Quality Management Practices in Construction Projects

A Case Study of New Benazir Bhutto International Airport

Session 2009-2013

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Bachelor of Engineering in Civil Engineering

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A project report submitted in partial fulfillment of the requirements for the degree of

Bachelor of Engineering

In

Civil Engineering

2013

NUST Institute of Civil Engineering (NICE)

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Islamabad Pakistan

This is to certify that the

Report Titled

QUALITY MANAGEMENT PRACTICES IN CONSTRUCTION PROJECTS

A CASE STUDY OF NEW BENAZIR BHUTTO

INTERNATIONAL AIRPORT

has been accepted towards the partial fulfillment

of

the requirements

for

Bachelor of Engineering in Civil Engineering

Assistant Professor Zia-Ud-Din

Department of Construction Engineering and Management

National Institute of Transportation (NIT)

School of Civil and Environmental Engineering (SCEE)

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DEDICATED

TO

OUR PARENTS, TEACHERS, FRIENDS AND COLLEAGUES

ACKNOWLEDGEMENTS

First of all we are thankful to Almighty Allah who gave us the strength and courage to accomplish this project.

We are grateful to Engr. Zia-Ud-Din for his extended guidance and supervision. We greatly appreciate his facilitation throughout. We extremely appreciate the immaculate assistance provided by Dr. Rafiq Muhammad Choudhry, Head, Department of Construction Engineering and Management, and for his valuable suggestions and advice. Finally we pay our deepest gratitude and respect to our families especially our parents for their eternal support, encouragement, love, prayers and patience

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Table of Contents

List of Figures

Abstract

This report gives an insight about quality management, how it evolved through the ages, the different ideas given by various quality gurus and detailed explanation of how it is applied in industries and companies and what are the methods and the benefits of implementing it. The quality industry started booming once mass productions started in virtually every industry. This led many influential people to give their opinions regarding management and maintaining quality of these huge productions. The basic purpose of quality management in any field is to have a systematic method of production in conformance with some standards that are set. In detailed study we find out that quality management has four phases viz. quality control, quality assurance, and quality management system and total quality management. The implementation of all these phases is necessary for success at the highest level. Furthermore there are some critical factors which need to be addressed in order to have a good quality culture in any company. These critical factors determine the overall working environment of the organization in which quality management has to be implemented. The Quality Management in construction industry includes the technical aspects which constitute the equipment, machinery and their standards, as well as managerial aspect which encompasses the mobilization of workforce and synchronization of ideas relating to quality management in any organization. The technical aspect includes the material testing i.e. concrete, steel aggregate, bitumen testing etc. there are different tests of every material which confirm it as being confirmatory to specific standard. This approach of quality management in construction industry is taken in the case study of Benazir Bhutto International Airport

Chapter 1

INTRODUCTION

Ever since the beginning of human civilization there always has been a continuous pursuit and quest for the betterment of humanity. This quest has led many a people into achieving such remarkable feats and accomplishments that left rest of the generation bewildered and at the same time thankful to these people for their achievements. The basic element of all these successes was to adopt a method to continuously improve the quality and the standard thereby leading to an efficient final product. Consequently, major philosophers, inventors and researchers treading on this path of evolution, not only gave the human race different tools of comfort but also left a huge footprint and a roadmap for the future generations to follow.

1. 1 HISTORY AND EVOLUTION

The concept of quality is not a new one as we might expect it to be. Only recently it has been organized into a full fledge field of practical study whereby it is implemented to get the desired results. Initially where there were insignificant mass productions quality at individual level started with the manual inspection by the artisan. This concept basically emerged from the revolution of industry. Back then the products were manufactured by exactly similar people and the rectification was done by manual inspection. This manual inspection included the tweaking and handcrafting. Eventually the huge scale production induced people to form partnerships identify different phases of production and also work on them where an individual will complete the product from start to finish in that particular stage of product completion. It was the job of the quality department of and it was ensured by catching defective products during an inspection by the concerned department.

Statistical control came later after the mid twentieth century wars and was advanced by of W. Edwards Deming, after the name of which the Deming Award for quality is established(Deming and Edwards, 1982). Joseph M. Juran fixed his sights more on how to manage the quality. He developed the "Juran's trilogy," an approach that emphasized the operation of three managerial components i.e. quality planning, quality control and quality improvement.(Juran, 1986).. All these people contributed to quality management in some way or the other and their theories are practiced and preached widely as of today. They are elaborated upon in next section.

1.2 OBJECTIVES

This report has the following objectives:

- To study quality management system and its components.
- To investigate different quality management practices implemented on construction projects.
- To observe the technical and managerial aspect of quality management in construction projects

1.3 QUALITY MANAGEMENT

Quality management is defined as the systematic and an organized path adopted to guarantee that the activities and events happen according to a specific plan. These organized efforts result in overall efficiency of the product, reduction in cost and most importantly creating an environment where the entire right attitude is adopted by the concerned employees.

The construction industry is one of the biggest beneficiaries of this management system. Applying a quality management system ensures that everything related to construction viz. the management and the technical aspects are done according to a certain standard supervised by qualified officials. The result is that the end product is free of any errors and is in conformance to set of standards allocated at the start of the project. Furthermore the cost of the project is balanced in such a way that that we get a more efficient product for a specific cost.

Chapter 2

LITERATURE REVIEW

Quality management as explained in the previous section is very important in any organizational structure. It is defined as the series of systematic procedures and steps which ensure the standard of the product according to specific specifications and attributes as defined in a particular manual or a theory. Many theories related to this have been presented by various researchers. A few of them have been explained above in short. The giant pioneer of quality management as we can call him to be considering his contribution in this field is Phillip Crosby. He stated "that quality management is systematic way of guaranteeing that organized activities happen the way they are planned. It is a management discipline concerned with preventing problems from occurring by creating the attitudes and controls that make prevention possible."

2.1 QUALITY MANAGEMENT SYSTEM

A system of quality management comprises of all the specific limbs of the company related to the processes that are undertaken to achieve the desired quality and also the products that are being made. Accordingly a quality management system or whole setup will require efficient management of the workforce and hierarchy and effective delegation of authority on behalf of the top quality manager (Jakobsson and Giversen, 2007).

Quality management system incorporates all the activities that organizations use to direct, coordinate and control quality. These policies include formatting a quality policy and setting quality objectives. Quality management also includes planning, control, assurance and improvement. This whole process constitutes a system which is called the quality management system. A process based quality management system uses the process approach to maintain the quality. It is a very complex process which is interconnected and its various steps intermingled with each other. Each process uses processes to transform input into outputs. These input output relations form the basic need of a total quality management system.

2.2 QUALITY CULTURE

A tool for asking questions about how things work, how institutions function, who they relate to, and how they see themselves **(**Harvey and STENSAKER, 2008) **.**

For a quality management system to be adopted in any organization it is important to develop a culture. Accordingly Bensimon (Bensimon, 1995) carried out his research on this topic and concluded that efforts to adopt a quality management system would succeed only if a cultural change was brought about. He also suggested four points as an approach for adopting the quality management philosophy:

- Develop a vision
- Promote a policy on quantity
- Create a total quality oriented culture
- Training and education

These four basic steps ensure towards developing a quality culture within an organization which will lead not only to the technical aspect of the quality management but also the managerial aspect of the quality management.

Accordingly Harber stated that" when an organization adopts Quality management as with the other major organizational change programs a cultural change is also necessary for successful implementation. In particular, the move to an emphasis of quality of products and services usually requires a significant change in organizational values and leadership styles"**(**Harber, Burgess and Barclay, 1993)**.** To implement this quality culture which will ensure quality management being a major tool for success many theories have been developed and formulated. Johnson in 1993 gave the ten steps which introduce quality culture in any organization are:

2.2.1 Leadership

The leadership is vital for any management program and similarly for this culture to develop the leader has to have the necessary plans and actions to back the ideas to develop this culture

2.2.2 Vision

The next thing is the vision. The leader should be able to efficiently share his vision with his followers and colleagues which will define the future out course of the company.

2.2.3 Customer Focus

When the vision has been laid to plan the next most important thing is the customer focus which pinpoints the methodologies to be adopted in order to satisfy the customer at all costs.

2.2.4 Employee Well Being

The leader has to ensure that employees are well educated and proper coordination is maintained to create an efficient environment for work.

2.2.5 Performance Management System

The standard of employees is also a main thing. Employees are selected through a rigorous procedure after giving them proper training to ensure that only those people are selected who have the requisite knowledge of the subject.

2.2.6 Reward System

Employees are rewarded based on their performance not on their seniority, longevity and nepotism. This is an important aspect of quality culture without which the lack of motivation factor will develop which significantly reduces the prospects of a well oiled and well drilled organization.

2.2.7 Communication System

The communication system as previously explained has to be very efficient and fool proof. Nothing should be hidden from the employees so that they do not second guess what is occurring and why.

