

**EFFECTIVENESS OF QUALITY ASSURANCE  
STRATEGIES IN PROJECT EXECUTION:  
A STUDY OF ROAD CONSTRUCTION PROJECTS  
IN OWERRI**

**BY**

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**A THESIS SUBMITTED TO THE POST  
GRADUATE SCHOOL, FEDERAL  
UNIVERSITY OF TECHNOLOGY, OWERRI.**

**IN PARTIAL FULFILLMENT OF THE  
REQUIREMENTS FOR THE AWARD OF THE  
DEGREE M.SC IN PROJECT MANAGEMENT**

**JANUARY, 2013**



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## CERTIFICATION

We certify that this research thesis titled Effectiveness of Quality Assurance Strategies in Project Execution: A Study of Road Construction Projects in Owerri is the work of **Victoria Osuagwu** with registration number **20074577148** in the Department of Project Management Technology, Federal University of Technology, Owerri.

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## **DEDICATION**

To

Ethel, Ozioma, Chisom, Okechi, Chika, Ebere, Odera and Tochi.

## **ACKNOWLEDGEMENT**

May I express my profound gratitude to my Supervisor, Dr. E.C. Ubani, whose wise supervision, guidance and constructive criticisms enabled the successful completion of this work. I also recognize all the other Lecturers in Project Management Technology, especially the Head of Department, Professor F.P.O. Ukwuoma.

I am equally highly indebted to the former dean of school of Management and Technology, Professor G.E. Nworuh for his pieces of advice and useful contributions.

My sincere gratitude also goes to my husband, Dr. E. C. Osuagwu for his moral and financial assistance throughout the period of this work.

I will not fail to mention with thanks my friends and course-mates, Ulari, Lydia, Igbokwe and Dozie for their sincere contributions and kind gestures.

To the staff of Zerock, Rhas and New Idea Construction companies, I say thank you for making some relevant information available to me.

May I also thank Lizzy and Ifeoma for their careful secretarial job.

To God be all the glory.

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## **ABSTRACT**

This research was conducted to determine if quality assurance and its strategies are effective for successful project execution in the construction industries. Data was obtained from both primary and secondary sources. The primary sources consisted of questionnaires and observations while the secondary data consisted of texts, websites and journals. Percentages were used to analyze data and analysis of variance (ANOVA) was adopted in testing hypothesis. Among the major result of data analysis include that most construction firms in Owerri did not apply quality assurance strategies and that quality assurance provides umbrella for continuous process improvement among others. The researcher inferred that many workers had no proper knowledge of cost benefit analysis as a quality assurance tool. Also many workers were not properly exposed to quality audits and process analysis. It was recommended that the construction firms should improve on the skills and capacity building of their employees in the areas of quality assurance and quality management in general. Equally, implemented defect repair should go with quality audits. It was concluded among others that quality assurance is a key to project customer satisfaction.

**KEYWORDS:** Effectiveness, Quality Assurance, Strategies, Project Execution and Road Construction.

# **INTRODUCTION**

## **1.1 BACKGROUND OF THE STUDY**

Over the years, most projects in organizations especially those of the Zerock, Rhas and New Idea Construction companies in Owerri, might have been subjected to poor performance and abandonment following the inability of the management of such projects to apply quality assurance techniques in the execution of such projects.

According to Jaideep (2009), the definition of quality varies in different contexts. On one hand, we talk of software quality that means adopting standards and measures to ensure the building of software product that meets all customer requirements (design, interface, business requirements, functional requirements, etc) and ready to deliver. On the other, hand, project quality refers to the standard and measures by means of building (or adopting) to ensure successful completion of a project, in terms of time and revenue. This starts right from initiation of the project to its implementation stage and continues to the post implementation stage. In the context of software-the quality means software strategy, plan, test cases, test scenarios, test results and fixing of bugs. Inclusion of quality in this context will vary from organization to organization and project to

project (within an organization). This will ensure the successful building of software product ready for delivery. In the context of project, the quality would mean managing quality standards and measures for a project right from its initiation to all stages coming forth. A project life cycle in standard terms would comprise of project initiation, project planning, development execution, implementation, execution, project close-out, and post implementation phase broadly, which remains on-going till the software built is in use by the customers for a period of years (Jaideep, 2009).

Also, according to the project management book of knowledge PMBOK (2005), to perform quality assurance means applying-the planned, systematic quality activities to ensure that the project employs all processes needed to meet requirements. Quality assurance is the application of planned systematic quality activities to ensure that the project will employ all processes needed to meet requirements. Quality assurance is the application of planned systematic quality activities to ensure that the project will employ all processes needed to meet requirements (PMBOK, 2005). A quality assurance department or similar organization often oversees quality assurance activities. Quality assurance supports, regardless of the unit's title, may be provided to the project team, the management of

the performing organization, the customer or sponsor, as well as other stakeholders not actively involved in the work of the project. Quality assurance also provides an umbrella for another important quality activity, continuous process improvement. Continuous process improvement provides an iterative means for improving the quality of all processes (PMBOK, 2005). Such quality assurance inputs as quality management plan, quality metrics, process improvement plan, work performance information, approved change requests, quality control measurement, implemented change requests, implemented corrective actions, implemented defect repair and implemented preventive action must be performed (Anyanwu, 2007).

Okoro (2006) opines that certain quality assurance tools and techniques like quality planning tools and techniques, quality audits, process analysis, quality control tools and techniques ought to be properly performed. There must also be the performance of quality assurance outputs including requested changes, recommended corrective actions, organizational process assets (updates), and project management plan (updates).

## **1.2 STATEMENT OF THE PROBLEM**

Many construction industries in Owerri had in the past delivered completed construction projects which fell short of design specifications and quality standard. (Ministry of Works, Owerri, 2012).

Indeed, most of the roads hardly survived one rainy season. Many roads constructed in the past lack durability and reliability in that they cannot withstand the climatic and environmental challenges in Owerri. Examples of such roads include St. Johns Laboratory through Relief Market to Egbu road and Transfiguration road between IMSU Junction and MCC road junction.

Experience has also shown that many project managers find it difficult to determine if quality assurance is effective for successful project execution in construction industries (Anyanwu 2007). It could also be dangerous for project completion if there are low performance indices due to inability to put in place quality assurance techniques in project construction.

It is also painful, as experience has shown that many project managers are yet to develop a relationship between quality audit and input materials in construction firms. This could be compounded by

the perceived poor attitude of project firms to quality assurance techniques (Kenny, 2010).

It is in the light of the above problems that this research is conducted.

### **1.3 RESEARCH QUESTIONS**

The research questions for this research work are:

- (a) Are quality assurance strategies effective for successful project execution in construction industries?
- (b) Are there performance indices for quality assurance in project construction?
- (c) Is there any relationship between quality audit and input materials in construction industries?
- (d) Do project managers apply quality assurance techniques in construction industries?
- (e) Are various factors that influence quality assurance properly identified and analyzed for effective project delivery?

## **1.4 OBJECTIVES OF THE STUDY**

The major objective of this study is to determine the effectiveness of quality assurance strategies on the execution and delivery of construction project. Specifically, this study is undertaken to:

- (a) Determine if quality assurance is effective for successful project execution in the construction industries.
- (b) Examine the performance indices for quality assurance in construction projects.
- (c) Determine the extent of application of quality audit to input materials in construction firms.
- (d) Investigate if project managers apply quality assurance techniques.

## **1.5 HYPOTHESES**

The hypotheses for this research work are:

**H<sub>oi</sub>:** There is no significant difference in the mean effectiveness of quality assurance in the success of projects in the construction industries.

- H<sub>o2</sub>:** There is no significant difference in the mean performance index of project deliverables in construction industries as a result of quality assurance.
- H<sub>o3</sub>:** The mean difference in the level of quality audit of input materials in construction industries is not significant.
- H<sub>o4</sub>:** The difference in the mean level of application of quality assurance techniques by project managers in construction industries is not significant.

## **1.6 SIGNIFICANCE OF THE STUDY**

Project managers will use this work to determine the essential roles which quality assurance can play in the satisfaction of project owners. Project workers will use this work to understand the need to improve their quality assurance skills. Project management consultants and project-based firms will use this work to educate their clients on quality assurance and improve the quality of their works respectively.

Further researchers will benefit extensively in the areas of literature review and methodology.

## **1.7 SCOPE AND DELIMITATION OF THE STUDY**

This study seeks to investigate the effectiveness of quality assurance in project execution as it affects all projects in various organizations, but due to time and financial constraints, the researcher has chosen to focus on project organizations like Zerock, Rhas and New Idea Construction Companies.

It is not only quality assurance that has effects on project execution, other factors like time management, motivation, project human resources development and project financial management all have impacts and effects on project execution.

## **1.8 LIMITATIONS OF THE STUDY**

There were a lot of constraints which the researcher encountered in the course of carrying out this research work. First, was the lack of sufficient funds to face the challenges of the research work. This was overcome by the intervention of relatives. It was difficult to educate the respondents on how best to complete the questionnaires administered to them. The researcher solved this problem by ensuring that the respondents filled the questionnaires in her presence.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 HISTORICAL BACKGROUND**

##### **2.1.1 EARLY EFFORTS IN THE CONTROL OF QUALITY OF PRODUCTION**

Early civil engineering projects were built from specifications, for example the four sides of the base of the great pyramid of Giza were required to be perpendicular to within 3.5 arc seconds. During the middle ages, guilds adopted responsibility for quality control of their members, setting and maintaining certain standards for guild membership. (Brown, 2004).

Royal governments purchasing material were interested in quality control as customers. For this reason, King John of England appointed William Wrotham to report about the construction and repair of ships. Prior to the extensive division of labour and mechanization resulting from the industrial revolution, it was possible for workers to control the quality of their own products. The industrial revolution led to a system in which large groups of people performing a similar type of work were grouped together under the supervisor or

a foreman who was appointed to control the quality of work manufacture. (Rudoff, 2006).

### **2.1.2 WARTIME PRODUCTION**

Around the time of World War I, manufacturing processes typically became more complex with larger numbers of workers being supervised. This period saw the widespread introduction of mass production and piecework, which created problems as workmen could now earn more money by the production of extra products, which in turn led to bad workmanship being passed on to the assembly lines.

To counter bad workmanship, full time inspectors were introduced into the factory to identify quarantine and ideally correct product quality failures. Quality control by inspection in the 1920s and 1930s led to the growth of quality inspection functions, separately organized from production and big enough to be headed by superintendents. (Mitroff, 2008).

The systematic approach to quality started in industrial manufacture during the 1930s, mostly in the USA, when some attention was given to the cost of scrap and rework. With the impact of mass production, which was required during the Second World

War, it became necessary to introduce a more appropriate form of quality control which was identified as statistical quality control, SQC. Some of the initial work for statistical quality control is credited to Walter A. Shewhart of Bell laboratory, starting with his famous one-page memorandum of 1924 (Edith, 2008).

Statistical quality control came about with the realization that quality cannot be fully inspected into an important batch of items. By extending the inspection phase and making inspection organizations more efficient, it provides inspectors with control tools such as sampling and control charts. Standard statistical techniques allow the producer to sample and test a certain proportion of the products for quality to achieve the desired level of confidence in the quality of the entire batch or production run (Bernstein, 2012).

### **2.1.3 POSTWAR**

In the period following World War II, many countries' manufacturing capabilities that had been destroyed during the war were rebuilt. The U.S sent General Douglas Macarthur to oversee the re-building of Japan. During this time, General Macarthur involved two key individuals in the development of modern quality concepts:

W. Edwards Deming and Joseph Juran. Both individuals promoted the collaborative concepts of quality to Japanese, business and technical groups, and these groups utilized these concepts in the redevelopment of the Japanese economy (Venette, 2006).

Although there were many individuals trying to lead United States industries towards a more comprehensive approach to quality, the U.S continued to apply the quality control (QC) concepts of inspection and sampling to remove defective product from production lines, essentially ignoring advances in quality assurance for decades (Rakowitz, 2010).

## **2.2 THEORETICAL FOUNDATIONS**

### **2.2.1 CONCEPT OF QUALITY ASSURANCE**

Quality assurance (QA) refers to a programme for the systematic monitoring and evaluation of the various aspects of a project, service, or facility to ensure that standards of quality are being met (Sholar 2010). It is important to realize also that quality is determined by the programme sponsor. Quality assurance cannot absolutely guarantee the production of quality products, unfortunately, but makes this more likely. Two key principles

characterize quality assurance. These are “fit for purpose” and “right first time”. Fit for purpose implies that the product should be suitable for the intended purpose while right first time and always implies that mistakes should be eliminated. Quality assurance includes regulation of the quality of raw materials, assemblies, products and components, services related to production, and management, production and inspection processes (Sholar, 2010).

It is important, to realize also that quality is determined by the intended users, clients or customers, not by society in general; it is not the same as expensive’ or high quality’. Even goods with low prices can be considered quality items if they meet a market need (Sholar, 2010).

### **2.2.2 QUALITY ASSURANCE VERSUS QUALITY CONTROL**

Quality control emphasizes testing of products to uncover defects, and reporting to management who make the decision to allow or deny the release, whereas quality assurance attempts to improve and stabilize production and associated processes, to avoid or at least minimize issues that led to defects (Kenny, 2010). Quality assurance is more to do with the quality of the project and adherence

to predefined set of norms and practices. These are termed standards, procedures, standard procedures, norms, standard practices or methodologies. It is at organization or project type level. It is broader in sense. Quality control is project specific. The main purpose of quality control lies in assuring a 'good' product going to customer. Quality control is more concerned with all types of testing to be done on the product to meet customer's current and future requirements (Jaideep, 2009).

To prevent mistakes from arising, several quality assurance methodologies are used. However, quality assurance does not eliminate the need for quality control. Some product parameters are so critical that testing is still essential. Quality control activities are treated as one of the overall quality assurance processes, (Kenny 2010).

### **2.2.3 QUALITY ASSURANCE AND PROJECT ASSESSMENT**

The ultimate success of IDABC (Interoperable Delivery of European Government Services to Public Administration, Business and Citizens) projects is determined by the effectiveness of their results for the beneficiaries, namely administrations, citizens and

enterprises. For this purpose, IDABC programme is defining, implementing and continuously updating an integrated quality programme, applicable both to the horizontal actions and measures and to the projects of common interest, (Donald, 2009).

