Proceedings of International Structural Engineering and Construction, 7(2), 2020
Emerging Technologies and Sustainability Principles
Edited by Askarinejad, H., Yazdani, S., and Singh, A.

ISSN: 2644-108X
www.doi.org/10.14455/ISEC.2020.7(2).CON-21

CONTRACTS EVALUATION THROUGH CLASSIFIED REWORK ROOT CAUSES IN THE CONSTRUCTION STAGE OF PROJECTS

RAMIN ASADI, SUZANNE WILKINSON, and JAMES OLABODE BAMIDELE ROTIMI

School of Built Environment, Massey University, Auckland, New Zealand

Rework occurs across the life cycle of projects and has significant impacts on construction project performance. A rational approach to managing rework is by identifying the main sources of rework; then mitigation measures can be implemented to enhance performance on projects. Rework has been widely studied within the construction industry, but the link between rework and contract conditions remain unexplored. This study identifies and classifies the root causes of rework at the construction stage of projects. It then examines the relationship between the conditions of contracts with the identified root causes. A comprehensive list of rework root causes was determined through the review of literature, which was categorized into five classified factors. The classified factors include process, human resource, material/equipment, technical, and other related environmental and financial factors. The next step comprises a questionnaire survey designed to determine relationships between rework and contracts. The result of the study is presented descriptively for ease of understanding. The results show that rework could be managed more efficiently through contracting processes, which ultimately benefits construction projects' performance.

Keywords: Classification, Contracting, Equipment, Human resources, Material, Process, Technical, Root-causes.

1 INTRODUCTION

The construction industry debatably has the least integration among other major industrial sectors (Isnaini *et al.* 2015). Rework has been recognized as a non-value adding problem that seriously affects the construction project's performance largely ignored by the construction industry (Ahmed and Naik, 2016). According to the given definition by Love, rework is "Doing something at least one extra time due to non-conformance to the requirements." Despite the considerable amount of research that has been undertaken to date, there is little evidence can be found on rework reduction in projects (Jingmond and Agren 2015), and future work is required to determine the underlying factors that contribute to rework. Regarding the origins of rework (Burati 1992) introduced five major areas, including design, construction, fabrication, transportation, and operability. Then the causes of rework have been classified into design-related factors, client-related factors, and contractor-related factors. Five other proposed categories were human performance, instruction and communication, design and engineering, planning and scheduling, material and equipment supply (Robinson *et al.* 2004), and recently an environmental causes group has been added to previous classification models (Mahamid 2016).

Evidence shows that new technologies make improvements, but they cannot effectively reduce construction problems. Advanced technology must be employed with a contemporary management concept (Aziz and Hafez 2013). One of the most influencing processes in which each participant's precise role has been defined is through contracting. Lacking focus on customers and creating adversarial relationships as per contract plays a major role in the weak reputation of the construction industry. The construction industry's performance can be improved through numbers of project management approaches and contracting management as one of those contemporary concepts has the potential of generating the highest value as it covers the life cycle of a project.

2 BACKGROUND OF THE STUDY

In construction projects, it is well established that rework contributes to the cost and schedule overrun (Love *et al.* 2010). The broad range of research is evidencing that schedule delay and cost overruns are the rules rather than the exception in the construction industry (Han *et al.* 2013). Previous research results have shown that adopting and implementing effective approaches to identifying rework root causes will positively affect project performance. Hereafter are some of the applied strategies and methods by previous researchers to reduce or minimize rework in the construction industry: "Design scope freezing, Value management, Information technology use, Subcontractor's involvement at the design stage, Integration of design management and project management, Supervision, Quality management, System dynamic models, Change management, Proper handling of materials." However, different methods have been used to control rework, investigating the contract process, and their document to manage rework has not been thoroughly examined yet. The possible interactions between rework and contract can be studied via searching rework root causes within contract documents. This paper the classifies the causes of rework as a base for further study on the contracting process through defined methodology in the next section.

3 METHODOLOGY

This paper is part of a research study that explores rework management in a construction project's contracting process. Identifying the causes of rework is the key priority of the study as it is used to evaluate contract documents. One way to provide a comprehensive list of identified rework root causes is through searching the published articles. As a result, the literature review method was used in the first step of the study to fulfill the initial research requirements. The sequences of implementing this method consist of identifying research by generating a strategy, criteria selection for including and excluding studies, collection of relevant articles, quality assessment of the collected studies, data extraction, and result summarization (Mohiuddin 2011). After defining the search scope, the following arrangements were established in compliance with the current study's employed method. A critical review on a selection of criteria for the methodology used in this paper was completed as the following 5 arguments:

- Including academic studies in the research area of rework in the construction industry.
- Updating the knowledge of rework management, particularly on root causes of rework.
- Demonstrating the coverage of recent research over the previously published papers.
- Assessing the quality of previous work through publications in respected journals.
- Justifying a model for the classification of extracted data to provide more reliable reports.

