INTERNATIONAL JOURNAL OF SUSTAINABLE CONSTRUCTION ENGINEERING AND TECHNOLOGY
Vol. 12 No. 2 (2021) 24-37

IJSCET

http://penerbit.uthm.edu.my/ojs/index.php/ijscet
ISSN : 2180-3242 e-ISSN : 2600-7959

International Journal of Sustainable Construction Engineering and Technology

Comparative Assessment of Rework on Buildings in Akure Municipal, Ondo State, Nigeria

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DOI: https://doi.org/10.30880/ijscet.2021.12.02.003
Received 27 November 2019; Accepted 20 May 2021; Available online 30 June 2021

Abstract: Rework is the repetition of work that constitutes waste in construction and reflects poor performance due to the failure of building components to satisfy the client's requirement and contract documentation's provision, which further results in cost and time overrun. In lieu of the nature of the subject matter, this study comparatively assessed rework occurrence on buildings in Akure municipal, Ondo state, Nigeria to ensure the building works prone to rework are carried out with utmost care and control to drastically reduce rework cost. A total of eighty-three (83) well-structured closed-ended questionnaires were distributed and the retrieved seventy (70) questionnaires formed 84% response rate. Primary data were obtained from 10 construction firms and 60 end-user clients using purposive and snowball sampling. Data collected from the retrieved questionnaires were on the defects in building components due to non-conformance to specification and client requirement and perception on the frequency of occurrence and cost of rework on buildings. The data were analysed using frequency, percentage, Relative Importance Index (RII), Mean Item Score, Mann-Whitney U Test and Spearman's Rank Correlation Coefficient. A descriptive analysis of the defects on building components from the end-user clients and construction professionals' perception revealed plumbing and sanitary system and electrical services as the most defective, respectively. Further analysis of the parameters shows a significant difference between the opinions of the end-user clients and professionals on the defects in the electrical appliances and installation; corrosion and discolouration of components; doors and accessories and ceiling and accessories. However, no significant difference exists between the overall opinions of the end-user clients and the construction professionals on building component defects. The result of the conducted analysis further showed that an increase in the frequency of rework on finishes and mechanical installations could speed up rework cost. This study, therefore, affirms the stakeholders' need to avoid rework occurrence on services components (mechanical and electrical), concrete works and finishes to experience a rapid decline in the cost of rework. The study contributed to the overall body of knowledge by establishing building components with high rework occurrence and their corresponding effect on cost from the perception of the end-user clients and built environment professionals.

Keywords: Component, construction, cost, defect, rework

1. Introduction

The construction industry is a significant sector that cannot be neglected in any country's economy. It occupies a focal point that drives every other form of development by providing adequate infrastructures required to advance other sectors (Ade-Ojo et al., 2016). But despite the indusry's substantial contribution to the GDP, an infrastructural shortage is experienced due to various issues such as time and cost overrun (NUCECFWW, 2015). These overruns have been

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seen to be significantly influenced by rework. Meanwhile, rework has become pervasive in its actions to hinder the timely fulfilment of the project objectives (Liu et al., 2018; Eze & Idiake, 2018a; Balouchi et al., 2019).

Rework is a phenomenon that every stakeholder in the construction industry wishes to displace. It is the act of redoing or repeating an activity that has been previously done. This repetition of work is brought about by several factors such as poor workmanship, insufficient skill level, omission, inadequate supervision and defect (Oyewobi & Ogunsemi, 2010; Zaiter, 2014). The building work faced with rework, however, constitutes a waste since previous efforts committed to the task are rendered futile (Oyewobi & Ogunsemi, 2010; Ade-Ojo et al., 2016).

Rework is caused by several factors relating to the quality management sub-system, human resources sub-system and technical and operational sub-systems (Zaiter, 2014). Across the three sub-systems are several factors influencing rework occurrence. The most prominent of these factors are break in information flow, non-conformance to specification, lack of experience, poor workmanship, absence of a working quality plan and failure to satisfy customer's requirements (Ajayi, 2017; Yap et al., 2017). The effect of these factors has been duly felt on the cost expended on rework. The sources of these costs were further identified to be a result of failed contractor field management, design management, and client management (Liu et al., 2018). A greater detail into the direct and indirect cost of rework shows direct cost expended on rework to fall within 5% - 20% of the contract sum for most countries across the globe, including Nigeria (Aiyetan, 2014; Balouchi et al., 2019). Moreover, the indirect cost of rework could amount to six times the actual direct rectification cost, which could lie below 3.6 - 6.6% initially excluding the indirect impact (Love et al., 2016) and according to Love (2002), combination of the direct and indirect impact could make the total rework cost as high as 23%. Therefore, studying rework in its entirety is pertinent and a resultant collaborative effort of all stakeholders involved in construction is required to underpin the necessary mitigative measures and concentrate in order of precedence, to the non-productive works responsible for rework (Oyewobi et al., 2011; Jarkas, 2015).

