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"Review study for rework causes in construction industry"

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ملخص البحث:
اعادة العمل هي ظاهرة عالمية في صناعة البناء والتشييد,والتي لايكاد اي مشروع بناء يخلو منها. تعتبر اعادة العمل احد المصادر الرئيسية لتجاوز الوقت وتكلفة المشروع, وعدم رضا الاطراف المشاركة.وطبقا لذلك,تم اجراء دراسة مستفيضة للادبيات لتحديد اسباب اعادة العمل. تم تحديد مامجموعة 81 عامل مسبب لاعادة العمل ,وتم تصنيفها الى خمسة مجموعات وهي,العوامل المتعلقة بالعميل, العوامل المتعلقة بالتصميم, العوامل المتعلقة بالمقاول,العوامل المتعلقة بالمقاول الثانوي(من الباطن), والعوامل المتعلقة بالقوى العاملة والاشراف. يتوجب على جميع الاطراف المعنية من المالكين ,المقاولين ,والاستشاريين النظر الى نتائج هذا البحث لمعرفة اسباب اعادة العمل, وبالتالي التقليل من حدوث اعادة العمل واثارة على اداء المشروع.

Abstract:

Rework is a global phenomenon in the construction industry, which is hard for any construction project to free from it. Rework is the main reason for time and cost overruns in construction projects, and dissatisfaction causes the parties involved in the project. Therefore, to reduce the rework occurrence and impact should be determined factors that causing rework in the construction project. Accordingly, a comprehensive literature review has been conducted to identify dominant factors causes of the rework. A total of 81 factors causes of rework were identified and categorized into the significant five groups were client-related factors, design-related factors, contractor related factors, subcontractor related factors, and the human capability and supervisory related factors. Stakeholders from clients, contractors, and consultants should consider the results of this research in order to reduce or avoid the occurrence and impact of the rework in construction projects.

1.Introduction

The construction industry is a global industry that contributed to increasing the national economy, for example in Palestine the construction industry contributes to the Gross Domestic Product (GDP) by about 26% (Mahamid, 2016), and in Egypt 15% (Gerges, 2015). However, the construction industry is still suffering from delays, cost overruns, and dissatisfaction of the parties concerned, the main reason for this is to rework.

Rework is defined as "Activities in the field that must be performed more than once or as activities which remove the works that previously installed in a field as part of the project" according to Construction Industry Institute (CII 2001). Rework is known as "non-conformance" or "quality deviations" (Abdul-Rahman 1995; Burati et al.1992). Besides, Zaiter (2014) defined rework as the unnecessary effort (people, material, time and equipment) of redoing a process or activity that was incorrectly implemented the first time or was not needed actually to complete the work.

Rework has a negative impact on project performance, where contributions to the cost and schedule overrun in construction projects (Shibnai, et al .2015; Love et al.2010; Hwang, et al. 2009). It is a significant source of cost overrun, quality degradation, time overrun (extension), contractual claims, disputes between contracted parties, design team dissatisfaction, end-user/client dissatisfaction, and contractor dissatisfaction in construction projects as a study conducted by (Eze and Idiake, 2018).

The cost of rework was estimated at 4.4% of the construction values of the observation period, and the time needed to correct them was 7.1% according to the case study by (Josephson et al.,2002) in Sweden. Additionally, Love et al. (2010) identified the cost of rework in civil infrastructure projects in Australia by accounted a 10% of the total contract value.

Many studies have been conducted to determine the causes of the rework in the construction industry in different countries such as (Mahamid 2016; Miri and Khaksefidi, 2015; Ajayi and Oyeyipo, 2015; Love et al.,2010; love et al., 2004b). Even so, several projects are stilled accompanied by rework. This is attributed to the ambiguity of the common causes of the rework, that different from country to others according to the culture of construction and extent of development of the construction industry in the country concerned. Accordingly, this study aims to conduct a comprehensive review of previous studies for different countries to determine the main causes of rework. Thus, reduce rework occurrence and its impact on construction project performance.

2.Previous studies

There are many research efforts undertaken to determine the causes of rework in the construction industry in different countries. Table 1 summarizes the technique, method of data collection, and the industry sector type targeted for each study conducted. Besides, Table 2 showing the summary top five factors causes of the rework for each study(country). The factors cause of the rework for the some of the previous studies of different countries will be excessive discussed, as described in the section below:

Aiyetan et al. (2013) examined the reasons for rework in public building projects in Nigeria. They indicated 71 rework factors and categorized into three groups related to the client, contractor, and design, based on the questionnaire survey. Their study concluded that wrongly laying of forming course (blockwork), poor quality of concrete, lack of correct interpretation of customer requirements, poor communication, and inadequate construction planning are the five major causes of construction rework.

