FACTORS INFLUENCING REWORKS OCCURRENCE IN CONSTRUCTION: A STUDY OF SELECTED BUILDING PROJECTS IN NIGERIA

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Abstract

Rework has become a menace in Nigerian construction industry and it has not been given required attention, it contributes to time and cost overruns in project. Hence, to improve the performance of projects the research work evaluated rework in some selected building projects in Niger State. The work identified some factors contributing to rework which was categorized under three main headings; technical, quality and human resources factors to actually dig down into the casual of rework. A structure questionnaire was self administered on projects identified to have experienced rework amongst the selected projects and these were ranked according to their perceived degree of severity. Response was further condensed using factor analysis to group the variables into identifiable factors and thus analyzed. The study revealed that sub-standard services rendered by professionals and lack of commitment to quality in term of project delivery by stakeholders are the main source of rework. Therefore, it was recommended that an improvement and total commitment to quality of services render and assurance would lead to a reduction in the occurrence of reworks as revealed by the research.

Keywords: Building projects, Cost overruns, Nigeria, Rework.

Introduction

The construction industry is almost as old as nature itself and unlike many manufacturing industries, is concerned mostly with one-off project. The construction is a sector that is sensitive to change in both fiscal and monetary disturbance. The construction industry is very important in the economic development of any nation especially in an expanding economy like Nigeria (Ibironke, 2003). An efficient construction sector is a pre-requisite to effective national development since building, civil and industrial engineering works are usually a major contribution to Gross Fixed Capital Formation, Gross Domestic Product and National Employment. The growth of construction industry in Nigeria in the past two decades indicates its success in greatly contributing to the country's Gross National Product, which was 1.72 in Year 2007 (Federal bureau of statistics). This industry sector is the second most important for absorbing human resources after the food.

The importance of the construction industry is not limited to the different measures of economic development alone, slumps or upsurges in its activities, have a high multiplier effects on almost every phase in the social and economic structure of the nation. It has been concluded that the high cost of house ownership in Nigeria and other housing problems of the lower income groups are results of the defect in the construction industry (Ibironke, 2003). "There is no gainsaying that the twin problem of cost and time overruns may not yet be over as they still characterize construction projects in most parts of the world especially in developing countries like Nigeria" (Ogunsemi, 2002). In Nigeria, cost and time overruns are common occurrences in the construction industry and these have continued unabated (Odeyinka, 1993). This is no exception as in the case of rework, as rework contributes to time and cost overruns (Love, 2002a). Earlier studies have shown that rework costs vary between 3 and 15 per cent of project's contract value (Burati, Farrington and Ledbetter, 1992; Abdul-Rahman, 1997; Josephson and Hammurlund, 1999). In addition, Rethinking construction, 1998 in Aminudin (2006) stated that: up to 30% of construction is rework, labour is used at only 40-60% of potential efficiency and at least 10% of materials are wasted. It was posited that rework costs could be significantly higher than figures reported in the previous literature (Love and Smith 2006). Indeed, Barber, Sheath, Tomkins and Graves (2000) suggested that rework costs could be as high as 23 per cent of the contract value. Typically, previous research efforts have focused on determining the performance of Nigerian construction industry with reference to time and cost overrun, of which rework is one of its causes and little or no attention has been directed towards this area whose effect is capable of increasing the contract sum and duration significantly. Love (2002) who sought to address this in Australia, found that indirect costs of rework could be as much as five times the cost of rectification.

Since rework has been seen as an ill wind that may blow no good to the construction industry because of its contributions to cost increases and time-delays couple with the facts that it cannot be totally avoided. Therefore, the evaluation of rework and identification of significant factors leading to the occurrence of rework with a view to determining its impact on building projects to enhance project delivery processes in Nigeria is essential.

Based on all this foregoing, this paper therefore intends:

1. to identify and evaluate the variables of the factors influencing the occurrence of reworks on building projects;
2. to identify the variables with specific group; and
3. to assess the relationship of the identified factors to enable fully appreciation of the study.