The first step of this review was to answer this question: What are the root causes of rework in the construction stage of projects? Based on this setup, the publications' search scope was

defined through the keyword of rework in the paper titles. Rework is a broad term that is widely used in many research fields. In this order, a search was restricted only to the construction industry, and the rest of the other areas were excluded; after following these steps, the numbers of papers reached over 80 relevant publications. All collected publications were reviewed thoroughly to find out the causes of rework. Narrowing down to this specific target with careful consideration of the quality of provided documents led the authors to the point that all identified cause of rework can be found in some recent publications. Assessment of the publication's quality was determined through the criteria of being published in well-known journals. Total numbers of 7 publications, as shown in Table 1, were selected for final consideration, which covers different regions over the world such as Australia, Nigeria, Canada, China, and Palestine. These publications also have covered a broad range of construction projects such as residential buildings, infrastructures, industrial plants, highways, etc. For covering the last step of the designed method on reviewing the literature, an extra strategy was developed to generate a suitable report on extracted data as described below.

The total identified rework root causes exceed 316 items for a project's life cycle on both sides of the contract (Asadi *et al.* 2019). The next research step to find relations between contract documents and rework would be more complex with the long list of 316 identified causes. Furthermore, the pre-mentioned list showed that some of the endorsed contents in various publications are the same. Thus, a model for categorizing identified rework root causes was designed. The proposed model comprises five broad areas, and each area included more details to give a full explanation about rework root causes. This model was adjusted by combining four previous classification concepts mentioned in the introduction section and adopted based on current research needs in three levels. The first level shows two major parties of contracts as client and contractor, the second level consists of project stages as the research is covering the life cycle of a project, and level three distributes between areas of the process, human resources, technical, material and equipment and other related factors (Asadi *et al.* 2019).

Table 1. List of selected articles following the strategy and criteria of the methodology section.

	Publication Sources	Authors	Year
A	The Journal of Performance of Constructed Facilities	Love *et al.*	2009
B	Journal of Building Performance	Oyewobi and Ogunsemi	2010
C	Journal of Construction Engineering and Management	Zhang *et al.*	2012
D	Journal of Construction Project Management and Innovation	Aiyetan and Das	2015
E	Journal of Management in Engineering	Ye *et al.*	2015
F	Jordan Journal of Civil Engineering	Mahamid	2016
G	International Journal of Sustainable Construction Engineering Technology	Enshassi *et al.*	2017

4 FINDINGS AND DISCUSSION

Various categories of rework root causes in the construction stage also show an uneven level in terms of quantity. Technical related factors with 14 items are the highest contributing category that produces rework in construction. Following that, the other related factors with 13 items are the second top category. Then human resources factors involving 10 rework root causes and are seated as the third category. Material and equipment related factors hold six items of rework root causes, and the lowest number of contributing factors in rework occurrence belongs to the category of the process-related factor with only four items. None of these figures prioritize ranking as the study has not measured the impacts of rework. The sum of 47 classified rework root causes in the construction stage of a project with more details is shown in Table 2.

Table 2. Classified rework root causes in the construction stage of a project.