Zeiter et al. (2017) studied the reasons for rework construction projects in the Caza strip, based on the questionnaire survey. They concluded that 57 reasons accounted for the construction rework, and categorized into 7 groups. Their findings indicated that the main reworks were due to, attempts to fraud by contractor, competitive pressure / low contract value, ineffective management and decision-making, schedule pressures construction process, and the absence of job security capability. Mahamid (2016) discussed causes of rework in residential buildings in West Bank, based on 86 contractor participants. He identified 43 causes of rework, and categorized them into five groups. his findings concluded to the major rework causes were the poor communication of client with the consultant and contractor, use of poor-quality material, poor site management, poor communication with the design consultant.

The causes of rework were studied by (Ye and Skitmore, 2014) regarding construction projects in China. They identified 39 major factors, based on 277

questionnaires, and categorized into 11 groups. According to their findings, the most significant factors were unclear and ambiguous project process management, poor quality of construction technologies used, use of poor construction materials, active rework made by the contractors to improve quality, and design error/omission because of too many design tasks and time boxing.

Simpeh (2012) studied the causes of the rework in construction projects in South Africa. He identified 43 causes of rework and categorized them into four groups related to client, design, site, and subcontractor. The most common causes of rework were non-compliance with the specification, low labour skill level, shortage of skilled labour, setting out errors, and changes made at the request of the client.

Jarkas et al. (2015) surveyed about the causes of rework in the building projects in Qatar. The survey included 36 causes of delay, which were grouped into 4 major categories related to the client ,designer, contractor, and exogenous. According to their findings, frequent changes during the construction phase, obscure contractual clauses and specifications, incomplete design details at the tendering stage, errors and omissions in design drawings, and shortage in skilled labour were the five most important causes of rework.

Raghuram and Nagavinothini (2016) studied the causes of rework in construction projects in India. In their study, they identified 40 causes of rework in India construction projects and categorized them into five groups related to the client, design, construction, site, and subcontractor. The most common causes of rework identified were errors due to inappropriate construction methods, shortage of skilled supervisors, low labour skill level, non-compliance with the specification, and lack of experience and knowledge of the design process.

Josephson et al. (2002) examined 7 different construction projects in Sweden. Hence, they identified 23 variables that cause the rework and categorized them into 6 groups. According to their findings, the five most important factors were erroneous workmanship, unsuitable or faulty design, lack of coordination, late deliveries, and mistakes in planning.

3. Categorization of Rework Factors.

Rework factors are classified into five common related groups, which were;1) client-related factors, 2) design-related factors, 3) contractors related factors,4) subcontractor related factors,5) human capability & supervisory related factors. The cause and effect (Fishbone) diagram are developed to show the main groups of rework causes, as shown in Figure 1.

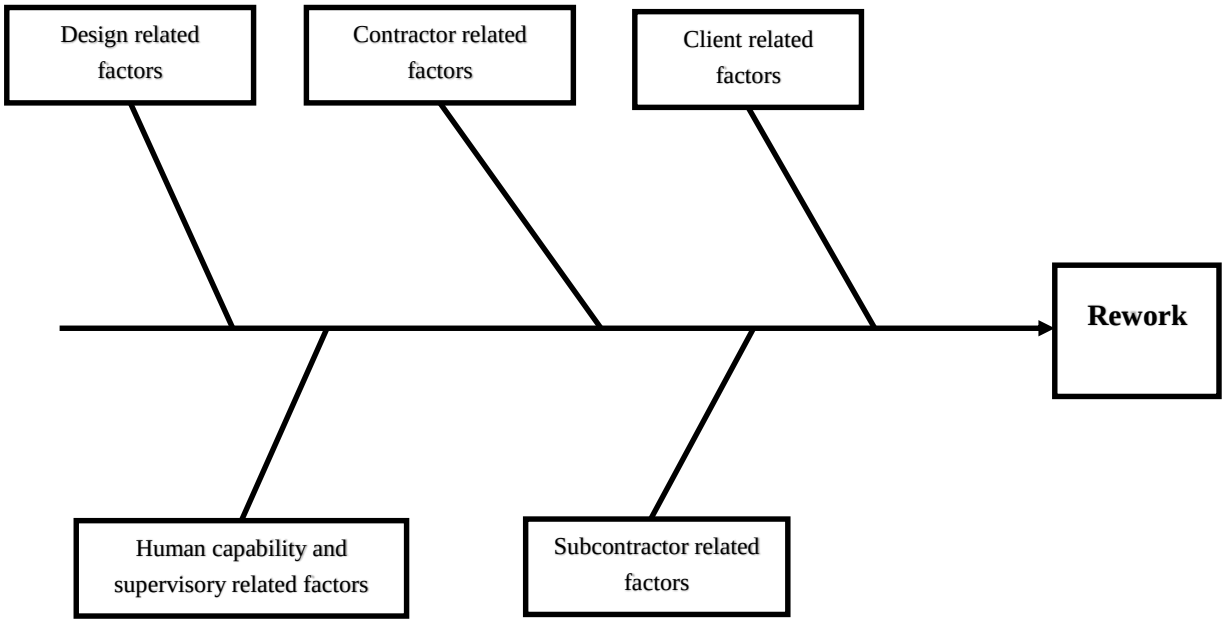

Figure 1. Fishbone diagram of rework groups

The rework factors will be discussed according to each related group in the following section, as described below.

