

Identification of People, Process and Environment (PPE) Rework Factors in Public Building Construction Projects: Experts' Perspective

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Abstract

Rework is a menace in construction projects and adversely affects the performance of projects in terms of cost overruns, schedule overruns and material wastage. This study was aimed at identifying the people, process and environment (PPE) related factors that cause rework in public building construction projects from the perspectives of the professionals in construction projects. To achieve this, extensive review was carried out on existing related literature and a list of 67 rework factors were obtained and categorized into people-related, process-related and environment-related factors. Data was sourced using structured research questionnaire which was self-administered using Google Forms on the construction professionals. Feedback of 74 respondents was used for the analysis. Mean score and Relative Importance Index (RII) were used to rank the PPE related factors of rework. The study revealed that poor workmanship and poor communication are the major factors that cause PPE related rework with mean scores of 4.57 each. Lack of coordination and poor communication have RII of 0.914 within people-related rework category; poor quality assurance and control and ineffective communication of project information and updates have RII of 0.892 and 0.889 respectively within process-related rework category while poor workmanship and poor-quality materials have RII of 0.911 and 0.897 respectively within the environment-related rework category. Factors related to communication and quality management form major causes of PPE related rework. It is recommended that effective communication, good quality management system and best practices, quality materials for construction works, and developing organizational process assets for the organization will help address the problem of PPE related rework.

Keywords: Field study, Survey, Construction, Rework, Project Management Offices, Program Management.

Introduction

Rework constitutes "the tasks of rectifying errors and dealing with changes in scope, quality deviations, and non-conformance, which is wasteful and non-value-adding activity" (Liu, et. al. 2020). It is when an already completed process is repeated so as to meet the quality requirements of the project which in the completed process was not achieved. Love (2020) defined rework as the total direct cost of redoing work in the field regardless of the initiating cause. According to Yim (2015), rework is the undertaking of a design project a second time, as the result of the original project failing to adequately meet design objectives. Its effect on construction is gigantic as the cost impact has been reported to range between 0.1% and 20% of the contract value (Love 2020, Ekwedam, et.al., 2022, Maseko 2017, Oyewobi et.

al., 2011, Hwang et. al., 2009), even as high as 30% of construction cost (Miri & Khaksefidi, 2015) while schedule impact is about 7.1% of total project work hours (Eze and Idiake, 2018; Josephson, Larsson and Li, 2002). The impact of the “unpleasant un-surprise” and ignoring of the “uncomfortable knowledge” (Love, et. al., 2019) has caused some researchers to propose what is called “active rework” (Ye, Jin, Xia & Skitmore (2014) where rework will no longer be viewed as a negative phenomenon but be regarded as part of the construction process.

The proposal by Ye, et. al., (2014) notwithstanding, all over the globe, rework continues to affect construction project performance negatively by causing both cost and schedule overruns in construction projects (Ade-Ojo, Akinola, & Fasuyi, 2020, Love, Matthews & Fang, 2021), low productivity and profitability, degraded stock value and organization’s reputation (Love & Matthews, 2020). In the United States of America, Dougherty, Hughes & Zack (2012) suggested that when direct cost and indirect cost are considered, the average cost of rework on projects is between 7.25% and 10.89% of total construction cost while the planned project time is delayed by 9.8%. The study focused on developing practical ways to avoid rework and its impact on cost and time of the project. Also, Safapour, Kermanshachi, & Taneja, (2019) in the same United States of America concluded that rework has a very unfavourable consequences on construction projects in terms of poor project performance and productivity.

In Australian construction projects, Love, Irani & Edwards (2003) opined that the cost of rework is up to 35% of total project cost and contributes as much as 50% of a project’s total cost overrun. It concluded that rework is in fact one of the primary factors contributing to Australian construction industry’s poor performance and productivity.

Yap & Tan (2021) observed rework to be a stubborn and persistent problem in construction projects in Malaysia, which causes wastage of resources and poor project performance. It adversely affects cost, time, quality and productivity outcome.

Rework is not only a menace in the conventional building construction projects but has also been discovered to harmfully impact greatly on green building construction projects. In Singapore, Hwang, Shan & Tan, (2016) showed great damaging effects in terms of cost and schedule overruns with the four most critical rework factors being, owner change, design change, design omission and contractor’s errors.

In India, Akshay & Konnur (2020) discovered rework as a major problem that hampers project performance causing quality degradation, cost and time overruns. It highlighted lack of experience, poor quality of construction technique and lack of knowledge of design as the factors causing rework in construction projects and recommended proper methodology, awareness and proper check mechanism as ways to reduce and eliminate rework.

In construction projects in Nigeria, rework is considered to have become like a cankerworm as it produces low quality products and does not provide value for money for the client (Ade-Ojo, et. al., 2020, Eze & Idiake, 2018).

Statement of Problem

The construction industry is a key driver towards socio-economic development especially in the developing nations of the world and consumes huge sums of money, man hours and energy (Eze et al. 2018). It creates employment opportunities for both the unemployed and underemployed and the goal of project owners and sponsors is always to get the constructions completed within time and planned budget. But rework has been a major albatross that has caused low project performance (Asadi et al. 2021; Yim, 2015), litigations and lack of client satisfaction in construction projects. Rework, as a menace, is causing abysmal performance of building construction projects which shows in terms of massive cost and time overruns (Hwang, et. al., 2016, Akshay & Konnur, 2020), low productivity and profitability and degraded organization's reputation (Love & Matthews 2020). Consequently, the construction industry suffers setbacks and complex issues which relates to cost, time, quality, productivity and safety (Tsegaye, 2019). It has been observed that in spite of the seriousness of the problem of rework, the attention paid to the root causes of rework in construction is limited (Ye et al., 2014, Taneja, 2019) even as the stubborn problem persists.