Previous studies have identified non-conformance to specification and client's demand as a significant theme of rework (Oyewobi et al., 2011; Aiyetan, 2014; Ajayi, 2017; Yap et al., 2017). But the building components facing rework as a result of this phenomenon remain unclear. According to Ade-Ojo et al. (2016), building elements remain at a maximum of 40% susceptibility rate to rework. There is an increase in the rework cost on elemental basis and focusing on the individual building components mostly affected by rework can geometrically reduce rework cost. Moreover, various studies exist on defect of buildings, but researches on defect due to non-conformance to specification are sparsely investigated. In the findings of Liu et al. (2018), the client was identified as a significant decision-maker among construction stakeholders and Oyewobi et al. (2011) and Hwang et al. (2014) opined that data retrieved from clients, coupled with those of the contractors and consultants, will be highly instrumental in solving rework issues. However, studies on rework have majorly been based on the construction professionals' perception with less focus on the clients' perception. Also, the rising increase in rework cost has sprouted the need to focus on rework's frequency of occurrence in relation to its effect on cost (Balouchi et al., 2019).

To fill the identified gaps and add to the body of knowledge on the concept of rework in the Nigerian construction industry, this study is aimed at comparatively assessing the rework occurrence on buildings in Akure municipal, Ondo state, Nigeria, to ensure the building works prone to rework are carried out with utmost care and control to drastically reduce rework cost. The objectives of the study are to:

i. identify defects induced by non-conformance to specification and client's requirements causing rework of building components

ii. assess the construction professional's perception on the frequency of occurrence and cost of rework on buildings

2. Literature Review

2.1 Concept of Rework

The advent of rework as a plague hindering project success rate with effect on cost, quality and schedule in the construction industry has sprouted series of studies (Hwang & Yang, 2014). Based on the research focus at different scenarios, numerous definitions were generated. An in-depth understanding of these definitions fosters a vast understanding of rework. Hornby (2015) defined rework as changes made to an already performed event to get it improved and make it more suitable. Also, Love et al. (2016) see rework to be a non-value adding activity and the primary result of non-conformance, error, change in scope and quality deviation.

Another unique definition is that of Oyewobi & Ogunsemi (2010) that expresses rework as any effort due to the repetition of work that constitutes waste in construction. In a further work of Oyewobi et al. (2011), rework was defined as the failure of building elements to meet customers' needs or conform to the specified requirement. Rework, based on recent studies, is seen as a menace causing loss of unnecessary effort expended on a project, which increases project cost, time and reduces project performance of construction projects at both the design and construction stages (Zaiter, 2014; Eze & Idiake, 2018a). Similarly, it is seen as repeating a part of construction work due to error, changes and poor implementation of the quality plan (Adomah, 2016; Ajayi, 2017).

The various definitions discussed significantly explain the concept of rework based on different related scenarios. However, considering the relevance to the objectives of this study, a combination of various study's definition was arrived to define rework as a repetition of work that constitutes waste in construction and reflects poor performance due to the failure of building components to satisfy customer's requirement and contract documentation's provision. The result of these actions results in cost and time overrun. This study reviewed relevant literature relating to rework and the summary of these studies is reflected in Table 1.

Table 1 - Summary of recent studies on rework occurrence

Rework variables	References
Rework on buildings	(Oke & Ugoje, 2013; Aiyetan, 2014; Hwang et al., 2014; Jarkas, 2015; Ade-Ojo et al., 2016; Adomah, 2016; Yap et al., 2017; Eze & Idiake, 2018a, 2018b; Liu et al., 2018)
Factors influencing rework	(Oyewobi & Ogunsemi, 2010; Meshksar, 2012; Simpeh, 2012; Zaiter, 2014; Adomah, 2016; Love et al., 2016; Ajayi, 2017; Enshassi et al., 2017)
Client-related rework	(Hwang et al., 2014; Jarkas, 2015; Ade-Ojo et al., 2016; Liu et al., 2018)
Building defects and rework	(Sommerville, 2007; Bakri & Mydin, 2013; Taggart et al., 2014)
Rework cost (direct and indirect)	(Oyewobi et al., 2011; Meshksar, 2012; Oke & Ugoje, 2013; Aiyetan, 2014; Zaiter, 2014; Love et al., 2016; Eze & Idiake, 2018a; Liu et al., 2018; Balouchi et al., 2019)

2.2 Rework on Buildings

The activities of the construction industry cover the development of infrastructures that include buildings, roads, hospitals and schools, among other facilities (Eze & Idiake, 2018a). Compared to every other facility, all of the elements of a building are susceptible to rework, ranging between 26% and 40% susceptibility rate and rework will generally affect the aesthetics and functional aspects of buildings (Ade-Ojo et al., 2016; Enshassi et al., 2017). Furthermore, rework on buildings shows a significant relationship between rework cost, initial and final project cost, cost overrun and project duration (Oke & Ugoje, 2013). It is a phenomenon that speeds up the cost of residential buildings (Liu et al., 2018).

Rework in buildings will normally be induced by errors, changes and omissions, which has direct and indirect effect on the project. Rework will indirectly impact individuals, organisational level and project performance. These are reflected in stress, fatigue, dissatisfaction, poor morale, working time, travelling time, idle time experienced by the participants involved in construction activities (Enshassi et al., 2017; Eze & Idiake, 2018b). The indirect effects though difficult to measure will speed up the direct effects.