2.2.8 Roles and relationships

The leaders should define the roles and the relationships directly spring up from these well defined roles. Process should be adopted to avoid conflicts and proper harmony should be created. This also should encourage teamwork and leaders are solely responsible for any differences that arise.

2.2.9 Structure

The organizational structure should be such planned that less employees perform more work so that too many cooks don't spoil the broth.

2.2.10 Teamwork

Finally the teamwork constitutes an important part of any organization promoting any new culture. Similarly to promote quality culture all the concerned members need to be on the same page and working with a good spirit.

2.3 MAJOR CONCEPTS OF QUALITY MANGEMENT

After the successful implementation of quality culture in any organization there are various ways to integrate a successful quality management system into an existing company or an industry. These methods or techniques were devised by many individuals who are considered as great named in the field of quality management. One such pioneer was W. Edwards Demming who presented the concept of management at the individual and collective level, stating that better management can reduce 94% of the quality related problems of any industry (Deming and Edwards, 1982). Below it is explained in a greater detail.

2.3.1 Deming's Management Plan

Dr Deming gave his famous fourteen points relating to the management at the individual and the company level. These fourteen points are a complete philosophy of management that can be applied to all organizations big or small either in the public or the private sector.

1) Create constancy of purpose towards improvement of product and service

2) Adopt the new philosophy. We can no longer live with commonly accepted levels of delay, mistakes and defective workmanship

3) Cease dependence on mass inspection. Instead, require statistical evidence that quality is built in

4) End the practice of awarding business on the basis of price

5) Find problems. It is management's job to work continually on the system

6) Institute modern methods of training on the job

7) Institute modern methods of supervision of production workers, The responsibility of foremen must be changed from numbers to quality

8) Drive out fear, so that everyone may work effectively for the company

9) Break down barriers between departments

10) Eliminate numerical goals, posters and slogans for the workforce asking for new levels of productivity without providing methods

11) Eliminate work standards that prescribe numerical quotas

12) Remove barriers that stand between the hourly worker and their right to pride of workmanship

13) Institute a vigorous program of education and retraining

14) Create a structure in top management that will push on the above points every day

(Deming and Edwards, 1982)

Deming also promoted a systematic approach in problem solving by giving his famous plan do check act which basically gives us the method of continuous improvement thereby reducing the difference between the requirements of a customer and the performance of the process.

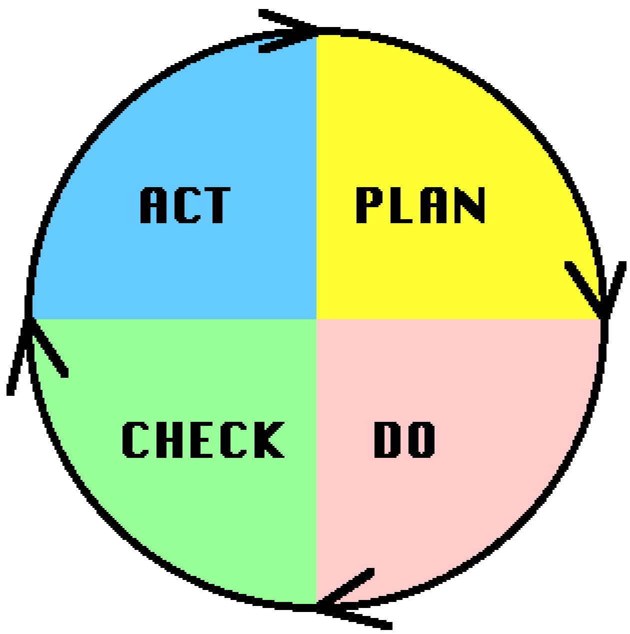


Figure 1: Deming management plan (Deming and Edwards, 1982)

Plan what is needed

Do it

Check that it works

Act to correct any problems or improve performance

The cycle is about learning and ongoing improvement learning what works and what does not in a systematic way. The cycle repeats after one cycle has finished.

2.3.2 Quality Trilogy of Joseph M. Juran

He developed the famous quality trilogy that is the quality planning quality control and quality improvement. The basic theme of this trilogy theory is that at one level of performance we can achieve a quality control. Then we have to devise methods to raise the level of performance via different methods such as the Pareto analysis and then try to maintain the quality control on this new and improved performance level.

Figure 2: Quality trilogy (Juran, 1986)

The quality improvement steps as proposed above were given by Juran (Juran, 1986) himself. He gave these steps for betterment of quality:

• Build awareness of the need and opportunity for improvement.

• Visualize targets for betterment.

• Manage wisely to reach the targets.

• Give opportunity of training.

• Conduct projects to find a way out of dilemmas

• Maintain the level of progress by reports.

• Give the due to people where it is necessary.

• Results should be passed on effectively to lower hierarchy.

• Maintain record of improvements achieved

• Keep a constant momentum.

(Juran, 1986)

The above mentioned steps enhance the consumer supplier relationship very effectively.

2.3.3 Total Quality Viewpoint of Kaoru Ishikawa

Dr Ishikawa presented the total quality viewpoint in which he emphasized on the company wide quality control, human side of quality, Ishikawa diagram and the assembly and use of six basic tools of quality which are as follows:

• Pareto analysis	what are the big problems?
• Cause and effect diagrams	Cause of the problems?
• Stratification	The makeup of the data?
• Check sheets	The repetition of activities
• Histograms	How do differences present themselves?
• Scatter charts	what is the link between different factors?

(Ishikawa, 1982)

One of his important contributions was the fishbone diagram in which he explained the relationships between real cause behind a problem and its effect. The theory behind this is to list a possibility of all the causes of a problem and narrow down the possible ones. The diagrammatic format helps when presenting results to others.

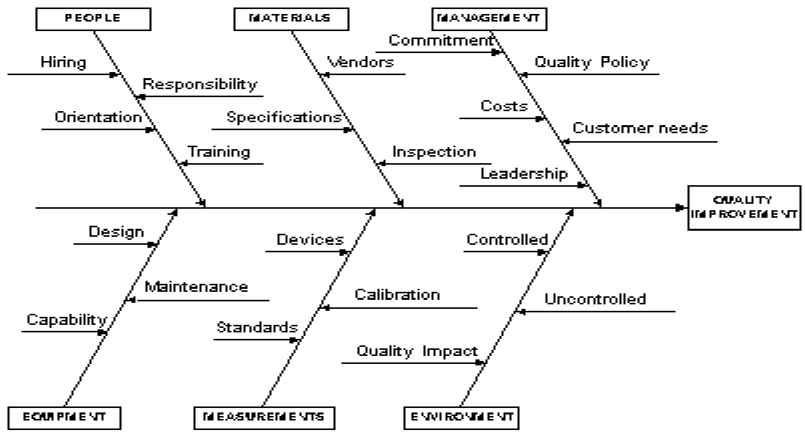


Figure 3: Total Quality Viewpoint **(**Ishikawa, 1982)

2.3.4 Free Quality Concept by Phillip Crosby

Phillip Crosby (Crosby, 1985) pioneered the concept of free quality and zero defects and his proposed theory is based on the following 14 points:

- Management is committed to a formalized quality policy

- Form a management level quality improvement team (QIT) with responsibility for quality improvement process planning and administration

- Determine where current and potential quality problems lie

- Evaluate the cost of quality and explain its use as a management tool to measure waste

- Raise quality awareness and personal concern for quality amongst all employees

- Take corrective actions, using established formal systems to remove the root causes of problems

- Establish a zero defects committee and program.

• Train all employees in quality improvement.

• Hold a Zero Defects Day to broadcast the change and as a management recommitment and employee commitment.

• Encourage individuals and groups to set improvement goals.

• Encourage employees to communicate to management any obstacles they face in attaining their improvement goals.

• Give formal recognition to all participants

• Establish quality councils for quality management information sharing

• Do it all over again – form a new quality improvement team

2.4 PHASES OF QUALITY MANAGEMENT

There are four phases of quality management which are explained in detail in the following headings.

2.4.1 Quality Control

Quality control is a methodology employed in manufacturing to prevent defects in manufactured products. Abbreviated as QC, the method has been implemented in a number of ways each of which has its own name and following. Quality control is typically associated with statistical approaches (Woodall, Spitzner, Montgomery and Gupta, 2004) .

Quality control refers to the process or the methodology in which all the finished products are gone through a checking cycle where all the products are monitored and examined for any defects before they are ready to be sold to the market. This venture focuses on the three important features:

•Things such as job managements, processes, performance and integrity and details of past performances.

•A defined level of competition in all aspects including technical and managerial

•Other aspects such as personal integrity, coordination and relationships.

The level of excellent output is at stake if these features are compromised upon. The products that are manufactured are shown to the quality control managers that are appointed from the consultant or the contractor if the contractor is managing the project himself. The job of this quality control manager is to verify if the product manufactured is of the desired quality and it meets the standard specifications or not. The products are passed through a series of tests to determine exactly this. For example a concrete sample after it is prepared it is checked for the cracks or blemishes and compressive strength is rechecked before it is used in construction (Woodall, Spitzner, Montgomery and Gupta, 2004).

