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LEAN CONCEPT THINKING-BASED QUALITY MANAGEMENT MODEL FOR RESIDENTIAL BUILDING CONSTRUCTION PROJECTS

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ABSTRACT

The level of quality management in the construction industry has been on a drastic decrease over the past years. Application of lean thinking principles in construction have been identified as a means of improving this major setback. To this end, this study is about modeling quality management parameters using lean thinking principles for residential building projects in order to prevent quality management problem as identified in the past. Convenience sampling method was adopted in sample selection in this study. A population size of 250 was used for this project. Data raised in this study includes: primary and secondary data while sample size of 200 was used.

The primary data was obtained through the administration of structured questionnaire designed in Likert scale of 1-5 to capture parameters which helped in creating a lean thinking based dynamic model for quality management on sites. 200 questionnaires were administered at random to elicit response from respondents on construction sites in Lagos State. Mean item score was used in analyzing the response from the respondents. The lean principles used to generate the model were further processed with regression analysis using factor analysis to reduce the factors to a sizeable number. The resultant factors were further rotated using factor analysis and direct Oblim method. The factors that had Eigen values between 0.995-1.000 were used to generate the model. It was discovered that some factors emerged with strong coefficient and Eigen values between 0.999-1.000 and these factors were judged as being strong and if one or many of them are combined, there is tendency for them to produce high quality output with zero waste. These factors include: Having maintenance expenditure based on machine/equipment age/utilization; improving construction processes thereby reducing project cost; Management should convey meeting on quality in maintenance issue periodically; and Identifying value from the client's perspective.

In conclusion, from the outcome of the analysis, lean thinking approach is the best approach that would lead to high quality work output and elimination of waste on site, it has tendency to eliminate waste such as time waste, manpower waste, material *waste and other types of wastes. Since Lean Thinking approach is alienate to our construction sector in Nigeria, the model generated in this study can provide a framework for the deployment of lean thinking principles in our construction activities which would in turn eliminate various types of waste.*

Keywords: Lean-Thinking, Quality, Management, Model, Buildings.
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1. INTRODUCTION

In Nigeria today, the construction industry has suffered a form of stagnation in the delivery of projects as well as productivity over the past few years. Management of these projects has also been affected greatly due to the traditional method adopted. It is claimed that complex, quick and uncertain projects cannot be managed in traditional ways (Ballard, 2004). Also in this system, the whole process is mostly not organized and planned which can lead to unnecessary repairs, rework, non-value adding activities etc. A new concept has been designed to address the vices often experienced on construction projects and the system has been successfully deployed in the construction industry. This concept is referred to as lean thinking. According to the Egan report (1998), "lean thinking presents a powerful and coherent synthesis of the most effective techniques for eliminating waste and delivering significant sustained improvements in efficiency and quality".

Lean thinking deals with elimination of waste activities as well as non-value adding activities thereby enhancing value for the customers. The invention of this concept can be traced to the Toyota Production System which started in the 1950s. The Toyota Production System worked with two major concepts: Just In Time concept (JIT) and the Jidoka concept (also known as automation). Lean thinking focuses largely on the entire production system. The main goal of lean thinking is to deliver projects of great quality at the lowest cost and in the shortest time frame. Lean thinking was rejected by the construction industry at first due to the belief that manufacturing is uniquely different from construction. However, over time the lean thinking concept has been integrated into the construction industry and can be simply defined as Lean Construction.

According to the Lean Construction Institute (LCI), lean construction is defined as "the application of lean thinking to the design and construction process creating improved project delivery to meet client needs and improved efficiency for constructors". NIST (2000) also defines Lean: "as a systematic approach to identifying and eliminating waste through continuous improvement, following the product at the pull of the customer in pursuit of perfection". Essentially, Lean Thinking is about elimination of waste activities and processes that absorb resources but create no value. Lean thinking in construction is a continuous process that works through design, procurement, manufacture and construction. It involves working with the major players in the construction industry which include the client, the architect, the builder, the contractors as well as the suppliers to achieve value at its peak.