#### **2.2.4 QUALITY ASSURANCE ACTIVITIES**

The quality assurance project includes four types of activities:

- ❖ Development of quality guideline and generic tools for the whole set of IDABC Projects Of Common Interest (PCIs) and Horizontal Action Measure (HAMs),
- ❖ Development of guidelines for cost benefit assessment of individual projects and horizontal measure.
- ❖ Evaluation of IDABC selected projects, including cost benefit analysis.
- ❖ The dissemination of the results throughout the IDABC community (Ward, 2009).

These activities aim to provide monitoring and advice during project implementation, as well as ex-post evaluations. The results are made available to the sectors/projects concerned and also to other administrative sectors. In this way, all participants in the IDABC

programme are informed of the lessons learned and mistakes to be avoided.

### **Objectives of Quality Assurance Activities**

The quality assurance activity aims to improve the manner in which project objectives and requirements are specified, and how individual projects are carried out, as well as the quality of the final project deliverables. It also evaluates key projects of common interest and horizontal actions and measures and the results of the IDABC programme as a whole. At the level of the individual projects, the results of these evaluations should lead to corrective actions (Turnow, 2010).

### **How Does it Work**

Quality assurance guidelines are meant to be an ongoing, centralized implementation activity aimed at facilitating a common understanding and agreement of key project issues such as the formulation of user requirements, the definition of project objectives, role and responsibilities, critical success factors, risk, constraints and organizational impact (Trewatha, 2009).

Framework contracts are established to provide quality control services to sectors and the central IDABC unit on a call-off basis. In this way, project managers have assistance in assessing the project quality plans and monitoring their execution, for measuring user satisfaction, determining the acceptance criteria for project deliverables and assessing deliverables against these criteria. Overall assessments of specific projects by means of cost-benefit analysis and end-user satisfaction measurement are also possible. (Trewatha, 2009).

## **ACHIEVEMENTS**

Quality assurance guidelines have been developed. They consist in a self-evaluation tool in combination with short guides to the different phases of IDABC projects (preparatory, feasibility, development and validation, implementation). Each of these short guides refers to a number of templates and checklists that can be used in each phase, such as for the project management and quality plan, user requirements, system requirements and guidance on metrics (Smith, 2010).

## **WHO BENEFITS**

The first direct impact of the quality assurance will be the improvement of the quality of project deliverables of projects funded by IDABC both in terms of compliance with project specification and in terms of satisfaction of user expectations. Hence the IDABC will benefit.

By providing transparency and accountability with regard to the programme management, it is also possible to say that the beneficiaries are more than just those directly involved in the IDABC programme (Ward, 2009).

## **2.3 RELEVANT MODELS AND THEORIES**

### **2.3.1 MODELS AND STANDARDS**

ISO 17025 is an international standard that specifies the general requirements for the competence to carry out tests and or calibrations. There are 15 management requirements and 10 technical requirements. These requirements outline what a laboratory must do to become accredited.

Management system refers to these organizations structure for managing its processes or activities that transfer inputs of resources

into a product or service which meets the organization's objectives, such as satisfying the customer's quality requirements, complying with regulation, or meeting environmental objectives (Edward, 2010).

The CMMI (Capability Maturity Model Integration) is widely used to implement quality assurance in an organization. The CMMI maturity levels can be divided into 5 steps, which a company can achieve by performing specific activities within the organization.

During the 1980s, the concept of "company quality" with the focus on management and people came to the fore. It was that, if all departments approached quality with an open mind, success was possible if the management led the quality improvement process.

According to Edward (2010), the company-wide quality approach places an emphasis on four aspects viz:

- (1) Elements such as controls, job management, adequate processes, performance and integrity criteria and identification of records.
- (2) Competence such as knowledge, skills, experience, qualifications.

- (3) Soft elements, such as personnel integrity, confidence, organizational culture, motivation, team spirit and quality relationships.
- (4) Infrastructure (as it enhances or limits functionality). The quality of the output is at risk if any of these aspects is deficient in any way.

The approach to quality management given here is therefore not limited to the manufacturing theatre only but could be applied to any business or non-business activity, such as design work, administrative services, consulting, banking, insurance, computer software development, retailing, transportation and education (Edward, 2010).

It comprises a quality improvement process which is generic in the sense that it can be applied to any of these activities and it establishes a behaviour pattern, which supports the achievement of quality. This in turn is supported by quality management practices which can include a number of business systems and which are usually specific to the activities of the business unit concerned. In manufacturing and construction activities, these business practices can be equated to the models for quality assurance defined by the

international standards contained in the ISO 9000 series and the specified specifications for quality systems.

Still, in the system of company quality, the work being carried out was shop floor inspection which did not reveal the major quality problems. This led to quality assurance or total quality control, which has come into being recently.

### **2.3.2 USING CONTRACTORS AND/OR CONSULTANTS**

It has become customary to use consultants and contractors when introducing new quality practices and methods, particularly where the relevant skills and expertise are not available within the organization. In addition, when new initiatives and improvements are required to boost the current quality system, or perhaps improve upon current manufacturing systems, the use of temporary consultants becomes a viable solution when allocating valuable resources (Donald, 2009).

There are various types of consultants and contractors available in the market, most will have the skills needed to facilitate improvement activities such as Quality Management Systems (QMS), auditing and procedural documentation writing. More experienced

consultants are likely to have knowledge of specialized quality improvement activities such as CMMI, six sigma Measurement System Analysis (MSA), Quality Function Deployment (QFD), Failure Mode and Effects Analysis (FMEA), Advance Product Quality Planning (APQP).

### **2.3.3 FAILURE TESTING**

One of the aspects of quality assurance is failure testing. This is a valuable process performed on a whole consumer product. It is also known as stress testing. In mechanical terms, failure testing is the operation of a product until it fails, often under stresses such as increasing vibration, temperature, and humidity. This exposes many unanticipated weaknesses in a product, and the data are used to drive engineering and manufacturing process improvements. Often quite simple changes can dramatically improve product services, such as changing to mold-resistant paint or adding lock-washer placement to the training for new assembly personnel (Edward, 2009).

#### **2.3.4 STATISTICAL CONTROL**

Many organizations use statistical process control to bring the organization to six sigma levels of quality, in other words, so that the likelihood of an unexpected failure is confined to six standard deviations on the normal distribution.

This probability is less than four one-millionths. Items controlled often include clerical tasks such as order-entry as well as conventional manufacturing tasks (Bruno, 2009).

Traditional statistical process controls in manufacturing operations usually proceed by randomly sampling and testing a fraction of the output. Variances in critical tolerances are continuously tracked and where necessary corrected before bad parts are produced. Invariably, the quality of output is directly dependent upon that of the participating constituents, some of which are sustainably and effectively controlled while others are not. The fluid state spells lack of quality control, and the process(es) which are properly managed for quality such that quality is assured, pertain to Total Quality Management. The major problem which leads to a decrease in sales is that the specifications do not include the most important

factors, “what the specifications have to state in order to satisfy the customer requirements?”

The major characteristics, ignored during the search to improve manufacture and overall business performance were reliability, maintainability, safety and strength (Coombs, 2009).

As the most important factor had been ignored, a few refinements had to be introduced. These include:

- (i) Marketing had to carry out their work properly and define the customer's specification.
- (ii) Specifications had to be defined to conform to these requirements.
- (iii) Conformance to specifications i.e. drawings, standards and relevant documents were introduced during manufacturing, planning and control.
- (iv) Management had to confirm that all operators are equal to the work imposed on them and holidays, celebrations and dispute did not affect any of the quality levels.
- (v) Inspections and tests were carried out, and all components and materials, bought in or otherwise, conformed to the specifications, and the measuring equipment was accurate.

This is the responsibility of the quality assurance /quality control department.

- (vi) Any complaints received from the customers were satisfactorily dealt with in a timely manner.
- (vii) Feedback from the user/customer is used to review designs.
- (viii) Consistent data recording and assessment and documentation integrity.
- (ix) Product and/or process change management and notification, (Brown 2009).

If the specification does not reflect the true quality requirements, the product's quality cannot be guaranteed. For instance, the parameters for a pressure vessel should cover not only the material and dimensions but operating, environmental, safety, reliability and maintainability requirements. (Brown, 2009).

## **2.4. CONTRIBUTIONS BY OTHER AUTHORITIES**

### **2.4.1 QUALITY ASSURANCE AS SUBSET OF PROJECT QUALITY MANAGEMENT**

According to PMBOK (2005), project quality management processes include all the activities of the performing organization that determine quality policies, objectives and responsibilities so that the project will satisfy the needs for which it was undertaken. It implements the quality management system through the policy, procedures, and processes of quality planning, quality assurance and quality control, with continuous process improvement activities conducted throughout, as appropriate.

### **2.4.2 PROJECT QUALITY MANAGEMENT PROCESSES**

The project quality management processes include quality planning, quality assurance and quality control. Figure 2.1 provides an overview of project quality management processes.

#### **QUALITY PLANNING**

Quality planning involves identifying which quality standards are relevant to the project and determining how to satisfy them.

## **QUALITY ASSURANCE**

This involves applying the planned, systematic quality activities to ensure that the project employs all processes needed to meet requirements.

## **QUALITY CONTROL**

This involves monitoring specific project results to determine whether they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.

These processes interact with each other and with the processes in the other knowledge areas as well. Each process can involve effort from one or more persons or groups of persons based on the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. Although the processes are presented here as discrete elements with well-defined interfaces, in practice they may overlap and interact in different ways (Roberts, 2009).

Project quality management must address the management of the project and the product of the project. While project quality management applies to all projects, regardless of the nature of their

product, product quality measures and techniques are specific to the particular type of product produced by the project. For example, quality management of software products entails different approaches and measures than nuclear power plants, while project quality management approaches apply to both. In either case, failure to meet quality requirements in either dimension can have serious negative consequences for any or all of the project stakeholders. For example:

- Meeting customer requirements by overworking the project team may produce negative consequences in the form of increase employee attrition, unfounded errors or rework.
- Meeting project schedule objectives by rushing planned quality inspections may produce negative consequences when errors go undetected.

Quality is “the degree to which a set of inherent characteristics fulfill requirements” (PMBOK, 2005). Stated and implied needs are the inputs to developing project requirements. A critical element of quality management in the project context is to turn stakeholder needs, wants, and expectations into requirements through stakeholder analysis, performed during project scope management (Womack, 2008).

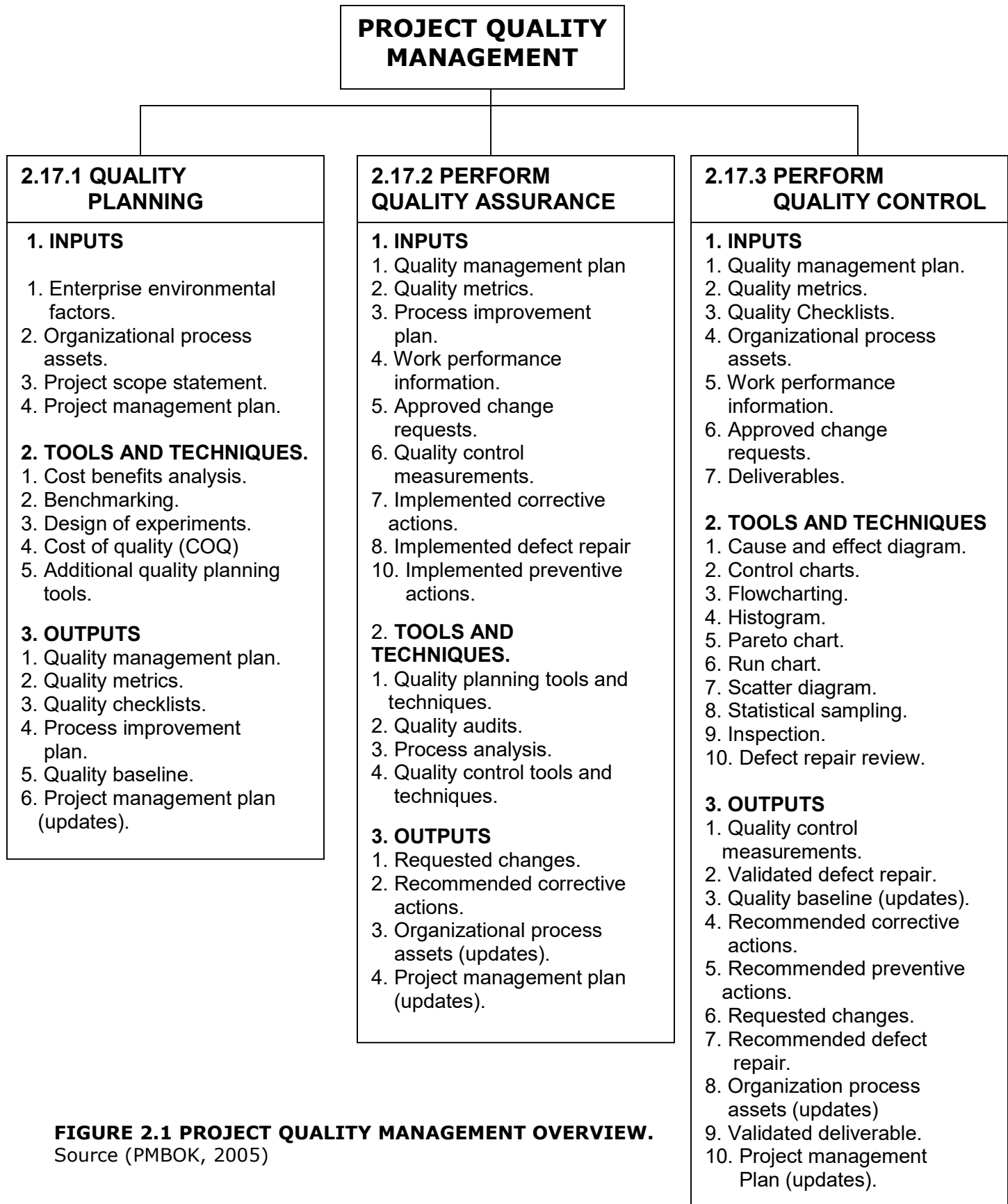
Quality and grade are not the same. Grade is a category assigned to products or services having the same functional use but different technical characteristics. Low quality is always a problem, low grade may not be. For example, a software product can be of high quality (No obvious defects, readable manual) and low grade (A limited number of features), or of low quality (Many defects, poorly organized user documentation) and high grade (Numerous features). The project manager and the project management team are responsible for determining and delivering the required levels of both quality and grade (James, 2009).