In public building construction projects in Nigeria, rework is causing the same damage as several studies have shown (Oyewobi & Ogunsemi 2010, Eze et al. 2018, Oluwaseyi & Opeyemi, 2015, Ade-Ojo et. al., 2020). To deal with the problem of construction rework, there must be good awareness of the causing factors through proper identification and creation of models to use in mitigating them. To this end, some researchers have attempted to group the rework causes using several categorizations, yet there is no definite list of people, process and environment related rework causes. These studies have failed to look at them within the context of these three-project management performance domain elements (3PMPDE) of people, process and environment (PPE) as proposed by Project Management Institute (2019). When these three domain elements are successfully integrated together in a construction system, they bring about the transformation of materials into deliverables. Therefore, the causes of rework and their interactions within these domains need to be clearly assessed so as to help all stakeholders in building construction to know how to mitigate against the causes of rework and avoid their adverse effects. The relationships between the causes of rework and their effects on the project delivery performance criteria need to be known which will guide the development of effective ways on how to eliminate or reduce rework within the project management domains. The existing literature has not broadly identified and listed the rework root causes based on PPE. categorization; neither has the frequency of the occurrence of these PPE causes of rework been ranked nor strategies proposed on how to reduce their effects in public building construction projects in Nigeria. Based on this gap, this research will focus on identifying the causes of rework in public building construction projects in Nigeria based on PPE categorization and recommendations on how to mitigate the rework problems.

Aim and Objectives of the Research

The aim of the research is to identify the people, process and environment (PPE) related factors of rework in the public building construction projects in Nigeria.

The objectives are:

- To identify the rework causes that are related to people, process and environment (PPE) from the opinions of the construction professionals.
- To rank the identified causes of rework on the basis of their importance, impact and frequency.
- To recommend ways to reduce rework based on the perceived relative importance.

Literature Review

The theoretical framework of this study is based on the enhanced fishbone model from the Construction Owners Association of Alberta (COAA), Canada which is a cause-and-effect diagram used to explore all the potential and actual causes of rework. It consists of five major categorizations namely, human resource capability, leadership and communications, engineering and reviews, construction planning and scheduling and material and equipment supply with four possible causes in each of the five broad areas of rework. This is shown in Figure i below.

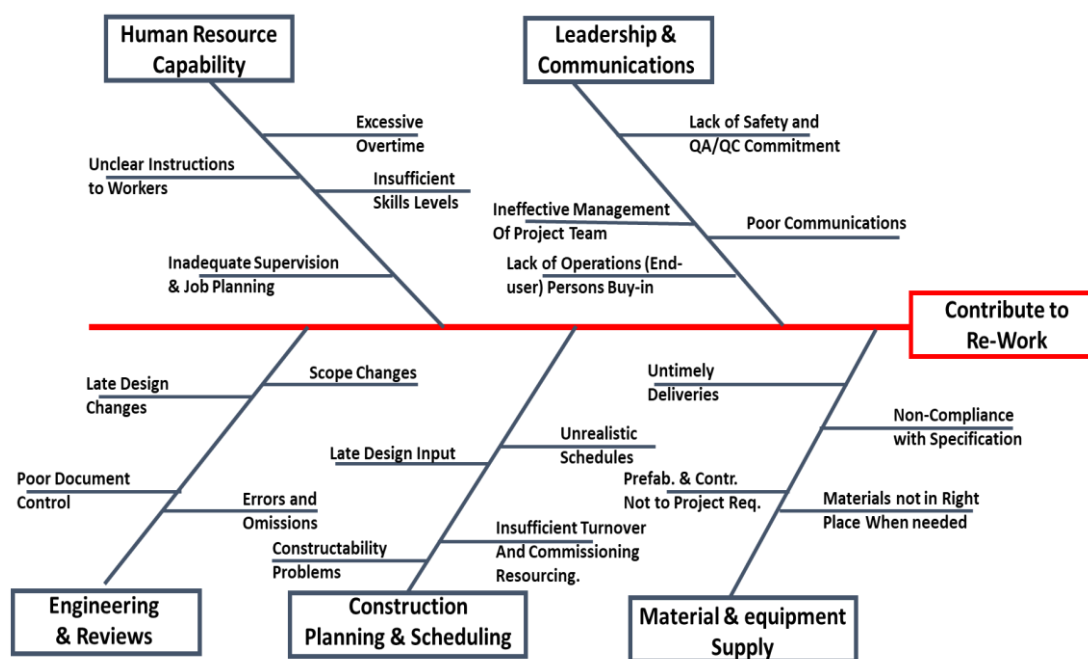


Figure i: COAA's Fishbone rework classification.

Source: Fayek, Dissanayake and Campero (2003)

Causes of rework are factors, variables, events and occurrences that result to rework (Eze, Idiake & Ganiyu, 2018). Both Trach, et. al., (2019) and Ade-Ojo, et. al., (2020) agree that identifying the causes of rework is necessary towards improving project performance. It is

the first step towards rework management, developing a mitigating approach and a preventive or reducing strategy (Asadi, et. al., 2022). Globally, several studies have been carried out by scholars to identify the causes of rework.

Ye, et.al., (2014) analyzed the causes of rework in construction projects in China and opined that direct rework cost ranges from 5% to 20% of the contract value which has significant implications on project success. Using factor analysis, the study revealed 11 groups of rework factors that comprises of design management, communication management, field management, scope management, project process management, subcontractor management, contract management, active reworks, project plan changes, owner capability and external environment.

Taghizadeh, Noorzai, Zaman, Amiri & Rahnee (2021) divided the factors that affect rework in Iran's construction projects into four groups namely project management, education, changes and interaction with the environment (immersion). They identified lack of understanding of the project model by the designer, contractor and user as a major factor that affects rework. The study proposed that being immersed in a virtual environment using virtual reality will help to reduce rework at the design stage.

Raghuram, et. al., (2016) investigated the causes and adverse effects of rework in construction projects in India and developed rework reduction models to mitigate time and cost. The research used comprehensive literature and questionnaire survey to identify 17 rework factors which were then categorized into 5 groups for analysis namely client-related factors, design-related factors, construction-related factors, site management-related factors and sub-contractor-related factors. Using mean ranking within the 5 categories, the following causes of rework were ranked highest among the 17 causes identified: lack of experience and knowledge in design and construction process, incomplete drawings, errors due to inappropriate construction methods, shortage of skilled labours and inadequate supervision. Isasare & Bhirud, (2018) in the same India suggested other factors like client's dissatisfaction, disagreement between the contractor and client which result in legislative dispute and material wastage as factors that cause rework in Indian construction projects. Rework cost is suggested to increase up to 10% of the project cost.

Asadi, et. al., (2021) investigating the common causes of rework in construction contracts in New Zealand agreed that rework is a chronic problem in construction projects which professionals are yet to make effective progress in reducing its occurrence. 22 causes were identified by the study with error in both design and construction being ranked highest by construction professionals in the country.