3.1. Client related factors

The client is the most influential part of the decision-making process within the project and considers as a main source of construction rework according to (Mahamid et al.,2016; Jeffrey et al.,2017; Forcada & Edwards, 2016; Love & Edwards, 2010; Eze & Ganiyu,2018., etc.). Hence the variation orders by the client may be accompanied by a construction rework (Enshassi et al., 2010). The cost of rework only caused by client-related factors was estimated at 6% among total rework costs in Swedish Construction Industry (Josephson et al., 2002), and amounted 7.1% and 14.73% as other studies conducted by Hwang et al (2014) in Singapore and Liu and Peng, (2018) in residential buildings of China, at respectively.

Table 1. Summary previous studies of rework in construction projects.

Res. no.	Authors	Country	Year of public	Project owner	Project type	Method of data collection	No. of participants	No. of rework causes	No. of Rework causes groups	What asked for participants	Technique used to rank delay causes	Technique used to get rank
1	Aiyetan et al	Nigeria	2013	public	buildings	Questionnaires	Contracting (69), Consulting (17), Federal Ministry (6), State Ministry (12), and Developer (16)	71	3	Severity in 5 levels	Mean	No
2	Zeiter et al	Palestine (Gaza Strip)	2017	N/A	N/A	Questionnaire	Owner (40), Contractor (89), Consultant (46)	57	7	Importance in 5 levels	Relative Importance Index (RII)	Spearman rank correlation coefficient
3	Mahamid	Palestine (West Bank)	2016	N/A	residential	Questionnaire	Contractor (86)	43	4	Severity in 5 levels	Severity index (S.I.)	No
4	Ye and Skitmore	China	2014	N/A	N/A	e-mail, postal letters, and on-site distribution Questionnaires	277 Questionnaire	39	11	Importance in 4 levels	Mean and Std. Dev	No
5	Simpeh	South Africa (Cape Town)	2102	N/A	Most facility types: commercial (18.4%), residential (18.4%), industrial (15.8%), and educational (10.5%)	Mailed questionnaire	Contractors (30), quantity surveyors (17), architects (12), consulting engineers (12), and project managers (6)	38	4	Agreement in 5 levels	Mean and Std. Dev	No
6	Jarkas et al	Qatar	2015	N/A	Buildings	Questionnaire	Contractors (93)	36	4	Importance in 5 levels	Relative Importance Index (RII)	No
7	El Hussein	Dubai	2014	N/A	N/A	Mailed questionnaire	project managers (4), quantity surveyor (16), consulting engineers (4), contractor (20), and architect (6)	31	4	Agreement in 5 levels	Mean and Std. Dev	No
8	Mahamid	Palestine	2017	Public	22 Highway of projects	hand, fax, and email questionnaire	Contractor (40), Consultant (30)	19	1(no named)	Influence in 5 levels	Mean	Spearman rank correlation coefficient
9	Ajayi & Oyeyipo	Nigeria	2015	N/A	Buildings	Questionnaire	Contracting (19), Consulting (30), and Client (3)	26	3	Agreement in 5 levels	Mean score	No
10	Eze & Ganiyu	Nigeria	2018	N/A	N/A	Questionnaire	builders (32), quantity surveyor (61), 44 Architects (44), and civil engineers (51)	47	4	Frequency of occurrence in 5 levels	Mean	Kruskal-Wallis H test
11	Yap & Wang	Malaysian	2017	N/A	Residential, Commercial, Institutional, Industrial, and Mixed development buildings	Questionnaire	Clients (39), 36 consultants (36), and contractors (39)	18	5	Importance in 5 levels	Mean and SD	Kruskal-Wallis H test
12	Liu & Peng	China	2018	N/A	Residential	Case-based	Respondents from 6	35	11	daily logs of	Contribution of	No

						approach	projects the included relevant staff from clients, designers, developers, suppliers, and contractors.			implementation and supervision, meeting summary, monthly progress reports, and rework bills.	causes to rework costs (%)	
13	Raghuram & Nagavinothini	India	2016	N/A	N/A	Questionnaire	Project manager (25%), site engineer (30%), structural engineer (25%), and supervisor (20%) from 20 construction projects.	40	5	Influence in 5 levels	Mean score	No
14	Wilson & Odesola	Nigeria	2017	Public	Oil and Gas	Questionnaire	contractors (458), consultants (342)	22	1	frequency and influence in 5 levels	Mean score	Spearman rank correlation coefficient
15	Hwang et al	Singapore	2016	N/A	Green buildings	Mailed questionnaire	Contractors (13), Architects (5), Quantity surveyors (3), and Consultants (9)	8	3	Likelihood and impact in 5 levels	Mean score	Spearman rank correlation coefficient
16	Love et al	Australia	2010	Public	Civil Infrastructures	telephone and Mailed questionnaire	115 questionnaires of consulting engineers, project managers, and contractors	42	7	Predictors of cost for each cause from contract value.	Stepwise multiple regression	No
17	Hwang et al	Singapore	2014	N/A	Residential and Commercial	Questionnaire	Contractors (169), Clients (N 57)	7	1	frequency of occurrence and contribution to client-related rework (CRR) in 5 levels	Mean	Spearman rank correlation coefficient
18	Josephson et al	Sweden	2002	Private and Public	Museum, School, University building, Housing, Industry, Fire station, and Shopping centre	Case-based approach	7 construction projects	23	6	variation registers, site instructions, requests for information, final accounts, progress reports, and extension of time claims.	Contribution of causes to rework costs (%)	No
19	Idowu & Aligamhe	Nigeria (Edo state)	2015	Public	Buildings	Questionnaire	Quantity Surveyor (17), Architecture (10), Civil Engineer (22), and Builder (16)	20	5	Importance in 5 levels	Mean	No