2.4.1.1 Difference between quality control and quality assurance

The difference between quality control and quality management is that quality control involves the checking of finished products to ensure that is there are no defects in the product and free of faults whereas the quality assurance is the proper process through which the product passes and the finished package is in no further need to check. Quality control is the filtering of finished product whereas the quality assurance is the proper process through which the product is passes to ensure it is prepared according to standard.

2.4.1.2 Total quality control

Application of quality management to all areas of business from design to delivery instead of confining them only to production activities (FEIGENBAUM, 2000).

Total quality control refers to the process whereby the whole product specification is altered according to which the material is tested once it is manufactured. For example the design of steel should not only consist of its dimensions, types but also the environmental factors, safety and reliability as well.

2.4.1.3 Quality control in project management

The quality inspection team is required to examine the products according to the specifications and with the scope of the project. All the projects have a separate department which focuses on the quality management of the concerned company.

2.4.2. Quality Assurance

Quality Assurance is defined as the application of all the processes and steps to ensure that the product being manufactured will be in conformation of the desired quality. This is different from the quality control in the sense that quality control refers to the quality of processed products whereas quality assurance involves the quality procedures while the product is being manufactured. The principle objectives that can be accounted for in quality assurance are "the product should be fit for use" i.e. and secondly "product should be correct at the first step" which means that the product should be produced in such a way that it does not require rectification once it has been produced. (FEIGENBAUM, 2000).

2.4.2.1 Steps for quality assurance

American Society for Quality (ASQ) defines assurance of quality as the steps taken by any organization which are systematic in nature to fulfill the needs of the product or service in terms of their respective quality (Weheba, 2002).

There are many shapes of the quality assurance varying with different dimensions. The fulfillment of any process is tailored to meet the requirement of the product.

A common process includes:

- Past products being tested
- Always looking for improvement plans

- Producing a multidimensional product design to include improvements
- Production betterment
- Betterment in products
- New product being put to the test

These plans for improvement include the series of steps required to bring the product according to the demands and the specifications.

2.4.3 Quality Management System

As explained in the beginning quality management system integrates in itself the whole process in the complete company or the industry in which it incorporates all the activities that organizations use to direct, coordinate and control quality. These policies include formatting a quality policy and setting quality objectives. They also include planning, control, assurance and improvement. This whole process constitutes a system which is called the quality management system. A process based quality management system uses the process approach to maintain the quality. It is a very complex process which is interconnected and its various steps intermingled with each other. Each process uses processes to transform input into outputs. These input output relations form the basic need of a total quality management system.

2.4.3.1 Total quality management

It involves the participation of all the stake holders who are concerned with the creation and consumption of the product. It capitalizes on the management, workforce, suppliers and also the customers. A relatively new concept but one which is fast developing and is becoming essential to the needs and demands of any company that desires to establish a management capable of providing quality.

2.4.3.2 Six Sigma

Six sigma is a total quality management system with a little variation. It involves the reduction in defects by minimizing variation in the processes. The total quality management system focuses more on the managerial aspects where as the six sigma concept focuses more on the technical aspects.(Linderman, Schroeder, Zaheer and Choo, 2003)

2.5 CRITICAL FACTORS OF QUALITY MANAGEMENT

As evident from the heading critical factors determine the environment and shape the nature of the process to be adopted for the quality management. A total of 27 different quality factors were first identified by the researchers but there are eight main factors which are listed below:

2.5.1 Top Management Support

The support from the management remains the top most priority of any employee working in the company. This support enhances and creates a netter environment for working which ensures coordination among the employees.

2.5.2 Quality Information Availability

The knowledge of quality management is critical in implementing any strategy for quality management. This knowledge should be readily available to the employees and this can only happen once the people sitting at the top of the food chain distribute their concepts. Technology is the order of the day and it has to be incorporated in the organization for effective working.

2.5.3 Quality Information Usage

The quality of the information is one thing but it’s use is of prime importance to any company as theoretical knowledge is wasteful until and unless it is successfully applied in practical field. The managers have a job on their hands because it is a very difficult task. They say that knowledge is power and this proverb epitomizes this situation of the quality managers needing to know what they are doing on the field related to the quality management.

2.5.4 Employee training

Employee training also is very important in developing a quality culture which will determine the efficiency of industry or any company

2.5.5 Employee Involvement

The employees should feel at home when working and nothing should be kept hidden from them. Only this will create a sustainable environment for work.

2.5.6 Product/process Design

The product design and the process determine the final outcome of the product. Quality control and assurance principles if properly adopted by the respective officials.

2.5.7 Supplier Quality

The supplier quality should also not be compromised when considering the quality management. The source should be properly screened and then the products should be ordered so that no losses are suffered.

2.5.8 Customer Orientation

The products should be so designed that they are customer oriented. After all, this final product is going to be used by the customer.

2.6 ASPECTS OF QUALITY MANAGEMENT

Quality management in construction industry has many aspects but is broadly divided into two main categories:

1. Technical Aspects
2. Managerial Aspects

2.6.1 Technical Aspects of Quality Management

By Technical Aspects we mean the different civil and scientific works that need to be tackled while building a construction project. In this, we are concerned in dealing with the solution of different problems and difficulties that may arise in construction projects. Any construction project needs these technical guidelines in order to construct a sustainable and safe project.

"Technical aspects of quality management" are explained as the different systematic checks and balances that ensure that quality of project is not neglected while performing and dealing with these technical aspects. These comprise of different operations that are regularly performed and cross checked to make our construction project in compliance with standards. Until these technical aspects are ensured, the construction project is deemed as dangerous and may not be certified. For International Standards like ISO certification, each and every operation needs to be performed as per quality checks given in the ISO standards.

Technical aspects in construction project are fundamentally concerned with the quality of materials and the standard procedures that are used while using these materials for building a project. Quality of Materials check is done to ensure that the construction materials that are to be used have the strength and capacity to withstand the demands of technical nature that our construction materials will be subjected to during the service life of the structure.

2.6.2 Managerial Aspects

The second aspect of quality management i.e. Managerial Aspects is basically concerned with proper management control and organization to ensure that quality of the project is not jeopardized during its construction.

The "managerial aspects" basically lays down a chain of command that is to be followed while performing the assigned duties by the employees. It sets up a system that ensures that each and every team member is working as per the protocols required to maintain the prerequisite quality of the construction project.

2.6.3 Detailed Explanation of Managerial Aspect of Quality Management

The major objective of “managerial aspect” is relevant to dealing with factors other than technical in nature that need to be tackled on a construction site. The managerial aspects are fundamentally relevant to organization structure of the company. It specifies the chain of command to be followed and used while performing construction jobs. Another important feature of managerial aspect is “Training of employees”. This training of employees is done to make all the working staff aware of the different quality standards and protocols that are to be followed to fulfill the quality requirements of the construction project. Employees and workers cannot be blamed if proper training has not been instilled in them. It is the responsibility of the contractor to arrange for the quality training of the workers. This training must be completed before the start of the work.

Another important managerial aspect is the “human resource management on construction site”. It deals with the human factor that has relevance to project quality. It has been found that there are different influencing factors related to humans that will affect our project. It is therefore necessary to adequately handle these issues and ensure employees’ satisfaction.

“Cultural Diversity Issues” among employees is another problem that may arise on construction site.”Cultural diversity” means the differences and problems that are bound to rise because of difference in cultural backgrounds of employees.

This diversity may affect the team work of our construction team and have adverse affects on our project and subsequently our quality standards requirement will also suffer setbacks. Therefore the “managerial aspects” also need to tackle this diversity issue and ensure that there is no such problem relevant that will affect the smooth working of our project. This problem should be tackled by regular sessions in which the in charge should re stress that they are here to work and there are no such things like racial and skin color discrimination.

“Leadership traits” are also an important requirement for achieving total quality management. These traits must be present in the “QC manager” on site checking whether these traits are present our concerned persons, or not is the responsibility of human resource department, who are responsible for employing these officials.

Along with that, managerial aspects devise a strategy to handle different issues that may arise during our construction process. These strategies are basically different possible paths that are available to the people working on site in case of any event that is unplanned. They basically give a solution to any problem that has not been planned before. In absence of these “emergency strategies” our project may get delayed causing huge financial damage. Therefore these strategies may not been devised before construction starts. Another objective of managerial aspect is to devise such steps and policies that will keep our employees motivated, so that we can make full use of their energies.

These motivational factors hold utmost importance in construction project as our workforce is not automated; rather these are humans so this is human psychology that unless they are comfortable and happy, they cannot give their best possible efforts. Therefore, “managerial aspects” deal with this factor by fulfilling their necessary demands, paying them on time, giving them proper facilities on site and having good behavior with them.