Moreover, the poor collaboration between the designer, contractor and client has been a major reason for the rise in rework, overtime (figure 1). The concerted effort of these individuals is required to alleviate rework of building constructions (Hwang et al., 2014; Jarkas, 2015; Yap et al., 2017). Rework has a detrimental effect on construction process and building performance. Hence, the need for a concerted effort of all relevant stakeholders to unanimously identify and attend to the sources of rework to alleviate rework in buildings (Jarkas, 2015).

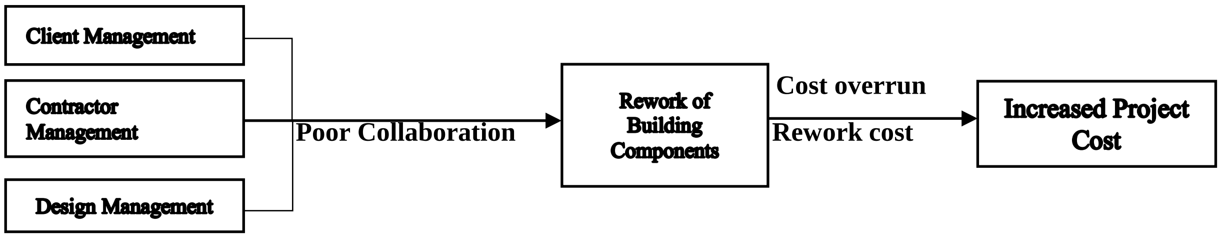


Fig. 1 - The framework of rework relating to stakeholders, cost and project output

2.3 Factors Influencing Rework

Generally, rework is made visible by several factors during the design implementation process (Oyewobi et al., 2011). Many of these factors have been highlighted to be responsible for rework occurrence and failure to appropriately classify and identify the sources of these factors could toughen the endeavour to mitigate rework (Love et al., 2016). Rework causes can be categorised under five headings, namely: "human resource capability, leadership and communication, engineering and review, construction planning and scheduling and material and equipment supply (Fayek et al., 2003; Meshksar, 2012; Jarkas, 2015; Enshassi et al., 2017). Based on the model generated for rework causes, Adomah (2016) listed the carelessness of workers, uncertainty about design changes, unclear specification and difficulty in some worker's behaviour as the major causes of rework. The factors identified were found to fall within Human resource capability and construction planning and scheduling, which could be seen to be the major causes of rework.

Oyewobi & Ogunsemi (2010) developed a similar model by classifying rework causes under quality factors, technical factors and human resources. The major factors influencing rework under these headings include lack of support to site management, use of inexperienced personnel, substandard services, defects and lack of trust and commitment on the side of the client. The major causes of rework were similarly identified to be limited knowledge on design and construction process, lack of client involvement, lack of quality focus, poor supervision and inspection (Love & Edwards, 2004; Simpeh, 2012; Jarkas, 2015; Yap et al., 2017). A review of several other studies carried out revealed rework to be caused majorly by ill efforts imputed in construction such as quality deviation, break in information flow, use of inferior materials, poor workmanship and supervision (Love et al., 2016; Ajayi, 2017). To attend to rework issues in its entirety, Aiyetan (2014), however, opined that avoiding mistakes and poor quality works resulting in defects and non-conformance will help to reduce rework occurrence drastically to a negligible percentage. In addition to this, a concerted effort of the construction stakeholders is required with more emphasis on the client and designer. This will be tailored towards making a unanimous effort to mitigate the wasteful effort caused by rework (Jarkas, 2015).

2.4 Building Defects and Rework

Defects occur in both new and old buildings. Defects in new buildings may be classified as caused by non-compliance to the cost and acceptable tolerance. In contrast, older buildings, though they may not conform with the current standards, must be judged according to the time it was constructed (Bakri & Mydin, 2013). The category of defect, according to Wen & Mydin (2013), can be structural and non-structural defects. Building structures such as columns, beams, stanchions and other structural supports with defects are considered structural defects. These defects may include cracks and deflection. This category of defects is majorly caused by human error during the construction, design and planning stage. They may also be induced by deterioration, wear, tear, overloading and poor maintenance. Non-structural defects are also seen to affect the non-structural members of a building due to an improperly done building work. These defects may include those on the bricks, plaster and roof. This class of defect is less capital intensive compared to those on the structural members.

Defects were also classified according to (Kasi et al., 2018) as technical, aesthetic and functional defects. Technical defects are a result of failure to meet required standards, thereby posing a threat to life and property. Aesthetics defects tend to affect the appearance and satisfaction of an individual of a building. Lastly, functional defects may cause a building not to fulfil its requirement and these defects are related majorly to planning, design and building location.

The plaguing influence of defects as depicted in its categories and the high probability of defects resulting to rework explains why defects are closely treated with rework. Rework has been defined as defects, quality failure and non-conformance (Jarkas, 2015; Enshassi et al., 2017). Defect remains a salient element fostering rework in various rework studies and a more careful study of the root causes of rework could help tackle rework of buildings and construction activities (Sommerville, 2007; Taggart et al., 2014).