Table 2. Summary outcomes of previous studies of rework in construction projects.

Res. No.	Authors	Country	Year	Rework groups	Top five causes of rework
1	Aiyetan et al	Nigeria	2013	1- Client 2-Contractors 3-Design	1-Wrongly laying of forming course (block work) 2- Poor quality of concrete 3-lack of correct interpretation of customer requirements 4-Poor communication 4- Inadequate construction planning
2	Zeiter et al	Palestine (Gaza Strip)	2017	1- Contractor related causes 2- Human resource capability related causes 3- Design related causes 4- External environment related causes 5- Client related causes 6- Materials and equipment supply relate causes 7- Construction process related causes	1-Attempts to fraud by contractor 2-Competitive pressure / low contract value 3-Ineffective management and decision-making 4-Schedule pressures construction process 5-The absence of job security capability
3	Mahamid	Palestine (West Bank)	2016	1- Client-related factors 2- Contractor-related factors 3- Consultant-related factors 4- Environmental factors	1- Poor communication with the consultant 2- Poor communication with the contractor 3- Use of poor-quality material 4- Poor site management 5- Poor communication with the design consultant
4	Ye and Skitmore	China	2014	1- Contractor field management 2- External environment 3- Contract management 4- Subcontractor management 5- Design management 6- Project communication management 7- Project plan changes 8- Changes for quality improvement 9- Client management 10- Project scope management 11- Project process management	1- Unclear and ambiguous project process management 2- Poor quality of construction technologies used 3- Use of poor construction materials 4- Active rework made by the contractors to improve quality 5-Design error/omission because of too many design tasks and time boxing
5	Simpeh	South Africa (Cape Town)	2012	1- Client 2- Design 3- Site 4- Sub-contractor	1- Non-compliance with specification 2- Low labour skill level 3- Shortage of skilled labour 4- Setting out errors 5- Changes made at the request of the client
6	Jarkas et al	Qatar	2015	1- Client 2- Designer 3- Contractor 4- Exogenous	1- Frequent changes during the construction phase 2- Obscure contractual clauses and specifications 3- Incomplete design details at the tendering stage 4- Errors and omissions in design drawings 5- Shortage in skilled labour
7	El Hussein	Dubai	2014	1- Client 2- Design 3- Site 4- Sub-contractors	1- Specification non-compliance 2- Low level of labor skill 3- Shortage of skilled labor 4- Setting out of errors 5- Defective workmanships
8	Mahamid	Palestine	2017	Nineteen causes of rework were selected	1- Non-conformance with specification requirements 2- Scope changes 3- Late design changes 4- Lack of labor skills 5- Improper subcontractor selection
9	Ajayi & Oyeyipo	Nigeria	2015	1- Client related causes 2- Design related causes 3- Subcontractor related causes	1- Poor communication with design consultant 2- Use of poor-quality materials 3- Poor workmanship 4- Lack of experience and knowledge of design and construction process 5- Incomplete design as at time of design
10	Eze & Ganiyu	Nigeria	2018	1- Client 2- Design 3- Contractor 4- External	1- Unclear instruction to workers 2- Shortage of skilled supervisors 3- Incomplete and inaccurate information 4- Errors in Setting out