Modern quality management complements project management. For example, both disciplines recognize the importance of:

- **Customer satisfaction:-** Understanding, evaluating, defining and managing expectations so that customer requirements are met. This requires a combination of conformance to requirements (the project must produce what it said it would produce) and fitness for use (The product or service must satisfy real needs).

- ❖ Prevention of over-inspection:- The cost of preventing mistakes is generally much less than the cost of correcting them, as revealed by inspection.
- ❖ Management responsibility: Success requires the participation of all members of the team, but it remains the responsibility of management to provide the resources needed to succeed.
- ❖ Continuous improvement: The plan-do-check-act cycle is the basis for quality improvement (PMBOK, 2005). According to the book, quality improvement initiatives undertaken by the performing organization, such as TQM and six sigma, can improve the quality of the project's management as well as the quality of the project's product.

The cost of quality refers to the total cost of all efforts related to quality. Project decisions can impact operational costs of quality as a result of product returns, warranty claims, and recall campaigns. However, the temporary nature of the project means that investments in product quality improvement, especially defect prevention and appraisal, can often be borne by the acquiring organization, rather than the project, since the project may not last long enough to reap the rewards (Lewis, 2010).



**FIGURE 2.1 PROJECT QUALITY MANAGEMENT OVERVIEW.**  
Source (PMBOK, 2005)

### 2.4.3 QUALITY PLANNING

Quality planning involves identifying which quality standards are relevant to the project and determining how to satisfy them. It is one of the key processes when doing the planning process group and during development of the project planning processes. For example, the required changes in the product to meet identified quality standards may require cost or schedule adjustments, or the desired product quality may require a detailed risk analysis of an identified problem. Figure 2.2 illustrates the quality planning inputs, tools and techniques, and outputs.

The quality planning techniques discussed here are those techniques most frequently used on projects. There are many others that may be useful on certain projects or in some application areas. One of the fundamental tenets of modern quality management is that quality is planned, designed, and built in -not inspected in (PMBOK, 2005).

INPUTS	TOOLS AND TECHNIQUES	OUTPUTS
<ol style="list-style-type: none"><li>1. Enterprise environmental factors.</li><li>2. Organizational process assets.</li><li>3. Project scope statement.</li><li>4. Project management plan.</li></ol>	<ol style="list-style-type: none"><li>1. Cost benefit analysis.</li><li>2. Bench marking.</li><li>3. Design of experiments.</li><li>4. Cost of quality (COQ).</li><li>5. Additional quality planning tools.</li></ol>	<ol style="list-style-type: none"><li>1. Quality management plan.</li><li>2. Quality metrics.</li><li>3. Quality checklists.</li><li>4. Process improvement plan.</li><li>5. Quality baseline.</li><li>6. Project management (updates).</li></ol>

**FIG 2.2 QUALITY PLANNING: INPUTS, TOOLS & TECHNIQUES, AND OUTPUTS.**

Source: (Goldman, 2007).

### **2.4.3 (A) QUALITY PLANNING: INPUTS**

#### **1. ENTERPRISE ENVIRONMENTAL FACTORS.**

Governmental agency regulations, rules, standards, and guidelines specific to the application area may affect the project (Warner, 2008).

#### **2. ORGANIZATIONAL PROCESS ASSETS**

Organizational quality policies, procedures and guidelines, historical databases and lessons learned from previous projects specific to the application area may affect the project.

The quality policy, as endorsed by senior management, is the intended direction of a performing organization with regard to quality. If the performing organization lacks a formal quality policy, or if the project involves multiple performing organizations (as with a joint venture, the project management team will need to develop a quality policy for the project (Shrivastava, 2009).

Regardless of the origin of the quality policy, the project management team is responsible for ensuring that the project stakeholders are fully aware of the policy through the appropriate distribution of information.

### **3. PROJECT SCOPE STATEMENT.**

The project scope statement is a key input to quality planning since it documents major project deliverables, the project objectives that serve to define requirements (which were derived from stakeholder needs, wants and expectations, thresholds, and acceptance criteria. Thresholds which are defined as cost, time, or resource values used as parameters, can be part of the project scope statement. If these threshold values are exceeded, it will require action from the project management team (Hellsloot, 2007).

Acceptance criteria include performance requirements and essential conditions that must be achieved before project deliverables are accepted. The definition of acceptance criteria can significantly increase or decrease project quality costs. The result of the deliverables satisfying all acceptance criteria implies that the needs of the customer have been met. Formal acceptance validates that the acceptance criteria have been satisfied. The product scope description, embodied in the project scope statement, will often contain details of technical issues and other concerns that can affect quality planning (Boin, 2009).

## **4. PROJECT MANAGEMENT PLAN**

The project management plan process includes the actions necessary to define, integrate and coordinate all subsidiary plans into a project management plan. The project management plan content will vary depending upon the application area and complexity of the project. This process results in a project management plan that is updated and revised through the integrated change control process. The project management plan documents the collection of outputs of the planning process of the planning process group.

The project management plan can be either summary level or detailed, and can be composed of one or more subsidiary plans and other components. Each of the subsidiary plans and components is detailed to the extent required by the specific project. One of the subsidiary plans or components of project management plan is quality management plan (Hart, 2006).

### **2.4.3 (B) QUALITY PLANNING: TOOLS AND TECHNIQUES**

#### **1. COST-BENEFIT ANALYSIS**

Quality planning must consider cost-benefits tradeoffs. The primary benefit of meeting quality requirements is less rework, which

means higher productivity, lower costs, and increased stakeholder satisfaction. The primary cost of meeting quality requirements is the expense associated with project quality management activities (Stern, 2009).

## **2. BENCHMARKING**

Benchmarking involves comparing actual or planned project practices to those of other projects to generate ideas for improvement and to provide a basis by which to measure performance. Those other projects can be within the performing organization or outside of it, and can be within the same or in another application area (Robert, 2011).

## **3. DESIGN OF EXPERIMENTS**

Design of experiments (DOE) is a statistical method that helps identify which factors may influence specific variables of a product or process under development or in production. It also plays a role in the optimization of products or processes. An example is where an organization can use design of experiments to reduce the sensitivity of product performance to sources of variation caused by environmental manufacturing differences. The most important aspect of this technique is that it provides a statistical framework for

systematically changing all of the important factors, instead of changing the factors one at a time. The analysis of the experimental data should provide the optimal conditions for the product or process, highlighting the factors that influence the results, and revealing the presence of interactions and synergisms among the factors. For example, automotive designers use this technique to determine which combination of suspension and tyres will produce the most desirable ride characteristics at a reasonable cost (Lamberton, 2009).

#### **4. COST OF QUALITY (COQ)**

Quality costs are the total costs incurred by investment in preventing nonconformance to requirements, and failing to meet requirements (Rework). Failure costs are often categorized into internal and external. Failure costs are also called cost of poor quality (Janette, 2010).

#### **5. ADDITIONAL QUALITY PLANNING TOOLS**

Other quality planning tools are also often used to help better define the situation and help plan effective quality management activities. These include brainstorming, affinity diagrams, force field analysis, normal group techniques, matrix diagrams, flowcharts, and prioritization matrices (Eduardo, 2011).

### **2.4.3 (C) QUALITY PLANNING: OUTPUTS**

#### **1. QUALITY MANAGEMENT PLAN**

The quality management plan describes how the project management team will implement the organization's quality policy. The quality management plan is a component or a subsidiary plan of the project management plan (Richard, 2003).

The quality management plan provides input to the overall project management plan and must address quality control (QC), quality assurance (QA), and continuous process improvement for the project. The quality management plan may be formal or informal, highly detailed or broadly framed, based on the requirements of the project. The quality management plan should include efforts at the front end of a project to ensure that the earlier decisions, for example on concepts, designs and tests, are correct. These efforts should be performed through an independent peer review and not include individuals that worked on the material being reviewed. The benefits of this review can include reduction of cost and schedule overruns caused by rework (Brown, 2004).

## **2. QUALITY METRICS.**

A metric is an operational definition that describes, in very specific terms, what something is and how the quality control process measures it. A measurement is an actual value. For example, it is not enough to say that meeting the planned schedule dates is a measure of management quality. The project management team must also indicate whether every activity must start on time or only finish on time and whether individual activities will be measured or only certain deliverables, and if so, which ones. Quality metrics are used in the quality assurance and quality control processes. Some examples of quality metrics include defect density, failure rate, availability, reliability, and test coverage (Hansen, 2008).

## **3. QUALITY CHECKLISTS.**

A checklist is a structured tool, usually component-specific, used to verify that a set of required steps has been performed. Checklists may be simple or complex. They are usually phrased as imperatives (“Do this!”) Or interrogatories (“have you done this?”) Many organizations have standardized checklists available to ensure consistency in frequently performed tasks. In some application areas,

checklists are also available from professional associations or commercial service providers. Quality checklists are used in the quality control process (Fyodor, 2009).

#### **4. PROCESS IMPROVEMENT PLAN**

The process improvement plan is also a subsidiary of the project management plan. The process improvement plan details the steps for analyzing processes that will facilitate the identification of waste and non-value added activity, thus increasing customer value such as:

- **Process Boundaries:** This describes the purpose, start and end of processes, their inputs and outputs, data required, if any, and other owner and stakeholders of processes.
- **Process Configuration:** This is a flow chart of processes to facilitate analysis with interfaces identified.
- **Process Metrics:** this maintains control over status of processes.
- **Target for Improved Performance:** This guides the process improvement activities.

## **5. QUALITY BASELINE**

The quality baseline records the quality objectives of the project. The quality baseline is the basis for measuring and reporting quality performance as part of the performance measurement baseline (Carol, 2008).

## **6. PROJECT MANAGEMENT PLAN (UPDATES)**

The project management plan will be updated through inclusion of a subsidiary quality management plan and process improvement plan. Requested changes (additions, modifications, deletions) to the project management plan and its subsidiary plans are processed by review and disposition through the integrated change control process (Suneel, 2011).

### **2.4.4 QUALITY ASSURANCE**

Quality assurance (QA) is the application of planned, systematic quality activities to ensure that the project will employ all processes needed to meet requirement.

A quality assurance department or similar organization, often oversees Quality assurance activities. Quality assurance support, regardless of the unit's title, may be provided to the project team, the management of the performing organization, the customer or

sponsor, as well as other stakeholders not actively involved in the work of project. Quality assurance also provides an umbrella for another important quality activity, continuous process improvement. Continuous process improvement provides an iterative means for improving the quality of all processes (Mei, 2009).

Continuous process improvement reduces waste and non-value-added activities, which allows processes to operate at increased levels of efficiency and effectiveness. Process improvement is distinguished by its identification and review of organization as well, from micro processes, such as the coding of modules within a software program, to macro-processes such as the opening of new markets (Kaplan, 2010).

Fig 2.3 illustrates the quality assurance inputs, tools and techniques, and outputs.

INPUTS	TOOLS AND TECHNIQUES	OUTPUTS
<ol style="list-style-type: none"> <li>1. Quality management plan</li> <li>2. Quality metrics</li> <li>3. Process improvement plan.</li> <li>4. Work performance information</li> <li>5. approved change requests</li> <li>6. quality control measurements</li> <li>7. implemented change requests</li> <li>8. Implemented corrective action.</li> <li>9. Implemented defect repair</li> <li>10. Implemented preventive action.</li> </ol>	<ol style="list-style-type: none"> <li>1. Quality planning tools and techniques.</li> <li>2. Quality and audits</li> <li>3. Process analyses</li> <li>4. Quality control tools and techniques.</li> </ol>	<ol style="list-style-type: none"> <li>1. Requested changes</li> <li>2. Recommended corrective actions</li> <li>3. Organizational process (updates)</li> <li>4. Project management plan (updates)</li> </ol>

Figure 2.3 Quality Assurance: Inputs, tools and techniques and outputs.

Source: (PMBOK, 2005)

## **2.4.4 (A) QUALITY ASSURANCE: INPUTS**

### **1. QUALITY MANAGEMENT PLAN:**

The quality management plan describes how quality assurance will be performed within the project. It provides input to the overall project management plan and must address quality control (QC), quality assurance (QA), and continuous process improvement for the project.

### **2. QUALITY METRICS**

A metric is an operational definition that describes, in very specific terms, what something is and how the quality control process measures it. A measurement is an actual value. For example, it is not enough to say that meeting the planned schedule dates is a measure of management quality. The project management team must also indicate whether every activity must start on time or only finish on time and whether individual activities will be measured or only certain deliverables and if so which ones. Quality metrics are used in the quality assurance and quality control processes (Lowry, 2012).

### **3. PROCESS IMPROVEMENT PLAN.**

The process improvement plan details the steps for analyzing processes that will facilitate the identification of waste and non-value added activity, thus increasing customer value.

### **4. WORK PERFORMANCE INFORMATION**

Work performance information, including technical performance measures, project deliverables status, required corrective actions and performance reports are important inputs to quality assurance and can be used in areas such as audits, quality reviews, and process analysis (Frankel, 2010).

### **5. APPROVED CHANGE REQUESTS**

Approved change requests can include modifications to work methods, product requirements, quality requirements, scope and schedule. Approved changes need to be analyzed for any effects upon the quality management plan, quality metrics or quality checklists. Approved changes are important inputs to quality assurance and can be used in areas such as audits, quality reviews, and process analysis. All changes should be formally documented in writing and verbally discussed, but undocumented changes should not be processed or implemented (Alexander, 2009).

## **6. QUALITY CONTROL MEASUREMENTS:-**

Quality control measurements are the results of quality control activities that are fed back to the quality assurance process for use in re-evaluating and analyzing the quality standards and processes of the performing organization.