A pathway showing the relationship between rework and defects is depicted in figure 2. The pathway identified the origin of rework to be from defective construction activities. The inflow of various factors causing rework led to a flawed action and the consequences of the flawed action reverted to rework.

Fig. 2 - Defect and rework pathway

2.5 Rework Cost

Rework cost are add-ons which could be avoided to minimize the project cost. These are costs that come into play from the point rework is identified to the time rework is completed and the activity made to suit requirements (Oyewobi

& Ogunsemi, 2010). The delay in identifying defect or rework activity would increase the cost of rework, mostly when the work has already been completed.

About 30% of construction is rework and at the inception of rework, labour efficiency is reduced to 40 – 60% and at the end of rework activity, material wastage could amount to about 10% (Oyewobi & Ogunsemi, 2010). Rework cost is a combination of rectification (direct) cost and indirect cost. Direct rework costs are measurable and they include the cost of material, man-hour, equipment and schedule. In contrast, Indirect cost cannot be easily determined but may be reflected in the cost of transport, additional cost of productivity, litigations and claims (Simpeh, 2012).

Direct rework cost can be 5% of the construction cost and it could be as high as 20% (Ade-Ojo et al., 2016; Balouchi et al., 2019). In most construction work, it could range from 3% - 10% (Zaiter, 2014). However, when the indirect cost is considered, the rework cost can be as high as 16 to 23% of the contract sum (Liu et al., 2018). Also, Love (2002) and Love et al. (2016) highlighted that indirect rework cost could be six times more than direct rework cost when considered in a project, resulting in a much higher total rework cost.

However, to reduce rework cost, most especially the direct rework cost, it is essential to identify the defects causing rework to generate rework preventions that will help to give a savings of about 15% of the construction cost accounted to rework (Zaiter, 2014).

3. Research Methodology

3.1 Questionnaire Design and Study Area

This research was carried out through careful review of literature and employment of survey research design to comparatively assess rework occurrence on building components in Akure municipal, Ondo state, Nigeria. The primary data were retrieved using a closed-ended questionnaire to elicit data from the professionals and end-user clients. A draft questionnaire was developed from the related literature on rework. The draft questionnaire passed through content validity with a panel of eight built environment professionals. These are individuals with a minimum of ten (10) years of professional experience and are conversant with the trend of rework in buildings. The questionnaire was revised based on the recommendations and expert input of the professionals to retain a total of forty-four (44) building components and activities relating to rework in the questionnaire.

After the approval of the revised questionnaire, a pilot test was conducted on five (5) end-user clients and three (3) professionals. The pilot testing was to ascertain their understanding of the questions and the time required to complete the questions. The participants confirmed their understanding of the questions. It was also established that their interpretation of the study's aim perfectly suits the requirement of the study. Besides, the professionals and end-user clients took approximately eight (8) and five (5) minutes respectively to complete the questionnaire.

The study area was determined based on the findings of Aiyetan (2014), where the research was conducted on two states in Nigeria, namely Lagos, the largest city in Nigeria (United Nations, 2018), and Ondo State. The result of the study on rework compared to that of Lagos shows a more prominent rework occurrence in Ondo State. Due to the paucity of research on this subject in the said location, this study decided to embark on a study in the capital city of Ondo State, which is the most populous, developed and easily accessible in the region.

3.2 Research Population

The population of this research comprises of the built environment professionals and end-user clients. The professionals consulted were those in the managerial level of construction companies owing to their vast knowledge of administrative, design and construction activities. The built environment professionals possessing the required characteristics for this study were identified using purposive and snowball approach because it was hard to identify the population with the desired characteristics (Naderifar et al., 2017).

Three professionals from three construction companies were initially purposively identified. After the first three professionals were identified, the snowball approach commenced (Figure 3). In the first level, one of the initially identified professionals enlisted one professional while the other two nominated two professionals each. For the second level, one of the identified professionals nominated two other professionals. A total of Ten (10) professionals were enlisted from ten companies situated in Akure with records of completed building projects in the location. One professional from each company was selected as a representative of the company to avoid duplication of data and ensure absolute relevance of the collected data to the study.

The end-user clients that served as the population for this study were clients who own and live in their property. A list of end-user clients with the desired characteristics was gotten from estate developers in Akure. A total of Seventy-three (73) end-user clients were retrieved from the estate developers.