Previously Reviewed Literatures on Rework

Rework is Waste

To improve quality it is necessary to understand the root causes of rework, that is, the basic reason for its existence or set of conditions that stimulate its occurrence in a process. A process consists of a number of activities or operations which acting on inputs in a given sequence transforms them into outputs. A process may consist of both value adding or non-value adding activities. The former are activities that convert materials and/or information towards that which is required by the customer and the latter are activities that take time, resources or require storage and do not add value to the output. In other words, a non-value adding activity is waste and origin of waste is as contained in figure ii below. According to Koskela (1992), there has never been any systematic attempt to observe all wastes in the construction process. Koskela (1992) suggested that the figures that have been presented tend to be conservative in as much as the motivation to estimate and share these figures has been by leading companies that have been attempting to implement best practice. Rework, however, has become an accepted part of the construction process. Those involved in the procurement of buildings invariably do not realize the extent of rework that actually occurs. There is an increasing need to improve the quality of operations throughout the procurement process, and therefore reduce the incidence of rework. It has been suggested that the major cause of rework is uncertainty (Koskela,1992). This uncertainty is generated by poor information, which often is missing, unreliable, inaccurate, and conflicting (Koskela, 1992). The authors suggest that uncertainty is a consequence of numerous interrelated factors and not solely information. Therefore, to reduce rework we must identify what its causes are, then understand how these causes are interrelated (Rodriguez and Bowers, 1996).

The Causes of Rework as a Waste in the Design and Construction Process

Construction waste was classified into three main categories by Ekanayake and Ofori (2000) as materials, labour and machinery waste. However, any effort in terms of labour, materials and machinery which is directed towards the construction of a part or element of a building and which has to be done again due to non-conformity to the design constitutes a waste which is also seen as rework. Andy, Andrew and Simon (n.d) viewed causes of waste at the design and construction process as: building complexity, poor co-ordination, fast tracking, inadequate communication, inefficient management practices and design process, poor quality management, lack of harmonious relationship among participants on the project and poor site management team. Many authors have different opinions as to the causes of rework as a waste. Koskela (1992) suggested that it ‘‘sometimes seems that the wastes caused by design are larger than the cost of design itself,’’ and he further stated that ‘‘even if there is a lack of data on internal waste in design, it can be inferred that a substantial share of design time is consumed by redoing or waiting for information and instructions.’’ Rounce (1998) has suggested that much of the design-related rework generated in projects is attributable to poor managerial practices of architectural firms.

Reducing Costs – Eliminating Waste

Rework costs are determined from the point where rework is identified to that time when rework is completed and the activity has returned to the condition or state it was in original. The duration of the cost tracking includes the length of the standby/relocation time once rework is identified, the time required to carry out the rework, and the time required to gear up to carry on with the original scope of the activity (Fayek, Dissanayake and Compero, 2003). The sequences of events that constitute rework are shown in Figure 2.

Waste in construction is prolific. The lead article of this issue refers to the report
‘Rethinking Construction which states that:
• up to 30% of construction is rework
• labour is used at only 40-60% of potential efficiency
• at least 10% of materials are wasted

Egan Report: Rethinking construction, 1998 in Aminudin (2006).

Following Latham in 1998, Sir John Egan presented report of the construction, Task Force on the scope for improving quality and efficiency in UK construction. Since Latham, the industry as a whole was underachieving even with the fundamental and radical change proposed by this report. With the economic meltdown the industry had experienced low profitability; low investments in research and development, low levels of training with too many clients were dissatisfied with the present performance of the industry.

In summary, the Egan report identified several shortcomings with the construction industry, and they includes;

- Underachievement of the industry as a whole
- Lack of predictability within the industry as a whole
- Unacceptable level of defects
- Lack of contractor profit
- Lack of investment in capital , research, and development and training
- Level of dissatisfaction amongst the industry’s clients.

Reflecting on Nigerian experience with similar occurrence where the industry as a whole were underachieving which is evident in the down turning nature of the industry’s contribution to the nation’s Gross Domestic Product (GDP).

Deviations in Construction

Deviations that are related to the construction phase of the project and consist of those activities and tasks that take place at the project site during the construction interface. A construction change could be seen as a change in the method of construction and construction changes are usually made to enhance the constructability of the project. Deviations in construction could be seen as a construction errors are the result of erroneous construction methods or procedures. Construction omissions are those deviations that occur due to the omission of some construction activity or task (Burati, Farrington and Ledbetter, 1992).

Concept of Quality Cost

Quality could be referred to as conformance to established requirement, therefore, any deviation from this requirement that affects with a severity sufficient enough to consider options on the projects to either accept or taken corrective action could also be seen as non-conformance (Burati, Farrington and Ledbetter, 1998).