Lean thinking in general works with a set of objectives that can simply be referred to as the Lean philosophy. This lean philosophy include waste elimination (zero waste); precisely specify value from the perspective of the ultimate customer; clearly identify the process that delivers what the customer values and eliminate all non-value adding steps; make the remaining value adding steps flow without interruption by managing the interfaces between the different steps; let the customer pull (i.e. do not make anything until it is needed, then make it quickly); and pursue perfection by continuous improvement.

In recent times, there has been an issue on collapse of buildings which occurred due to a dropped standard in quality management of projects. With this observation, application of lean thinking principles can be put in place to correct such errors. These errors occurred due to the use of sub-standard materials in the construction of projects as well as faults in human resources (i.e. using the wrong person for the right job.) Moreover, in a study carried out by Koskela (1992) concepts that guides lean thinking was presented, the concepts include Transformation; Flow; and Value generation (TFV).

The principles of lean thinking when appraised intensely and deployed is primarily for maintaining quality in a construction system. In this study, the focus is to generate a system in background therefore that this study is about developing a model which is based on lean thinking principles which would be used to manage quality on residential building projects.

1.2. THE BASIC PRINCIPLES OF LEAN THINKING

There are five principles of lean thinking which define the philosophy of lean according to Womack and Jones (1996). These lean principles define the aim of any lean system which is to "specify value, line up value creating actions in the best sequence, conduct these activities without interruption whenever someone requests them, and perform them more and more effectively". (Womack and Jones, 1996) This statement leads to the principles of lean thinking which are as follows: Specify what creates value from the customer's perspective, Identify all steps across the whole value stream, Make those actions that create value flow, Only make what is pulled by the customer just-in-time, and Strive for perfection by continually removing successive layers of waste. This can be further explained as: (i) Value; (ii) Value Stream; (iii) Flow; (iv) Pull and; (v) Perfection.

1.3. VALUE FROM THE CUSTOMER'S PERSPECTIVE

Value is defined as a "capability provided to customer at the right time at an appropriate price, as defined in each case by the customer." (Womack and Jones, 1996) Value is the critical starting point for lean thinking, and can only be defined by the ultimate end customer. The ultimate end customer, or the user of the product, is contrasted with interim customers, such sales, marketing, distribution, suppliers, etc. It is this value that determines how much money the customer is willing to pay for the product and services. Value also is product-specific, and it is only meaningful when expressed in terms of a specific product. (Weigel, 2000) This is also about building a relationship around clear communication and shared understanding in a way that will allow the organization to deliver what it is that the customer needs.

2. IDENTIFICATION OF STEPS ACROSS THE VALUE STREAM

The value stream is defined in Lean Thinking as the set of all the "specific activities required to design, order, and provide a specific product, from concept to launch, order to delivery, and raw materials into the hands of the customer." (Womack and Jones, 1996) Value stream helps to see in more detail how our processes work. To create a value stream, describe what happens to a product at each step in its production, from design to order to raw material to delivery. (Weigel, 2000) For example, choose a typical material, element or component part used on site, and follow the part through its life cycle from when it is specified, to being ordered, made, transported, stored, transported again and finally assembled. With this process, all of the movements, hold ups and rework can be mapped out and the waste activities within the current process are identified.

The process of mapping out these activities is described as Value Stream Mapping. A value stream map is a comprehensive model of the project that reveals issues hidden in current approaches. Value stream maps can be understood as process flow charts that identify what action releases work to the next operation. Mapping brings choices to the surface and raises the possibility of maximizing performance at the project level. (Ballard and Howell 1998) Value Stream Maps (VSM) have several characteristics that are unique to Lean Thinking which include: VSMs are created by teams comprising of front-line employees who do the work of mapping i.e. the real experts in the process, A VSM always begins and ends with the Customer, VSMs capture both the product flow and the management information flow, Once the basic flow is drawn, the VSM team goes out to the 'Gemba' (the place where the work actually happens) and observes the workflow, and While observing the workflow, cycle times, quality/defect counts, inventories, and other data are collected. Because of their visual impact, VSMs make it easy to identify the barriers to quality, service, and productivity so improvements can be tackled.