Safapour, Kermanshachi, & Taneja, (2019) in the United States of America investigating and analyzing the rework indicators that affect change orders, cost and schedule performance, grouped the factors of rework into 3 categories namely people, project and organization. The result of the study suggests that the experience of the project management team (PMT) in the design phase and construction phases and the number of the project management team who are part of the construction work are the most

important rework indicators. Dougherty, et.al., (2012) in the United States concluded that average rework on projects can cost between 7.25% and 10.89% of total construction cost when both direct and indirect cost are considered. Also, it can cause approximately 9.8% project schedule delay of the planned project time. 8 factors considered were grouped into change and errors/omissions. The changes include constructor, design, owner and vendor changes while the error/omissions were constructor, design, transportation and vendor errors and omissions. Some of the rework remedies proposed by the study include the use of Building Information Modelling (BIM) and Virtual Design and Construction (VDC), biddability review, early and continuous stakeholder involvement, design freeze prior to construction and delegation of authority, and other reviews like constructability, change order, and operability.

Yap & Tan (2021) investigating rework in construction projects in Malaysia revealed that the leading causes of rework include poor quality management, improper planning, design changes, improper planning, and poor subcontractor management. Minimization measures were also suggested which include improving communication, Building Information Modelling (BIM) and project management flexibility. This agrees with Dougherty, et.al., (2012).

In exploring the critical frequent factors of rework in the Egyptian construction projects, Akal & El-Kholy, (2021) analyzed 38 rework factors lifted from literature using the mean score of 3.50 as a critical cut of value. The causes of rework were scored by 69 construction practitioners using the questionnaire which was the research instrument. The result highlighted 15 factors as critical frequent rework factors affecting the Egyptian construction sector. These critical factors include accelerating the schedule and fast-tracking, payment delay, lowest bidder policy, poor local vocational education, design errors and design omission, poor workmanship, lack of training programs in the construction organization, staff turnover and staff allocation, compulsory changes and modifications due to site conditions, poor communication, poor quality materials and incomplete and incorrect design information.

Idowu & Aligamhe (2016) assessed the causes and effects of rework on public buildings in Edo State, Nigeria. It observed that rework has not been helpful to the construction projects performance delivery in Nigeria. 20 causes of rework were identified from literature and further categorized into 5 groups namely leadership and communications, human resources capabilities, engineering and review, construction planning and scheduling, and materials and equipment supply. The study ranked non-compliance with specification, poor supervision, incompetent supervision, unclear work specification and ineffective project management team, as the prime causes of rework within the categories while insufficient commissioning, start-up resources and excessive overtime were ranked lowest. The impact of rework identified in the research include project abandonment, time and cost overruns which induces several forms of project disputes and litigations. Good implementation of

quality control plan and project inspection are also recommended as the preventive strategies against construction rework.

People-related rework factors

The challenges facing project managers and construction teams increase by the day as the complexities of construction projects continues to increase (Hayat, 2018). While investigating the causes of manageable construction rework and related successful strategies, Taneja, (2019) opined that about 18% of the causes of rework are traceable to the experience of the Project Manager in construction and design and other issues that are related to the project team. About 34% of the identified rework causes are people-based. Other listed rework causes which are rated high according to the research study include: owner/client involvement issues like requests for enhancement and changes, lack of skill, lack of experience and expertise, adversarial attitude, lack of supervision, type of partnership, poor decision-making process, misinterpretation due to lack of knowledge, accountability, well-being, personality type, motivation and morale level, absenteeism and team conflict among others. This tends to agree with Project Management Institute (2019) which allocated 42% to the project management tasks and enablers that are found in people domain for those preparing for the Project Management Professional (PMP) certification evaluation. Safapour and Kermanshachi (2019b) is also in agreement with the opinions expressed above. The research categorized rework factors into organization, project and people and the result reveals that the experience of the Project Management Team (PMT) in the design and / or construction phase and the number of PMTs who work in a construction project are the most important indicators in causing rework. The causes of rework listed in this people category are skill shortage (p0.069), socio-cultural factors (p0.011), changes in construction method (p0.063) & defect in design (0.082).

The result of Enshassi, Sundermeier & Zeiter, (2017) in Palestine shows that out of the seven categorized rework causes studied, contractors-related and human resource capability-related causes are the major categories that impact on construction project performance. Other rework factors that bear considerable influence on the project are attempts to fraud, competitive pressure, ineffective management, and absence of job security. All these are people problems. Incompetence of project personnel is touted as a factor that causes rework as most of the people in construction in developing countries especially are unskilled. Adi & Niam (2012) estimates that 62% of construction labour in Indonesia, for example, is an unskilled labour. This statistic is even worse in some other developing economies. Unskilled labour is a major factor in causing rework. Sources of rework include planning effort (construction and design), project manager goal commitment, project team motivation, project manager technical capabilities, scope and work definition, and control systems. Safapour & Kermanshachi (2019a) ranked the following as the rework factors that are based on the people who work on the project: lack of experience, lack of skill, lack of knowledge, lack of safety commitment, and lack of motivation. Love, et. al., (2018) opined

that when there is no strong commitment to safety, project workers tend to adopt dangerous behaviours, doing what was not planned, causing injuries and putting undue pressure on the other workers thereby causing rework at the end. Emuze & Sorensen (2014) equally argues that in labour intensive constructions, rework is bound to occur.

Maseko, (2017) suggested the most significant causes of rework in design to include: design errors, changes incomplete, shortage of labour, lack of professionalism and poor document control. This result was obtained out of a collection of factors comprising of eight factors that cause rework. Lack of proper coordination during the design phase is also a factor that can cause rework and thereby increase the cost of construction (Hyun, Kim, Lee, Park & Lee, 2020). In detecting errors, every member of the project team must be involved in ensuring that proper reviews are done and completed and these activities must be coordinated by the project manager who engages the subject matter experts required (Taneja, 2019).

Process-related factors of rework

When specific inputs like materials and information are acted upon in a sequenced manner by a number of activities or operations to transform them into a given output, that consists a process (Oyewobi & Ogunsemi, 2010). Rework occurs within the sub-systems and systems of the processes of a construction project. Construction projects have a life cycle in which the processes are related in sequential, overlapping and iterative ways.