Process related factors	Side	Source
1,2- Changes in the construction process or after completed work due to officials, additions, omission, removal, and modifications in any order	Client and Contractor	A,B,D,E,G
3- Any construction error due to inappropriate construction method, poor design, complexity, and incomplete understanding of design intent	Contractor	A,B,D,E,F
4- Omission of some tasks during construction		B
Human Resources related factors		
5,6- Lack of knowledge of the construction process	Client and Contractor	A,B,F
7,8- Lack of experience in the construction process		A,B,G
9- Labor reallocation, alteration, and staff turnover	Contractor	A,B,F
10- Unqualified technical staff and unavailability of skilled labors due to lack of training and inadequate local education		A,B,F,G
11- Insufficient skills in both labor and supervisory levels such as poor teamwork in problem-solving		A,B,F
12- Lack of motivation and care, Carelessness		B,F
13- Poor workmanship approach and attitudes such as incorrect interpretation of customer requirements, misreading of drawings, or incomplete understanding of design intent		B,D,G
14- Personal issues such as disturbance in planning, attempt to fraud, rigidity to improvement, random human error, lack of trust and commitment, and conflict of opinions between participants		B,F,G
Material and Equipment related factors		
15- Defective materials due to shortage in the market	Client	B
16- Inadequate procurement of quality material or use of poor-quality material such as substandard products and services instead of advance material by subcontractors	Contractor	B,D,E,F
17- Replacement or misplacement of material and equipment in construction sequences due to insufficient functions or technological issues		C,E,G
18- Defective or damaged materials due to poor handling, poor supervision of admission, or prefabrication errors		A,C,D,E,G
19- Use of inefficient equipment or altered material due to inadequate resources, shortage in the market, emergency conditions or other technological issues		B,D,E,F,G
20- Untimely deliveries of material and equipment		G
Technical related factors	**Side**	**Source**
21,22- Ineffective use of quality management practices and lack of attention to quality or failure to implement QMS	Client and Contractor	A,B,D,F,G
23,24- Deviation and failure due to poor monitoring, audit, control, and inspection or non-compliance to standards/specification and project requirements		A,B,D,F,G
25,26- Ineffective or lack of information technology and use of inappropriate construction technology applications		A,B,E
27,28- Ineffective management practice due to poor contractual relationship and poor communication and integration with project participants such as design, construction team members, and subcontractor's coordination		A,B,D,E,F
29,30- Inadequate construction planning and poor planning of workload or unrealistic programs such as time boxing and fixed time allocated to tasks without work separation		A,B,D,F,G
31,32- Conflicting and incomplete information due to poor information flow and inaccurate use of work specification and data		B,D
33- Poor project documents due to the absence of a clear uniform standard, lack of procedures to accept work, and late designer input	Contractor	B,D,E,G
34- Poor site management practice and ambiguous instructions due to lack of support and inadequate supervision, poor techniques implementation and ineffective construction methods use		B,D,E,F,G

Table 2. Classified rework root causes in the construction stage of a project (contd).

Other related factors		
35- Unpredictable factors from different sources such as new request made by end-user during the construction to improve standards or during final inspection and certification,	Client	E
36- Financial issues such as budget compression or increase, cost pressure, and inadequate funding allocated for site investigation and consultation		D,G
37- Lack of constructability because of separation between design achievements and construction conditions		E
38-Changes in government regulations, laws, and policies		E
39- Poor safety considerations and failure to provide protection to the completed works	Contractor	A,B,D,E,F,G
40- Damage or defect by contractor and subcontractors due to construction errors and carelessness		A,B,D,F
41- Poor site condition such as delay in providing water and electricity		B,E,G
42- Delay in paying contract fees and payment of low contract fees due to low contract price		B,E,G
43- Cost pressure and Financial weakness such as inadequate funding and budget compression		B,E,G
44- Schedule acceleration, schedule pressures, excessive overtime, and working under high time pressure due to delay and untimely delivery		B,E,G
45- Adverse natural conditions such as hot weather, rain, cold, earthquakes, and floods and uncertainty of environmental aspects such as soil condition		B,E,G
46- Unpredictable factors from different sources such as government roles		B,F
47- External factors such as social, cultural, political, and economic influences and environmental situation such as the physical condition of a project		E,F,G

5 CONCLUSION

This paper presents classified rework root causes in the construction stage of projects through a literature review. This review was conducted by following the guideline steps in the methodology section to categorize existing papers on rework causes. It was discovered that previous studies have mostly focused on the contractor side of the contract. Of the 47 classified root causes of rework in this stage, 33 items are associated with the contractor side, which is about more than 60 percent of all classified root causes in the construction stage. In addition, very few focuses are perceived on human resources factors, particularly in the contract's client-side. Another highlighted fact in the rework analysis is the frequency of repeating some of the roots, as can be seen in the table. Results showed that lots of effort had been put in certain areas mainly because of their impacts on a project or their probability of occurrences, such as deviation and failure by contractor, ineffective management and poor communication of contractor, poor site management practice by contractor, and changes made by the client. Rework root causes in the construction stage of the project will be summarized as the following five categories:

1. Changes by client and contractor, error, omission, lack of control documents by contractor.
2. Knowledge and experience of the client and contractor's staff, unqualified labor, insufficient skills, poor workmanship approach, lack of motivation, and personal issues.
3. Defective materials by the client, inadequate supply of material, replacement, damaged material, inefficient equipment uses, and untimely delivery of material by the contractor.
4. Ineffective use of quality management, deviation and failure, lack of IT, ineffective management practice, poor planning, and incomplete information by both parts of the contract plus lack of procedures and poor site management by the contractor.
5. Governmental issues and constructability problems by the client, safety consideration, damage or defects, site situations, payment issues, schedule pressure, natural conditions, and external factor from the contractor, financial issues, and unpredictable factors for both sides of the contract.