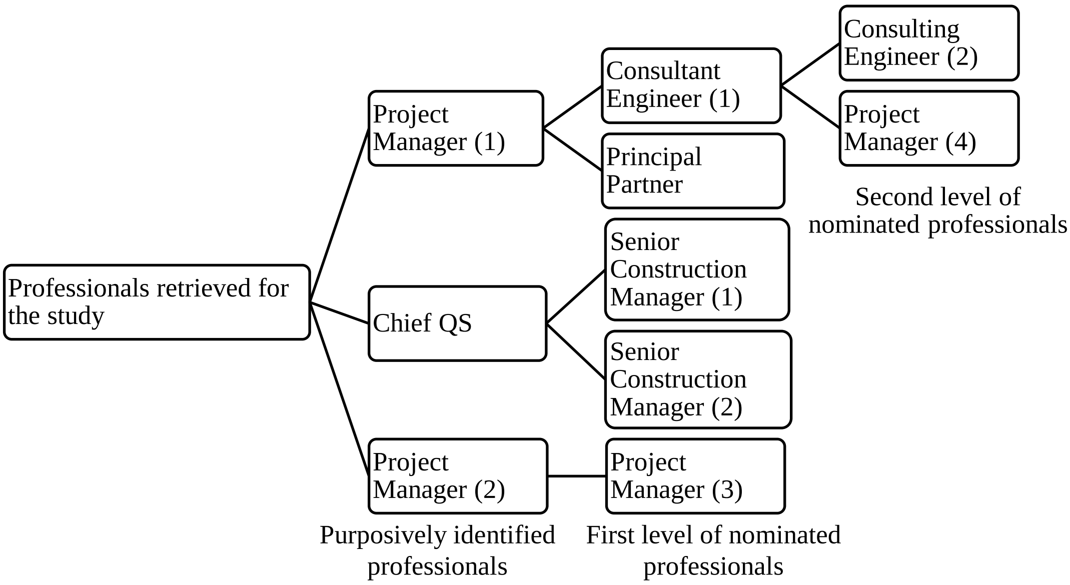


Fig. 3 - Snowball process for recruiting professionals from ten companies

3.3 Sampling

All ten (10) professionals identified were involved in the study. The sample size for the end-user clients was determined using the following statistical equation (Cochran, 1977) and the final list of end-user clients employed for the study was based on informed consent.

$$n_0 = \frac{Z^2 \times pq}{e^2} \quad (1)$$

Where:
n_0: Initial sample size
Z: Z value (1.645 for 90%confidence interval)
p: the estimated proportion of the population which has the attribute in question (0.5 used for this study)
q: 1-p
e: desired level of precision (0.05).

$$n_0 = \frac{1.645^2 \times 0.5\ (1-0.5)}{0.05^2} = 270.6 \approx 271$$

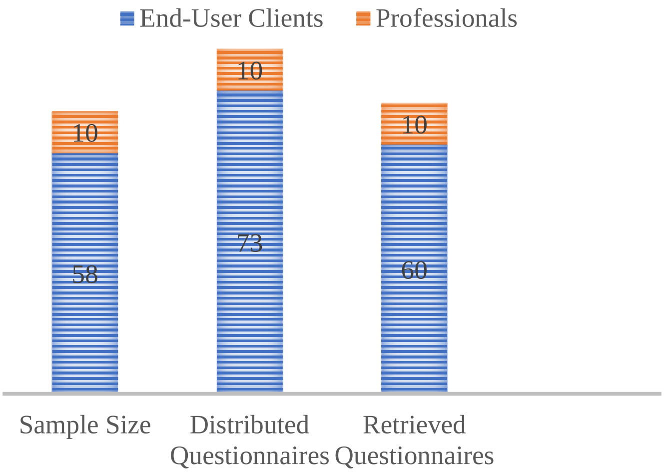
For a finite population, the resultant equation is:

$$n = \frac{n_0}{1+\frac{(n_0-1)}{N}} \quad (2)$$

Where:
N: Population size
n: Final sample size

$$n = \frac{271}{1+\frac{(271-1)}{73}} = 57.67 \approx 58.$$

Seventy-three (73) questionnaires were distributed, while sixty (60) were retrieved. The details on the respondents' response rate are illustrated in Figure 4 and 5.



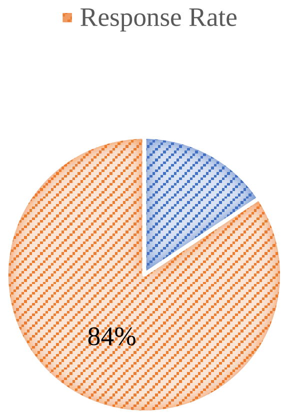


Fig. 4 - (a) Respondents' response data; (b) Respondents' response rate

3.4 Data Measurement and Data Analysis Methods

Nominal and ordinal scales were employed for this study. The nominal scale was used to retrieve demographic attributes of the respondents, while a five (5) point Likert ordinal scale was used to retrieve data on the study's objectives. The data retrieved from the professionals on rework were based on their experience on numerous completed projects, while the information retrieved from the end-user clients were based on their knowledge of defects of building components inducing rework caused by non-conformance to requirements and client's specification. Altogether, a total of 70 questionnaires were retrieved and analysed using IBM SPSS Statistics version 25. Descriptive (Mean Item Score, frequency, percentage and Relative Importance Index) and inferential (Mann-Whitney U test and Spearman rho) statistics were employed to analyse the retrieved data.

4. Result and Analysis

4.1 Demographic Attributes of Respondents

This section describes the respondents according to the information given in the distributed questionnaire. Table 2 covers the age categories of the end-user clients; age category, professional background, designation, professional affiliation, year of experience and highest academic qualification of the professionals.