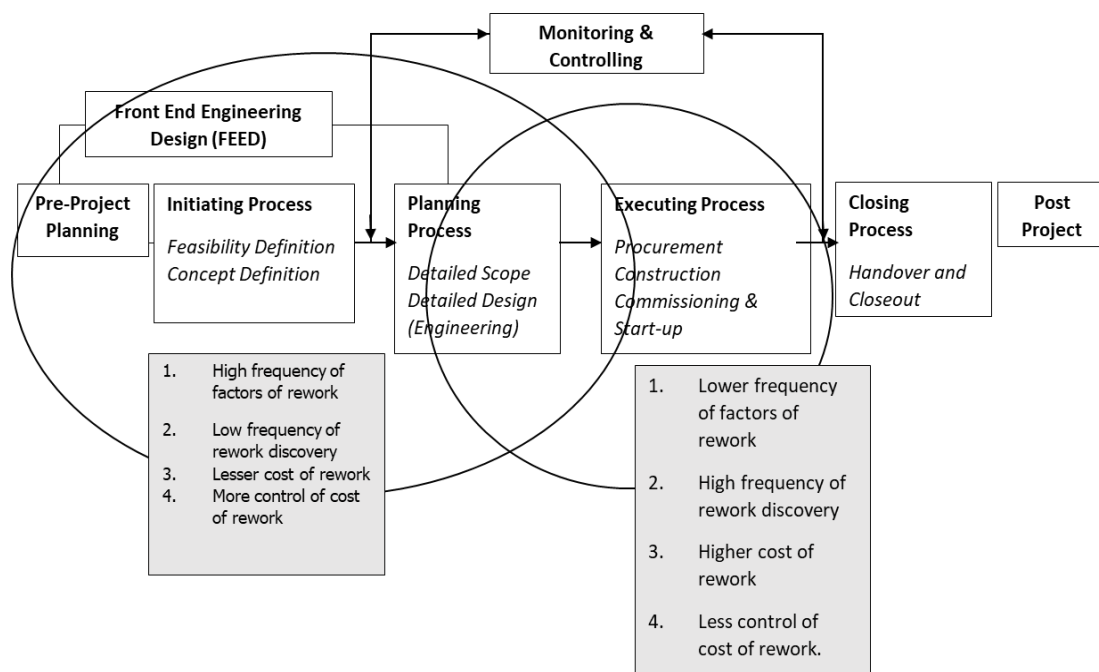


Figure ii: Construction Project Process.

Source: Field survey 2023.

The figure ii above is a combination of the contributions of Project Management Institute (2017), Murray (2015), Jha (2011), National Building Code (2006) and Samant, (2016) which shows the construction project processes – The pre-project planning, initiating, planning, executing, closing and post project processes. The unique nature of the construction industry is that within most of the processes, several projects can be executed and multiple contracts issued respectively depending on the size of the main project. The three processes the research focuses on are initiating process (Pre-design), planning process (Design) and executing (Construction) process. It is within these processes that rework majorly occurs.

As part of the design process, it is important that several gates be created for design review by responsible subject matter experts and subsequently design-freeze using the instrumentality of the client's approval and signing off. ConSIG CWG, (2020) suggests that too often, good attention is not paid to the review gates which results in incorrect and incomplete designs being issued for construction. When there are missing requirements (Tan, et. al., 2017), it worsens the situation. The concept phase requirements analysis must be completed with all the requirements changes and trade-offs concluded before the information is given to the designers. The design defects caused by the incomplete information from conceptual phase causes rework along the construction process. Also, when design freeze is either too early due to impositions or too late due to incompetence or iteration in the design process, errors and omissions that cause rework are inevitable (Eger, Eckert & Clarkson, 2005). Change requests increases the risk of rework within the project. Proactive customer participation, contract value and project duration have been identified, among others, as the causal factors for rework (Gontijo & Braga, 2019).

Rework in construction phase is discovered either in the process of execution or when quality assurance and quality control are carried out. That is where efforts must be made to correct the discovered error. Rework are performed to rectify defects after design phase within transportation and onsite phases and this kind of rework is called field rework (Hyun, et al. 2020, Construction Industry Institute, 2001).

Kakitahi, Alinaitwe, Landin & Mone, (2016) shows that design information omission is a major factor construction-related rework can be attributed to. The study discovers that lightning conductor, electrical and roofing installations were the building elements that have the highest frequency of rework. From the projects researched, the cost and schedule impacts of the construction-related rework are 4.63% and 8.42% respectively. This inadequate design management factor agrees with the result of Oladokun & Alshaikh, (2018). Deficient design management in the form of incomplete project documentation results in cost and schedule overrun as they inundate the project with errors that cause rework. The quality of design documents affects the efficiency of the construction process, hence when the drawings communicated to the contractor have issues, there will be errors and conflicting information which when utilized for construction will cause rework and variations (Oladokun & Alshaikh. 2018).

Fast-tracking during construction process is an arrangement that must be planned for and specific contract put in place to deal with all the complexities (Moazzami, Dehghan, Ruwanpura, 2011). Though when properly managed, the overlapping of the project activities is touted to help achieve good schedule performance (Khoueiry, Srouf & Yassine, 2013), the potential and risk of rework is very high in this process. When a project is under pressure to meet up with missed deadlines and fast-tracking is chosen as a crashing method, the project risks include construction errors and omissions, construction change orders and construction damage which lead to rework and modifications.

Communication during the construction process is a key contributor to project success (Project Management Institute, 2017). When there is poor communication either among a phase stakeholder or between the stakeholders from one phase of the construction process to another phase, this success is hampered. The result of Oluwaseyi & Opeyemi (2015) shows that poor communication between the contractor and designer consultant is one of the main causes of rework in the examined projects.

Environment-related factors of rework

The project environment is the context within which a project is processed and it includes internal and external contexts. This context creates connections and interactions of several factors such as political climate, economic (financial), social, technology, legal (regulatory and legislative), physical, people (stakeholders), organizational and regional cultures, operational behaviours (Egeland, 2011, Project Management Institute, 2017, Project Management Institute, 2020). The influences these enterprise environmental factors and organizational process assets (Project Management Institute, 2017) cast on the existence and operation of the construction project and the climate and culture they create determine whether the project will be successful or not. They influence quality and information flow which are two major issues that affect rework.

Organizations create the direct environment that affects the performance of a construction project. Love, et. al., (2018) revealed that rework can be significantly reduced by giving authentic leadership style, encouraging behavioural changes and cultivating error management culture. This culture, claims the study, when harnessed in construction projects, will improve performance and productivity.