					5- Contractor's Ineffective use of quality management practices
11	Yap & Wang	Malaysian	2017	1- Project coordination management 2- Technology, machines and material management 3- Project implementation management 4- Design process management 5- Site workmanship management	1- Poor coordination among design team 2- Poor quality management by contractor 3- Poor sub-contractor management 4- Construction errors due to misunderstanding of design 5- Unclear project management process
12	Liu & Peng	China	2018	1- Contractor field management 2- External environment 3- Contract management 4- Subcontractor management 5- Design management 6- Project communication management 7- Project plan changes 8- Voluntary rework 9- Client management 10- Project scope management 11- Project process management	1- Lack of communication between client and project users 2- Overfull design assignment with limited time leading to mistake of design 3- Erroneous or contradictory instructions 4- Ineligible technique 5- Insufficient on-site constructional conditions
13	Raghuram & Nagavinothini	India	2016	1- Client 2- Design 3- Construction 4- Site 5- Subcontractor	1- Errors due to inappropriate construction methods 2- Shortage of skilled supervisors 3- Low labour skill level 4- Non-compliance with specification 5- Lack of experience and knowledge of the design process
14	Wilson & Odesola	Nigeria	2017	1- Design-related causes	1- Error and omission in design document 2- Ineffective communication 3- Lack of site verification by design team prior to detailed design 4- Design changes 5- Lack of as-built documentation
15	Hwang et al	Singapore	2016	1-Change 2-Omossions 3-Errors	1-Owner change 2-Design error/omission 3-Design change 4-Contractor’s error/omission 5-Contractor change
16	Love et al	Australia	2010	1-Design 2-Contract management 3-Designer 4-Client management 5- Site management 6-Contractor 7-Subcontractor	1- Ineffective use of IT by design team members 2- Lack of client involvement in the project 3- Working procedures and communication lines were clearly defined 4- Change(s) made at the request of the client 5- Change(s) initiated by the contractor to improve quality
17	Hwang et al	Singapore	2014	1- Client-related rework	1- Change of plans or scope by the client 2- Inadequate/incomprehensive project objectives by the client 3- Change in specification by the client 4- Impediment in prompting the decision making of the client 5- Replacement of materials by the client
18	Josephson	Sweden	2002	1-Client 2-Workmanship 3-Production management 4-Design 5-Mechine 6-Materail	1- Erroneous workmanship 2- Unsuitable or faulty design 3- Lack of coordination 4- Late deliveries 5- Mistakes in planning
19	Idowu & Aligamhe	Nigeria (Edo state)	2015	1- Leadership and Communications 2- Human Resource Capabilities 3- Engineering and Review 4- Construction Planning and Scheduling 5- Materials and Equipment Supply	1- Noncompliance with specifications (Materials and Equipment) 2-Incompetent supervision and poor job planning 3-Unclear work specifications 4-Ineffective management of project team 5-Insufficient skill levels

Hwang et al (2014) they investigated about causes of rework related to the client in seven different construction projects in Singapore. Their findings are concluded to that *"replacement of materials by the client"* and *"change of plans or scope by the client"* are contributed most to client-related rework and exerted most impact. As a study carried out by Mahamid (2016) to analysis the causes of the rework in Palestine residential building projects, it was identified eight-factor related to the client, and his findings concluded that the two major causes notable are the poor communication of the client with the consultant and poor communication of the client with the contractor. Additionally, Jarkas et al, (2015) demonstrated that "poor client brief" was the main factor causing of the rework in building projects of Qatar. Table 3 showing the summary of 17 factor causes of rework related to the client, and that identified from a survey of some previous studies.

Table 3. Factors of rework related to client.

No	Factor causes of rework	Sources
1	Lack of client participation during design and construction processes	Mahamid (2016); Miri & Khaksefidi (2015); Ajayi & Oyeyipo (2015); Raghuram & Nagavinothini (2016); Love et al. (2010); love et al.(2004b)
2	Insufficient knowledge and experience for the construction and design process	Mahamid (2016); Miri & Khaksefidi (2015); Ajayi & Oyeyipo (2015); Zeiter et al (2017); Raghuram & Nagavinothini (2016); Love et al. (2010); love et al.(2004b)
3	Lack of funding for consultations and site investigation	Mahamid (2016); Miri & Khaksefidi (2015); Ajayi & Oyeyipo (2015); Zeiter et al. (2017); Raghuram & Nagavinothini (2016); love et al.(2004b); love et al.(2004b)
4	Delay in providing site requirements to Contractors, such as water and electricity	Ye and Skitmore (2014)
5	Poor coordination and communication with design consultants	Mahamid (2016); Miri & Khaksefidi (2015); Ajayi & Oyeyipo (2015); Love et al., (2010); love et al.(2004b)
6	Poor coordination Between the owner and End-users	Ye and Skitmore (2014); Aiyetan et al, (2013)
7	lack of owner commitment	Feng & Tommelein (2009); Aiyetan et al, (2013)
8	Poor management practices	Aiyetan et al, (2013)
9	Cost pressure and change in plan, and scope	Mahamid (2016); Ye and Skitmore (2014); Hwang et al. (2014); Aiyetan et al. (2013)
10	Lack of quality focus	Aiyetan et al. (2013)
11	Change the specifications by the client	Hwang et al. (2014); Aiyetan et al, (2013); Raghuram and Nagavinothini (2016)
12	Financial problems faced by the client	Hwang et al. (2014); Aiyetan et al, (2013)
13	Poor communication with contractor	Mahamid (2016); Aiyetan et al, (2013)
14	Payment of low fees for preparing contract Documentation	Ye and Skitmore (2014); Raghuram & Nagavinothini (2016); Love et al. (2010)
15	Inadequate of summary of things or client's brief	Miri & Khaksefidi (2015); Ajayi & Oyeyipo (2015); Love et al. (2010); Aiyetan et al, (2013); Love et al.(2004b); Simpeh (2012)
16	Inadequacies in contract documentation	Mahamid (2016); Ajayi & Oyeyipo (2015); Ye and Skitmore (2014); Love et al. (2010); Zeiter et al. (2017)
17	Lack founding for contract documentation	love et al.(2004b)