There are three types of activities in the value stream – one type adds value while the other two are "muda" (the Japanese word for waste). They include: Value-Added: Those activities that unambiguously create value, Type One Muda: Activities that create no value but seem to be unavoidable with current technologies or production assets, and Type Two Muda: Activities that create no value and are immediately avoidable. Some examples of muda are mistakes which require rectification, groups of people in a downstream activity waiting on an upstream activity, or goods which do not meet the needs of the customer. (Weigel, 2000).

3. RESEARCH METHODOLOGY

Convenience sampling method was adopted in sample selection in this study. A population size of 250 was used for this project. Data raised in this study includes: primary and secondary data while sample size of 200 was used.

The primary data was obtained through the administration of structured questionnaire designed in Likert scale of 1-5 to capture parameters which helped in creating a lean thinking based dynamic model for quality management on sites. 200 questionnaires were administered at random to elicit response from respondents on construction sites in Lagos State. Mean item score was used in analyzing the response from the respondents. The lean principles used to generate the model were further processed with regression analysis using factor analysis to reduce the factors to a sizeable number. The resultant factors were further rotated using factor analysis and direct Oblim method. The factors that had Eigen values between 0.995-1.000 were used to generate the model. It was discovered that some factors emerged with strong coefficient and Eigen values between 0.999-1.000 and these factors were judged as being strong and if one or many of them are combined, there is tendency for them to produce high quality output with zero waste.

3.1. MODEL DEVELOPMENT

Various methods have been employed by researchers to create models that can be used to benchmark quality management parameters on residential building projects using lean thinking principles. The aim of this model is to establish the major parameters to be considered when creating a dynamic model to manage quality on residential building projects. Chan and Tam (2000) employed a combination of multiple regression and factor analysis. However for the purpose of this research work, a combination of stepwise multiple regression methods and factor analysis was adopted. The responses gathered from the structured questionnaires were loaded onto the Statistical Package for the Social Science (SPSS) software, after which the factors were subjected to factor rotation so as to achieve a stable criteria which would be used in defining the model and representing the relationship among the thirty-one variables regarded as the lean thinking parameters. The resultant factors were subjected to stepwise regression analysis to establish a pattern of relationship amongst them.

3.2. FACTOR EXTRACTION

The relative agreement index obtained from each of the independent variables (thirty-one) i.e. the lean thinking principle-based parameters for managing quality was examined. Chan and Tam (2000) adopted two approaches to determine the parameters to be included in the model which were the Screeplot and Eigen value approach. Chan and Tam (2000) submitted that in Eigen value approach, only variables with Eigen value greater than one (1) should be included in the model formation while in the screeplot approach, there is always a distinct demarcation between large variables on steep slope and gradual trailing off scores of the rest variables. (Amusan *et al.*, 2013) For the purpose of this research, the Eigen value and regression coefficient approach was adopted as shown in Table 4.13. The model was based on the first fifteen factors as extracted during the factor analysis.

3.3. FACTOR ROTATION

Factor rotation involves the repositioning of factors in order to distinguish the relationship of individual variables to the arrangement of normal component incorporated. The Oblim rotation can be used to achieve this and was adopted in this research. Rostom and Amber (2006) used variance rotation method and were able to discover each variable with a single factor. Table 4.13, page 52 shows the relationship of the variables to the new factors and elements related to each factor. This study followed the line of summation used by Amusan *et al.,* (2013), whereby the combination of the multiple regression analysis and factor analysis was adopted.

3.4. RESPONDENT'S PROFESSION

The professions of the respondents were required to acquire general information. The result for this information is shown below in Table 4.1.

Table 4.1 Results of Designation of respondents

PROFESSIONALS	FREQUENCY	PERCENTAGE
Architects	11	13.25%
Builders	28	33.73%
Quantity Surveyors	13	15.66%
Engineers	16	19.28%
Contractors	12	14.46%
Others	3	3.62%
Total	83	100

Source: 2015 survey

From Table 4.1 above, it is shown that 13.25% (11) of the total respondents are Architects, 33.73% (28) are Builders, 15.66% (13) are Quantity Surveyors, 19.28% (16) are Engineers, 14.46% (12) are Contractors while 3.62% (3) fall into others which are Land Surveyors.