## **7. IMPLEMENTED CHANGE REQUESTS**

The implemented change requests are the approved change requests that have been implemented by the project management team during project execution.

## **8. IMPLEMENTED CORRECTIVE ACTIONS.**

The implemented corrective actions are the approved corrective actions that have been implemented by the project management team to bring expected future project performance into conformance with the project management plan.

## **9. IMPLEMENTED DEFECT REPAIR**

During project execution, the project management team has implemented approved product defect corrections.

## **10. IMPLEMENTED PREVENTIVE ACTIONS**

The implemented preventive actions are the approved preventive actions that have been implemented by the project management team to reduce the consequences of project risks (Daniel, 2002).

### **2.4.4 (B) QUALITY ASSURANCE: TOOLS & TECHNIQUES**

#### **1. QUALITY PLANNING TOOLS AND TECHNIQUES**

All the quality planning tools already disused such as cost-benefit analysis, benchmarking, design of experiments, cost of quality, brainstorming etc can also be used for Quality Assurance activities.

#### **2. QUALITY AUDITS**

A quality audit is a structured dependent review to determine whether project activities comply with organizational and project policies, processes, and procedures. The objective of a quality audit is to identify inefficient and ineffective policies, processes, and procedures in use on the project. The subsequent effort to correct these deficiencies should result in a reduced cost of quality and an increase in the percentage of acceptance of the product or service by

the customer or sponsor within the performing organization. Quality audits may be scheduled or at random, and may be carried out by properly trained in-house auditors or by third parties, external to the performing organization.

Quality audits confirm the implementation of approved change requests, corrective actions, defect repairs, and preventive actions (Wren, 2004).

### **3. PROCESS ANALYSIS**

Process analysis follows the step outlined in the process improvement plan to identify needed improvements from an organizational and technical standpoint. This analysis also examines problems experienced, constraints experienced, and non-value-added activities identified during process operation. Process analysis includes root cause analysis, a specific techniques to analyze a problem or situation, determine the underlying causes that led to it, and create preventive actions for similar problems.

### **4. QUALITY CONTROL TOOLS AND TECHNIQUES**

The quality control tools and techniques which are also used for Quality Assurance include cause and effect diagram, control charts,

flowcharting, histogram, pareto chart, run chart, scatter diagram, statistical sampling, inspection and defect repair review.

#### **2.4.4 (C) QUALITY ASSURANCE: OUTPUTS**

##### **1. REQUESTED CHANGES**

Quality improvement includes taking action to increase the effectiveness and efficiency of the policies, processes, and procedures of the performing organization, that should provide added benefits to the stakeholders of all projects. Changes requested to expand or reduce project scope, to modify policies or procedures, to modify project cost or budget or to revise to project schedule are often identified while project work is being performed. Requests for a change can be direct or indirect, externally or internally initiated, and can be optionally legally/contractually mandated (Metcalf, 2007).

##### **2. RECOMMENDED CORRECTIVE ACTIONS**

Quality improvement includes recommending actions to increase the effectiveness and efficiency of the performing organizations. Corrective action is an action that is recommended

immediately as a result of Quality assurance activities, such as audits and process analysis.

### **3. ORGANIZATIONAL PROCESS ASSETS (UPDATES)**

Updated quality standards provide validation of the effectiveness and efficiency of the performing organizations quality standards and processes to meet requirements. These quality standards are used during the perform quality control process.

### **4. PROJECT MANAGEMENT PLAN (UPDATES)**

The project management plan will be updated from changes to the quality management plan that result from changes to the perform Quality Assurance process. These updates can include incorporation of processes that have been through continuous process improvement and are ready to repeat the cycle and improvements to processes that have been identified and measured and are ready to be implemented.

## **2. 4.5 QUALITY CONTROL**

Performing quality control (QC) involves monitoring specific project and result to determine whether they comply with relevant

quality standards and identifying ways to dominate causes of unsatisfactory results. It should be performed throughout the project. Quality standards include project processes and product goals. Project results include deliverables and project management results, such as cost and schedule performance. Quality control is often performed by a quality control department or similarly titled organizational unit. Quality control can include taking action to eliminate causes of unsatisfactory project performance. Figure 2.4 illustrates quality control inputs, tools, techniques and outputs.

The project management team should have a working knowledge of statistical quality control, especially sampling and probability, to help evaluate quality control outputs. Among other subjects, the team may find it useful to know the difference between the following pairs of terms.

- Prevention (keeping errors out of the process) and inspection (keeping errors out of the hands of the customer).
- Attribute sampling (the result conforms or it does not) and variables sampling (the result is rated on a continuous scale that measures the degree of conformity).

- Special causes (unusual events) and common causes (normal process variation) common causes are also called random causes.
- Tolerances (the result is acceptable if it falls within the range specified by the tolerance) and control limits (the process is in control if the results fall within the control limits (Urwick, 2008).

INPUTS	TOOLS AND TECHNIQUES	OUTPUTS
<ol style="list-style-type: none"> <li>1. Quality management plan.</li> <li>2. Quality metrics</li> <li>3. Quality checklist</li> <li>4. Organizational process assets.</li> <li>5. Work performance information.</li> <li>6. Approved change requests.</li> <li>7. Deliverables.</li> </ol>	<ol style="list-style-type: none"> <li>1. Cause and effect diagram.</li> <li>2. Control charts</li> <li>3. Flowcharting</li> <li>4. Histogram</li> <li>5. Pareto chart</li> <li>6. Run chart</li> <li>7. Scatter diagram</li> <li>8. Statistical sampling</li> <li>9. Inspection</li> <li>10. Defect repair review</li> </ol>	<ol style="list-style-type: none"> <li>1. Quality control measurements.</li> <li>2. Validated defect repair</li> <li>3. Quality baseline (updates)</li> <li>4. Recommended corrective actions</li> <li>5. Recommended preventive actions</li> <li>6. Requested changes</li> <li>7. Recommended defect repair</li> <li>8. Organization process assets (updates)</li> <li>9. Validated deliverables</li> <li>10. Project management plan (updates).</li> </ol>

Figure 2.4: Quality control: inputs, tools and techniques and outputs.  
Source: (PMBOK, 2005).

## 2.4.5 (A) QUALITY CONTROL: INPUTS

### 1. QUALITY MANAGEMENT PLAN

As described earlier, the quality management plan describes how the project management team will implement the performing organizations quality policy.

The quality management plan provides input to the overall project management plan and must address quality control (QC),

quality assurance (QA), and continuous process improvement for the project (Brown, 2004).

## **2. QUALITY METRICS**

A metric is an operational definition that describes, in very specific terms what something is and how the quality control process measures it. Quality metrics are used in the Quality Assurance and Quality Control processes.

## **3. QUALITY CHECKLIST**

A checklist is a structured tool, usually component specific, used to verify that a set of required steps has been performed. Many organizations have standardized checklist available to ensure consistency in frequently performed tasks. Quality checklists are used in the quality control process (Brown, 2004).

## **4. ORGANIZATIONAL PROCESS ASSETS**

Any and all of the assets that are used to influence the projects success can be drawn from organizational process assets. Organizational process assets also represent the organization's learning and knowledge from previous projects; for example, completed schedules, risk data, and earned value data.

The organization's process assets could be grouped into two categories.

(a) Organization's processes and procedures for conducting work which among others include organizational standard processes, such as standards, policies (e.g. safety and health policy and project management policy), standard product and project life cycles and quality policies and procedures (e.g. process audits, improvement targets, checklists, and standardized process definitions for use in the organization.

(b) Organizational corporate knowledge base for storing and retrieving information which among others include project files (e.g. scope, cost, schedule and quality baselines, performance measurement baselines, project calendars, project schedule network diagrams, risk register, planned response actions and defined risk impact (Suneel, 2011).

## **5. WORK PERFORMANCE INFORMATION**

Work performance information including technical performance measures, project deliverables completion status, and the implementation of required corrective actions, are important inputs to quality control. Information from the project management plan about the planned or expected results should be available along with information about the actual results and implemented change requests.

## 6. APPROVED CHANGE REQUESTS

Approved change requests can include modifications such as revised work methods and revised schedule. The timely correct implementation of approved changes needs to be verified

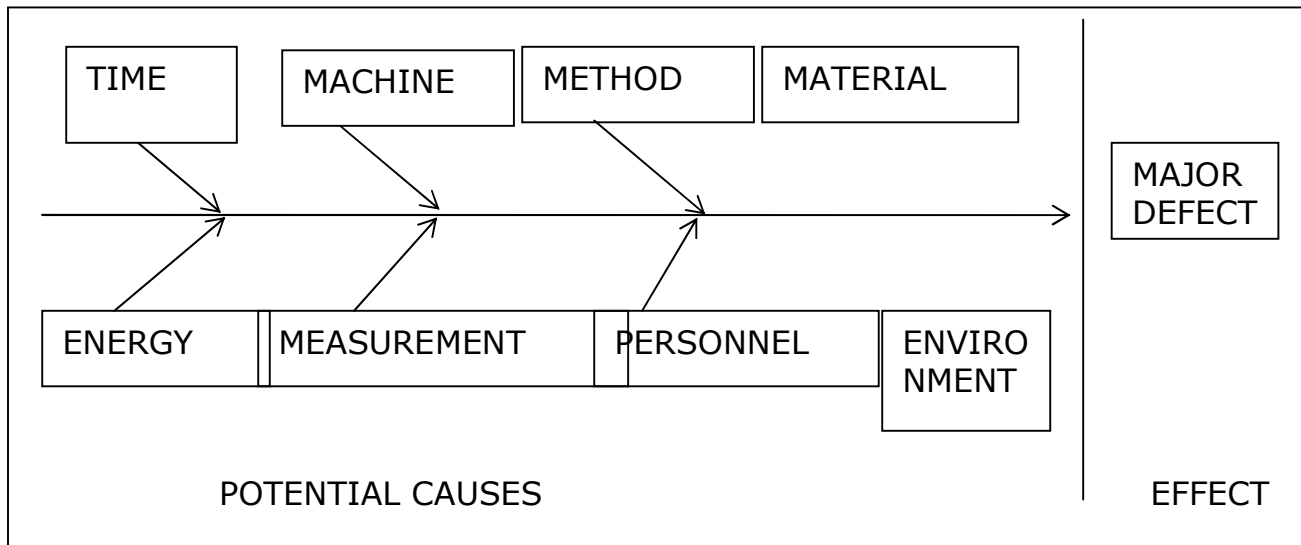
## 7. DELIVERABLES

A deliverable is any unique and verifiable product, result or capability to perform a service that is identified in the project management planning documentation and must be produced and provided to complete the project, (Suneel, 2011).

### 2.4.5 (B) QUALITY CONTROL: TOOLS & TECHNIQUES

#### 1. CAUSE AND EFFECT DIAGRAM

Cause and effect diagrams, illustrate how various factors might be linked to potential problems or effects. This is illustrated in figure 2.5 below.



**Figure 2.5 Cause and effect diagram**

Source: (Fyodor, 2009)

## **2. CONTROL CHARTS:**

The purpose of a control chart is to determine whether or not a process is stable or has predictable performance. Control charts may serve as a data gathering tool to show when a process is subject to special cause variation, which creates an out of control condition. Control charts also illustrate how a process behaves over time. They are a graphic display of the interaction of process variables on a process to answer the question, are the process variables within acceptable limits? By monitoring the output of a process over time, a control chart can be employed to assess whether the application of process changes resulted in the desired improvements.

Control charts can be used for both project and product life cycle processes. An example of project use of control chart is determining whether cost variances or schedule variances are outside of acceptable limits. An example of product use of control charts is evaluating whether the number of defects found during testing are acceptable or unacceptable in relation to the organization's standards for quality (Fyodor, 2009).

### 3. FLOWCHARTING

A flowchart is a graphical representation of a process. Flowcharting helps to analyze how problems occur. There are many styles but all process flowcharts show activities decision points, and the order of processing. Flowcharts show how various elements of a system interrelate. Flowcharting can help the project team anticipate what and where quality problems might occur and this can help develop approaches for dealing with them. Figure 2.6 is an example of a process flowchart for design reviews.

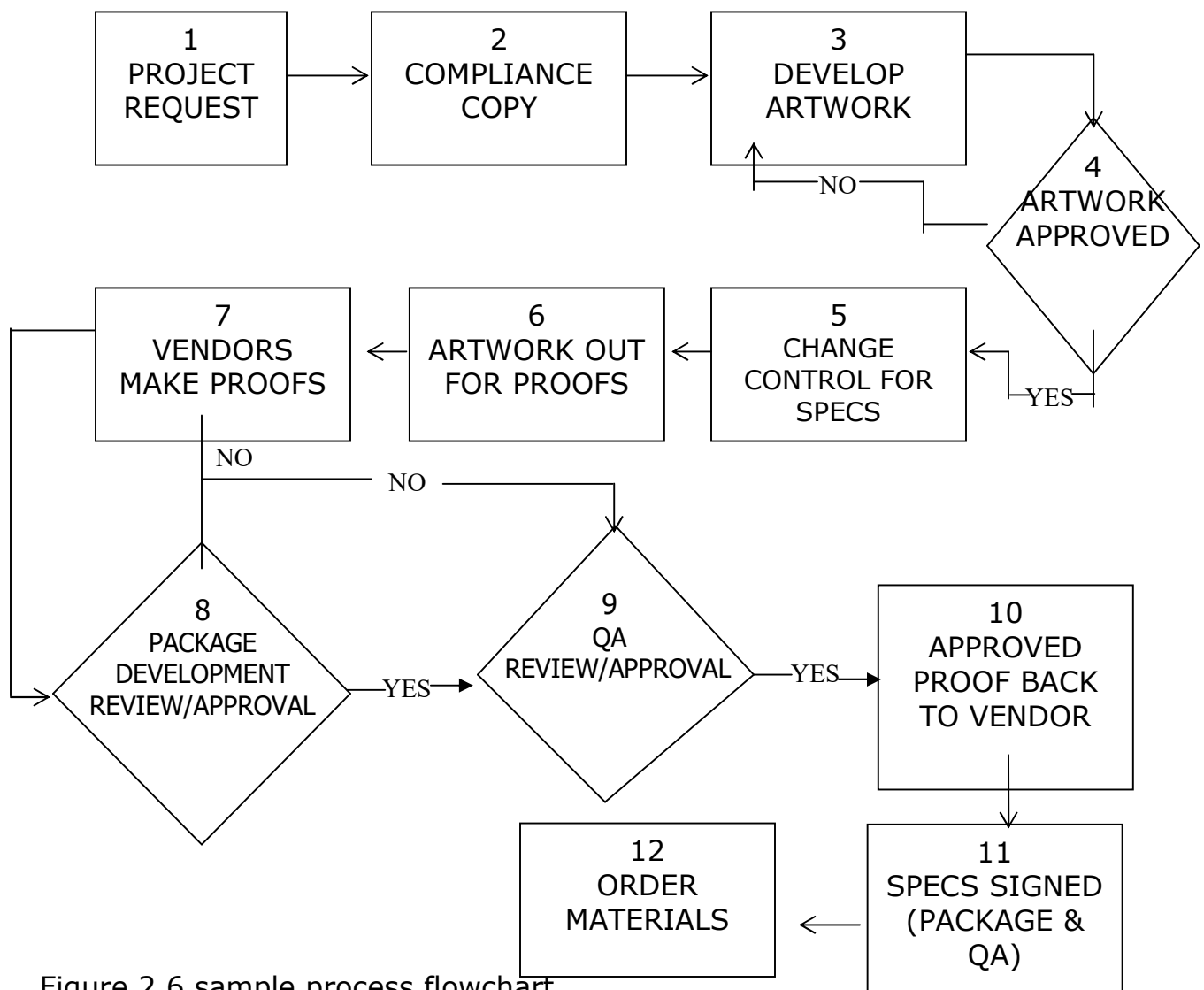


Figure 2.6 sample process flowchart

Source: (Fyodor, 2009)