3.2. Design related factors.

The design is an important and essential part of any construction project, and this may be accompanied by many omissions, errors, and changes of the design, that cause the rework and occurring as through both design or construction process. Many studies

have categorized the design as one of the main reasons of construction rework (e.g., Love and Edwards, 2004; El Hussein et al.,2014; Feng and Tommelein, 2009; Zeiter et al., 2017). By a study of Josephson and Li (2002) in Sweden, estimated the rework cost regard to design only 26% among all rework costs, and accounted it for 18.91% in residential buildings in china (Liu and Peng, 2018). Wilson et al.(2019) demonstrated that the most five significant rework factors related to design, which affects the time and cost of oil and gas projects in Nigeria were, errors and omission in design document, ineffective communication between project team members, design changes, lack of site verification/investigation by design team, and lack of as-built documentation.

In addition to, Ekambaram et al.(2007) identified the inadequate time frame for overall design phase, very tight consultancy fee that led to insufficient resources, Ineffective use of quality management systems, inadequate of knowledge and experience, poor leadership of the project team, poor interface coordination, and key staff reallocation during the project were the main root causes of design rework in construction projects. Table 4 shows the 18 most common rework factors related to design, which has been identified from excessive previous studies.

Table 4. Factors of rework related to design.

No	Factor causes of rework	Sources
18	Incomplete design at the time of tender	Zeiter et al. (2017); Raghuram and Nagavinothini (2016); Mahamid (2016); Love et al. (2010); El Hussein (2014); love et al.(2004b); Simpeh (2012); Aiyetan (2013); Ajayi & Oyeyipo (2015)
19	Design change based on client request or end user	Raghuram and Nagavinothini (2016); Love et al. (2010); El Hussein (2014); love et al.(2004b); Simpeh (2012)
20	Errors and omission during the prepare design	Zeiter et al. (2017); Ye and Skitmore (2014); Raghuram and Nagavinothini (2016); Mahamid (2016); Aiyetan (2013)
21	Poor coordination between design team	Ye and Skitmore (2014); Mahamid (2016); Love et al. (2010); Miri & Khaksefidi (2015); El Hussein (2014); love et al.(2004b); Simpeh (2012); Aiyetan (2013); Ajayi & Oyeyipo (2015)
22	Incomplete information for design or misunderstanding of client specification.	Zeiter et al. (2017); Love et al. (2010); Aiyetan (2013)
23	Lack of use modern technology by design team	Love et al. (2010); love et al.(2004b); Aiyetan (2013)
24	Lack of quality practices in design	Love et al. (2010); Miri & Khaksefidi (2015); Simpeh (2012); Aiyetan (2013)
25	Method of procurement	Zeiter et al. (2017);
26	Lack of IT usage	Love et al. (2010); Miri & Khaksefidi (2015); love et al.(2004b); Simpeh (2012); Aiyetan (2013)
27	Insufficient supervision by designers	Fayek et al. (2003)
28	Complex design details are difficult to implement, or Inappropriate design process	Ye and Skitmore (2014); Raghuram and Nagavinothini (2016); Mahamid (2016); Aiyetan (2013)
29	Design change due to financial changes	Raghuram and Nagavinothini (2016);
30	Changes in drawing or drawings are unclear/wrong	Raghuram and Nagavinothini (2016);
31	Low design fees	Zeiter et al. (2017); Mahamid (2016)
32	Insufficient experience for design consultants	Zeiter et al. (2017); Mahamid (2016); El Hussein (2014)
33	Design change as contractor request during construction	Raghuram and Nagavinothini (2016); Love et al. (2010); El Hussein (2014); love et al.(2004b); Simpeh (2012)
34	Insufficient time for contract documentation	Mahamid (2016); Love et al. (2010); El Hussein (2014); love et al.(2004b); Ajayi & Oyeyipo (2015)
35	Errors or omissions in the contract documentation	Love et al. (2010); El Hussein (2014); love et al.(2004b); Simpeh (2012); Aiyetan (2013)

3.3. Contractor related factors

The contractor related factors considered one source causes which have an importance influencing rework (Ye and Skitmore, 2014; Aiyetan et al., 2013; Eze and Ganiyu, 2018; Zeiter et al., 2017., etc). The rework cost attribute to the contractor estimates about 20.1% of total rework cost as a study of (Liu and Peng, 2018) in residential buildings of China.

Zeiter et al. (2017) identified the main factors related contractor that caused rework in construction projects of Gaza Strip which are, the attempts to fraud, competitive pressure (low contract value), the unqualified technically contractors, poor quality system, financial weakness, misreading of drawings and specifications.