From the analysis above, the Builders have the highest percentage amongst the respondents while the Engineers are following in the rank with 19.28%. The combination of these two professions show that the response given to the questionnaire is valid thereby showing the authenticity of the outcome of the research. It also indicates that the Builders have more experience due to their regular presence on site in the applicability of the lean thinking concept in managing quality on residential building projects.

3.5. RESPONDENTS' YEARS OF PRACTICE

The years of practice of the respondents is required to acquire an idea of the respondents' experience in the field of construction. The result for this information is shown below in Table 4.2.

Table 4.2 Percentage of years of practice of the respondents

YEAR OF PRACTICE	FREQUENCY	PERCENTAGE
0-5	16	19.51%
6-10	30	36.59%
11-15	8	9.76%
16-20	13	15.85%
20 and above	15	18.29%

Source: 2015 survey

The table 4.2 above shows that 16 respondents (19.51%) have 0-5 years of practice, 30 respondents (36.59%) have 6-10 years of practice, 8 respondents (9.76%) have 11-15 years of practice, 13 respondents (15.85%) have 16-20 years of practice and 15 respondents (18.29%) have 20 and above years of practice.

Based on the analysis above, it indicates that a majority of the respondents i.e. 36.59% have 6-10 years of practice which shows that they are well trained and have adequate experience in construction works and it implies that the information gathered would be appropriate enough.

3.6. AWARENESS OF THE CONCEPT OF LEAN THINKING

The awareness of the concept of lean thinking is required to acquire specific information from the respondents. Table 4.3 shows the percentage of awareness of the concept of lean thinking.

Table 4.3 Percentage of awareness of the concept of lean thinking

Awareness Measurement Parameter	FREQUENCY	PERCENTAGE
Are you aware of the concept of lean thinking?		
Yes	28	35%
No	52	65%

Source: 2015 survey

From the Table 4.3 above, it is shown that 35% of the respondents (28) are aware of the concept of lean thinking while 65% of the respondents (52) are not aware of the concept of lean thinking.

From the analyses above, it can be deduced that the concept of lean thinking is not common amongst the professionals in the construction industry as well as not practiced by these professionals. Due to the lack of this knowledge the lean thinking concept is not implemented in construction. It can also be deduced that this concept is not practiced even by the professionals that are aware of it. This analysis shows the importance of this research as it can bring about reduction of waste and also improved construction practices in residential building projects.

3.7. RESULTS ON THE ANALYSIS OF THE EXTENT OF APPLICABILITY OF LEAN THINKING PRINCIPLES IN RESIDENTIAL BUILDING PROJECTS.

As stated in the methodology, the data analysis for the parameters that indicate the applicability of lean thinking principles in residential building projects is to be presented using the relative agreement index. This method was used so as to rank the lean thinking parameters being practiced by professionals consciously or unconsciously on residential building projects in order of strongly agree, agree, strongly disagree, disagree and undecided. The formula for relative agreement index is indicated as:

$$\text{Relative Agreement Index (R.A. I)}: \frac{5SA + 4A + 3SD + 2D + 1U}{5(SA + A + SD + D + U)}$$

Where:

SA= No. of Respondents answered (Strongly Agree)

A= No. of Respondents answered (Agree)

SD= No. of Respondents answered (Strongly Disagree)

D= No. of Respondents answered (Disagree)

U= No. of Respondents answered (Undecided)

The suggested areas through which the lean thinking principles can be applied in construction have been identified and have been ranked based on the agreement index by the respondents.