Love, Smith, Ackermann & Irani, (2019) wondered why construction organizations do not put in place mechanisms to contain and reduce rework occurrence, even when they know that it is an issue in their projects. The study, which was carried out in Australia, discovered that rework is regrettably accepted as a norm or an "unpleasant un-surprise" by senior managements of organizations who see reporting of nonconformance as a sign of poor project management leadership or an unfortunate event, hence project managers tend to hide their occurrence and keep them unreported. This practice causes the construction organizations not to learn anything from their previous projects, deterrence capacity is not built against rework in the future, perpetuation of unethical practices and promotion of

unsafe conditions in projects. The research observes that because the construction organizations in Australia lack the controls and routines to moderate the effects of people's behaviour and actions, it reinforces inappropriate decisions to continue in the system.

The climate within which the project team operates has been suggested to influence their activities (Anvuur & Kumaraswamy, 2016). The work climate can generate system pressure (Gontijo & Braga, 2019) that will constitute a rework risk. Workload and System pressure team motivation and performance which creates the conditions of rework. Anvuur & Kumaraswamy, (2016) findings suggest that it is when the four dimensions of work climate are pursued that the full individual's cooperative behaviour in project settings can be unleashed to realizing the project objectives. Rework does not happen in isolation of the factors that cause them, hence lack of management commitment and supervision, demand for excessive overtime, unclear instructions were gathered as factors that make the organization not to exercise corporate control and management over the project process that results in rework (Maseko, 2017). The study also opined that though most companies acknowledged the unpredictability and problematic nature of rework in the construction projects, they failed to develop a management policy on how to deal with it when it comes. This lack of a conceptual model exacerbates rework occurrence. Safapour et al. (2019) suggest that ineffective coordination, lack of resource management, ineffective communication and lack of organizational training plan are among the highly ranked indicators that make an environment to be susceptible to rework. If the project organization has an experienced project management team with a very good coordination and communication information sharing, the likelihood of reducing rework is high. Lack of experience and poor management will result in poor management of the project team which will eventually cause rework. When there is no management support or what the study calls authority support, the stability of the project team can be disrupted which will lead to misunderstandings in communication which results in errors and mistakes. (Project Management Institute, 2017, Anvuur & Kumaraswamy, 2016). Every project must have a clear communication plan which defines how the different stakeholders ought to share information and reports on the project.

Though Love, et.al., (2003) did not find any significant negative relationship between organization's learning practice and rework costs in their projects, it was very clear that not having quality management systems and lack of its implementation suggests that the firm does not even have the tools and techniques required to identify and analyze costs of rework. Organization's learning practice includes proper documentation and lessons learned. Rework mistakes made in previous projects are likely to be repeated if firms do not take record, review and document lessons learned at the end of their projects. Not only that, better management practices have to be adopted to ensure the implementation of results from the reviews.

Research Methodology

The aim of this study was to identify the people, process and environment (PPE) category of rework in public construction projects. This was achieved by collecting the perspectives of construction project professionals and analyzing them with the purpose of identifying the highly rated causes of rework. A structured Questionnaire was used for data collection which was self-administered by the author through Google Form and printed copies. These were distributed among the construction professionals through their respective registered bodies. A seven-step research framework was developed to help achieve success as shown in figure iii below.

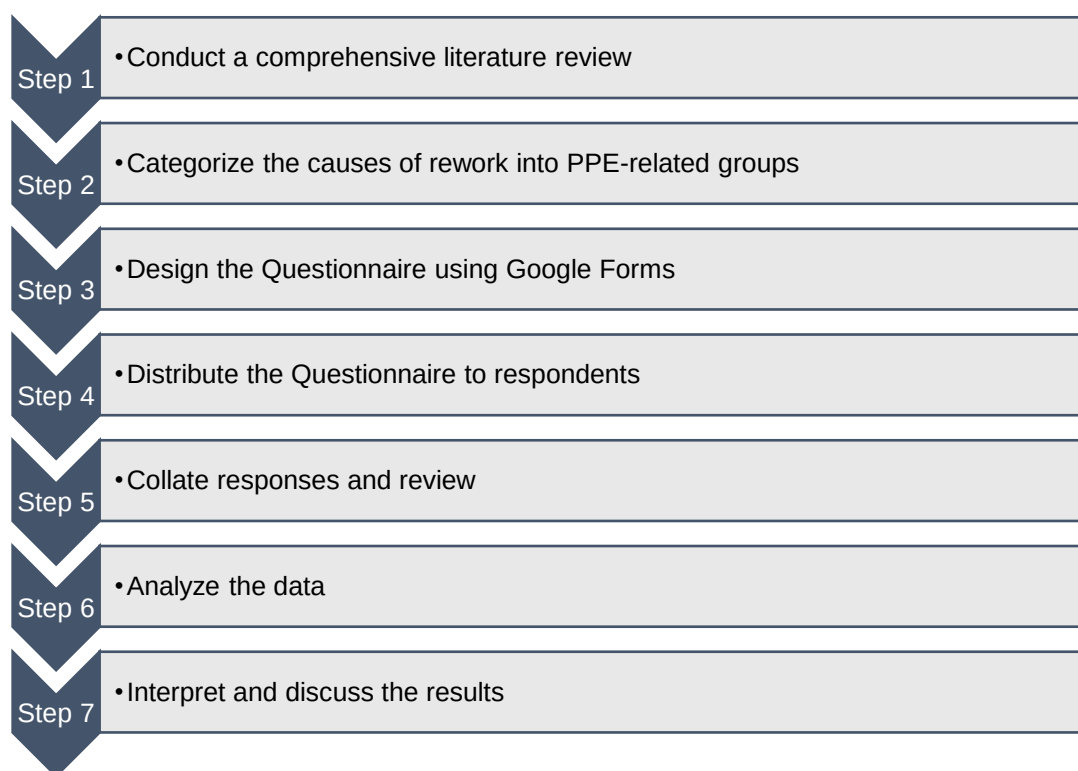


Figure iii: Research Framework. Source: Field survey 2023

A total of sixty-seven (67) causes of rework were obtained from relevant literature. These were grouped into more manageable and significant sizes and categorized into people-related, process-related and environment-related (PPE) rework causes.

Research Population

The population of the study consisted of registered professionals in the construction industry which include project managers, builders, architects, quantity surveyors, land surveyors, engineers, contractors and other construction workers.

A total of one hundred (100) questionnaires were distributed and seventy-eight (78) were returned which is a 78% response rate. However, four (4) responses were discarded because

of cancellations which rendered them invalid. Seventy-four (74) responses were used for data analysis. Efficiency rate was 74%.