Quality cost of construction work or design comprises of all costs incurred by client/contractor because the project refuses to meet the users' requirement (Davis, Ledbetter and Burati, 1989). Rounce (1998) captured quality cost in the design process "as the cost of writing procedures and obtaining quality assurance certification". In broad term, quality cost to a client is the total expenditure incurred in given client best value for money both in term of functionality of the design and aesthetic value of the project.
Thus, Rounce (1998) postulated that;
Quality cost = cost of conformance + cost of non-conformance

Rounce (1998) went further by positing that conformance cost is the minimum expenditure incurred or required to meet an established requirement of a client on a project. Non-conformance cost on the other hand contains all total sum incurred through redesigning and reworking construction work previously executed due to non-compliance is capable causing strain relationship among the participant due to loss of profit. It's important to note that error during design mostly lead to rework or fault during construction phase of projects blame is usually borne by the contractor because of the gap between the design and construction. Josephson and Hammarland (1999), asserted that averagely 32% of defect cost that either lead to rework or non-conformance emanated at the design stage where briefing are not well captured or interpreted by the designers, 45% of the cost originated on site while 20% is from defective materials or machine.

Research Method

Data Collection and Procedure

The review of the existing literature on reworks, cost and time performance of projects revealed factors responsible for the occurrence of rework which was categorised into technical, quality and human resources factor. The questionnaire was structured in way that variables regarded as contributor to each of the factor were separated and well captioned under the appropriate heading. 77 variables were identified in all for all the three factors aforementioned.

The questionnaire was prepared to take care of the data to be sourced and to provide the respondents the opportunity to score the factors or variables which is capable of contributing to the occurrence of rework in construction projects. The following five levels of scoring was adopted using Likert scale 'extremely severe' (5 points), 'very severe' (4 points), 'severe' (3 points), 'Least severe' (2 points) and 'not severe' (1 point). Respondents were required to score only the factor that influences the occurrence of rework costs as it affects such projects.

Method of Data Analysis

Severity Index

Considering each of the factors, relative importance index was determined which was then used to rank the variables according to their degree of importance. Having observed the most likely important rework causes based on frequencies, a test of severity will be carried out to establish this observation. The severity indices will be measured using the formula referenced by (Idrus and Newman, 2002).

$$\mathbf{S.I} = \left(\sum_{i=1}^{i=n} \frac{[(\mathbf{wifi})\mathbf{x100}}{\mathbf{n}}] \right. \qquad \text{..(i)}$$

Where:
S.I. is the severity index, *f i* is the frequency of response, *wi* is the weight for each rating (= rating in scale/number of points in a scale), and *n* is the total number of responses. *n* is the valid number of respondents.

Factor Analysis

Factor analysis is employed to condense large number of variables with a view to identifying the underlying variables that really explains the pattern of correlation with a set of observed variables. The main essence of factor analysis is to describe the covariance relationship among large number of variables in terms of a few groups Johnson and Witchen (1992) in (Awakul and Ogunlana, 2002). Factor analysis model specifies that variables are determined by common factors (the factors estimated by the model) and unique factor which (do not overlap between observed variables); with the assumption that all the unique factors calculated correlate with each other and with the common factor

Results and Discussion

Ranking the Influencing Factors: Frequency and Severity Index Analysis

Data collected from the field survey were ordinal in that the distances between the numbers (ratings) assigned in the Likert scale are not known. The ratings in this scale indicate only a rank order of importance of the factors, rather than how much more important each rating is than the other. Using parametric statistics (means, standard deviations, etc.) to analyse such data would not produce meaningful results, and therefore nonparametric procedures was adopted (Idrus and Newman, 2002). The non-parametric procedures adopted for this study was frequency and severity index analysis.

Severity index analysis was conducted on the sample data to rank the factors according to their relative importance. Severity indices rather than mean scores were used since the data were ordinal in nature. In this procedure, frequency analysis was first carried out to obtain the percentage ratings of different selection factors. This was done with the help of the Microsoft excel. The percentage ratings were then used to calculate severity indices via the formula in the methodology.

Based on the magnitude of the extracted factor loading from the factor analysis, important factors were identified and the severity indices of the factors were arranged in descending order as shown in Table. There appears to be a relatively narrow gap separating the variables: sub-standard product and services rendered by professional rank most under technical factor and closely followed by defects. Quality factors have lack of support to site management as the most severe variables which may be induced by lack of teamwork, this followed by late involvement of users and lack of trust and commitment on the part of the participants within the industry. Severity indices for human resources factors indicated that disturbance of personnel planning are most responsible for rework occurrence; carelessness followed the variable which was rank second while lack of skill and usage of inexperienced personnel have the same rank a piece.