Table 2 - Demographic attributes of respondents

Variables	Frequency	Percent
End-User Clients		
Age category		
21-30	5	8.3
31-40	14	23.3
41-50	22	36.7
51-60	17	28.3
above 60	2	3.3
Total	**60**	**100.0**
Construction Professionals		
Age category		
21-30 years	2	20.0
31-40 years	2	20.0
41-50 years	5	50.0
above 60 years	1	10.0
Total	**10**	**100.0**

Variables	**Frequency**	**Percent**
Professional background		
Architect	1	10.0
Builder	4	40.0
Engineer	3	30.0
Quantity surveyor	2	20.0
Total	**10**	**100.0**
Designation		
Project Manager	4	40.0
Senior Construction Manager	2	20.0
Consulting Engineer	2	20.0
Principal Partner	1	10.0
Chief Quantity Surveyor	1	10.0
Total	**10**	**100.0**
Professional affiliation		
NIA	1	10.0
NIOB	4	40.0
NSE	3	30.0
NIQS	2	**20.0**
Total	**10**	**100.0**
Years of experience		
5-10 years	2	20.0
11-15 years	2	20.0
16-20 years	4	40.0
21-30 years	1	10.0
above 30 years	1	10.0
Total	**10**	**100.0**
Highest academic qualification		
Higher National Diploma	1	10.0
Bachelor’s degree	5	50.0
Master’s degree	3	30.0
Post Graduate Diploma	1	10.0
Total	**10**	**100.0**

The majority of the end-user clients were 22 (36.7%) and 17 (28.3%) within the 41 – 50 and 51 – 60 age range, respectively. The result of the age of the end-user clients reveals the relevance of their contribution to the study. The highest age categories discovered by this study fall within the major age category of building owners in Nigeria (Adewumi, 2020). Those identified are individuals that own and use their properties. They also understand the relevance of this research work based on their observation of events in their property.

The professionals involved in this study include 4 (40%) builders, 3 (30%) Engineers, 2 (20%) Quantity surveyors and 1 (10%) Architect. Oyewobi and Ogunsemi (2010) identified the coordinated activities of the architects, contractors, engineers, planners and clients as a significant influence in rework activities and based on this fact, the information for this study was targeted towards the majority of this class of professionals that are the major stakeholders of rework activities. The retrieved data on their years of experience revealed that 4 (40%) had between 16-20 years of experience; 2 (20%) had 5-10 years; 2 (20%) had 11-15 years; 1 (10%) had 21-30 years and above 30 years. 5 (50%) were Bachelor degree holders, 3 (30%) had master’s degree, 1 (10%) had a postgraduate diploma and the last respondent had a Higher National Diploma (HND). All of the professionals were affiliated to at least one professional body. Their year of experience, educational background and affiliation to professional bodies are attestations to their vast knowledge required to provide relevant data required for this study.

Lastly, information sourced on the professional’s designation revealed 4 (40%) to be project managers, 2 (20%) senior construction managers, 2 (20%) consulting engineers, 1 (10%) principal partner and 1 (10%) chief quantity surveyor. The designations of the professionals sufficiently fulfil the requirements of this study as all of the identified respondents were members of the managerial body of their respective firms who are required to best provide relevant data to support the results of this study.

4.2 Identification of Defects Induced by Non-conformance to Specification and Client's Requirements Causing Rework of Building Components

The defects of building components induced by non-conformance to specification and client's requirements were identified and analysed according to the responses of the end-user clients and professionals. Table 3 shows the list of the identified defects and the difference in the respondents' opinion on the various defects. The Mean Item Score generated for each component were regarded as Relative Agreement Score (RAS) to reflect the measure chosen to analyse the objective.

Table 3 - A comparison of perception between end-User Clients and Professionals towards defects in building

	END-USER CLIENTS			**PROFESSIONALS**			**MANN-WHITNEY U TEST**		
Building components	R	RAS	MR	R	RAS	MR	Z	P. val.	sig.
Plumbing and sanitary system	1	3.67	35.33	2	3.70	36.50	-0.181	0.856	NS
Roofing sheet	2	3.27	35.56	7	3.20	35.15	-0.630	0.949	NS
Poor plastering	3	3.23	35.62	7	3.20	34.80	-0.123	0.902	NS
Painting works and other finishes	4	3.18	34.67	4	3.50	40.50	-0.884	0.377	NS
Electrical appliances and installation	4	3.18	33.02	1	4.00	50.40	-2.656	0.008	S
External works and drainage	6	3.07	35.83	12	2.90	33.55	-0.348	0.728	NS
Corrosion and discoloration of components	7	3.00	37.92	16	2.20	21.00	-2.585	0.010	S
Wall	8	2.98	34.76	7	3.20	39.95	-0.791	0.429	NS
Tiles	9	2.97	35.59	10	3.00	34.95	-0.098	0.922	NS
Concrete works	10	2.85	34.95	10	3.00	38.80	-0.577	0.564	NS
Door handle and accessories	11	2.68	32.63	3	3.60	52.70	-3.084	0.002	S
Window locks and accessories	11	2.68	35.49	13	2.70	35.55	-0.009	0.993	NS
Windows	13	2.62	35.13	13	2.70	37.70	-0.393	0.694	NS
Doors	14	2.53	33.60	6	3.40	46.90	-2.029	0.042	S
Steel components	15	2.52	37.00	19	2.00	26.50	-1.589	0.112	NS
Sealant failure	16	2.43	34.70	13	2.70	40.30	-0.846	0.398	NS
Ceiling and accessories	17	2.32	32.52	4	3.50	53.40	-3.204	0.001	S
Air conditioning unit	18	2.05	34.89	16	2.20	39.15	-0.659	0.510	NS
Floor	19	1.83	34.48	18	2.10	41.60	-1.145	0.252	NS