Data Measurement and Analysis

The causes of rework were rated by the respondent with a 5-point Likert scale of 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree. Data collected was analyzed using IBM Statistical Package for Social Science (SPSS) Version 26 software. The mean score analyzed the causes of rework to show the ratings based on the perception of the respondents. Descriptive statistics like percentages was used to analyze the demographic information of the respondents. The Relative Importance Index (RII) for the causes of rework was computed in Microsoft Excel 2016, using the formula in equation (1) below, within the categories of PPE-related rework causes and presented using tables.

$$\text{Relative Importance Index} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{A * N} \quad (1)$$

Where,

n_5 is the respondents for strongly agree occurrences

n_4 is the respondents for agree occurrences

n_3 is the respondents for undecided occurrences

n_2 is the respondents for disagree occurrences

n_1 is the respondents for strongly disagree occurrences

A is the highest weight = 5

N is the total number of respondents

The value of RII is between 0 and 1. The indication is that rework causes with higher RII are viewed as more important than the others by the respondents.

Results and Discussions

Demography of respondents

The Table i below shows the demographic information of the respondents for the study. Those within the age range of 20years - 29years are 9.5% while 30years - 39years are 29.7%. 40years - 49years are 31.1%, 50years - 59years are 25.7% and those 60years and above are 4.1%. This shows that the greater percentage of the respondents are between the ages of 40 years and 59 years. Ages between 20years and 29 years being 9.5% seems to be a reflection of the economic condition of the country where most young people do not settle on a career job after graduation from school (Anah, Nwosu & Ezeji, (2017), Erunke, (2021), Ayomide, (2022)).

The Project Managers and Builders constitute 29.7% and 23% of the respondents respectively while the Engineers are 20.3%. Another considerable group of professionals among the respondents are the Quantity/Land Surveyors with 14.9% while the Contractors were 4.1%. This suggests that a lot of practitioners among the respondents are identifying increasingly with the project management profession since most of them must have got their first degree in a different course of study before entering into project management

practice. This may explain why the greater percentage of the respondents, a combined percentage of 63.5%, have 11years of experience and above.

The educational qualification of the respondents shows an enlightened group. 47.3% have their first degree while 41.9% have a Master's degree, 9.5% of the respondents hold a PhD. This may explain why their job positions are more of senior management, 37.8% are Managers and Directors are 23%. Supervisors are 20.3% while Engineers are 18.9%.

Table i: Demographic information of the respondents

Age of respondents			
	Frequency	Valid Percent	Cumulative Percent
20years - 29years	7	9.5	9.5
30years - 39years	22	29.7	39.2
40years - 49years	23	31.1	70.3
50years - 59years	19	25.7	95.9
60years and above	3	4.1	100
Total	74	100	

Profession of respondents			
	Frequency	Valid Percent	Cumulative Percent
Project Manager	22	29.7	29.7
Builder	17	23	52.7
Engineer	15	20.3	73
Architect	6	8.1	81.1
Quantity / Land Surveyor	11	14.9	95.9
Contractor	3	4.1	100
Total	74	100	

Years of Experience of respondents			
	Frequency	Valid Percent	Cumulative Percent
Below 5years	6	8.1	8.1
5years - 10years	21	28.4	36.5
11years - 20years	24	32.4	68.9
21years and above	23	31.1	100
Total	74	100	

Educational Qualification of respondents

	Frequency	Valid Percent	Cumulative Percent
OND	1	1.4	1.4
HND / BSc	35	47.3	48.6
MSc	31	41.9	90.5
PhD	7	9.5	100
Total	74	100	

Job Position of respondents

	Frequency	Valid Percent	Cumulative Percent
Supervisor	15	20.3	20.3
Engineer	14	18.9	39.2
Manager	28	37.8	77
Director	17	23	100
Total	74	100	

Source: Field survey 2023

Mean score analysis of PPE-related causes of rework

Table ii, below shows the respondents' rating of the 67 PPE-related causes of rework in order of their score. The 10 most rated causes of rework that relate to PPE include: poor workmanship (4.57), poor communication (4.57), poor quality materials (4.50), poor communication channel and method (4.47), ineffective communication of project information and updates (4.45), lack of coordination (4.45), poor quality assurance and control (4.45), project team lacking a clear objective (4.41), construction error (4.41), poor project planning (4.41), while the following 5 causes are rated poorly by the respondents: virtual cloud software problems (3.30), overtime (3.50), labour intensive project (3.59), lack of diversity and inclusion (3.61), and management mandates (3.64). Poor workmanship being on the top of the list shows that first and foremost, the major causes of rework are human-related. Communication and quality issues generally are also considered as very serious factors by the professionals in the building construction projects as concerns people-, process- and environment-related causes of rework since they constitute about 50% of the first 10 factors that cause PPE-related rework. This agrees with Safapour, Kermanshachi, Taneja & Pamidimukkala, (2021) who revealed that inexperienced workers and lack of communication were among the first-ranked indicators of rework in human, project and organization categories and Tsegaye, (2019), who concluded that defective workmanship was among the top 3 major causal factors of rework in Ethiopia. In Al-Janabi, Abdel-Monem, & EL-dash, (2020), schedule compression was ranked 2nd as a top rework factor in the Egyptian construction industry, 4th in Palestine (Enshassi, Sundermeier & Zeiter, 2017), and 14th in China (Ye, et.al., (2014) respectively, but from this

study, fast-tracking which is a method of schedule compression is 59th on the list. This may suggest lack of schedule consciousness generally in most projects in Nigeria, hence, people do not work in most projects under pressure working to avoid schedule overrun.

It is important to observe from the mean scores that the range of scores for all the identified PPE-related causes of rework is between 3.30 and 4.57. None is below 2.5 which is the average score for ranking 1 – 5. This shows that the respondents suggest that professionals should pay attention to these causes of rework in order to achieve project success.