Causes of Reworks

Factors Extraction

In this research work, the principal component method was carried out due to its simplicity nature using SPSS software package. Kaming et al(1997), asserted that the total number of factor estimated by the model (common factor) is equal to or less than the number of variables involved which is shown by the result of the analysis as in the appendix. Tables 4,5 and 6 show the extracted number of factors from principal component analysis for technical, quality and human resources factors as they contribute to the occurrence of rework. The tables show, the initial eigenvalue in terms of total, percentage of variance and cumulative percentage of variance. It is essential to note that relevant factors rae those factors having eigenvalue greater than 1, this is simply because eigenvalue in principal component analysis denotes relative importance of each of the factors as they contribute, and only factor with eigenvalue >1 are retained in the factor extraction process.

The extraction of sums of squared loading and rotation of sums of squared loadings of factor analysis for technical factors indicate 15 factors, 9 factors for quality and 8 factors for human resources factor. Tables 4, 5 and 6, show extraction factor loading which is greater than 0.50 and their respective communalities (h2). The criteria for this was that any variable that has the highest loading with value >0.50 in one component belongs to that component. It is equally essential to note that many variables might contribute to a factor if the absolute value is greater than 0.50, this was supported by Kaming et al(1997) that the higher the absolute value of a factor loading, the higher the contribution of that variable to that factor. The factor loading (extracted) for technical factor of the determinant of quality failure is 0.514 and the communalities which explain the variables in the factor that the analysis accounted for by the extracted factor is 0.767(76.7%), 81.8% of variables in “defect” is accounted for technical factors estimated by the fifteen factors. In this vein, 82.4% of variance “in inadequate construction planning” is accounted for by the extracted factor for quality factor and 81.2% of variance in “inexperienced personnel” is accounted for human resources factor loading to rework by the extracted factors.

Factors Rotation

To simplify the interpretation of factors, varimax method of rotation with Kaiser Normalization was used to reproduce calculations generating the final solution to the problem, with an orthogonal rotation method that minimises the number of variables that has high loading on each factor. The criterion for grouping of the factors was also based on the principle that a variable that exhibits highest loading with value greater than 0.50 in one component belongs to that component.

Tables 7, 8 and 9 show the component that surfaced from the factor analysis factor loading (rotated) for each factor. The tables show that there are 3 components in TTF_1 for technical factors, 5 components in factor HMF_1 in quality factor. Under technical factors, the variables "conflicting information" that has the highest loading of 0.872 was found in TTF_8, in quality factors, "inadequate construction planning" has the highest loading 0.870 which came under the QFF_9 and finally, "inexperienced personnel" exhibits the highest factor loading 0.889 in human resources factor HMF_7. It becomes imperative to group the component contributing to a factor into a new heading to remove ambiguities surrounding the acronyms in the analysis.

Under Technical Factors:

Factor TF_1 as "documentation issues", Factor TF_2 as "precontract" ,Factors TF3 as "communication", Factor TF4 as "monitoring", Factor TF5 as "site possession", Factor TF6 as "alteration", Factor TF7 as "consultant initiated changes", Factor TF8 as "coordination", Factor TF9 as "design error", Factor TF10 as "quality", Factors TF11 as "design phase"Factor TF12 as employer's issue", Factor TF13 as poor information", Factor TF14 as "technology application", Factor TF15 as "evaluation"

Under Quality Factor:

QFF1 as "finance", QFF2 as "integration", QFF3 as "management of manpower", QFF5 as "team work", QFF6 as "untimely delivery", QFF7 as "tendering issue", QFF8 as "changes", QFF9 as "contract management"

Under Human Resources:

HMF1 as "resilience", HMF2 as "incentives", HMF3as "resources", HMF4 as "site environment", HMF5 as "training",HMF6 as "multichannel flow of information",HMF7 as "inexperienced personnel", HMF8 as "delay"

Rotated Factors for Rework Causes

Considering the component in each factor/ group that have the highest loading with value greater than 0.50 in any component of the factors, it is obvious that "inexperience personnel" exhibits the highest rotated loading factor 0.889, followed by "conflicting information" 0.872 and "inadequate construction planning" of 0.870 factor loading in human resources, technical and quality factor respectively.