R = Rank, RAS = Relative Agreement Score, MR = Mean Rank, S = Significant and NS = Not Significant

The building components identified to be defective by the end-user clients with their corresponding mean score in decreasing order are plumbing and sanitary fitting (RAS = 3.67), roofing sheet (RAS = 3.27), poor plastering (RAS = 3.23), painting works and other finishes (RAS = 3.18), electrical appliances and installation (RAS = 3.18), external works and drainage (RAS = 3.07) and corrosion and discolouration of components (RAS = 3.00).

On the other hand, the professionals identified the defective building components to be electrical appliances and installation (RAS = 4.00), Plumbing and sanitary appliances (RAS = 3.70), door handles and accessories (RAS = 3.60), ceiling and accessories (RAS = 3.50), painting works and other finishes (RAS = 3.50), doors (RAS = 3.40), roofing sheet (RAS = 3.20), poor plastering (RAS = 3.20), wall (RAS = 3.20), tiles (RAS = 3.00) and concrete work (RAS = 3.00).

According to Oyewobi et al. (2011), the reworks due to defects were identified to be more in the finishes, frames and upper floors, mechanical installations, doors, windows, roof and covering. Also, according to Aiyetan (2014), the activities that led majorly to rework were plastering, mechanical installations and roof and covering. This study agrees with these previous findings as the defective components identified by the respondents of this study were similar to those prompting rework in the previous findings. However, the electrical installation was found to be more defective in this study, but according to Oyewobi et al. (2011), electrical works contribute less to rework.

Test of Agreement Among Respondents

Mann-Whitney U test was conducted on the parameters to analyse the difference that exists between the opinion of the end-user clients and the professionals at a 5% (0.05) significance level. According to the rules of the test, parameters lesser than the significance level will reflect a significant difference between the opinions of the End-User Clients and the Professionals. The result of the analysis of this parameter, as shown in Table 3, revealed the opinions of the end-user clients and the professionals to be different on only five building components that had their significance level below 0.05. The components and their corresponding significant levels are electrical appliances and installation (p-value = 0.008), corrosion and discoloration of components (p-value = 0.010), door handles and accessories (p-value = 0.002), doors (p-value = 0.042) and ceiling and accessories (p-value = 0.001).

Taggart et al. (2014) identified the activities of electricians on electrical works as one of the three activities having more snag of all other activities. The information supplied by the end-user clients and professionals aligns with the findings of Taggart et al. (2014) as they both identified electrical installations and accessories to be defective. Still, there seems to be a significant difference in the opinion of the end-user clients and professionals on this particular component, according to the Mann-Whitney test conducted. The difference identified was, however, discovered to be due to the large variation between the level of agreement of the end-user clients and professionals.

Table 4 shows a further analysis conducted to test the overall differences that exist between the two class of respondents on the components. The result revealed the p-value of the test to be 0.174, which implies that the clients and construction professionals have significantly related opinions on the defects induced by non-conformance to specification and client's requirement. This shows the independent relevance of the two groups of respondents to this study.

Table 4 - Mann-Whitney U test of the difference in opinion between the end-user clients and the professionals on the defects of building components

Rank Group	N	Mean Rank	Sum of Ranks
End-User Clients	19	17.05	324.00
Professionals	19	21.95	417.00
Total	38		
End-User Clients / Professional's Opinion			
Mann-Whitney U	134.000		
Wilcoxon W	324.000		
Z	-1.359		
Asymp. Sig. (2-tailed)	0.174		

4.3 Perception on the Frequency of Occurrence and Cost of Rework

The perception of the professionals on the frequency of occurrence of rework was analysed using the Relative Importance Index (RII), also referred to as Relative Occurrence Score (ROS), due to the scale of measurement used for analysis. The result of the analysis is presented in Table 5. The building components and activities with frequent occurrence of rework in decreasing order with their associated RII values were revealed to be door handles and accessories (ROS = 0.76), mechanical works and installations (ROS = 0.74), finishes (ROS = 0.74), electrical works and installations (ROS = 0.72), concrete works (substructure) (ROS = 0.66), ceiling, door frames, doors and frames (beams and columns) (0.64), window locks and accessories; roof and covering and window frames (ROS=0.62), laying and arrangement of reinforcement (substructure) and window (ROS = 0.60).

According to the frequency of occurrence in the study of Ajayi (2017), the rework occurrence in tiling, sanitary fittings, blockwork, roofing, electrical works and frame were higher than every other component. This corresponds with the result of this study.

The perception on the cost of rework on component and activities of construction also depicted on Table 5 shows an intensive cost of rework on finishes, concrete works (substructure), concrete work (superstructure), electrical installations, roof and covering, frames (beams and columns), mechanical installations, laying and arrangement of reinforcements (substructure) and external works and drainage compared to every other activities or component of construction work.