Table 4.5 Extent of Applicability of Lean Thinking Principles in Residential Building Projects

Lean Thinking Parameters Being Practiced	Agreement Index	Rank
Identifying and minimizing process wastes by using work structuring	0.849	1st
Identifying value from the client's perspective	0.838	2nd
Improving construction process thereby reducing project cost	0.838	2nd
Eliminating activities that do not add value in the construction process	0.829	4th
Creating a continuous flow atmosphere of activities on site	0.820	5th
Using quality systems and focusing mainly on process characteristics affecting project performance	0.817	6th
Adopting standardized work by defining sequence, rhythm and inventory	0.800	7th
Designing processes to detect problems immediately	0.773	8th
Just-in-time applications among trades or for the supply of specific materials	0.746	9th
Designing a future value stream mapping of materials	0.735	10th

Source: 2015 survey

3.8. LIKELY CHALLENGES THAT CAN BE ASSOCIATED WITH THE APPLICATION OF LEAN THINKING PRINCIPLES IN RESIDENTIAL BUILDING PROJECTS

The likely challenges that can be associated with the application of lean thinking was gotten from the literature review and given out to the respondents to know which challenge has a greater chance of occurring in residential building projects due to the application of lean thinking principles. The Table 4.11 below shows the likely challenges that can be associated with the application of lean thinking principles in residential building projects.

Table 4.11 Likely challenges that can be associated with the application of lean thinking principles in residential building projects

Parameters	Agreement Index	Rank
Reduction in flexibility to react to new conditions during execution of project	0.724	1st
The process of management can be expensive and cost-intensive.	0.719	2nd
Application of lean principles gives little or no space for changes in the construction process	0.711	3rd
Non-favourable disposition of workers to the application of the principles.	0.709	4th
Just-in-time deliveries cause congestion on the supply chain	0.684	5th

Source: 2015 survey

Reduction in flexibility to react to new conditions during execution of project was ranked as the first by the respondents with an agreement index of 0.724. Application of lean thinking in construction operations can bring about a rigid structure in the execution of projects. The whole idea of lean thinking is centred on carrying out the same activities in the same manner but at a more specialized level with the aim of obtaining perfection. Lean itself reduces the flexibility of workers to bring in new ideas in the construction operations and they have to adapt to a stereotype working condition. The process of management can be expensive and cost-intensive was ranked as the second challenge with an index of 0.719. The process of implementing lean thinking is usually expensive as it requires acquiring new skills and a higher level of specialization. It might require a large amount of capital to put in to play in an organization. The least likely challenge suggested by the respondents is that just-in-time deliveries cause congestion on the supply chain. Just-in-time deliveries involving production at the point when it is needed and this can cause congestion on the supply chain where there is a bulk demand at the same time.

3.9. CAUSES OF WASTAGE IN CONSTRUCTION OPERATION ON THE QUALITY AND MANAGEMENT OF RESIDENTIAL BUILDING PROJECTS.

The concept of lean thinking is focused on the elimination of waste activities in a construction operation. This section identified the various causes of wastage in construction operations and the respondents were required to assess the most effective cause of wastage in residential building projects.

Table 4.12 Causes of wastage in Construction Operation

Parameters	Agreement Index	Rank
Delay occasioned by late delivery of work	0.829	1st
Correction of work such as retest and repair work	0.822	2nd
Interruption of work	0.818	3rd
Equipment breakdown on site	0.810	4th
Labour deficiencies	0.803	5th
Poor handling of materials on site	0.800	6th
Execution errors	0.800	6th
Non-productive time on site	0.783	8th
Design errors during setting out	0.779	9th
Over production of materials on site	0.768	10th

Source: 2015 survey

From Table 4.12 above, delay occasioned by late delivery of work was ranked first. Delay refers to something happening at a later time than planned, expected, and specified in a contract or beyond the date that the parties agreed upon for the delivery of a project (Pickavance, 2005). Delay occasioned by late delivery of work occurs when work is not delivered at the expected time thereby leading to late completion of project work and increased time related costs which causes wastage on the construction project. Correction of work such as retest and repair work ranked second based on the response by the respondents. Correction usually occurs on site as a result of design errors or work defects which calls for repair work. This causes a major amount of construction waste including both labour waste and material waste. The factor ranking third is interruption of work with an index of 0.818. Interruption of work is related to delay and this occurs when work has to put on hold due to delay in the delivery of materials to site. This factor causes more of labour waste than material waste.