The factors have different representation and determinant of rework cause. Thus, it is necessary to offer explanation on the identified components of different factors.

a. Conflicting information:

One major factor responsible for having building that will be rework free is lack of adequate information,buildability of many designs and the separation the contracts interfaces (that is the design and construction interface) couple with the fact that our construction processes are still sequential in nature. Adejimi (2005) argued that construction are not well connected or integrated until at the terminal tail end of each other rather than overlapping and benefiting from one another . He also of the opinion that if design process is to be enhanced, the participants within the industry (i.e. architects, planners, engineers, contractors and including the initiator of the process) need to come together and be well coordinated if rework free construction is so desired. Josephson, Larsson and Li (2002) posited that lack of coordination is capable of increasing cost of project by 28%, so also unsuitable design (18%), faulty design(13%), incomplete design(10%)and others (33%). It has been reported that the genesis of the problems that the (construction) Industry and its clients experience lie in the division of the responsibilities between the design aspect and the construction aspect". A direct criticism of the organizational structure of the construction industry has been given by many researchers that the construction industry is different in the sense that the design process is separated from construction process.

b. Inexperience personnel:

Management of contract is as important as the contract itself, it involves adequate planning, coordinating, controlling and evaluation of every aspect of the construction programme and method that is capable of leading to reduction in the menace of reworks with the consequential effects such as time and cost overruns. Okpala and Aniekwu (1988), was of the opinion that most of the indigenous contractors operating within the nation's construction industry are small-scale outfit with fair level of ignorance in prevailing research breakthroughs that can improve their output and efficiency both in term of technical know-how (application of technology) and management techniques. Their inability to employ qualified and experienced personnel coupled with lack of ploughing back profit as way of investment.

Inexperience personnel involved in management of projects and contracts is a serious issue in construction since many other variables identified from the rotated factor loadings emerges from lapses noticed in management of contract by the participants in the industry. Mistake in planning could contribute (24%) and faulty contract preparation (18%) as asserted by Josephson, Larsson and Li (2002). The essence of contract management cannot be waved away if rework occurrence have to be reduced to a considerable level. This is simply because good contract management will increase efficiencies, minimize wastes, enhance cost control mechanism and improve overall management of construction site.

c. Inadequate construction planning:

It is certain that a project must be well conceived; start right for it to end well. At the outset of the planning stages, the building owner, the initiator of the contract and the designer must come together and properly plan the work to prevent occurrence of rework. Inadequate planning can doom a well conceived construction works which may leave all the participants; designers, client and contractors dissatisfied at the end of the project. Therefore, it's imperative to recognise the close interaction between the design and construction. Construction planning involves a process of identifying activities and resources required to make the design a physical reality. Thus, construction involves the execution of a design envisioned by the Architects and Engineers, ineffective execution of this design process will unavoidably lead into rework together with consequential time and cost overruns in both phase- design and construction. Change orders due to improper planning contribute significantly to rework cost as opined by Josephson, Larsson and Li (2002) which could be as high as 34%, wrong information (15%) and bad planning method (15%).

Conclusion

Based on the findings from the projects considered sub-standard services rendered by professional rank most under technical factor and closely followed by defects. Quality factors have lack of support to site management as the most severe variables which was induced by lack of teamwork, this followed by late involvement of users and lack of trust and commitment on the part of the participants within the industry. In the case of human resources factors, disturbance of personnel planning are most responsible for rework occurrence; carelessness was rank second while lack of skill and usage of inexperienced personnel have the same rank a piece. From the condensed variables, the analysis only precipitated 32 variables that really explain the pattern of correlation with a set of observed variables. Meaning only 32 of the 77 observed variable contributed to rework occurrence of the studied projects.

Though, the findings relates Nigerian experience but corroborated the results of the previous studies in the UK, Australia and Indonesia. An improvement and total commitment to quality of services render and assurance would lead to a reduction in the occurrence of reworks. The panacea to this could be drawn from suggestion made by Josephson, Larsson and Li (2002) for Swedish Construction Industry, to put in place an agreed and feasible mechanism by the participants within the industry to minimise and control changes that can induce rework. Further research should be carried out in the other states of federation both on public and private projects to have a better understanding of the menace of rework and probably reduce if not total elimination.