Contract documents are the core connections of client and contractor, and it defines authorities and responsibilities to cover any probable circumstances. The paper's result can serve as an authentic base for defining a new strategy on rework management to cooperate with the contract. Thus, it can cover the scholar gap searching for integrated rework solutions that affect both contract sides. Evaluation of involved contract clauses and the contract attachments through a questionnaire based on classified rework root causes can reveal the weak connection points. Revising and amending contract documents under this perspective will strengthen the construction project outputs, such as performance and productivity. This study relies only on journal papers, so the result may have some limitations as the other conference papers have been excluded from the study's scope, so consider all papers for future studies is recommended. Furthermore, the same approach can be used for evaluating the other stages of design and procurement. Test and analysis of identified rework root causes through a survey among construction firms in future studies also is recommended.

References

Ahmed, S. A., and Naik, B. H., *Rework Management in Construction Projects and Comparision with Time and Cost*, Int. J. of Inn. Research in Sc., Eng. and Tec., 5(10), 17973-17980, 2016.

Aiyetan, A. O., and Das, D., *Using System Dynamics Principles For Conceptual Modeling To Resolve Causes Of Rework In Construction* Projects, J. of Con. Pro. Man. and Inn., 5(2), 1266-1295, 2015.

Asadi, R., Wilkinson, S., and Rotimi, J., *Contract Document Appraisal and Rework Root Causes Classification in Tendering Stage of Projects,* Proceeding of the 43rd AUBEA conference, 86-98, 2019.

Aziz, R. F., and Hafez, S. M., *Applying Lean Thinking in Construction and Performance Improvement,* Alexandria Engineering Journal, 52(4), 679-695, 2013.

Burati, J. L., Farrington, J. J., and Ledbetter, W. B., *Causes of Quality Deviations in Design and Construction*, J. of Con. Eng. and Man., 118(1), 34-49, 1992.

Enshassi, A., Sundermeier, M., and Abo Zeiter, M., *Factors Contributing to Rework and Their Impact on Construction Projects Performance,* The Int. J. of Sus. Con. Eng. Tec., 8(1), 12-33, 2017.

Han, S., Love, P., and Pena-Mora, F., A *System Dynamics Model for Assessing The Impacts of Design Errors in Construction Projects,* Mathematical and Computer Modelling, 57 (9-10), 2044-2053, 2013.

Isnaini, J. N. A., Ahmad, N., and Ismail, F., *Clients' Involvement in Purchasing Process for Quality Construction Environment,* Procedia - Social and Behavioral Sciences 168, 30-40, 2015.

Jingmond, M., and Agren, R., *Unravelling Causes of Defects In Construction,* Construction Innovation, 15(2), 198-218, 2015.

Love, P., Edwards, D., Watson, H., and Davis, P., *Rework in Civil Infrastructure Projects: Determination of Cost Predictors,* Journal of Construction Engineering and Management, 136(3), 275-282, 2010.

Love, P., Edwards, D., Smith, J., and Walker, D., *Divergence or Congruence? A Path Model of Rework for Building and Civil Engineering Projects,* J. of Perf. of Cons. Fac., 23(6), 480-488, 2009.

Mahamid, I., *Analysis of Rework in Residential Building Projects in Palestine*, Jordan Journal of Civil Engineering, 10(2) 197-208, 2016.

Mohiuddin, M., *Reseach on Offshore Outsourcing: A Systematic Literature Review*, Journal of International Business Research, 10(1), 2011.

Oyewobi, L. O., and Ogunsemi, D. R., *Factors Influencing Rework Occurrence in Construction: A Study of Selected Building Projects in Nigeria,* Journal of Building Performance, 1(1), 1-20, 2010.

Robinson, F. A., Dissanayake, M., and Campero, O., *Developing a Standard Methodology for Measuring and Classifying Construction Field Rework,* Can. J. of Civil and Engeneering, 31, 1077-1089, 2004.

Ye, G., Jin, Z., Xia, B., and Skitmore, M., *Analyzing Causes for Reworks in Construction Projects in China*, Journal of Management in Engineering, ASCE, ISSN 0742-597X/04014097(9), 2015.

Zhang, D., Haas, C., Goodrum, P., Caldas, C., and Granger, R., *Construction Small-Projects Rework Reduction for Capital Facilities*, Journal of Construction Engineering and Management, 138(12), 1377-1385, 2012.