Table ii: Mean score analysis of PPE related causes of rework from the respondents' rating

SN	PPE-related rework causes	N	Sum	Mean Score	Std. Deviation
1	Poor workmanship	74	338	4.57	0.621
2	Poor communication	74	338	4.57	0.643
3	Poor quality materials	74	333	4.50	0.625
4	Poor communication channel and method	74	331	4.47	0.744
5	Ineffective communication of project information and updates	74	329	4.45	0.622
6	Lack of coordination	74	329	4.45	0.644
7	Poor quality assurance and control	74	329	4.45	0.761
8	Project Team lacking a clear objective	74	326	4.41	0.701
9	Construction error	74	326	4.41	0.810
10	Poor project planning	74	326	4.41	0.660
11	Poor interpretation of drawing	74	325	4.39	0.737
12	Design information omission	74	323	4.36	0.837
13	Incompetence among project team	74	322	4.35	0.748
14	Incomplete project documentation	74	320	4.32	0.704
15	No clear role of the owner and the contractor	74	318	4.30	0.656
16	Lack of appropriate design skill	74	318	4.30	0.772
17	Natural hazards	74	317	4.28	0.958
18	Project changes	74	317	4.28	0.820
19	Unclear project information	74	316	4.27	0.708

20	Lack of proper decision-making delegation	74	315	4.26	0.777
21	Unclear objectives and instructions	74	315	4.26	0.908
22	Poor Stakeholder engagement	74	313	4.23	0.820
23	Lack of records of rework and lessons learned asset	74	312	4.22	0.727
24	Construction damage	74	312	4.22	0.745
25	Client's poor decision making	74	312	4.22	0.815
26	Missing scope	74	312	4.22	0.926
27	Absence of shared understanding	74	310	4.19	0.734
28	Adverse weather condition	74	310	4.19	0.822
29	Poor use of technology	74	310	4.19	0.788
30	Unskilled labour	74	309	4.18	0.956
31	Poor risk identification and mitigation	74	308	4.16	0.861
32	Inadequate resources	74	307	4.15	0.886
33	Lack of training among team members	74	305	4.12	0.810
34	Changes in construction method	74	305	4.12	0.810
35	Wrong procurement approach	74	303	4.09	0.968
36	Improper stakeholder analysis and engagement	74	303	4.09	0.797
37	Not able to address and remove impediments, obstacles, and blockers for the team	74	302	4.08	0.772
38	Deficiencies in documentation control	74	302	4.08	0.807
39	Project complexity	74	301	4.07	0.800
40	Cost and schedule changes	74	300	4.05	0.858
41	Poor team growth and development	74	298	4.03	0.640
42	Bad WBS and incomplete activity list	74	297	4.01	0.884
43	Unmotivated workforce	74	297	4.01	0.884
44	Adverse organizational culture	74	297	4.01	0.836
45	Damage done by subcontractor	74	296	4.00	0.922

46	Change of government policies	74	296	4.00	1.110
	Lack of iterative assessment and	74	294	3.97	0.740
47	prioritization of tasks				
	Bad contract relationship	74	292	3.95	0.978
48	structure				
49	Leadership Change	74	292	3.95	0.949
50	Client's financial problems	74	291	3.93	0.998
51	Caustic leadership style	74	291	3.93	0.764
52	Unresolved conflict	74	289	3.91	0.909
53	Team Conflict	74	289	3.91	1.036
	Failure to provide protection for	74	289	3.91	1.062
	construction workers and				
54	constructed work				
	Regulatory and compliance	74	289	3.91	0.939
	demands				
55					
56	Multi-layered sub-contracting	74	287	3.88	0.921
57	Poor rewards system	74	285	3.85	0.917
58	Owner alignment	73	281	3.85	0.908
59	Fast tracking	74	283	3.82	1.012
60	Supply chain problems	74	280	3.78	0.926
61	Organizational changes	74	277	3.74	0.877
62	Staff turnover	74	271	3.66	1.089
63	Management mandates	74	269	3.64	0.930
64	Lack of diversity and inclusion	74	267	3.61	1.083
65	Labour intensive project	74	266	3.59	1.059
66	Overtime	74	259	3.50	1.024
67	Virtual cloud software problems	74	244	3.30	0.947

Source: Field survey 2023

Relative Importance Index (RII) of the PPE-related causes of rework

The formula above was used to calculate the RII for the causes of rework within the categorized groups. This was to identify the causes of rework the respondents see as more important than the others. These are presented in tables iii – v below.

RII for people-related causes of rework

Table iii shows that within the category of people-related causes of rework, the respondents are in agreement in considering these factors in order of importance: poor communication (0.914), lack of coordination (0.914), project team lacking a clear objective (0.881), incompetence among project team (0.870), and lack of appropriate design skill (0.859). The following are considered the 5 least important factors within the people-related rework

category: lack of diversity and inclusion (0.722), team conflict (0.781), unresolved conflict (0.781), owner alignment (0.786) and caustic leadership style (0.786). It is good to note that it does not mean that these factors do not cause rework. It only shows that in relation to all the causes identified, the respondents have positioned them according to what they consider more important than the other.

Table iii: RII for people-related causes of rework.

People-related Causes of Rework	Strongly agree (5n ₅)	Agree (4n ₄)	Undecided (3n ₃)	Disagree (2n ₂)	Strongly disagree (1n ₁)		RII	Rating
Poor communication	235	92	9	2	0	338	0.914	1st
Lack of coordination	235	92	9	2	0	338	0.914	2nd
Project Team lacking a clear objective	190	116	18	2	0	326	0.881	3rd
Incompetence among project team	180	120	18	4	0	322	0.870	4th
Lack of appropriate design skill	165	132	15	6	0	318	0.859	5th
Lack of proper decision-making delegation	155	136	18	6	0	315	0.851	6th
Client's poor decision making	150	144	15	6	0	315	0.851	7th
Unclear objectives and instructions	185	92	33	4	1	315	0.851	8th
Poor Stakeholder engagement	160	120	27	6	0	313	0.846	9th
Unskilled labour	185	84	36	6	1	312	0.843	10th
Absence of shared understanding	130	152	24	4	0	310	0.838	11th
Lack of training among team members	125	144	33	2	1	305	0.824	12th
Not able to address and remove impediments, obstacles, and blockers for the team	115	148	36	4	0	303	0.819	13th
Poor team growth and development	75	192	33	0	0	300	0.811	14th
Unmotivated workforce	120	136	30	12	0	298	0.805	15th
Client's financial problems	140	108	36	14	0	298	0.805	16th

Damage done by subcontractor	120	128	39	8	1	296	0.800	17th
Leadership Change	105	152	15	20	0	292	0.789	18th
Caustic leadership style	80	160	45	6	0	291	0.786	19th
Owner alignment	90	140	57	4	0	291	0.786	20th
Unresolved conflict	100	136	39	14	0	289	0.781	21st
Team Conflict	115	132	21	20	1	289	0.781	22nd
Lack of diversity and inclusion	75	124	45	20	3	267	0.722	23rd

Source: Field survey 2023

RII for process-related causes of rework

Table iv shows that considering the order of importance within the process-related causes of rework category, the respondents are in agreement that the following are serious factors: poor quality assurance and control (0.892), ineffective communication of project information and updates (0.889), poor communication channel and method (0.884), poor project planning (0.881), poor interpretation of drawing (0.878) and construction error (0.878). The causes that have low relative importance index are: virtual cloud software problems (0.662), labour intensive project (0.716), supply chain problems (0.751), fast tracking (0.765), bad contract relationship structure (0.803) and bad WBS and incomplete activity list (0.803). This suggests that during project execution, the quality of the process and quality inspection, communication and good planning are serious areas to pay attention to, as considered by the respondents.