Additionally, the most influential factors causes of the rework related to contractor in China that have been identified are: the ineligible construction technique, ineligible materials, insufficient check of the materials and equipment, ineligible quality of construction process, non-standard construction management, misunderstanding of the design intention, and lack of use of advanced mechanical equipment, according to (Ye & Skitmore,2014; Liu and Peng, 2018).

A total of 23 factors of rework related to the contractor has been identified based on the literature review, as shown in Table 5.

Table 5. Factors of rework related to contractors.

No	Rework factors	Sources
36	Poor quality system	Zeiter et al. (2017); Mahamid (2016); Love et al. (2010); love et al.(2004b); Simpeh (2012); Aiyetan (2013)
37	Setting-out errors during construction process	Love et al. (2010); El Hussein (2014); love et al.(2004b); Simpeh (2012); Aiyetan (2013)
38	Omission during the construction process	Love et al. (2010); love et al.(2004b); Aiyetan (2013)
39	Bad practices on site.	El Hussein (2014); Simpeh (2012); Aiyetan (2013)
40	Lack of proper monitoring, and poor safety considerations	Zeiter et al. (2017); Simpeh (2012); Aiyetan (2013)
41	Lack of communication with design consultants	Ajayi & Oyeyipo (2015); Mahamid (2016)
42	Weak funding and cash flow	Zeiter et al. (2017)
43	Inappropriate construction technology due to site conditions	Raghuram and Nagavinothini (2016); Love et al. (2010);
44	Poor coordination of resources (e.g. subcontractors)	Love et al. (2010); El Hussein (2014); love et al.(2004b); Simpeh (2012)
45	Insufficient support for site management	Mahamid (2016); Aiyetan (2013)
46	Unqualify contractors	Zeiter et al. (2017)
47	Non-compliance with specifications or specifications of work is unclear	Zeiter et al. (2017); Mahamid (2016)
48	schedule pressure	Zeiter et al. (2017)
49	Lack of use of modern (poor) construction technology	Ye & Skitmore (2014); Liu and Peng (2018)
50	Lack of protection for construction work	Ajayi & Oyeyipo (2015); Mahamid (2016); Love et al. (2010); El Hussein (2014); love et al.(2004b); love et al.(2004b); Simpeh (2012); Raghuram and Nagavinothini (2016);
51	Errors resulting from inappropriate construction methods	Raghuram and Nagavinothini (2016); Love et al. (2010); love et al.(2004b)
52	Use of poor-quality materials	Ye & Skitmore (2014); Liu and Peng (2018); Mahamid (2016); Aiyetan (2013)

53	Poor site management	Mahamid (2016)
54	Lack of use of advanced mechanical equipment	Ye & Skitmore (2014); Liu and Peng (2018)
55	Use of defective equipment and tools	Ye & Skitmore (2014); Liu and Peng (2018); Mahamid (2016)
56	Poor supervision of admission materials/equipment	Ye & Skitmore (2014); Liu and Peng (2018)
57	Ineffective use of construction management standard	Ye & Skitmore (2014); Liu and Peng (2018)
58	Construction error due to misunderstanding of the design intention	Ye & Skitmore (2014); Liu and Peng (2018); Zeiter et al. (2017)

3.4. Sub-contractor related factors.

Subcontractor related factors are an important group that influencing rework according to studies conducted by each of (Ye and Skitmore, 2014; Miri et al., 2015; El Hussein,2014; Love et al., 2004). The rework cost due to subcontractor is estimated to account as 10.54% of total rework cost in residential buildings (Liu and Peng, 2018).

The poor communication of construction managers, poor coordination of subcontractor between upstream and downstream(contractor), poor communication of construction team members, and damage to the completed works are primary factors that contribute to rework related to subcontractors as (Ye and Skitmore, 2014; Liu and Peng, 2018). Besides the improper subcontractor selection was identified as a significant factor of rework (Ajayi and Oyeyipo, 2015; Zeiter et al.,2017). According to Love et al. (200b,2010), the major subcontractor related factors are an ineffective use of quality management practices, damage due to carelessness, inadequate managerial and supervisory skills, and use of poor materials. Table 6 illustrated the ninth most common rework factors related to subcontractor.

Table 6. Factors of rework related to subcontractor.

No	Rework factors	Sources
59	Poor coordination and communication with the contractor	Ye and Skitmore (2014); Liu and Peng (2018); Miri & Khaksefidi (2015); Liu and Peng (2018)
60	Insufficient administrative and supervisory skills	Love et al. (2010); love et al.(2004b); Ajayi & Oyeyipo (2015)
61	Improper subcontractor selection	Ajayi & Oyeyipo (2015); Zeiter et al. (2017)
62	Poor communication of construction managers, construction team members	Ye and Skitmore (2014); Liu and Peng (2018);
63	Damage to completed works	Ye and Skitmore (2014); Liu and Peng (2018); Raghuram and Nagavinothini (2016); Love et al. (2010); El Hussein (2014); love et al.(2004b); Simpeh (2012); Ajayi & Oyeyipo (2015)
64	Non-compliance with specifications	Raghuram and Nagavinothini (2016); El Hussein (2014); Simpeh (2012); Ajayi & Oyeyipo (2015)
65	Restrictions in many activities and tasks	Miri & Khaksefidi (2015); Simpeh (2012)
66	Use of poor materials	Love et al. (2010); Miri & Khaksefidi (2015); Miri & Khaksefidi (2015); love et al.(2004b); Liu and Peng (2018); Ajayi & Oyeyipo (2015)
67	Ineffective use of quality management practices	Love et al. (2010); love et al.(2004b)