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Appendix

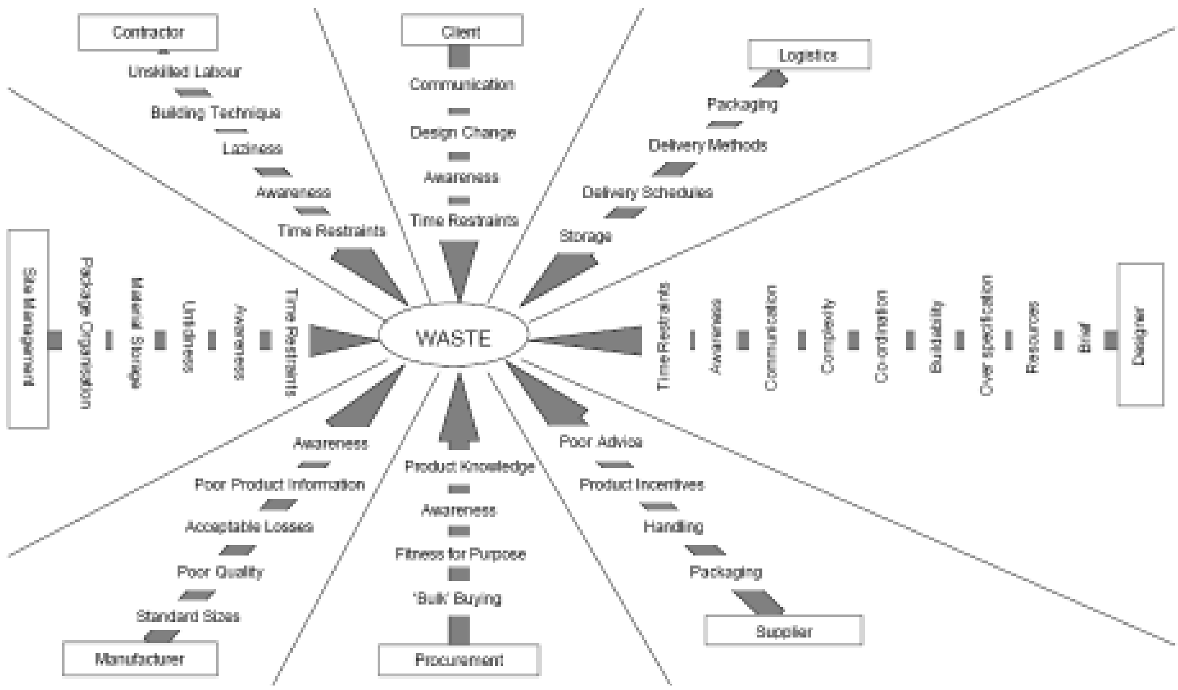

Figure 1: Origin of waste
Source: Andy Keys, Andrew Baldwin and Simon Austin (n.d)

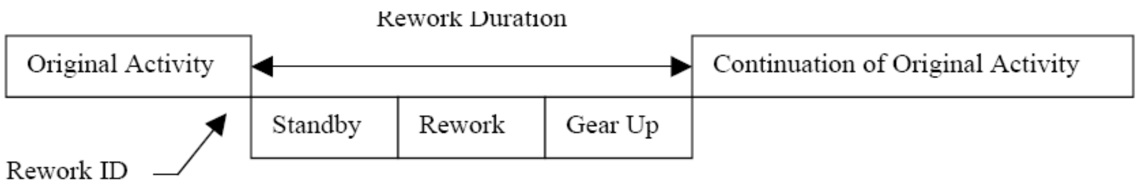

Figure 2: Components of reworks

Source: Fayek, Dissanayake and Compero (2003)

Table 1: Variables of technical factors leading to rework and their severity index and rank

Causes of rework	severity index %	Rank
Quality failure	45	8
Safety considerations	48	4
Lack of understanding and correct interpretation of client's requirement	47	5
Omission during design	38	14
Change in plan and scope by client	47	5
Error during design	40	13
Ineffective coordination and integration of components	49	3
Checking procedure	**47**	**5**
Inadequate resources	**43**	**10**
Conflicting information	44	9
Overlooked site condition	41	11
Sub-standard product and services	51	1
Defect	50	2
Complex details	**41**	11

Table 2: Variables of Quality factors leading to rework and their severity index and rank