The least two factors include design errors during setting out and over production of materials on site. Design errors can be as a result of execution errors or disobedience to the contractor by the manual operatives on site. Design errors are major contributors to change orders and rework, which in turn result in a high volume of construction waste. Over production of materials deals mainly with wastage in materials on site which can occur during casting of a slab on site.

3.10. CORRELATION MATRIX FOR LEAN THINKING-BASED QUALITY MANAGEMENT MODEL

The purpose of this correlation matrix is to analysis the factors to be considered when creating a dynamic quality management model based on lean thinking principles and to rank their level of importance and also distinguish their relationship with one another.

Table 4.13 Factor Rotation of Parameters for Lean Thinking-Based Quality Management Model

S/N	Variable	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8
1	Having maintenance expenditure	1.000							
2	Improving construction processes		1.000						
3	Minimizing expenditure		0.990	1.000					
4	Allowing contingencies	0.994			1.000				
5	Effective communication		0.991			1.000			
6	Management should convey meeting		0.997	0.990			1.000		
7	Establishing line of command		0.999	0.995			0.998	1.000	
8	Identifying value		0.995	0.993			0.999	0.998	1.000
		F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}	F_{15}	
9	Designing a future value stream	1.000							
10	Delegation of responsibility		1.000						
11	Policy implementation	0.992	0.998	1.000					
12	Eliminating activities				1.000				
13	Personnel to be taught ways of assessing maintenance		0.995	0.990		1.000			
14	Identifying and minimizing process wastes				0.995		1.000		
15	Conventional method of detecting faults	0.991	0.993			0.996		1.000	

Source: 2015 survey

The correlation matrix i.e. factor rotation of the parameters for lean thinking based-quality management model is presented in Table 4.13. The table consists of benchmarked parameters that could be used to create a lean thinking based-quality management model in residential building projects. The parameters had been analysed based on their respective agreement index and ranked based on their level of importance. The thirty-one (31) parameters that were identified as the lean thinking parameters to be considered when creating a quality management model were further reduced to a sizeable number using factor analysis and the top fifteen (15) parameters that influence the creation of the model were extracted. The resultant factors were examined considering the magnitude of their Eigen value using co-efficient of 1.000- 0.995 as a boundary limit. The following factors emerged with reference to the Eigen values with the 1.000- 0.995 Eigen coefficient dichotomies: F_1, F_2, F_3, F_6, F_7, F_8, F_{10}, F_{12}, F_{13}.

Three quality parameters were defined and were identified as follows: (i) High Quality; (ii) Medium Quality; and (iii) Low Quality.

$1.000F_1 + 0.999F_2 + 0.999F_6 + 0.999F_8$ ______ (For High Quality)

$0.998F_6+0.998F_7+0.998F_{10}+0.997F_2+0.997F_6+0.997F_8$ ______ (For Medium Quality)

$0.996F_7+0.996F_{13}+0.995F_2+0.995F_3+0.995F_{10}+0.995F_{12}$ ______ (For Low Quality)

Figure 12 Bench marked Model Parameters for Result of Lean Thinking-Based Quality Management Model.

3.11. HIGH QUALITY PARAMETERS

High quality parameters have been itemized for the purpose of achieving high quality as well as zero waste on residential building projects. The boundary limit for these factors is 0.999-1.000. These parameters based on the factor analysis carried out as shown in figure 4.1 are as follows: (i) F1- Having maintenance expenditure based on machine/equipment age/utilization. This factor influences the cost effect on project by eliminating equipment that absorb resources and create no value. Machines and equipment that regularly require maintenance or repairs can be easily replaced and this can effect better quality in the construction operations as well as increase in efficiency. (ii) F2- Improving construction processes thereby reducing project cost. Improving construction processes would eliminate redundant activities that do not add value in construction. Specialization in the construction process would be increased and a saving in both material and resources would be achieved. (iii) F6- Management should convey meeting on quality in maintenance issue periodically. This factor encourages a line of communication between the superiors and the subordinates on site. Organising periodic meetings also help works to be thoroughly briefed on the work to be carried and they are constantly reminded of the level of quality expected which would contribute in achieving near zero wastage. (iv) F8- Identifying value from the client's perspective. Putting the satisfaction of the client first is very essential as it would aid in applying output towards the expectation of the client. Fulfilling the requirements of the client would reduce the chances of increased expenditure as a result of rework. A proper combination of these factors explained above, would bring about zero wastage in residential building projects as well as high quality on the project output.