3.5. Human resources capability and supervisory related factors.

Poor workmanship and inadequate supervisory/managerial skills are two main sources of rework in Nigeria construction projects, according to (Ajayi & Oyeyipo,2015). From other hands, Zeiter et al, (2017) explained ineffective management and decision-making, the absence of job security, an insufficient skill level are most influential factors related to human resources capability, that causing rework. Additionally, the shortage of skilled labor, lack skilled supervisors, defective workmanship, Inadequate supervisor, and Instructions which are unclear to workers has been described as significant rework factors according to studies that conducted by (love et al.,2004b; Love et al.,2010; El Hussein 2014; Simpeh 2012).

The role of professional supervisors is important to reduce rework in construction. Where, Alwi & Mohamed (1999) explain that the contractors, who spend more money, as training costs, to develop supervisory skills can reasonably reduce their rework costs ranging between 11% to 22%. The total of 14 rework factors related to human resources capability and supervisory has been identified, summarized in Table 7.

Table 7. Factors of rework related to human resources capability and supervisory.

No	Rework factors	Sources
68	Lack of supervision	Mahamid (2016); El Hussein (2014); Simpeh (2012); Alwi et al. (1999)
69	Lack of skills of laborers	Zeiter et al. (2017); Raghuram and Nagavinothini (2016); Mahamid (2016); Love et al. (2010); Miri & Khaksefidi (2015); El Hussein (2014); love et al.(2004b); Simpeh (2012); Alwi et al. (1999)
70	Lack safety and job security procedures at site	Zeiter et al. (2017); Raghuram and Nagavinothini (2016); El Hussein (2014); Simpeh (2012)
71	Turnover or reallocation of employees to other projects	Ajayi & Oyeyipo (2015); Zeiter et al. (2017); Mahamid (2016); Love et al. (2010); love et al.(2004b)
72	Lack of training and skill development	Raghuram and Nagavinothini (2016); El Hussein (2014)
73	Disturbance in planning of personnel or poor job planning	Zeiter et al. (2017); Mahamid (2016); Miri & Khaksefidi (2015)
74	Absence of incentives and rewards for laborers	Zeiter et al. (2017); Mahamid (2016)
75	Poor communication and integrated coordination	Zeiter et al. (2017)
76	Inadequately skilled labor to accomplish work tasks	Love et al. (2010); Miri & Khaksefidi (2015); El Hussein (2014); love et al.(2004b); Simpeh (2012)
77	Lack of proper interpretation of specifications and design by the supervisor	Alwi et al. (1999)
78	Insufficient supervision skill	Raghuram and Nagavinothini (2016); Mahamid (2016); El Hussein (2014); Simpeh (2012)
79	Poor workmanships	Ajayi & Oyeyipo (2015); Raghuram and Nagavinothini (2016); El Hussein (2014); Simpeh (2012)
80	Unclear instruction to workers	Raghuram and Nagavinothini (2016); El Hussein (2014)
81	Excessive overtime	Zeiter et al. (2017); Raghuram and Nagavinothini (2016); El Hussein (2014); Simpeh (2012)

4. Conclusion

Rework is one of the primary sources for the cost and time overrun in construction projects, which no project is free from its. Therefore, the objectives of this study were to identify the main factors causes of rework in the construction industry. A comprehensive review of the literature was conducted to determine the factors causing rework. Accordingly, a total of 81 rework factors identified, and its categories into five major groups related to; client, design, contractor, subcontractor, and human capability & supervisory.

The results of the comprehensive review of previous studies showed that among the most important factors causing rework related to client are, lack funding for consultations and site investigation, lack of client participation during design and construction processes, insufficient knowledge and experience for the construction and design process, inadequate of summary of things or client's brief, and poor coordination and communication with design consultants.

Additionally, the main factors of rework related to design were incomplete design at the time of tender, poor coordination between the design team, design change based on client request or end user, and lack of quality practices in design. Besides, the lack of protection for construction work, poor quality system, and setting-out errors during the construction process are the most significant factors of rework related to the contractor.

The most influential factors of rework related to subcontractors were damage to completed works, use of poor materials, poor coordination and communication with the contractor, and non-compliance with specifications. Finally, the lack of skills of laborers, turnover/reallocation of employees to other projects, inadequately skilled labour to accomplish work tasks, and insufficient supervision skills are the primary rework factors related to human capability and supervisory.

Based on the above research results, the stakeholders from, clients, contractors, and consultants should consider these results to reduce/minimize the rework of construction projects.

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