Proper policies are devised to ensure that employees are given not only technical guidance but also guidance on problems that are personal in nature.“Legal Issues or Handling” is also one of the many sub-headings of managerial aspects. Any issue that may lead towards law-suits and legal actions are also tackled by effectively planning events in accordance with local and international laws. People with right level of competence need to be bright into the company. There should be proper checks to ensure that people who are used in construction have the expertise and they know what they are dealing with.

The foremost importance given in managerial aspects is framing of “Quality policy”. This quality policy is basically set of guidelines and rules that are to be observed during construction. It should be properly planned after careful considerations.

The person over-seeing managerial aspects of quality management needs to perform the following duties on construction site.

- Coordination of activities of staff by giving them due direction
- Identify different needs of employees and try to fulfil those needs
- Check and evaluate employees' performance
- Making sure that errors that arise are removed and then finding possible reason that might have caused that error.
- Keep an overall check to ensure that quality protocols are properly applied and maintained
- Apply new techniques to ensure that best level of quality is maintained
- Maintain favourable public relations
- Deal appropriately with any unforeseen changes that are likely to arise during construction
- Handle legal issues in accordance with company's policy

(Evans and Lindsay, 1999)

2.6.4 Technical Aspects of Quality Management in Construction Industry

In technical aspects of quality management we are concerned in dealing with the quality of materials, the designing of structures, construction plant's maintenance and selection of machinery along with other factors.

The most fundamental item that is found to effect quality is the materials of construction that are implied while construction a building. Out of these construction materials, the most basic are those that are responsible for affecting quality, for example, concrete, steel, aggregates.

As these materials are heavily used and will ultimately be used in carrying the loads of the building, therefore these materials should be stiff enough to carry the load they are likely to carry during their service life. Therefore, the type of these materials, and the specific characteristics of each and every one of these materials is important for the sustainability and serviceability of our structure. Quality management techniques are made to ensure that every material of construction is up to the mark.

These techniques basically comprise of different laboratory tests along with other statistical techniques that have the objective of removing the substandard materials from getting used in construction. Apart from concrete and steel other main types of materials that are used in building project includes

- Timber
- Metal
- Bitumen
- Bricks
- Polymers

Another important technical aspect ensured in quality management techniques includes the designing of our relevant civil structure. The aspect of quality management that is ensured in quality management that is ensured in designing of building makes sure that there are no structural defects present in our design. This is an important factor to be considered, because if defects are present in our design, then even the use of best possible materials will not suffice the quality requirement demands of our project. It is the responsibility of the consultant of the project to ensure that all the structural designs and drawings of the project are in conformance with the quality standards.

In case our project i.e. Airport, the consultants have designed different packages of the airport keeping the view the ISO 9000 and Violation Standards. If faulty drawings are presented by the consultant, then contractor will claim that it was not his fault if any unwanted event occurs. Therefore designing holds pivotal importance in a construction project.

One of the technical aspects is the operation of “construction plants”. Construction plants are basically responsible for providing the controlled conditions under which construction materials are prepared. An important consideration while operating these “construction plants” is to set up different procedural guidelines for operating these construction plants.

These are important for quality of the project, because unless these construction plants are properly set up, we may not be able to prepare construction materials properly.

“Machinery use” in construction project also affects the quality of project. A specialized machine is likely to save not only our time but also give us an output that is close to our required quality standards. Therefore the rate of output cost and conformance of this machinery with ASTM and BS is taken into consideration.

2.7 MATERIAL TESTING

In order to ensure that best quality materials are used in our site material testing is done. Material testing labs are established on site to ensure that every material is tested before its use. Mostly concrete testing, aggregate testing bitumen testing etc. are performed in the field in the construction industry. Furthermore quality management techniques are there to ensure that the tests are performed as per ASTM, AASHTO etc. standards. Also all the apparatus used are standard ones that are specified. The following tests are conducted to ensure the quality of materials being used at a site. Here only the names are mentioned. For their details see Chapter 4 Field Observations.

Concrete

- Sieve analysis of washed concrete
- Air content measurement
- Compressive strength
- Flexure strength

Steel

- Steel yield
- Ultimate tensile strength
- Bend Test Steel
- Chemical analysis of steel

Asphalt

- Sieve analysis
- Stripping test
- Marshall density test/Flow/Void analysis
- Extraction test
- Compact density of asphalt

Bitumen

- Bitumen penetration test
- Flash and fire point determination
- Density of bitumen
- Viscosity of bitumen

Aggregates

- Sand equivalent
- Specific gravity
- California Bearing ratio (CBR)
- Plasticity index
- Field Density test
- Maximum dry density test

Chapter 3

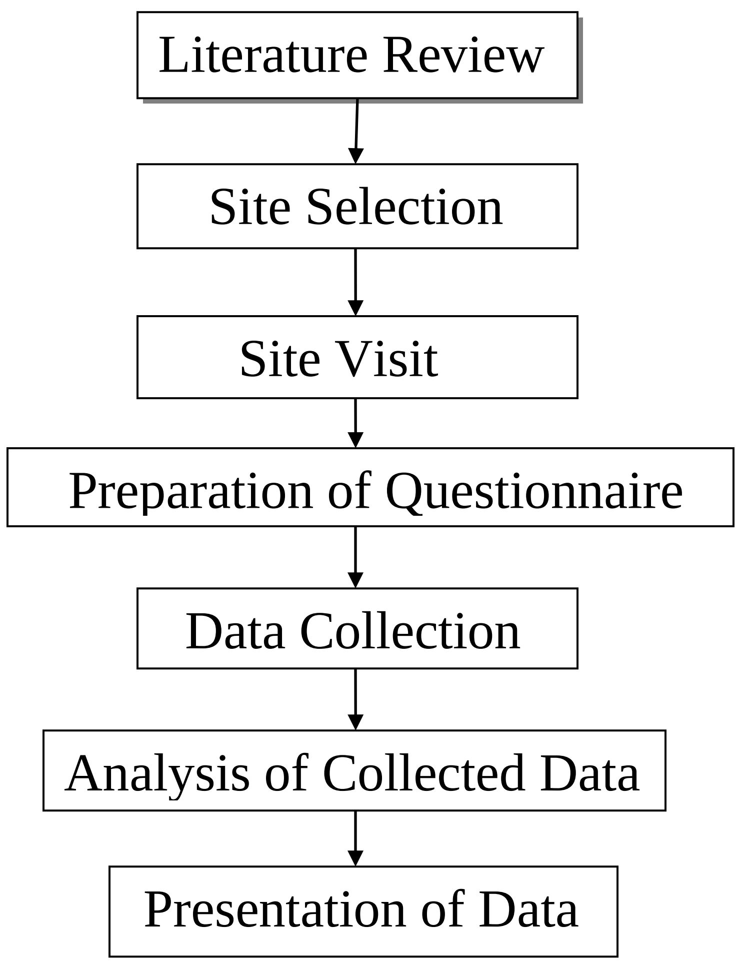
METHODOLOGY

3.1 AREA OF CONCERN

As our project is quality management practices of Benazir Bhutto International Airport, we studied the practices being implemented for quality management. Our focus was towards study of quality management techniques and practices being carried out in the field.

3.2 STEPS

The following is the flow chart representing the sequence of steps undertaken in this project:



3.2.1 Literature Review

The literature review consisted of going through relevant books and journals as well as usage of internet.

3.2.1 Site Selection

The site after consultation with our project advisor was New Benazir Bhutto International Airport Fatehjang**.**

3.2.3 Site Visit

We visited the site a number of times to gather the required data from the officials.

3.2.4 Preparation of Questionnaire

For the collection of data on the site visit we prepared a relevant questionnaire which we prepared after going through relevant literature and through mutual discussion.

3.2.5 Data Collection

The data given to us by the officials was in the form of presentations, journals and relevant soft copy material. We also noted down the response of the officials to the questionnaire we had prepared earlier in our notebooks.

3.2.6 Analysis of Collected Data

The collected data was analyzed and then organized in a proper fashion by discussing it with further meetings with the concerned officials at the airport and also with our project supervisor.

3.2.7 Presentation of Data

Finally the data was presented to the class in the form of presentation and also in the form of report after mutual discussion and relevant guidance from our supervisor.

Chapter 4

QUALITY MANAGEMENT OF NEW BENAZIR BHUTTO INTERNATIONAL AIRPORT

4.1 Introduction

4.1.1 General Information

The project we selected has the following salient features:

- The project was conceived in 1984.
- The land acquisition process took 20 years from 1984-2004.
- Prequalification of contractors was completed in May 2006.
- Approval of implementation plan and hiring of consultants was done in October 2004.
- Appointment of design consultants was completed in March 2007.
- The ground breaking ceremony was held in April 2007.
- An area spanning 35 km in length just gives one a glimpse of what might become of a place so barren.
- It is estimated to be one of the largest airports of Asia.
- It has an estimated budget of 123 billion rupees.
- The whole project has a total of 8 packages which are further subdivided to facilitate the different contractors in completing the project on time.
- Employers are the CAA (civil aviation authority) of Pakistan.
- Consultants include LBG (Louis Berger group), NESPAK, and CPG airport Singapore.
- Contractors include CSCEC (China State Corporation Engineering Company), FWO.