#### **4. HISTOGRAM**

A histogram is a bar chart showing a distribution of variables. Each column represents an attribute or characteristic of a problem or situation. The height of each column represents the relative frequency of the characteristic. This tool helps identify the cause of problems in a process by the shape and width of the distribution

#### **5. PARETO CHART**

A pareto chart is a specific type of histogram, ordered by frequency of occurrence, which shows how many defects were generated by type or category of identified cause. The pareto technique is used primarily to identify and evaluate nonconformities.

The project team should take action to fix the problems that are causing the greatest number of defects first.

#### **6. RUN CHART**

A run chart is a line graph that shows data points plotted in the order in which they occur. A run chart shows the history and pattern of variation. Run charts show trends in a process over time, variation over time, or declines or improvement in a process over time. Trend analysis is performed using run charts. Trend analysis involves using

mathematical techniques to forecast future outcomes based on historical results.

## **7. SCATTER DIAGRAM**

A scatter diagram shows the pattern of relationship between two variables. This tool allows the quality team to study and identify the possible relationship between changes observed in two variables. Dependent variables versus independent variables are plotted. The closer the points are to a diagonal line; the more closely they are related.

## **8. STATISTICAL SAMPLING**

Statistical sampling involves choosing part of a population of interest for inspection (for example, selecting ten designs at random from a list of seventy-five). Appropriate sampling can often reduce the cost of quality control. The project management team should be familiar with a variety of sampling techniques.

## **9 INSPECTIONS**

An inspection is the examination of a work product to determine whether it conforms to standards. Generally the results of an inspection include measurements. Inspection can be conducted at any level. For example, the results of a single activity can be

inspected, or the final product of the project can be inspected. Inspections are also called reviews, peer reviews, audits, and walkthrough. Inspections are also used to validate defect repairs.

## **10. DEFECT REPAIR REVIEW**

Defect repair review is an action taken by the quality control department or similarly titled organization to ensure that product defects are repaired and brought into compliance with requirements or specifications (Mei, 2009).

### **2.4.5. (C) QUALITY CONTROL: OUTPUTS**

#### **1. QUALITY CONTROL MEASUREMENT**

Quality control measurements represent the results of quality control activities that are fed back to quality assurance to reevaluate and analyze the quality standards and processes of the performing organization.

#### **2. VALIDATED DEFECT REPAIR**

The repaired items are re-inspected and will be either accepted or rejected before notification of the decision is provided. Rejected items may require further defect repair.

### **3. QUALITY BASELINE (UPDATES)**

The quality baseline records the quality objective of the project. The quality baseline is the basis for measuring and reporting quality performance as part of the performance measurement baseline.

### **4. RECOMMENDED CORRECTIVE ACTIONS**

Corrective actions involve actions taken as a result of a quality control measurement that indicates that the manufacturing or development process exceeds established parameters.

### **5. RECOMMENDED PREVENTIVE ACTIONS**

Preventive action involves action taken to forestall a condition that may exceed established parameters in a manufacturing or development process, which may have been indicated through a quality control measurement.

### **6. REQUESTED CHANGES:**

Requested changes are changes requested in order to expand or reduce project scope, to modify policies or procedures, to modify project cost or budget or to revise the project schedule. These are

often identified while the project work is being performed. If the recommended corrective or preventive actions require a change to the project, a change request should be initiated in accordance with the defined integrated change control process.

## **7. RECOMMENDED DEFECT REPAIR**

A defect is where a component does not meet its requirements or specifications, and needs to be repaired or replaced. Defects are identified and recommended for repair by the quality control department or similarly titled organization. The project team should make every reasonable effort to minimize the errors that cause the need for defect repair.

## **8. ORGANIZATION PROCESS ASSETS (UPDATES)**

In the development of a project charter and subsequently project documentation, any and all the assets that are used can be drawn from organizational process assets. Organizational process assets also represent the organization's learning and knowledge from previous projects, for example completed schedules, risk data and earned value data.

When checklists are used, the completed checklists should become part of the project's records. The causes of variances, the reasoning behind the corrective action chosen, and other types of lessons learned from quality control should be documented so that they become part of the historical database for both this project and the performing organization.

## **9. VALIDATED DELIVERABLES**

The goal of quality control is to determine the correctness of deliverables. The results of the execution of quality control processes are validated deliverables.

## **10. PROJECT MANAGEMENT PLAN (UPDATES)**

This involves updating the project management plan to reflect changes to the quality management plan that results from changes in performing the quality control process. Requested changes (additions, modifications or deletions) to the project management plan and its subsidiary plans are processed by review and disposition through the integrated change control process, (Lowry, 2012).

## **CHAPTER THREE**

### **RESEARCH DESIGN AND METHODOLOGY**

#### **3.1 INTRODUCTION**

This chapter will x-ray the research procedure. It shows the research design, population of the study, sampling design and procedure as well as the method of determination of the sample size, instrumentation validity and reliability of instrument. The chapter will also describe the methods of data collection and procedure for data analysis.

#### **3.2 RESEARCH DESIGN**

The study adopted the survey methods of research namely: personal interviews, questionnaires and observations.

#### **3.3 POPULATION OF THE STUDY**

The population of this study includes the management and staff of Zerock, Rhas, and New Idea Construction companies in Owerri. According to the human capital department of the construction firms, there are about 200 workers in Zerock, 225 in Rhas and 140 in New

Idea. Thus the population of this study is 565 (five hundred and sixty five).

### **3.4 SAMPLING DESIGN AND PROCEDURE**

The non-probability sampling method was used for this research. Anyanwu (2002) defined this non-random process as a process by which the respondents are selected based on their understanding of the universe, its components and the nature of the research objectives.

Indeed about 200 members of Staff of the Zerock, 225 of Rhas and 140 of New Idea Construction companies in Owerri constituted the population of this study, the population to be sampled.

#### **3.4.1 SAMPLE SIZE DETERMINATION**

The sample size for the research was determined by using the Yaro Yame's formula as quoted by Alugbuo (2002). See appendix II. Sample size for Zerock Construction Company was 133 that of Rhas was 144 while that of New Idea Construction Company was 104.

### **3.5 DATA COLLECTION INSTRUMENT AND METHOD OF ADMINISTRATION**

The questionnaire and interview instruments were used to reach the respondents for this research work. The questionnaire consisted of both open ended and close ended questions. It was also sectionalized to reflect various classes of respondents. The questionnaires were distributed to the staff of the various companies with assistance from some of the staff of the construction companies.

#### **3.5.1 VALIDITY OF INSTRUMENT**

The instrument was pre-tested with some project workers in the study organizations. The pilot study was done to find out if the instrument measured what it was supposed to measure. Nworuh (2001:211) is of the view that “validity is concerned with the answer to this question: does this instrument measure what it is supposed to measure?”

#### **3.5.2 RELIABILITY OF INSTRUMENT**

The reliability of the instrument was determined by conducting a test-retest exercise with the instrument. In each case, the Spearman Product Moment Correlation Coefficient  $r$  was computed. The value

of  $r_1$  was 0.8 and  $r_2$  was 0.7. The average value for  $r$  was 0.75 which meant 75% reliability.

### **3.6 METHODS OF DATA COLLECTION AND ANALYSIS/PROCEDURES FOR PROCESSING COLLECTED DATA.**

Primary and secondary data sources were used.

#### **3.6.1 PRIMARY SOURCES:**

The primary sources of data collection included the questionnaire, oral interviews and observations. A hundred and thirty-three questionnaires were taken to Zerock respondents, one hundred and forty-four to Rhas respondents and one hundred and four to New Idea respondents. The questionnaire was structured to reflect two major sections A and B. While Section A handled the personal data, section B handled the core items meant to represent research questions.

#### **3.6.2 SECONDARY SOURCES**

The secondary sources included texts, journals, newspapers, published statistics and internet.

### **3.6.3 PROCEDURE FOR DATA ANALYSIS**

Data collected were presented in tables, analyzed using percentages and hypothesis stated earlier tested using Analysis of Variance (ANOVA).

## CHAPTER FOUR

### PRESENTATION AND ANALYSIS OF DATA

#### 4.1 INTRODUCTION

This chapter discusses the secondary data and data from questionnaire administration (primary data) which were presented in tables and analyzed in percentages. The results were interpreted and hypotheses stated earlier tested.

#### 4.2 CRITERION GROUP RETURNS AND ANALYSIS

The construction companies used for the study were Rhas Construction Company, New Idea Construction Company, and Zerock Construction Company. The questionnaire distribution and collection is presented in Table 4.1 below.

Table 4.1: Questionnaire distribution and collection.

Companies	No Distributed	No Returned	No. not returned	% of no returned	% of no. not returned
RHAS	144	120	24	$\frac{320}{381} \times \frac{100}{1}$	$\frac{61}{381} \times \frac{100}{1}$
NEW IDEA	104	100	4		
ZEROCK	133	100	33		
Total	381	320	61	84%	16%

Out of the 381 questionnaires distributed to three construction companies in Owerri, Imo State, a total of 320 respondents returned theirs giving a return rate of 84%. The questionnaires revealed that 31.5% of respondents belonged to the Rhas Limited, 26.2% to New Idea and 26.2% also to Zerock.

### 4.3 DATA PRESENTATION AND ANALYSIS

#### 4.3.1 SECONDARY DATA

Some data based on published statistics from Imo State Ministry of Works and related literatures are presented in Table 4.2.

**Table 4.2 – Report of quality assurance on road projects in Owerri.**

Year	Road name	Company's name	Quality Status	
			Reliable	Not reliable
2003	Sylvester Nkwocha road by Tripple M junction, Works Layout, Owerri.	Rhas		√
2004	Naze-Nekede-Ihiagwa road	Hardel & Enic Group of company		√
2005	Old Nekede road through West End	New Idea Construction company		√
2006	Major roads in Owerri Municipal	MCC	√	
2007	Naze-Nekede-Ihiagwa-Obinze road	Melbourne		√

2008	St. John's Lab - Relief Market - Egbu Road	Zerock		√
2009	Transfiguration road (from IMSU junction to MCC road junction)	ZEROCK		√
2010	Owerri – Ontisha Road	Julius Berger	√	

Source: Ministry of Works (Owerri, 2012).

From Table 4.2, it is evident that Sylvester Nkwocha road constructed by Rhas did not last up to three months after construction, as potholes developed all over. Hence the quality of the road was not reliable. This road has been re-awarded to Emeri Chuks Construction Company. The Naze-Nekede Ihiagwa road, constructed by Hardel and Enic group of company was not completed due to the use of poor quality human and material resources. This road was therefore reawarded to another company. For similar reasons, the old Nekede road through West End constructed by New Idea Construction Company did not last. Quality assurance strategies were not implemented during the construction of Naze-Nekede-Ihiagwa-Obinze road by Melbourne, thus yielding poor results. The St. John's Laboratory-Relief market-Egbu road and the Transfiguration road both constructed by Zerock did not survive the

first rainy season after construction. The former was reawarded to Vinpat group and the later to Manity resources.

In contrast, major roads in Owerri Municipal by MCC and Owerri-Onitsha road by Julius Berger had stood the taste of time after many years of construction. From the interview with Ministry of Works, Owerri, these roads are durable because quality assurance strategies were used in the project execution.

There is increasing empirical evidence to suggest that road project execution in Owerri could be more effective when quality assurance strategies are used. The report prepared by the State Ministry of Works shows that some roads were poorly constructed though completed and some were not completed. Based on the data and statistics collected from Imo State Ministry of Works, related literatures and on the spot assessment, it could be affirmed that the effectiveness of road construction projects depend on quality assurance strategies.

#### **4.3.2 PRIMARY DATA**

The results of section B of the questionnaires administered to respondents are presented below.

## SECTION B OF THE QUESTIONNAIRE: STAFF

### ITEM 1A

Effectiveness of quality assurance provides umbrella for continuous process improvement in construction industries.

Table 4.3: Provision of umbrella for continuous process improvement.

Options	RHAS		NEW IDEA		ZEROCK	
	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	30	25	25	25	38	38
SA	20	16.7	25	25	22	22
D	60	50	35	35	30	30
SD	10	8.3	15	15	10	10
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

**RHAS:** According to Table 4.3 above, 25% of the respondents agreed that quality assurance provides umbrella for continuous process improvement whereas 16.7% of the respondents strongly agreed that quality assurance provides umbrella for continuous process improvement. 50% of the respondents disagreed that quality assurance provides umbrella for continuous process improvement. Indeed 8.3% of the respondents strongly disagreed with the statement.