3.12. MEDIUM QUALITY PARAMETERS

The combination of the factors listed under this parameter would accommodate wastage to a permissible level and these factors fall under this category as a result of the threshold of their Eigen value which is between 0.997-0.998 which is not as strong as the set of factors highlighted for high quality likewise the factors for low quality as shown in figure 4.1 i.e. they are average factors with fair Eigen value. The factor include: (i) F2- Improving construction processes thereby reducing project cost. As explained earlier, this factor identifies non-value adding activities which add no extra value whilst absorbing resources and increasing expenditure of the overall project. (ii) F6- Management should convey meetings on quality in maintenance issue periodically. This factor does not only concentrate on the maintenance work but also the project at large. These meetings act as a means of communication at all levels of authority on site which would bring out effective and improved outputs. (iii) F7- Establishing line of command is essential. Delegation of authority which would ensure flow of power from the superior to subordinates would be established. In a situation where there is diffused instruction, wastage is inevitable therefore, establishing a line of command is paramount. (iv) F8- Identifying value from the client's perspective. As earlier stated, identifying what the client wants and working towards achieving it is essential. This would increase the value of the output in the eyes of the client. (v) F10- Delegation of responsibility is essential for operation success. If responsibility is delegated, it would give room for individuals involved in the construction operation to show their potentials. Through individual participation, the corporate success of the project would be achieved.

3.13. LOW QUALITY PARAMETERS

Low quality being referred to under this parameter does not mean a minimal level of quality instead it signifies a minimal level of wastage occurring. The Eigen values under this parameter are between the boundaries of 0.995-0.996. The factors that are itemized under this parameter include F2, F3, F7, F10, F12 and F13. F2 represents improving construction processes thereby reducing project cost; F3 represents minimizing expenditure to maximize profit which involves reduction in wasteful spending on site for instance renting equipment on site which on the long run would have to be purchased due to its level of usefulness on site. This would prevent wastage in resources and also improve prudence in spending. F7 represents establishing a line of command; F10 represents delegation of responsibility is essential for operation success while F12 represents eliminating activities that do not add value in the construction process. Monitoring of events and activities on site would assist in identifying activities that add no value on site and steps can be further carried out to eliminate these activities. F13 which is the last factor under this parameter represents personnel should be taught ways of assessing maintenance works done. Personnel on site should be enlightened on the know-how of identifying work done efficiently and according to the required standard on site. Substandard works carried out are easily detected and eliminated on site. An effective combination of these factors explained above would bring about a minimal level of waste of site i.e. 10%-15%.

3.14. MODEL INTERPRETATION

The interpretation of factors F_1 to F_{15} as contained in the structure of the model is as follows:

F1- Having maintenance expenditure based on machine/equipment age/utilization

F2- Improving construction processes thereby reducing project cost

F3- Minimizing expenditure to maximize profit.

F4- Allowing contingencies for tools and incidental: internal and external failure

F5- There should be effective communication of information on work quality standard to the maintenance personnel.

F6- Management should convey meeting on quality in maintenance issue periodically.

F7- Establishing line of command is essential.

F8- Identifying value from the client's perspective.

F9- Designing a future value stream mapping of materials.

F10- Delegation of responsibility is essential for operation success.

F11- Policy implementation committee needs to be established.

F12- Eliminating activities that do not add value in the construction process.

F13- Personnel should be taught ways of assessing maintenance works done.

F14- Identifying and minimizing process wastes by using work structuring.

F15- Conventional method of detecting faults should be in place.

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