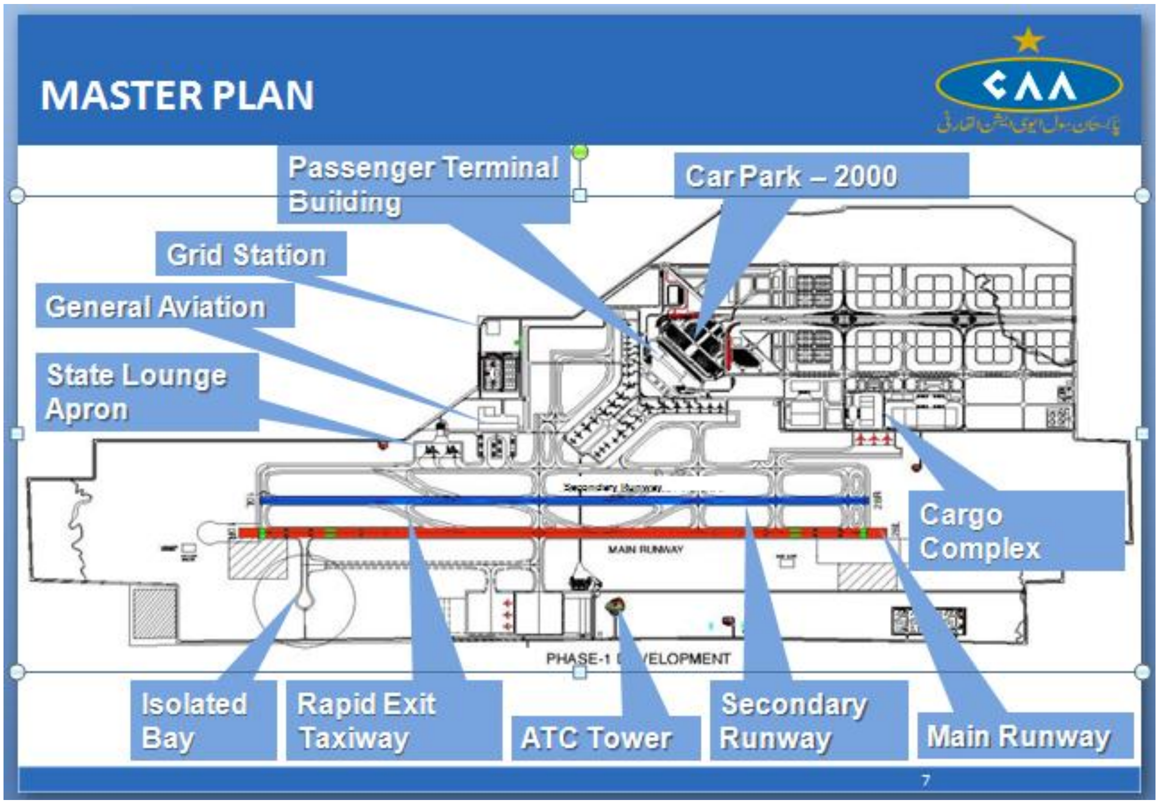


Figure 4: Master Plan

4.1.2 Packages of airport

Owing to the large size of the project the construction of the airport is divided into different packages. We worked on the following three packages:

4.1.2.1 Package 1: Air infrastructure

Phase- I: <u>Airside Infrastructure</u>

Aprons	Air traffic control
Taxiways	Operational buildings
Runways	Navigational Aids
Airfield Lighting System (AFL)	Hydrant refueling system

Figure 5: Package 1 (airside infrastructure) Land clearing for runways

4.1.2.1.1 Air infrastructure facilities:

Two runways (Primary & Secondary)

Rapid exit taxiways

Special areas to park hijacked aircraft (Isolation Bays)

Special areas to park ground handling equipment

Cargo Complex – 150,000 to 300,000 m. tons capacity

(Present capacity existing Airport – 40,000 m. tons)

(Present capacity all Airports – 350,000 m. tons)

4.1.2.1.2 Packages

The Airside infrastructure is divided into following packages:

Package 1: awarded to LTH JV (Lagan-Technical Associates Pvt. Ltd-HCL Pvt. Ltd)

Package 7A (Airside Lighting System): awarded to Siemens

Package 6 (Hydrant Refueling System): awarded to ATL (Al-Tariq Construction)

Package 8C-1(Air Traffic Control): awarded to Beixin Gammon JV

Package 7-B (Navigational Aids): awarded to Jaffer Brothers

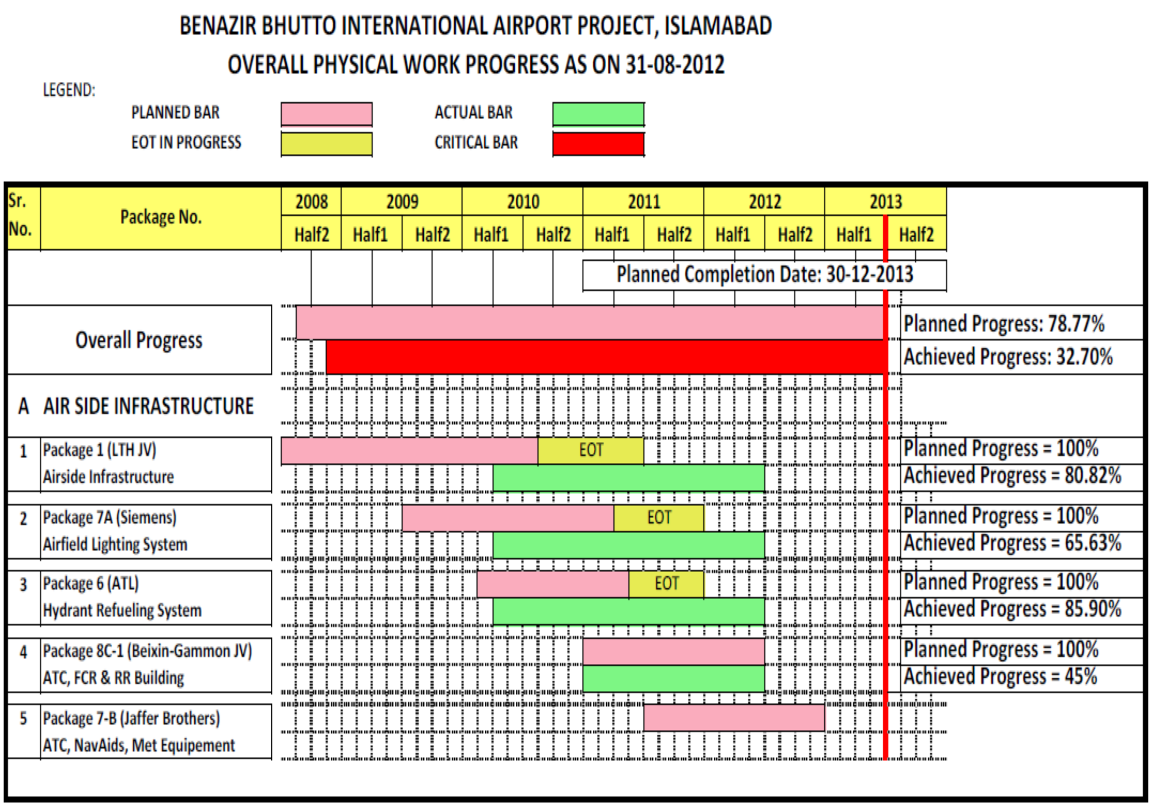


Figure 6: Progress of air side infrastructure

Figure 7: Package 6: (Hydrant refueling system) Trenches being excavated to lay the pipeline for providing fuel to the aircraft.

4.1.2.2 Package 8-A Land side infrastructure:

4.1.2.2.1 Land side infrastructure:

It is concerned with the construction of major access road linking the airport to Islamabad city. Another predominant feature of this package includes the construction of departure level bridge. It consists of the following

Internal road network

Telecommunication network

Bridges / underpasses

Road / Street Lighting

Water and Sewage Treatment Plants

Fire Hydrant network

Electrical power Sub-stations

Cargo Complex and Allied Facilities

4.1.2.2.2 Departure level bridge:

As per International standards the airports to be constructed should be user friendly and attractive for the people using it. Keeping this aspect in mind the designers of this project have decided to introduce the new concept of departure level bridge. These bridges are intended to eliminate the use of staircases by passengers during landing. This bridge will directly give them the access to the terminal building and by the use of elevators they will exit the building. This facility is nonexistent in the old Benazir Bhutto airport. This is what makes this project so unique.

The following picture gives us a glimpse of the departure bridge under construction.