Causes of rework	severity index %	Rank
Conflicting of opinions between participants	51	9
Lack of trust and commitment by participants	58	3
Lack of quality management system	54	6
Late user involvement	60	1
Poor management practice	49	11
Poor contractual relationship	47	13
Contractor selection method	51	9
Cost pressure	**55**	**5**
Poor communication	**47**	**13**
Poor team work/joint problem solving	57	4
Lack of support to site management	60	1
Inadequate construction planning	54	6
Untimely delivering	49	11
Poor information flow	54	6

Table 3: Human resource factors leading to rework and their severity index and rank

Variable/ Causes of rework	**severity index %**	**Rank**
Staff turnover	**47**	**12**
Ignorance and lack of knowledge	**55**	**7**
Disturbance in personnel planning	64	1
Uncertainty(weather, soil etc)	56	6
Lack of training	49	11
Alteration	51	9
Defective workmanship	52	8
Carelessness	60	2
Inadequate funding	58	5
Lack of skill development	59	3
Inexperienced personnel	59	3
Delays	51	9

Table 4: Factor loading extracted for technical factor

	Variables	TF_1	TF_2	TF_3	TF_4	TF_5	TF_6	TF_7	TF_8	TF_9	TF_{10}	TF_{11}	TF_{12}	TF_{13}	TF_{14}	TF_{15}	h^2
1	QF	0.514															0.767
2.	SC	-0.521															0.717
3.	LUCCICK		-0.517														0.620
4.	ODC			0.654													0.795
5.	CPSC			0.537													0.773
6.	EDC				0.516												0.673
7.	ICIC				0.541												0.841
8.	CP				-0.519												0.685
9.	IR					-	0.567										0.749
10.	COF							-0.508									0.824
11.	OSC								0.611								0.747
12.	SSPS								0.500								0.712
13.	DEF									-	-0.528						0.818
14.	COD											-	0.504				0.798

Table 5: Factor loading (extracted) for quality factor

	Variables of QF	QTF_1	QTF_2	QTF_3	QTF_4	QTF_5	QTF_6	QTF_7	QTF_8	QTF_9	h_2
1	CPBP	-0.567									0.821
2.	LTCP	0.578									0.680
3.	LQMS		0.537								0.790
4.	LUI		0.525								0.482
5	PMP			-0.529							0.613
6	PCR			0.542							0.576
7	CSM				0.429						0.611
8	CP				0.486						0.668
9	PC					0.467					0.534
10	PTW						0.500				0.885
11	LPSM						0.646				0.723
12	ICP							0.560			0.824
13	UD								-0.501		0.765
14	PIF									0.143	0.662

Table 6: Factor loading extracted (human and extracted factor)

	Variables	HMF_1	HMF_2	HMF_3	HMF_4	HMF_5	HMF_6	HMF_7	HMF_8	h^2
1.	ST	0.510								0.620
2.	ILK	0.505								0.715
3.	DPR	0.777								0.614
4.	UNC	0.603								0.622
5.	LOT		-0.516							0.671
6.	ALT		0.615							0.584
7.	DW			0.526						0.596
8.	CRS				0.561					0.645
9.	IF				0.533					0.546
10.	LSD					0.550				0.725
11.	IP						0.580			0.812
12.	DE							0.552		0.735

Table7: Factor loading rotated for technical factor

	Variables	TF 1	TF2	TF3	TF4	TF5	TF6	TF7	TF8	TF9	TF10	TF11	TF12	TF13	TF14	TF15
1	0MD	0.793														
2.	PQCD	-0.693														
3.	LUCICR	-0.607														
4.	ODC		0.691													
5	IAINF		-0.506													
6	UP		0.730													
7	DC			0.59												
8	LIT			0.729												
9	SSPS				0.82											
10	CP				-0.559											
11	PSP					0.635										
12	IDATA					-0.821										
13	ININF						0.545									
14	CPSC						0.802									
15	COMC							0.867								
16	ICIC								0.504							
17	COF								0872							
18	EDD									-0.83						
19	NPR										0.504					
20	DEF										0.845					
21	COD											0.847				
22	SC											0.594				
23	CISB												0.815			
24	LAQ												-0.541			
25.	PFU													0.815		
26.	PTA														0.569	
27.	LPME															0.853