Table iv: RII for process-related causes of rework.

Process-related Causes of Rework	Strongly agree (5n ₅)	Agree (4n ₄)	Undecided (3n ₃)	Disagree (2n ₂)	Strongly disagree (1n ₁)	RII	Rating
Poor quality assurance and control	215	100	9	6	0	330	0.892 1st
Ineffective communication of project information and updates	190	124	15	0	0	329	0.889 2nd
Poor communication channel and method	215	92	15	4	1	327	0.884 3rd
Poor project planning	180	132	12	2	0	326	0.881 4th
Poor interpretation of drawing	190	116	15	4	0	325	0.878 5th
Construction error	205	96	18	6	0	325	0.878 6th

Design information omission	205	92	24	2	1	324	0.876	7th
Incomplete project documentation	150	152	12	4	0	318	0.859	8th
Project changes	165	124	24	2	1	316	0.854	9th
Inadequate resources	165	124	21	4	1	315	0.851	10th
Unclear project information	140	148	24	2	0	314	0.849	11th
Construction damage	135	148	24	4	0	311	0.841	12th
Missing scope	170	108	21	12	0	311	0.841	13th
Changes in construction method	120	156	24	4	1	305	0.824	14th
Improper stakeholder analysis and engagement	120	140	42	2	0	304	0.822	15th
Poor risk identification and mitigation	135	128	30	10	0	303	0.819	16th
Wrong procurement approach	145	120	30	6	2	303	0.819	17th
Deficiencies in documentation control	115	152	27	8	0	302	0.816	18th
Project complexity	105	156	36	2	1	300	0.811	19th
Lack of iterative assessment and prioritization of tasks	105	144	45	4	0	298	0.805	20th
Bad WBS and incomplete activity list	120	128	39	10	0	297	0.803	21st
Bad contract relationship structure	125	120	45	6	1	297	0.803	22nd
Fast tracking	105	112	54	10	2	283	0.765	23rd
Supply chain problems	80	128	57	12	1	278	0.751	24th
Labour intensive project	85	84	78	16	2	265	0.716	25th
Virtual cloud software problems	45	84	84	32	0	245	0.662	26th

Source: Field survey 2023

RII for environment-related causes of rework

Table v shows that within the environment-related causes of rework category, the respondents consider the following factors in order of importance: poor workmanship (0.911), poor quality materials (0.897), no clear role of the owner and the contractor (0.859), natural hazards (0.854), lack of records of rework and lessons learned asset (0.846), and

poor use of technology (0.841). The factors that are considered of lower importance include: overtime (0.697), management mandates (0.727), staff turnover (0.730), organizational changes (0.751) and poor reward system (0.778). This suggests that the respondents consider factors at the site where construction is taking place as causing rework more than the policies within the executing organization.

Table v: RII for environment-related causes of rework

Environment-related Causes of Rework	Strongly agree (5n ₅)	Agree (4n ₄)	Undecided (3n ₃)	Disagree (2n ₂)	Strongly disagree (1n ₁)	RII	Rating
Poor workmanship	230	92	15	0	0	337	0.911 1st
Poor quality materials	200	124	6	2	0	332	0.897 2nd
No clear role of the owner and the contractor	150	144	24	0	0	318	0.859 3rd
Natural hazards	195	88	24	8	1	316	0.854 4th
Lack of records of rework and lessons learned asset	145	136	30	2	0	313	0.846 5th
Poor use of technology	150	124	33	4	0	311	0.841 6th
Adverse weather condition	140	144	21	4	1	310	0.838 7th
Cost and schedule changes	120	144	30	6	1	301	0.814 8th
Change of government policies	165	84	36	10	3	298	0.805 9th
Adverse organizational culture	120	116	54	6	0	296	0.800 10th
Regulatory and compliance demands	110	132	33	16	0	291	0.786 11th
Failure to provide protection for construction workers and constructed work	135	92	45	16	1	289	0.781 12th
Multi-layered sub-contracting	110	108	63	8	0	289	0.781 13th
Poor rewards system	100	128	48	12	0	288	0.778 14th
Organizational changes	60	160	45	12	1	278	0.751 15th
Staff turnover	90	100	63	14	3	270	0.730 16th
Management mandates	60	132	60	16	1	269	0.727 17th
Overtime	65	100	69	22	2	258	0.697 18th

Source: Field survey 2023

Conclusion

The objective of the study was to identify the PPE-related causes of rework in public building construction projects in Nigerian. To achieve this objective, extensive literature review was done and a list of 67 causes of rework was developed. These causes of rework were then categorized into people-related causes of rework (23), process-related causes of rework (26) and environment-related causes of rework (18). A structured questionnaire was used to collect the opinions and perceptions of construction professionals on the causes of rework with greater impacts as categorized.

According to the results of the analyzed data, it can be observed that the respondents considered all the factors listed from literature as important, hence though the mean grade was from 1(strongly disagree) to 5(strongly agree), they rated the factors between 3.30 and 4.57. This shows that on the average, all the listed factors are considered significant. The 15 identified PPE causes of rework from the categories are thus listed: people-related - poor communication, lack of coordination, project team lacking a clear objective, incompetence among project team and lack of appropriate design skill; process-related - poor quality assurance and control, ineffective communication of project information and updates, poor communication channel and method, poor project planning, poor interpretation of drawing and construction error; environment-related - poor workmanship, poor quality materials, no clear role of the owner and the contractor, natural hazards, lack of records of rework and lessons learned asset and poor use of technology.

Recommendations

Based on the conclusion of this study, the following are recommended:

- In construction projects, effective communication generally is key to achieving success and reducing rework. This study has strongly highlighted this point.
- The use of a good quality management system and best practices to enhance the construction process.
- Ensure the use of quality materials for construction works,
- Training of the workers involved in site works,
- Using relevant technology like BIM etc and
- Develop proper organizational process assets for the organization which will include records of challenges and lessons learned.

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