Figure 8: Departure level bridge under construction

Figure 9: Another view of Departure level bridge under construction

4.1.2.2.3 Packages:

Package 8-A(Landside Infrastructure): Awarded to LTH JV

Package 8-B(Power and telecom network): Awarded to Siemens

Package 8-C2(Landscaping):LTH JV

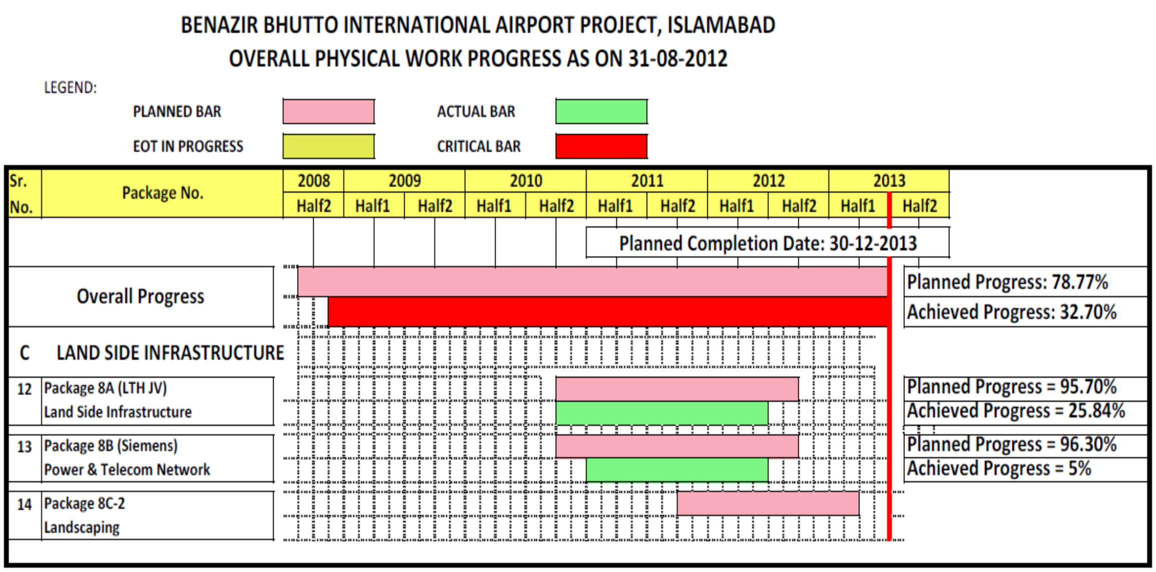


Figure 10: Progress of Landside infrastructure

4.1.2.3 Package 3:

Construction of passenger terminal building and allied electrical and mechanical works

Passenger Terminal Building

Passenger Terminal Building Civil work

Building Management Systems

Baggage / Passenger Handing Systems

Flight Information Display System

Various Technical Systems

Heating, Ventilation, & Air Conditioning

Passenger Boarding Bridges

Terminal Building Lighting & Signage

Figure: 11 Construction of foundations of the Passenger Terminal building

4.1.2.3.1 Packages

The project is divided into further six packages:

Package 2(Piling and Foundation): Awarded to CRFG)

Package 3-A(PTB pile caps): Awarded to Sambu-Sachal JV

Package 3 (Passenger Terminal Building): Awarded to CSCEC-FWO JV

Package 9(Aircraft stand equipment)

Package 4(PTB Special Systems)

Package 5(Furniture and signage)

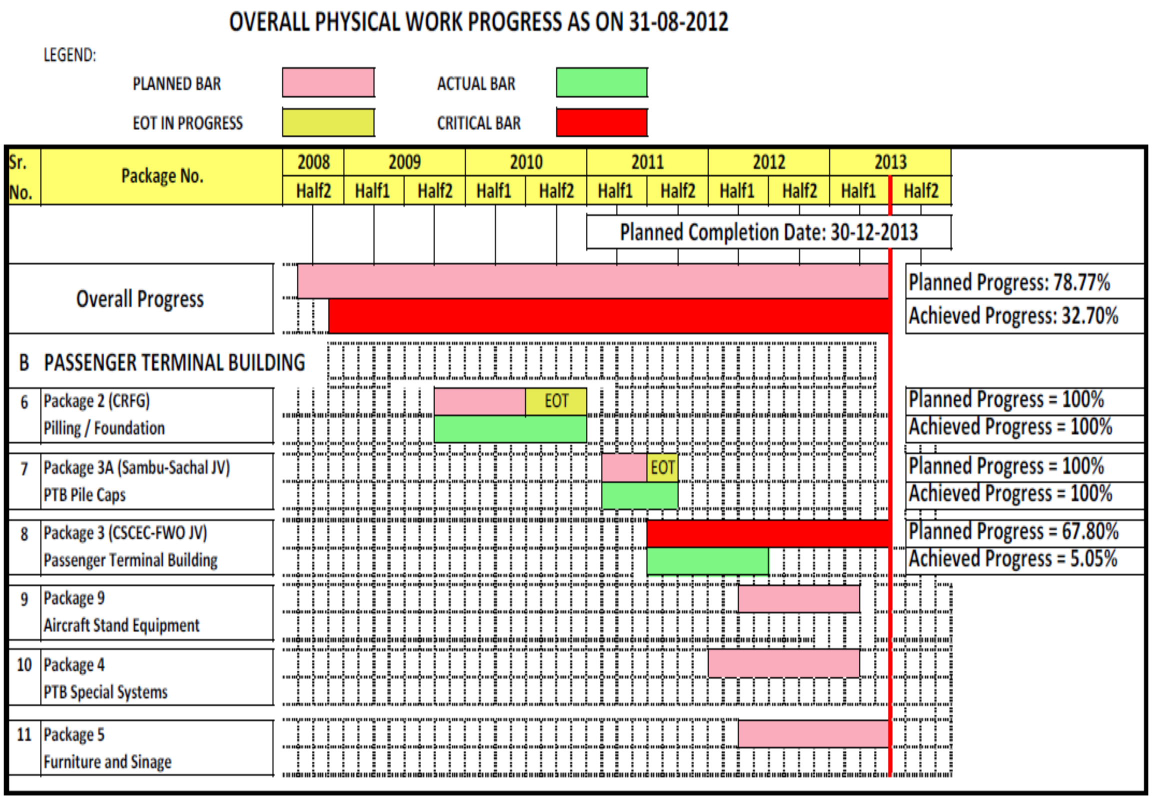


Figure 12: Progress of passenger terminal building

4.1.3 Quality Management Application

This section describes the roles and responsibilities of project participants as they relate to quality assurance. Quality Assurance organization includes of following:

Quality Assurance Supervision Team

Third Party Validation Team

Design Review Team

A brief description of each quality assurance team is as under:

4.1.3.1 Quality assurance supervision team

Team Leader along with his supervisory team will be responsible for overall quality assurance of the project. He is the key person responsible for the planning, coordination and controlling of project from inception to completion, meeting the project's requirements and ensuring that each road package is completed on time, within budget and to the required quality standards

In order to assure quality at all levels, each work done/ request for inspection (RFI) before certification for payment will be checked and verified at various levels i-e from Site inspector/LT/Surveyor to Team Leader. Material/ Quality Engineer will carry out frequent site visits to ensure that all sampling, testing and construction material are in accordance with the specifications.

Project Management review meetings will be held monthly in the office of Team Leader to discuss the management and quality issues. The meetings will be chaired by Team Leader and attended by REs/ AREs. Other site staff will be asked to attend the meetings as required.

4.1.3.2 Third party validation team

Third party validation will be carried out by Head office through Project Manager and other Head office staff i-e Material Engineer, Chief surveyor and Chief Quantity Surveyor. Material Engineer from the Head office will be sent to road packages at various stages of construction. He will take random samples, carryout various tests and report to Project Manager regarding performance of Material laboratory staff. Conducting random sampling is the best practice to ensure quality of road.

Similarly, Measurement Engineer and Chief Surveyor will conduct site visits to assure quality in their respective fields.

4.1.3.3 Design review team

The reviewing sections and individuals have specific responsibilities as part of the process. The design review team will comprise of Geometric Design Engineer, Pavement Engineer, Structure Engineer, Measurement Engineer, Environmental Specialist, Resettlement Expert and Gender Expert. Each member of team will be responsible for the design review of respective section.

Based upon the design review of each road, recommendations will be prepared by the Consultants in form of report which will include comments that could provide improvements to the particular road section. Design Review Report for each road package will be prepared for review of the WSD & ADB and for further necessary action in case of any amendments in the design.

4.1.3.4 Management responsibility

In order to ensure that appropriate standards of quality are established at every level, the following roles and responsibilities have been identified for Construction Supervision Team:

Team Leader

The Team Leader has the responsibilities of following:

He will report to Head office of PMC.

He will have overall responsibility for the organization, conduct and delivery of consultancy services and construction contracts, and reporting.

He will head the PMC and will be responsible for quality assurance of the project.

He will work directly, and manage relations, with the client.

He will be responsible for all liaisons with and reporting to the client, and for financial control of the consultancy.

He will provide overall guidance and advise the construction supervision/contract administration team on all project related matters.

He will amicably resolve any disputes during the construction and provide decisions whenever required.