Table 8: Factor loading (rotated) quality factor

	Variables	QFF1	QFF2	QFF3	QFF4	QFF5	QFF6	QFF7	QFF8	QFF9
1	PMP	-0.685								
2.	CP	0.753								
3.	PPSWL		0.635							
4.	PI		0.685							
5	LQMS		0.623							
6	LUI			0.535						
7	LPSM			0.801						
8	CPBP				-0.856					
9	WUHTP				0.663					
10	PCR					0.683				
11	PTW					0.740				
12	UD						0.840			
13	PM							0.584		
14	CSM							0.761		
15	UCC								-0.825	
16	PIF									0.557
17	ICP									-0.870

Table 9: Factor loading rotated for human factor

	Variables	HMF_1	HMF_2	HMF_3	HMF_4	HMF_5	HMF_6	HMF_7	HMF_8
1	DIPP	0.753							
2.	LOT	-0.788							
3.	LMC		0.559						
4.	ILK		0.795						
5	EOT		-0.605						
6	IPPS			0.688					
7	IF			-0.720					
8	ST				0.599				
9	UNC				0.537				
10	UFFDR				0.788				
11	LSD					0.834			
12	CRS					0.603			
13	DW						0.709		
14	AI						0.761		
15	IP							0.889	
16	DE								0.820

Table 4.5.4(a,bandc): Tables showing the coding of the variables used in factor loading extraction and rotation tables.

NO	FACTOR	
A	**TECHNICAL FACTORS**	
1	Error during design	EDD
2	Omission during design	OMD
3	Errors during construction	EDC
4	Omissions during construction	OMC
5	Quality failure	QF
6	Quality deviation	QD
7	Design changes	DC
8	Poor quality contract documentation	PQCD
9	Defective materials	DEM
10	Complex details	COD
11	Overlooked site condition	OSC
12	Poor site practices	PSP
13	Lack of proper monitoring and evaluation	LPME
14	Ineffective coordination and integration of components	ICIC

15	Inaccurate information	IAINF
16	Incomplete information	ININF
17	Conflicting information	COF
18	Unrealistic programme	UP
19	Inadequate resources	IR
20	Inadequate work separation	IWS
21	Constraint in carrying out activities	CICOA
22	Change in plan and scope by client	CPSC
23	Change in specification by client	CISBC
24	Contractor initiated changes	CIC
25	Consultant initiated changes	CONIC
26	Lack of attention to quality	LAQ
27	Lack of information technology use	LIT
28	Non-compliance to standards/ specification	NSS
29	Non-conformance to project requirements	NPR
30	Lack of understanding and correct interpretation of customer requirements	LUCICR
31	Sub-standard products and services	SSPS
32	Safety considerations	SC
33	Defect	DEF
34	Incomplete documentation at the time of award	IDATA
35	Poor information use	PFU
36	Poor technology application	PTA
37	Checking procedures	CP

NO	FACTOR	
B	**QUALITY MANAGEMENT FACTORS**	
1	Poor management practices	PMP
2	Poor contractual relationship	PCR
3	Conflict of opinions between participants	CPBP
4	Poor communication	PC
5	Lack of quality focus	LQF
6	Poor information flow	PIF
7	Poor planning and scheduling of work load	PPSWL
8	Poor team work/ joint problem solving	PTW
9	Poor instructions	PI
10	Ineffective coordination and integration of project participants	ICIPP
11	Procurement method	PM
12	Contractor selection method	CSM
13	Lack of Quality management system	LQMS
14	Lack of trust and commitment by participants	LTCP
15	Unanticipated consequences of change	UCC
16	Late user involvement	LUI
17	Lack of support to site management	LPSM
18	Working under high time pressure	WUHTP
19	Cost pressure	CP
20	Untimely delivering	UD
21	Inadequate construction planning	ICP

NO	FACTOR
C	**HUMAN RESOURCE FACTORS**

1	Staff turnover	ST
2	Inadequate personnel planning and supervision	IPPS
3	Disturbance in personnel planning	DIPP
4	Lack of training	LOT
5	Lack of motivation and care	LMC
6	Inexperienced personnel	IP
7	Insufficient skill level	ISL
8	Defective workmanship	DW
9	Ignorance and lack of knowledge	ILK
10	Disturbance in personnel planning	DPP
11	Delays	DE
12	Alteration	ALT
13	Lack of skill development	LSD
14	Carelessness	CRS
15	Excessive over time	EOT
16	Inadequate funding	IF
17	Ambiguous instruction	AI
18	Uncertainty (weather. Soil condition etc)	UNC
19	Unpredictable factors from different sources	UFFDS