## **NEW IDEA**

Twenty five percent of the respondents agreed, that quality assurance provides umbrella for continuous process improvement. 25% of the respondents strongly agreed, 35% of the respondents disagreed while 15% strongly disagreed that quality assurance provides umbrella for continuous process improvement. (Table 4.3)

## **ZEROCK**

Thirty eight percent of the respondents agreed that quality assurance provides umbrella for continuous process improvement. 22% of the respondents strongly agreed, 30% disagreed while 10% of the respondents strongly disagreed that quality assurance provides umbrella for continuous process improvement. (Table 4.3)

## **ITEM 1B**

Quality assurance justifies the funds spent on project execution.

## **RHAS**

According to Table 4.4, 37.5% of the respondents agreed that quality assurance justifies the funds spent on project execution. 8.3% of the respondents strongly agreed, 29.2% of the respondents

disagreed while 25% of the respondents strongly disagreed that quality assurance justifies the funds spent on project execution.

Table 4.4: Justification of funds spent on project execution.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Rep	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	45	37.5	26	26	46	46
Sa	10	8.3	34	34	34	34
D	35	29.2	18	18	10	10
SD	30	25	22	22	10	10
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

### **NEW IDEA**

Twenty six percent of the respondents agreed that quality assurance justifies the funds spent on project execution while 34% of the respondents strongly agreed that quality assurance justifies the funds spent on project execution. 18% disagreed, and 22% of the respondents strongly disagreed that quality assurance justifies the funds spent on project execution.

### **ZEROCK**

Forty six percent of the respondents agreed that quality assurance justifies the funds spent on project execution while 34% of the

respondents strongly agreed that quality assurance justifies the funds spent on project execution, but 10% of respondents disagreed that quality assurance justifies the funds spent on project execution. Indeed, 10% of the respondents strongly disagreed that quality assurance justifies the funds spent on project execution.

#### **ITEM IC**

Quality Assurance is a key to project customer satisfaction.

#### **RHAS**

As shown in Table 4.5, 16.7% of the respondents agreed that quality assurance is a key to project customer satisfaction while 25% of the respondents strongly agreed that quality assurance is a key to project customer satisfaction. However 33.3% of the respondents disagreed that quality assurance is a key to project customer satisfaction and 25% strongly disagreed that quality assurance is a key to project customer satisfaction.

Table 4.5: Quality assurance as a key to project customer satisfaction.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Rep.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	20	16.7%	20	20	18	18
Sa	30	25	30	30	22	22
D	40	33.3	30	30	10	10
SD	30	25	20	20	50	50
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

### **NEW IDEA**

Twenty percent of the respondents agreed that quality assurance is a key to project customer satisfaction whereas 30% of the respondents strongly agreed that quality assurance is a key to project customer satisfaction. 20% of the respondents disagreed that quality assurance is a key to project customer satisfaction while 20% of the respondents strongly disagreed that quality assurance is a key to project customer satisfaction.

### **ZEROCK**

According to Table 4.5, at Zerock Construction Company, 18% of the respondents agreed, 22% strongly agreed, 10% disagreed

while 50% strongly disagreed that quality assurance is a key to project customer satisfaction.

## ITEM 1D

It is a tool for applying the planned, systematic quality activities for meeting project requirements.

## RHAS

According to Table 4.6, 36.7% of the respondents agreed that quality assurance is a tool for applying the planned systematic quality activities for meeting project requirements. 9.2% of the respondents strongly agreed, 28.3% disagreed while 25.8% strongly disagreed that quality assurance is a tool for applying the planned, systematic quality activities for meeting project requirements.

Table 4.6: Quality assurance as a tool for applying quality activities.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	44	36.7	17	17	16	16
SA	11	9.2	33	33	24	24
D	34	28.3	27	27	30	30
SD	31	25.8	23	23	30	30
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

## **NEW IDEA**

Seventeen percent of the respondents agreed while 33% of the respondents strongly agreed that quality assurance is a tool for applying the planned, systematic quality activities for meeting project requirements. 27% of the respondents disagreed, while 23% strongly disagreed that quality assurance is a tool for applying the planned, systematic quality activities for meeting project requirements.

## **ZEROCK**

Sixteen percent of the respondents agreed that quality assurance is a tool for applying the planned, systematic quality activities for meeting project requirements. 24% of the respondents strongly agreed, 30% disagreed while 30% also strongly disagreed that quality assurance is a tool for applying the planned, systematic quality activities for meeting project requirements.

## **ITEM 2A**

The level of quality assurance affects the performance of construction project deliverables in construction industries.

## RHAS

Table 4.7 showed that 16.7% of the respondents agreed, 25.8% of the respondents strongly agreed, 31.7% disagreed while 25.8% of the respondents strongly disagreed that project deliverables were performance indices of quality assurance in construction industries.

Table 4.7: Project deliverables as performance indices of quality assurance in construction industries.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	20	16.7	33	33	23	23
SA	31	25.8	12	12	37	37
D	38	31.7	31	31	16	16
SD	31	25.8	24	24	24	24
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

## **NEW IDEA**

Thirty three percent of the respondents agreed that project deliverables were performance indices of quality assurance in construction industries whereas 37% of the respondents strongly agreed, 16% disagreed and 24% strongly disagreed that project deliverables were performance indices of quality assurance in construction industries.

## **ZEROCK**

Twenty three of the respondents agreed that project deliverables were performance indices of quality assurance in construction industries while 37% strongly agreed that project deliverables were performance indices of quality assurance in construction industries. 16% of the respondents disagreed, while 24% of the respondents strongly disagreed that project deliverables were performance indices of quality assurance in construction industries.

## **ITEM 2B**

Quality assurance plan is a performance index of quality assurance.

## **RHAS**

Table 4.8 showed that 20% of the respondents agreed that quality assurance plan was a performance index of quality assurance

whereas 22.5% of the respondents strongly agreed that quality assurance plan was a performance index of quality assurance. However 29.2% disagreed, while 28.3% strongly disagreed that quality assurance plan was a performance index of quality assurance.

Table 4.8: Quality assurance plan is a performance index of quality assurance.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	24	20	32	32	20	20
SA	27	22.5	13	13	40	40
D	35	29.2	30	30	13	13
SD	34	28.3	25	25	27	27
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

## **NEW IDEA**

Thirty two percent of the respondents agreed that quality assurance plan was a performance index of quality assurance while 13% of the respondents strongly agreed that quality assurance plan was a performance index of quality assurance. Thirty percent disagreed while, 25% of the respondents strongly disagreed that quality assurance plan was a performance index of quality assurance. (Table 4.8).

## **ZEROCK**

Twenty percent of the respondents agreed that quality assurance plan was a performance index of quality assurance. 40% of the respondents strongly agreed, 13% disagreed, while 27% of the respondents strongly disagreed that quality assurance plan was a performance index of quality assurance (Table 4.8).

## **ITEM 2C**

Proper use of cause and effect diagrams was a performance index of quality assurance in construction projects.

## **RHAS**

According to Table 4.9, 16.7% of the respondents agreed that proper use of cause and effect diagrams was a performance index of quality assurance in construction projects. 25.8% of the respondents strongly agreed, while 31.7% of the respondents disagreed that proper use of cause and effect diagrams was a performance index of quality assurance in construction projects. Indeed 25.8% of the respondents strongly disagreed that proper use of cause and effect diagrams was a performance index of quality assurance in construction projects.

Table 4.9: Use of cause and effect diagrams.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	20	16.7	33	33	15	15
Sa	31	25.8	14	14	45	45
D	38	31.7	27	27	15	15
SD	31	25.8	26	26	25	25
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

## NEW IDEA

Thirty three of the respondents agreed that proper use of cause and effect diagrams was a performance index of quality assurance in the constructions projects, while 14% of the respondents strongly agreed that proper use of cause and effect diagrams is a performance index of quality assurance in construction projects. However, 29% of the respondents disagreed that proper use of cause and effect diagrams was a performance index of quality assurance, while 26% of the respondents strongly disagreed that proper use of cause and effect diagrams was a performance index of quality assurance in construction projects.

## **ZEROCK**

At Zerock Construction Company, 15% of the respondents agreed, 45% of the respondents strongly agreed, 15% disagreed, while 15% of the respondents also strongly disagreed that proper use of cause and effect diagrams was a performance index of quality assurance in construction projects.

## **ITEM 2D**

Successful inspection of results was a performance index of quality assurance.

## **RHAS**

Table 4.10 revealed that 19.2% of the respondents agreed that successful inspection of results was a performance index of quality assurance in the construction industries, whereas 23.3% of the respondents strongly agreed that successful inspection of results was a performance index of quality assurance. Twenty five percent of the respondents disagreed while 32.5% of the respondents strongly disagreed that successful inspection of results was a performance index of quality assurance in the companies.

Table 4.10: Successful result inspection as a performance index of quality assurance.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	23	19.2	20	20	14	14
SA	28	23.3	25	25	40	40
D	30	25.0	25	25	19	19
SD	39	32.5	30	30	27	27
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

### **NEW IDEA**

Twenty percent of the respondent agreed that successful inspection of results was a performance index of quality assurance in the road construction projects, while 25% of the respondents strongly agreed. Another 25% disagreed, while 30% of the respondents strongly disagreed that successful inspection of results was a performance index of quality assurance in the projects.

### **ZEROCK**

Fourteen percent of the respondents agreed while 40% of them strongly agreed that successful inspection of results was a performance index of quality assurance in the projects. Nineteen percent of the respondents disagreed, while 27% of the respondents

strongly disagreed that successful inspection of results was a performance index of quality assurance in the construction projects.

### ITEM 3A

Quality audits confirm the implementation of approved change requests.

### RHAS

Table 4.11 shows that 28.3% of the respondents agreed while 36.7% strongly agreed that quality audits confirm the implementation of approved change requests. On the other hand, 25.8% disagreed while 9.2% strongly disagreed that quality audits confirm the implementation of approved change requests in the projects.

Table 4.11: Quality audits and approved change requests.

Options	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	34	28.3	33	33	24	24
Sa	44	36.7	27	27	16	16
D	31	25.8	17	17	29	29
SD	11	9.2	23	23	31	31
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

## **NEW IDEA**

Thirty three percent of the respondents agreed that quality audits confirmed the implementation of approved change requests in the projects while 27% of the respondents strongly agreed, 17% of the respondents disagreed and 23% of the respondents strongly disagreed. (Table 4.11).

## **ZEROCK**

At Zerock, 24% of the respondents agreed while 16% of the respondents strongly agreed that quality audits confirm the implementation of approved change requests. Twenty nine percent of the respondents disagreed, whereas 31% of the respondents strongly disagreed that quality audits confirm the implementation of approved change requests in the projects (Table 4.11).

## **ITEM 3B.**

The implementation of preventive action depended on quality audits.

## **RHAS**

According to Table 4.12, 32.5% of the respondents agreed that the implementation of preventive action depended on quality audits.

Twenty five percent of the respondents strongly agreed. However, 17.5% and 25% disagreed and strongly disagreed respectively that the implementation of preventive action depended on quality audits of the projects.

Table 4.12: Quality audits as a determinant of implementation of preventive action.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	39	32.5	31	31	16	16
Sa	30	25	12	12	24	24
D	21	17.5	24	24	37	37
SD	30	25	33	33`	23	23
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

## **NEW IDEA**

Thirty one percent of the respondents agreed that the implementation of preventive action depended on quality audits while 12% of the respondents strongly agreed. However, 24% and 33% disagreed and strongly disagreed respectively that the implementation of preventive action depended on quality audits of the construction projects.

## **ZEROCK**

Sixteen percent of the respondents agreed that the implementation of preventive action depended on quality audits while 24% strongly agreed to that. 37% of the respondents disagreed while 23% strongly disagreed that the implementation of preventive action depended on quality audits.

## **ITEM 3C**

Quality audits relate strongly to implementation of corrective action.

## **RHAS**

Table 4.13 shows that 18.3% of the respondents agreed while 24.2% of the respondents strongly agreed that quality audits relate strongly to implementation of corrective action. However, 25.8% of the respondents disagreed while 31.7% of the respondents strongly disagreed with the statement.

Table 4.13: Quality audits and corrective action.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	22	18.3	25	25	15	15
SA	29	24.2	20	20	40	40
D	31	25.8	24	24	18	18
SD	38	31.7	31	31	27	27
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

### **NEW IDEA**

Twenty five percent of the respondents agreed that quality audits relate strongly to implementation of corrective action, whereas 20% of the respondents strongly agreed to that. However, 24% of the respondents disagreed while 31% of the respondents strongly disagreed that quality audits relate strongly to implementation of corrective action.

### **ZEROCK**

Fifteen percent of the respondents agreed that quality audits relate strongly to implementation of corrective action. Forty percent of the respondents strongly agreed that quality audits relate strongly to implementation of corrective action while 18% and 27% of the

respondents disagreed and strongly disagreed respectively that quality audits relate strongly to implementation of corrective action.

### ITEM 3D

Implemented defect repair go with quality audits.

### RHAS

Twenty five percent and 20.8% agreed and strongly agreed respectively that implemented defect repairs go with quality audits, while 30.8% of the respondents disagreed and 23.4% of the respondents strongly disagreed with the statement (Table 4.14).

Table 4.14: Quality audits as a complement of implemented defect repair.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	30	25	21	21	26	26
Sa	25	20.8	39	39	34	34
D	37	30.8	18	18	30	30
SD	28	23.4	22	22	10	10
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

## **NEW IDEA**

Twenty one percent of the respondents agreed and 39% of the respondents strongly agreed that implemented defect repair go with quality audits. However, 18% and 22% of the respondents agreed and strongly disagreed respectively that implemented defect repair go with quality audits. (Table 4.14).

## **ZEROCK**

Twenty six percent of the respondents agreed while 34% of the respondents strongly agreed that implemented defect repair go with quality audits. However, 30% of the respondents disagreed and 10% of the respondents strongly disagreed with the statement.

## **ITEM 3E.**

Quality control measurements go with quality audits.

## **RHAS**

According to Table 4.15, 17.5% of the respondents agreed that quality control measurements go with quality audits whereas 25% of the respondents strongly agreed to that. 24.2% of the respondents disagreed that quality control measurements go with quality audits.