He will have overall responsibility for progress and completion with assistance from team members.

He will be responsible for Certifying work volume and recommending interim certificates to the Client for progress payments.

He will conduct monthly site visits to ensure construction work to be executed in conformance to specification.

He will be responsible for the random checking and verification of work done upto 10% of each interim payment certificate (IPC) amount.

He will have close liaison with construction supervision team.

He will be responsible for approving contractor's work program as per Contract.

He will initiate variations (if any) to the Client for approval.

He will be responsible for processing the contractor's possible claims

Resident Engineer

The description of duties for Resident Engineer will be as under:

He will report to Team Leader.

He will supervise the work of assistant resident engineers and rest of construction supervision teams.

He will manage the construction milestones and quality control of works.

He will provide assistance to the Team Leader in overall management, monitoring and reporting.

He will be responsible for day-to-day management of works.

He will responsible for the execution of work in accordance with the Conditions of Contract contained in ADS's standard documents as appropriate and in accordance with Conditions of Contract.

He will conduct weekly or fortnightly progress review meeting with Resident Engineers.
He will be responsible for approving method statements, material sources, etc; Preparing and issuing reports as defined subsequently;
He will be responsible for the random checking and verification of work done upto 50% of each interim payment certificate (IPC) amount.
He will be responsible for approving and/or issuing working drawings, approving the setting out of the works, and instructing the contractor;
He will be responsible for taking measurements and keep measurement records;
He will be responsible for maintaining records, correspondence, and diaries;
He will be responsible for certifying work volume and recommending interim certificates for progress payments;
He will be responsible for maintaining consolidated project accounts, and preparing of financial statements and withdrawal applications for submission to the ADS;
He will be responsible for certifying completion of part or all of the works;
He will be responsible for inspecting the works at appropriate intervals during the defects liability period and issuing the defects liability certificate;
He will be responsible for processing the contractor's possible claims;
He will be responsible for ensuring minimum disruption/damage to the environment by approval of contractors' work statement/methodology, including monitoring the impact of construction works on the environment and local settlements and providing information on the monthly progress reports;
He will be responsible for providing the employer with complete records and reports, and approving the contractors' as -built drawings for the works;
He will compile a Project completion report providing details of Project implementation, problems encountered, and solutions adopted, and detailing and explaining any variation

in Project costs and implementation schedules from the original estimates.

Materials / Quality Engineer

Description of duties for Material engineer will be as under;

He will report to Team Leader.

Material Engineer will assist the RE and will be responsible for quality of material used in construction by performing field and laboratory tests and certifying their acceptance based on his recommended specifications for the materials.

He will stipulate Material Testing Procedures and Specifications

He will identify sources of materials, quarry sites and borrow areas

He will confirm the suitability and availability of material in the borrow pits and quarries for pavement.

If required, identify and evaluate additional sources of materials

Responsible for reviewing calibration records, to ensure that all the measuring and test equipment used for Quality inspection are calibrated in accordance with standard procedure.

Undertake field and laboratory testing of the materials to determine their suitability for various components of the work;

Prepare mass haul diagram for haulage purposes giving quarry charts indicating the location of selected borrow areas, quarries and the respective estimated quantities;

Make suitable recommendations regarding making good the borrow and quarry areas after the exploitation of materials for construction of works; and

Be responsible for Material Testing and specification and certification of material quality.

Preparation and testing of concrete mixes of different design mix grades using suitable materials (binders, aggregates, sand filler etc.) as identified during Material Investigation to conform to specification applicable in Pakistan.

Quantity Surveyor

He will report to Resident Engineer.

The quantity surveyors shall review detailed estimates for quantities (considering designs and mass haul diagram) and project cost for the entire project (civil packages wise), including the cost of environmental and social safeguards proposed and market rate for the inputs or the local schedule of rates.

He will ensure correctness of documentation, IPCs and quantities during the construction and confirming the computation and processing of interim payment certificate.

He will be responsible for producing details of the final bill and total quantities consumed during the project.

He will prepare quantitative estimates for any suggested variation with its cost impact on the project.

Lab Technicians

He will report to Assistant Resident Engineer.

He will assist the RE and Material Engineer in performing all specified quality control tests on materials and mixes as per specifications drawn/approved by Material Engineer, all specified quality laboratory tests on materials samples and geotechnical samples as specified by the RE.

He will assist the Inspectors in assessment of concrete mixes etc.

Surveyors

He will report to Assistant Resident Engineer.

The Surveyors shall carry out joint surveys with contractor's staff before commencement.

He will assist the Resident Engineer in checking the correctness of layout drawn at site by the contractors during executing for the road construction.

He will maintain all documentation on survey works, record of control points and bench marks.

He will ensure that works commences according to the working drawings approved by the Resident Engineer.

Inspectors

He will report to Assistant Resident Engineer.

The Inspectors shall be responsible for inspection of works at site and testing the material used.

He will check and ensure correct fixing of steel bars as per drawings and bar bending schedule approved by the Resident Engineer.

He will inspect the workmanship of masonry and concrete work including proper curing.

Material Inspector shall perform all specified quality control tests on materials and mixes as per specifications drawn/approved by the Material and Quality control Engineer

He will assist Material Engineer in design of asphalt and concrete mixes etc.

Contract Specialist

He will be responsible for assisting the client, Team Leader and Resident Engineers in all the activities pertaining to contract management *of* civil works contracts.

He will advise the Team leader for issuing notices, early warning of key contractual actions.

He will assist Team Leader in approving Contractor's work program.

He will be responsible for evaluating/resolving contractor's claims and contractual disputes.

4.1.4 Quality Assurance Process

4.1.4.1 Purpose

One of the Engineer's role in FIDIC based contracts is to ensure that the Construction work is to the specified quality. This is achieved by checking that the construction work is to the quality as required by the Contract.

There can be certain stages of construction (hold points) where the Contract specifically requires the Contractor to obtain a quality check for subsequent approval / acceptance before covering up the work.

If the Contract does not specifically have such a requirement, the Engineer / Project Manager can direct the Contractor not to proceed beyond a certain stage (and cover up work) until a quality check has been done, and approval / acceptance has been given.

4.1.4.2 Quality assurance documents

Each of the various construction activities included herein has a series of related forms that are to be completed by inspection staff thereby providing information on which decisions regarding the acceptability or otherwise of a particular activity can be made. The forms comprise the following:

Check Lists : These provide lists of questions regarding specific items that are to be checked before, during and after an activity takes place.

Log Sheets : These are to record the details of an activity as it is happening, e.g. drilling, concrete placement, pile driving, etc.

Report Sheets : These are to summarise the results of an activity after its completion with details of the times, quantities, etc. actually involved on site.

The Check Lists and Log Sheets are intended to be completed as the work is being carried out and are the source documents for the final decision making process.

Inspection staff should not write information on other pieces of paper or notebooks and later transfer this information to these sheets. They must be written on at the time the event is occurring and whilst care should be taken to keep the sheets neat and legible, it is understood that in the course of the work they may become marked or creased.

On completion of the various record sheets described above, a summary of each of the elements of the inspection process is prepared on an ISQ (Inspection / Survey / Quality) sheet. This is completed by the relevant Site Inspector, Surveyor and Laboratory Technician and is intended to be a summary of the results of the inspection process undertaken by each member of the inspection team.

The ISQ sheet with its attachments is checked by the concerned Assistant Resident Engineer and then by the Resident Engineer to ensure that all the necessary information has been provided and he can then make a suitable recommendation regarding the acceptability of the works inspected.

The following procedures set out how this system works, the Engineer's Site Team and the documentation and records required such that evidence exists the Quality Control checking has been carried out including how the Contractor is to be advised of the results of the Checking.

This procedure includes details of the various types of checks which are carried out to provide the information necessary for the approval / acceptance of the work to be given.

4.1.4.3 Processing system

The Contractor will inform the ARE/Site office by notice (*REQUEST FOR INSPECTION / SURVEY / QUALITY TEST*) at least 24 hours before that section of work is ready for quality checking. The notice must provide the full details of the description and nature of work, location and chainage of work and should be returned without acknowledging receipt to the Contractor if it does not have the above details.

The Computer Operator or other designated person is responsible for immediately entering the date and time received and the Contractor's reference details of the notice into the Request Notice Index where it will be assigned a unique RFI number prefixed with I, S or Q indicating the type of checking required.

A signed copy of the notice (RFI) will be returned to the Contractor indicating receipt of the original.

The original RFI along with two duplicate copies will be passed on to the ARE/Site Inspector.

ARE/Site Inspector will immediately assign the task of checking to an inspection team comprising one or all of Site Inspector, Survey and Laboratory Technician (as per requirement) to carry out the work.

The Site Inspector / Surveyor / Laboratory Technician will undertake the quality check of the work using the check lists, logs, level sheets etc. having due regard to the requirements of the General Specifications and the approved Drawings and will report their findings on ISQ summary sheet attached to RFI along with relevant documents to ARE/Site Inspector.

