options in projects may result in different types of contract. Since the causes of rework appear in construction projects regardless of their procurement routes, the result of this study is not subject to a specific type of contract. Therefore, further investigation of rework causes under different procurement approaches is advised in future studies. This paper is also limited to the project's design, procurement, and construction stages. Investigating the other stages such as operation, maintenance, and demolishing, is another area for future studies to complete the study of rework in the project life cycle. The approach used for sorting the identified causes under each stage of the project was based on the number of references from previous studies to show the level of interest from previous researchers. This approach is considered as another limitation to this research but based on the research needs; it can be justified by the inapplicability of measuring the severity of causes in this study. Lastly, even though the result of this paper cannot be generalized for various types of projects; nevertheless, it supports the next stage of the research to investigate addressing rework issues in the construction contracts.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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