Indeed, 33.3% of the respondents strongly disagreed that quality control measurements go with quality audit.

Table 4.15: Quality control and quality audits.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	21	17.5	18	18	20	20
Sa	30	25.0	27	27	34	34
D	29	24.2	25	25	19	19
SD	40	33.3	30	30	27	27
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

### **NEW IDEA**

Eighteen percent of the respondents agreed, while 27% of the respondents strongly agreed that quality control measurements go with quality audit. Indeed 25% of the respondents disagreed while 30% of the respondents strongly disagreed that quality control measurements go with quality audits (Table 4.15).

### **ZEROCK**

At Zerock, 20% of the respondents agreed that quality control measurements go with quality audits whereas 34% of the

respondents strongly agreed that quality control measurements go with quality audits. Nineteen percent and 27% of the respondents disagreed and strongly disagreed respectively that quality control measurements go with quality audits.

#### **ITEM 4A**

Project managers use quality audits

#### **RHAS**

According to Table 4.16, 23.4% and 18.3% of the respondents agreed and strongly agreed respectively that project managers use quality audits. On the contrary, 33.3% and 25% of the respondents disagreed and strongly disagreed that project managers use quality audits.

Table 4.16: Quality audits as quality assurance technique.

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	28	23.4	27	27	34	34
Sa	22	18.3	18	18	20	20
D	40	33.3	30	30	19	19
SD	30	25.0	25	25	27	27
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

## **NEW IDEA**

Twenty seven percent of the respondents agreed that project managers use quality audits whereas 18% of the respondents strongly agreed that project managers use quality audits. On the other hand, 30% and 25% of the respondents disagreed and strongly disagreed respectively that project managers use quality audits. (Table 4.16).

## **ZEROCK**

Thirty four percent of the respondents agreed that project managers use quality audits while 20% of the respondents strongly agreed that project managers use quality audits. Nineteen percent of the respondents however disagreed that project managers use quality audits. Indeed, 27% of the respondents strongly disagreed that project managers use quality audits (Table 4.16).

## ITEM 4B

Project managers apply process analysis

### RHAS

According to Table 4.17, 32.5% and 25.8% of the respondents agreed and strongly agreed respectively that project managers apply process analysis. On the other hand, 16% percent and 25% of the respondents disagreed and strongly disagreed respectively that project managers apply process analysis.

Table 4.17: Process analysis as a quality assurance technique

Options	RHAS		NEW IDEA		ZEROCK	
	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. Of Resp.	% of Resp.
A	39	32.5	12	12	37	37
Sa	31	25.8	31	31	23	23
D	20	16.7	24	24	24	24
SD	30	25.0	33	33	16	16
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

### NEW IDEA

Twelve percent of the respondents agreed that project managers apply process analysis whereas 31% of the respondents strongly agreed that project managers apply process analysis. Twenty four percent and 33% of the respondents disagreed and

strongly disagreed respectively that project managers apply process analysis (Table 4.17).

## **ZEROCK**

Thirty seven percent and 23% of the respondents agreed and strongly agreed respectively that project managers apply process analysis while 24% of the respondents disagreed with the statement. Indeed, 16% of the respondents strongly disagreed that project managers apply process analysis. (Table 4.17).

## **ITEM 4C**

Project managers use cause and effect diagrams

## **RHAS**

According to table 4.18, 15.8% and 25% of the respondents agreed and strongly agreed respectively that project managers use cause and effect diagrams. However, 32.5% and 26.7% disagreed and strongly disagreed respectively that project managers use cause and effect diagrams.

Table 4.18: Use of cause and effect diagrams

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	19	15.8	30	30	15	15
Sa	30	25.0	17	17	44	44
D	39	32.5	27	27	16	16
SD	32	26.7	26	26	25	25
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

### **NEW IDEA**

Thirty percent of the respondents agreed that project managers use cause and effect diagrams while 17% of the respondents strongly agreed with the statement. Twenty seven percent of the respondents disagreed that project managers use cause and effect diagrams while 26% of the respondents strongly disagreed with the statement.

### **ZEROCK**

Fifteen percent of the respondents agreed that project managers use cause and effect diagrams whereas 44% of the respondents strongly agreed with the statement. On the contrary, 16% and 25% of the respondents disagreed and strongly disagreed respectively that project managers use cause and effect diagrams (Table 4.18).

#### **ITEM 4D- Project managers use control charts.**

##### **RHAS**

According to Table 4.19, 29.2% of the respondents agreed that project managers use control charts. 16.7% of the respondents strongly agreed while 28.3% disagreed that project managers use control charts. Indeed 25.8% of the respondents strongly disagreed that project managers use control charts.

Table 4.19: Use of control charts

	<b>RHAS</b>		<b>NEW IDEA</b>		<b>ZEROCK</b>	
Options	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.	No. of Resp.	% of Resp.
A	35	29.2	33	33	24	24
Sa	20	16.7	17	17	16	16
D	34	28.3	27	27	29	29
SD	31	25.8	23	23	31	31
<b>Total</b>	<b>120</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

##### **NEW IDEA**

Thirty three percent of the respondents agreed that project managers use control charts while 17% of the respondents strongly agreed with the statement. However 27% and 23% of the

respondents disagreed and strongly disagreed respectively that project managers use control charts. (Table 4.19).

## **ZEROCK**

At Zerock, 24% and 16% of the respondents agreed and strongly agreed respectively that project managers use control charts. On the contrary, 29% of the respondents disagreed that project managers use control charts while 31% of the respondents strongly disagreed with the statement (Table 4 19).

## **4.4 HYPOTHESES TESTING**

### **HYPOTHESIS ONE**

**H<sub>o1</sub>:** There is no significant difference in the mean effectiveness of Quality Assurance in the success of project in the construction industries.

### ANOVA TABLE

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM DF	MEAN SQUARE MS	F-RATIO COMPUTED	AT 5% (0.05)
Between Rows	SSR = 1463	r-1 = 3-1 = 2	MSr = $\frac{1463}{2}$ = 731.5	$\frac{MSR}{MSE}$ = $\frac{731.5}{565}$ = 1.29	19.25
Between Columns	SSC = 66.7	c- 1 4 - 1 = 3	MSC = $\frac{66.7}{3}$ = 22.2	$\frac{MSC}{MSE}$ = $\frac{22.2}{565}$ = 0.04	9.01
Between Errors	SSE =565	(r-i) (c-i) 2 x 3 = 6	MSE = $\frac{565}{6}$ = 94.2	$\frac{94.2}{565}$ = 0.2	4.39
Between Totals	SST = 2094.7	n - 1 = 12-1 = 11	MST $\frac{2094.7}{11}$ = 190.4	$\frac{190.4}{2094.7}$ = 0.09	3.2

(See calculations in Appendix 4A)

Since the f-ratios computed at 5% level of significance are less than the f-ratios tabulated at 5% level of significance, the null hypothesis was accepted and the alternative hypothesis rejected. This implies that there was no significant difference in the mean effectiveness of quality assurance in the success of projects in the construction industries.

## HYPOTHESIS TWO

**H<sub>02</sub>:** There is no significant difference in the mean performance index of project deliverables in construction industries as a result of quality assurance.

### ANOVA TABLE

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM DF	MEAN SQUARE MS	F-RATIO COMPUTED	AT 5% (0.05)
Between Rows	SSR = 14	r - 1 = 3 - 1 = 2	MSr = $\frac{14}{2}$ = 7	$\frac{MSR}{MSE}$ = $\frac{7}{652}$ = 0.01	19.25
Between Columns	SSC = 66.7	c - 1 4 - 1 = 3	MSC = $\frac{66.7}{3}$ = 22.2	$\frac{MSC}{MSE}$ = $\frac{22.2}{652}$ = 0.03	9.01
Between Errors	SSE = 652	(r - 1) (c - 1) 2 x 3 = 6	MSE = $\frac{652}{6}$ = 108.7	$\frac{MSE}{SSE}$ $\frac{108.7}{652}$ = 0.17	4.39
Between Totals	SST = 732.7	n - 1 = 12 - 1 = 11	$\frac{732.7}{11}$ = 66.7	$\frac{66.7}{732.7}$ = 0.09	3.2

(See calculations in Appendix 4B)

Since, the F-ratios computed at 5% level of significance are less than the F-ratios tabulated at the same level of significance the alternative hypothesis was rejected and null hypothesis accepted. The conclusion was that there was no significant difference in the

mean performance index of project deliverables in construction industries as a result of quality assurance.

### HYPOTHESIS THREE

**H<sub>03</sub>:** The mean difference in the level of quality audit of input materials in construction industries is not significant.

#### ANOVA TABLE

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM DF	MEAN SQUARE MS	F-RATIO	AT 5% (0.05)
Between Rows	SSR = 134.7	r-i = 3-1 = 2	MSr = $\frac{134.7}{2}$ = 67.4	$\frac{MSR}{MSE}$ = $\frac{67.4}{709.3}$ = 0.1	19.25
Between Columns	SSC = 66.7	c-i = 4-1 = 3	MSC = $\frac{66.7}{3}$ = 22.2	$\frac{MSC}{MSE}$ = $\frac{22.2}{709.3}$ = 0.03	9.01
Between Errors	SSE = 709.3	(r-i) (c-i) 2 x 3 = 6	MSE = $\frac{709.3}{6}$ = 118.2	$\frac{MSE}{SSE}$ $\frac{118.2}{709.3}$ = 0.17	4.39
Between Totals	SST = 910.7	n-i = 12-1 = 11	$\frac{910.7}{11}$ = 82.8	$\frac{82.8}{910.7}$ = 0.09	3.2

(See calculations in Appendix 4C)

Since the F-ratios computed at 5% level of significance are less than the F-ratios tabulated at 5% level of significance, the null hypothesis was accepted and the alternative hypothesis rejected,

indicating that the mean difference in the level of quality audit of input materials in construction industries was not significant.

#### **HYPOTHESIS FOUR**

Ho4: The difference in the mean level of application of quality assurance techniques by project managers in construction industries is not significant.

#### **ANOVA TABLE**

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM DF	MEAN SQUARE MS	F-RATIO COMPUTED	AT 5% (0.05)
Between Rows	SSR = 188.7	$r - 1$ $= 3 - 1$ $= 2$	$MSR = \frac{188.7}{2}$ $= 94.4$	$\frac{MSR}{MSE}$ $= \frac{94.4}{203.3}$ $= 0.46$	19.25
Between Columns	SSC = 66.7	$C - 1$ $4 - 1$ $= 3$	$MSC = \frac{66.7}{3}$ $= 22.2$	$\frac{MSC}{MSE}$ $= \frac{22.2}{203.3}$ $= 0.11$	9.01
Between Errors	SSE = 203.3	$(r - 1)(c - 1)$ $2 \times 3$ $= 6$	$MSE = \frac{203.3}{6}$ $= 33.9$	$\frac{MSE}{SSE}$ $\frac{33.9}{203.3}$ $= 0.17$	4.39
Between Totals	SST = 458.7	$N - 1$ $= 12 - 1$ $= 11$	$\frac{458.7}{11}$ $= 41.7$	$\frac{41.7}{458.7}$ $= 0.09$	3.2

(See calculations in Appendix 4D)

Since the F-ratios computed at 5% level of significance are less than the F-ratios tabulated at the same level of significance the null hypothesis was accepted, indicating that the difference in the mean

level of application of quality assurance techniques by project managers was not significant.

#### **4.5 DISCUSSION OF RESULTS**

A lot of findings were made in this work. The fact that the effectiveness of quality assurance provides umbrella for continuous process improvement in construction industries as shown in table 4.3 indicate that quality assurance is quite essential.

This agrees with the views of Kaplan (2010) who opines that quality assurance is a key to continuous process improvement. Again, the fact that quality assurance justifies the funds spent on project execution as shown on table 4.4 tends to prove Richard (2003) right. According to him, if quality assurance is properly done, the funds used for project execution can no longer be termed wastages. No wonder Hansen (2008) believes strongly that quality assurance is a key to project customer satisfaction and a tool for applying the planned, systematic quality services for meeting project requirements.

It is necessary therefore, as Carol (2008) maintains that the level of quality assurance affects the performance of project deliverables in construction industries. However, the successful inspection of results is a performance index of quality assurance. It is also interesting that project managers use control charts as Daniel (2002) insists.

## **CHAPTER FIVE**

### **SUMMARY, CONCLUSION AND RECOMMENDATION**

#### **5.1 SUMMARY OF FINDINGS**

Among the major findings made in this research included that there was no significant difference in the mean effectiveness of quality assurance in the success of projects in the construction industries. Equally there was no significant difference in the mean performance index of project deliverables in construction industries as a result of quality assurance. Quality assurance is a key to project customer satisfaction. Also, the mean difference in the level of quality audit of input materials in construction industries was not significant. Quality assurance techniques' application among project managers in construction industries was not very significant.

#### **5.2 CONCLUSIONS**

Most often, the construction firms do not apply quality assurance strategies. Quality assurance provided umbrella for continuous process improvement of the construction projects and justified the funds spent on project execution. It is also a key to project customer satisfaction. Quality assurance plan and successful

inspection of results are performance indices of quality assurance. In addition, project deliverables are indices of quality assurance in construction projects. Quality audits confirm the implementation of approved change requests and the implementation of preventive action depends on quality audits. Implemented defect repair and quality control measurement go with quality audits. Some project managers use quality audits, apply process analysis and also use control charts.

### **5.3 RECOMMENDATIONS.**

The following recommendations are hereby proposed.

- 1 The construction firms should improve on the skills of their employees in the areas of quality assurance and also monitor its application.
- 2 Quality assurance should be used to provide umbrella for continuous process improvement.
- 3 Quality assurance should be used to justify the funds spent on project execution.
- 4 Quality assurance plan should be a performance index of quality assurance.
- 5 Project deliverables should be indices of quality assurance in construction projects.

- 6 Successful inspection of results should be a performance index of quality assurance.
- 7 Quality audits should confirm the implementation of approved change requests.
- 8 The implementation of preventive action should depend on quality audits.
- 9 Implemented defect repair should go with quality audits.
- 10 Quality control measurement should go with quality audits.
- 11 All project managers should use quality audits, apply process analysis and also use control charts for more prompt project delivery.