Table 5 - Perception on the frequency of occurrence and cost of rework

	Frequency of occurrence		Cost of Rework	
Building components and activities	**Rank**	**RII**	**RANK**	**RII**
Door handles and accessories	1	0.76	22	0.44
Finishes	2	0.74	1	0.76
Mechanical installations	2	0.74	7	0.66
Electrical installations	4	0.72	4	0.72
Concrete works (sub structure)	5	0.66	1	0.76
Ceiling	6	0.64	10	0.64
Door frames	6	0.64	24	0.42
Doors	6	0.64	21	0.46
Frames (beams and columns)	6	0.64	6	0.68
Window locks and accessories	10	0.62	25	0.38
Roof and covering	10	0.62	5	0.70
Window frames	10	0.62	22	0.44
Window	13	0.60	19	0.48
Laying and arrangement of reinforcements (sub structure)	13	0.60	7	0.66
Material selection	15	0.58	17	0.54
External works and drainage.	16	0.56	7	0.66
Wall	16	0.56	15	0.60
Concrete works (super structure)	18	0.54	3	0.74
Stairs and Balustrade	18	0.54	19	0.48
Excavation works	18	0.54	16	0.56
Reinforcement to slab (super structure)	21	0.52	12	0.62
Reinforcement to column (super structure)	22	0.50	12	0.62
Reinforcement to beam (super structure)	23	0.48	12	0.62
Block works	24	0.46	18	0.52
Floor	25	0.40	11	0.64

Test of Relationship using Spearman rho

In a further analysis carried out on the cost and frequency of occurrence of rework, Spearman rho was conducted to determine the relationship between the top five frequent rework components with their corresponding cost perception and the top five perceptions on the cost of rework with their corresponding frequent rework components. The result of this analysis is shown in Table 6. The parameters in order of decreasing relationship with their corresponding rho value include finishes (0.762), mechanical installation (0.666), concrete work superstructure (0.618), electrical installations (0.615), roof and covering (0.449), concrete work (substructure) (0.439) and door handles and accessories (0.267). All of the parameters had correlation coefficients greater than zero (0), which indicates that a positive relationship does exist between the correlated factors. According to Gogtay & Thatte (2017), correlation below 0.5 are considered weak and tends to get weaker as it moves towards zero while coefficients of correlation greater than 0.5 are considered strong and tend to get stronger as it moves towards 1. This rule applies to this study since ρ values were used in determining the relationships between parameters.

Table 6 - Spearman rho for perception on the frequency of occurrence and cost of rework

				Corresponding Perception on the cost of rework						
		Building Components		A	B	C	D	E	F	G
frequency	A	Concrete works (substructure)	P	0.439						
			P-Value	0.204						
	B	Concrete works (superstructure)	P		0.618					
			P-Value		0.057					

C	Mechanical installations	P P-Value			0.666* 0.036				
D	Electrical installations	P P-Value				0.615 0.058			
E	Door handles and accessories	P P-Value					0.267 0.455		
F	Roof and covering	P P-Value						0.449 0.193	
G	Finishes	P P-Value							0.762* 0.010

ρ = Spearman Rank Correlation coefficient

The relationship between the perception on the frequency of occurrence and cost of rework was found to be stronger in finishes and mechanical works as they tend closer to 1 when compared to other parameters. These two components were also seen to be significantly relevant as their p-values were less than 0.05. The results of the correlated factors affirm that an increase in rework cost is ascertained as frequent rework of components occur. However, the frequent occurrence of rework on finishes and mechanical installations was perceived to be more and seen to sporadically increase the cost of rework compared to other components. This study agrees with the findings of Oyewobi et al. (2011) that identified finishes as the major contributor to rework cost. Also, it agrees with the findings of Aiyetan (2014), which identifies finishes and mechanical installations as the second and third major contributors to rework cost, respectively.

5. Conclusion

This study identified the defects causing rework of building components, induced by non-conformance to specification and client's requirements and the perception on rework occurrence and cost. The rework prone building components and activities were identified from the thorough review of previous related literature. The findings of this study revealed the plumbing and sanitary fittings, roofing sheets, plastering, electrical appliances and installation, door handles and accessories to be the rework induced defects caused by non-conformance to specification and client's requirement. Further to this, the frequency of rework occurrence was discovered to be prominent in the door handles and accessories, finishes, mechanical works and installation and concrete work (substructure). Also, the cost of rework was severe on the finishes, concrete work (substructure), concrete work (superstructure), electrical installations and appliances, roof and coverings, frames (beams and columns) and mechanical installations.

Furthermore, the Mann Whitney U test conducted shows an agreement between the opinion of the end-user clients and the professionals on the rework causing defects in building components. Also, the Spearman Rank Correlation revealed the building components with frequent rework leading to exorbitant cost to be finishes and mechanical works. The study affirmed that careful and painstaking attention on the services components (mechanical and electrical), concrete works and finishes will influence a rapid decline in the cost of rework.

This study will, therefore, help the construction stakeholders to identify the components of a building that require extra attention to reduce rework cost. Hence, a reduction in the overall rework and improvement in project performance will be evident.

Acknowledgement

The authors would like to thank and acknowledge Federal University of Technology Akure for all kinds of supports.

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