#### **5.4 SUGGESTIONS FOR FURTHER STUDIES.**

Work should be done on the impact of motivation on project execution, the use of process time management on prompt project delivery, and the role of project scope management on effective project delivery.

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## **APPENDIX I**

Dept of Project Mgt. Technology  
Federal University of Technology,  
Owerri  
8<sup>th</sup> July, 2011

Dear Respondent,

### **Response to Questionnaire**

I am an M.Sc Research Student of the Department and Institution stated above. I am conducting a research on the effectiveness of Quality Assurance on project execution.

Kindly fill the questionnaire administered to you as your company has been chosen as a study company for my research work.

I promise absolute confidentiality of any material information you may reveal to me.

Thank you for your co-operation.

Yours faithfully,

**Osuagwu Victoria (Mrs.)**

## QUESTIONNAIRE

Instruction: Below are typical questions. Kindly indicate the options you consider appropriate by ticking ☒ against such options. It is a four likert scale: agree (A), strongly agree (SA), Disagree (d) and Strongly Disagree (SD).

### SECTION A: PERSONAL DATA/INFORMATION

- 1) Sex
  - a. Male ☐. Female ☐
- 2) Age
  - a. Below 20 years ☐
  - b. 20-25 years ☐
  - c. Above 25 years ☐
- 3) Level of Education
  - a. B.Sc ☐
  - b. Below B.Sc ☐
  - c. Above B.Sc ☐
- 4) Marital Status
  - a. Single ☐
  - b. Married ☐
- 5) Working experience
  - a. Below 1 year ☐
  - b. 1-5 years ☐
  - c. Above 5 years ☐

## SECTION B: STAFF

FROM RESEARCH QUESTION ONE:

CLUSTER ONE: Items to show that Quality Assurance is effective for successful project execution in construction industries.

Options

ITEMS	A	SA	D	SD
(a) Quality Assurance provides umbrella for continuous process improvement.				
(b) Quality Assurance justifies the funds spent on project execution.				
(c) Quality Assurance is a key to project customer satisfaction				
(d) It is a tool for applying the planned, systematic quality activities for meeting project requirements.				

FROM RESEARCH QUESTION TWO:

CLUSTER TWO: Performance indices for Quality Assurance in project construction.

Options

ITEMS	A	SA	D	SD
(a) Project deliverables				
(b) Quality management plan				
(c) Proper use of cause and effect diagrams				
(d) Successful inspection of results				

FROM RESEARCH QUESTION THREE:

CLUSTER THREE: Relationship between quality audits and input materials in construction industries.

Options

ITEMS	A	SA	D	SD
(a) Quality audits confirm the implementation of approved change requests.				
(b) The implementation of preventive actions depend on quality audits.				
(c) Quality audits relate strongly to implementation of corrective actions.				
(d) Implemented defect repair goes with quality audits.				
(e) Quality control measurement goes with quality audits.				

FROM RESEARCH QUESTION FOUR:

CLUSTER FOUR: Quality assurance techniques applied by project managers.

Options

ITEMS	A	SA	D	SD
(a) Project managers use quality audits.				
(b) They apply process analysis.				
(c) Project managers use cause and effect diagrams.				
(d) They also use control charts.				

FROM RESEARCH QUESTION FIVE:

CLUSTER FIVE: Factors that influence Quality Assurance for effective project delivery.

Options

ITEMS	A	SA	D	SD
(a) The use of quality management plan can be helpful.				
(b) Application of quality metrics can be useful.				
(c) Quality control measurement are properly identified.				
(d) Project teams have experts in Quality Assurance.				
(e) There is lack of training for Quality Assurance experts.				

## **APPENDIX II**

### **SAMPLE SIZE DETERMINATION**

The sample size for the research was determined using the Yaro Yame's formula as quoted by Alugbuo (2002).

According to him, the formula is:

$$n = \frac{N}{1+N(e)^2}$$

Where

n = Sample size

N = Number of items in the universe or population

$e^2$  = Square of maximum allowance for sampling error (here 5% is used as maximum allowance for sampling error (level of significance)).

#### **FOR ZEROCK**

$$n = \frac{200}{1+200(0.05)^2}$$

$$n = \frac{200}{1+200(0.0025)^2}$$

$$n = \frac{200}{1+200(0.05)^2}$$

$$n = \frac{200}{1.5}$$

$$n = 133.33$$

$$n \approx 133$$

### FOR RHAS

$$n = \frac{225}{1+225 (0.05)^2}$$

$$n = \frac{225}{1+225 \times 0.0025}$$

$$n = \frac{225}{1+0.5625}$$

$$n = \frac{225}{1.5625}$$

$$n = 144$$

### FOR NEW IDEA

$$n = \frac{140}{1+140 (0.05)^2}$$

$$n = \frac{140}{1+140 \times 0.0025}$$

$$n = \frac{140}{1+0.35}$$

$$n = \frac{140}{1.35}$$

$$n = 103.703$$

$$n \approx 104$$

## APPENDIX III

### ANOVA TABLE

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM DF	MEAN SQUARE MS	F-RATIO COMPUTED	AT 5%
Between rows	SSR	R-1	$Ms = \frac{SSr}{r-1}$	$\frac{MSR}{MSE}$	
Between Columns	SSC	C-1	$MSC = \frac{SSC}{c-1}$	$\frac{MSC}{MSE}$	
Between Errors	SSE	(r-1) (c-1)	$MSE = \frac{SSE}{(r-1) (c-1)}$	$\frac{MSE}{SSE}$	
Between Totals	SST	n -1	$MST = \frac{SST}{n-1}$	$\frac{MST}{SST}$	

Source: Nworuh (2001:117)

Where:

SST = Sum of squares of totals

SSC = Sum of squares of between columns

SSR = Sum of squares of rows

SSE = Sum of squares of errors.

$$SST = \sum_{l=j} \sum X_{ij}^2 - \frac{T^2}{rC}$$

With n-1 degree of freedom

$$SSC = \frac{\sum T^2}{lr} - \frac{T^2}{rC}$$

With c-1 degree of freedom.

$$SSR = \frac{\sum X_i^2}{C} - \frac{T^2}{rC}$$

With r-1 degree of freedom.

SSE = SST-SSC-SSR with (r-1) (c-1) degrees of freedom

Nworuh (2001:115)

## APPENDIX IV

### CALCULATIONS ON HYPOTHESES

#### A) Calculations on Hypothesis One

To test this hypothesis, table 4.3 was used. ANOVA test was used to conduct the hypothesis. In order to do this, the following calculations were carried out.

SST = Sum of Squares of Totals

SSC = Sum of Squares between Columns

SSR = Sum of Squares of Rows

SSE = Sum of Squares of Errors

$$SST = \sum_{i=1}^r \sum_{j=1}^c x_{ij}^2 - \frac{T^2}{rc}$$

With n-i degree of freedom.

$$SSC = \frac{\sum T_j^2}{c} - \frac{T^2}{rc} \quad \text{With } c-1$$

Degree of freedom.

$$SSR = \frac{\sum x_i^2}{r} - \frac{T^2}{rc} \quad \text{with } r-1 \text{ degrees of freedom.}$$

$$SSE = SST - SSC - SSR \quad \text{with } (r-1) (c-1) \text{ degrees of freedom.}$$

(Nworuh, 2001:115).

Then, arranging the above in a table of ANOVA, we have:

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM DF	MEAN SQUARE MS	F-RATIO COMPUTED	AT 5%
Between Rows	SSR	$r - 1$	$MSR = \frac{SSR}{r-i}$	$\frac{MSR}{MSE}$	
Between Columns	SSC	$c - 1$	$MSC = \frac{SSC}{c-1}$	$\frac{MSC}{MSE}$	
Between Errors	SSE	$(r-i)(c-i)$	$MSE = \frac{SSE}{(r-1)(c-1)}$	$\frac{MSE}{SSE}$	
Between Totals	SST	$n - 1$	$MST = \frac{SST}{n-1}$	$\frac{MST}{SST}$	

From table 4.3

	RHAS	NEW IDEA	ZEROCK	TOTAL
	30	25	38	93
	20	25	22	67
	60	35	30	125
	10	15	10	35
<b>TOTAL</b>	120	100	100	320 = $\sum x$
$\bar{x}$	30	25	25	

$$SST = \frac{30^2 + 25^2 + 38^2 + 20^2 + 25^2 + 22^2 + 60^2 + 35^2 + 30^2 + 10^2 + 15^2 + 10^2 - \frac{320^2}{12}}{12}$$

$$SST = \frac{900 + 625 + 1444 + 400 + 625 + 484 + 3600 + 1225 + 900 + 100 + 225 + 100 - 102400}{12}$$

$$SST = 10,628 - 8,533.3$$

$$SST = 2,094.7$$

$$SSR = \frac{93^2 + 67^2 + 125^2 + 35^2}{3} - \frac{320^2}{12}$$

$$SSR = \frac{29988}{3} - \frac{320^2}{12}$$

$$SSR = 9,996 - 8533.3$$

$$SSR = 1462.7$$

$$SSR = 1463$$

$$SSC = \frac{120^2 + 100^2 + 100^2}{4} - \frac{320^2}{12}$$

$$SSC = 8,600 - 8533.3$$

$$SSC = 66.7$$

$$SSE = SST - SSC - SSR$$

$$SSE = 2094.7 - 66.7 - 1463$$

$$SSE = 565 \text{ with } (r-i) \text{ (c-i) degree of freedom}$$

$$\text{i.e. } (3-1)(4-1) = 2 \times 3 = 6$$

## B) Calculations on Hypothesis Two

To test this hypothesis, table 4.7 was used.

	RHAS	NEW IDEA	ZEROCK	TOTAL
	20	33	23	76
	31	12	37	80
	38	31	16	85
	31	24	24	79
<b>TOTAL</b>	120	100	100	320 = x
$\bar{x}$	30	25	25	

$$\text{SST} = 20^2 + 33^2 + 23^2 + 31^2 + 12^2 + 37^2 + 38^2 + 31^2 + 16^2 + 31^2 + 24^2 + 24^2 - \frac{320^2}{12}$$

$$\text{SST} = 9266 - 8,533.3$$

$$\text{SST} = \underline{732.7}$$

$$\text{SSR} = \frac{76^2 + 80^2 + 85^2 + 79^2}{3} - \frac{320^2}{12}$$

$$\text{SSR} = \frac{25642}{3} - 8,533.3$$

$$\text{SSR} = 8,547.3 - 8,533.3$$

$$\text{SSR} = \underline{14}$$

$$\text{SSR} = \frac{120^2 + 100^2 + 100^2}{4} - \frac{320^2}{12}$$

$$\text{SSC} = 8600 - 8533.3$$

$$SSC = \underline{66.7}$$

$$SSE = SST - SSC - SSR$$

$$SSE = 732.7 - 66.7 - 14$$

$$SSE = 652 \text{ with } (r-1) (c-1) \text{ degrees of freedom.}$$

### C) Calculations on Hypothesis Three

To test this hypothesis, table 4.11 was used.

From table 4.11

	RHAS	NEW IDEA	ZEROCK	TOTAL
	34	33	24	91
	44	27	16	87
	31	17	29	77
	11	23	31	65
<b>TOTAL</b>	120	100	100	320 = x
$\bar{x}$	30	25	25	

$$SST = \frac{34^2 + 33^2 + 24^2 + 44^2 + 27^2 + 16^2 + 31^2 + 17^2 + 29^2 + 11^2 + 23^2 + 31^2 - \frac{320^2}{12}}$$

$$SST = 1156 + 1089 + 576 + 1936 + 729 + 256 + 961 + 289 + 841 + 121 + 529 + 961 - 8,533.3$$

$$SST = 9444 - 8533.3$$

$$SST = \underline{910.7}$$

$$SSR = \frac{91^2 + 87^2 + 77^2 + 65^2}{3} - \frac{320^2}{12}$$

$$SSR = \frac{8281 + 7569 + 5929 + 4225}{3} - 8533.3$$

$$SSR = \frac{26004}{3} - 8533.3$$

$$SSR = 8668 - 8533.3$$

$$SSR = \underline{134.7}$$

$$SSC = \frac{120^2 + 100^2 + 100^2}{4} - \frac{320^2}{12}$$

$$SSC = \frac{34400}{4} - 8533.3$$

$$SSC = 8,600 - 8,533.3$$

$$SSC = \underline{66.7}$$

$$SSE = SST - SSC - SSR$$

$$SSE = 910.7 - 66.7 - 134.7$$

$$SSE = \underline{709.3} \text{ with } (r-i)c-i \text{ degrees of freedom.}$$

## D) Calculations on Hypothesis Four

To test this hypothesis, table 4.16 was used.

From table 4.16

	RHAS	NEW IDEA	ZEROCK	TOTAL
	28	27	34	89
	22	18	20	60
	40	30	19	89
<b>TOTAL</b>	30	25	27	82
$\bar{x}$	120	100	100	320 = x
	30	25	25	

$$SST = \frac{28^2+27^2+34^2+22^2+18^2+20^2+40^2+30^2+19^2+30^2+25^2+27^2 - 320^2}{12}$$

$$SST = \frac{784 + 729 + 1156 + 484 + 324 + 400 + 1600 + 900 + 361 + 900 + 625 + 729 - 102400}{12}$$

$$SST = 8992-8533.3$$

$$SST = \underline{458.7}$$

$$SSR = \frac{89+60^2+89^2+82^2}{12} - \frac{320^2}{12}$$

$$SSR = \frac{7921+3600+7921+6724}{3} - 8533.3$$

$$= 8722 - 8533.3$$

SSR = 188.7 with r-1 degree of freedom.

$$SSC = \frac{120^2 + 100^2 + 100^2}{4} - \frac{320^2}{12}$$

$$SSC = \frac{14400 + 10,000 + 10,000}{4} - 8533.3$$

$$SSC = 8600 - 8533.3$$

SSC = 66.7 with c-1 degree of freedom.

$$SSE = SST - SSC - SSR$$

$$SSE = 458.7 - 66.7 - 188.7$$

SSE = 203.3 with (r-1) (c-1) degrees of freedom.



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