ARE will check the findings on the ISQ sheet, ensuring that all the necessary reports, check lists, level sheets, lab test reports, etc have been completed correctly and are attached and will evaluate the results and complete the "Engineer's Instruction" on the original RFI to advise the Contractor if the work is accepted or not and giving reference to the relevant Specification clause or Approved Drawing no. Record of original laboratory test results will be kept in laboratory. RFI's for concrete which have been returned to the Contractor based on visual assessment or 7 day strength results are held by the Assistant Resident Engineer pending final 28 days strength results to be advised by the Materials Engineer.

The original approved RFI with ISQ sheets and attachments will be forwarded to Resident Engineer. One duplicate of approved RFI will be forwarded to the Contractor and one will be kept for office record.

The Resident Engineer will check RFIs randomly and forward original RFI with all relevant record to the QS for measurement and certification of quantities.

Quantity certification sheet with all relevant record will be forwarded to Team Leader office for checking and compilation of IPC. Material/ Quality Engineer will check and verify the laboratory tests results.

The carrying out of quality checks and the return to the Contractor of the RFI notice with advice of any decisions made should be completed as soon as reasonably possible of receipt of notice or when the section is ready for testing, whichever is the later, unless there is laboratory testing which requires specified time periods before which results cannot be made available. It is mandatory to mention that RFI should be received in ARE office up to 02:00 PM. Any RFI received after 02:00PM will be considered to be submitted next day.

In cases where quality needs to be checked and the Contractor has not submitted a request, the Assistant Resident Engineer will initiate the quality check process and ensure that the results are conveyed using the above procedure to the Contractor.

In the majority of situations details and results contained on the various reports, logs, etc. and summarized on the RFI sheets are not to be passed over to the Contractor, whether they indicate conformance or otherwise.

Whilst arguments may develop as to the accuracy or validity of test results given that the Contractor may carry out his own testing in the field, the Contract Documents are quite clear that acceptance testing is carried out by Consultant’s staff.

4.1.4.4 Responsibilities

The Assistant Resident Engineer is responsible for ensuring that the system reflects the requirements of the Contract and that the system is followed.

He is also responsible for :

Ensuring that the system works on a day by day basis.

Advising the Resident Engineer / Team Leader of potential problems

Ensuring that all areas / sections that are to be checked do in fact get checked and eventually conform to requirements.

4.1.4.5 Records

Laboratory test results on relevant materials files (held in laboratory)

Quality Records requiring control (table A-2 see Appendix)

Copies of original RFI notices with all records sheets provided.

4.1.4.6 Attachments

Request for Inspection / Survey / Quality Test (RFI)

Request Notice Index

Action	By	To
Submit Request for Inspection / Quality Test	Contractor	Computer Operator / Site Inspector
Enter data on Request Index and pass on Request	Computer Operator	Assistant Resident Engineer
Assign quality testing task and delegate inspection team to carry out inspection / testing	Assistant Resident Engineer	Site Inspector / Surveyor / Laboratory Technician
Evaluate results and make decision for approving / disapproving the work. Complete Engineer's Instruction part of Request Form for signature	Site Inspector / Surveyor / Laboratory Technician	Assistant Resident Engineer
Copy of RFI return to Contractor	Assistant Resident Engineer	Contractor
Forward original RFI and relevant document to RE office for further action.	Computer Operator	Resident Engineer
Register return of original and copy of RFI and file one copy for record.	Computer Operator	File Relevant [Roadworks] File Relevant [Structures] File Relevant [General]

Action	By	To
Prepare Quantity Agreement sheets from completed Requests	Quantity Surveyor	Resident Engineer
Check Quantity Agreement sheets and forward to Team Leader with all relevant record.	Resident Engineer	Team Leader
Randomly check & assign task to PQS for compilation of IPC.	Team Leader	Project Quantity Surveyor
PQS check and compile IPC	Project Quantity Surveyor	Team Leader
Check & sign IPC and forward to the Client	Team Leader	Client, PMU

Chapter 5

FIELD OBSERVATIONS

5.1 Material Testing

5.1.1 Concrete

The following are experiments conducted on site and it covers all the packages of the airport:

1) Sieve Analysis of Washed Concrete

Aggregate gradation (sieve analysis) is the distribution of particle sizes expressed as a percent of the total dry weight. Gradation is determined by passing the material through a series of sieves stacked with progressively smaller openings from top to bottom and weighing the material retained on each sieve. Different sieve numbers and sizes are most often used in grading aggregates. ASTM C-136

2) **Air Content Measurement**

This method use on the site is the "Volumetric Method." Air is removed from a known volume of concrete by agitation in an excess of water. It may be used with any type of aggregate including light weight and porous material. The test is not affected by atmospheric pressure and the specific gravity of the material need not be known. Applicable Standards: ASTM C 173, AASHTO T-196

3) Compressive Strength:

The cube test is performed on the site. Cubes of various sizes depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used. The concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load is applied gradually at the rate of 140 kg/cm2 per minute till the specimens fail. Load at the failure divided by area of specimen gives the compressive strength of concrete. ASTM C-39

4) Flexural Strength:

Flexural strength is a measurement that indicates a material's resistance to deforming when it is placed under a load. The values needed to calculate flexural strength are measured by experimentation, with rectangular samples of the material placed under load in a 3- or 4-point testing setup. AASHTO T-97

5.1.2 Steel Testing:

1) Steel Yield and Ultimate Tensile Strength:

The yield strength of steel is determined by experimentation in a pulling machine. A sample of a standard size is taken and then it is extended until the steel reaches the yielding point and then breaks. The load at which the steel breaks is recorded using electronic equipment attached or some mechanical device which plots the graphs.

2) Bend Test Steel:

A bend test is used to determine whether a specific piece of metal in question will break or fracture under pressure. To perform a bend test, a specific sheet or strip of metal is bent by a predetermined amount, often into an arc shape. After the bend is made, the metal is carefully examined to see if any breaks or cracking occurred in the piece, and the testers note whether the metal broke along or against the grain. The grain is a term used to describe the direction that lines in the metal appear to run when examined closely.. Results for the test are determined by how the metal held up during the bend test, and how much it may have fractured or broken.

3) Chemical Analysis of Steel:

It determines the quantitative chemical analysis of the elements in a steel sample. The instrument used forms a plasma with the surface of a solid metal sample and as all the elements fall back to their original energy state they give off light at different wavelengths for each element. The intensity of light is measured at multiple wavelengths and used to provide a quantitative analysis of each measured element. The resulting analysis provides a complete chemical analysis of all required elements for steel.

5.1.3 Asphalt Testing:

1) Sieve Analysis:

Aggregate gradation (sieve analysis) is the distribution of particle sizes expressed
As a percent of the total dry weight. Gradation is determined by passing the material
Through a series of sieves stacked with progressively smaller openings from top to bottom and weighing the material retained on each sieve. Different sieve numbers and sizes are most often used in grading aggregates. In Asphalt both the bin and the cold method are used. AASHTO T-27/T-88

2) Stripping Test:

For good performance it is necessary that the aggregates should adhere to the bitumen film. The stripping test measures the adhesion of bitumen with aggregates. The aggregates are mixed with 5 percent binder at specified temperature with regard to the bitumen used. The coated aggregates are then immersed in water and kept undisturbed at controlled temperature for about 24 hours. The percentage area uncoated due to action of water is measured.

3) Marshall Density Test/Stability/Flow/Void Analysis:

The whole process comes under the Marshall Mix design. The method seeks to meet the conditions of stability and flow range values for the asphalt binder content.

4) Extraction Test:

Extraction is the procedure used for separating the asphalt from the mineral aggregate in an asphaltic paving mixture. The purpose of extraction is to provide a basic for determining the asphalt content of a mixture and to provide asphalt free aggregates which may be used for gradation analysis and such other tests on the aggregates as may be desired.

5) Determination of Compact Density of Asphalt:

In this test we take a flat piece of compacted and cold asphalt, the size of a palm. It is put in a container and packed well. Remove the contents and put the sand alone back into the container. The depth of sand by Area gives the volume of sand. Total container volume is given by:

Total container volume - Volume of sand = Volume of compacted asphalt. Find the weight and divide by the volume to get bulk density of compacted asphalt.

5.1.4 Bitumen out Source Test:

1) Bitumen Penetration Test:

This experiment is done to measure the penetration of bitumen. The penetration test consists of a needle penetrating a bitumen sample under specified conditions to a tenth of mm vertically. Greater value of penetration indicates softer consistency. Generally higher penetration bitumen is preferred for use in cold climate and smaller penetration bitumen is used in hot climate areas.

2) Bitumen Flash and Fire Determination:

Flash Point: The flash point indicates the moment at which the vapors of a substance momentarily catch fire with the brilliance of a flash at the lowest possible temperature.

Fire Point: The fire point specifies the moment at which the material ignites for at least five seconds when a flame is applied at the lowest possible temperature.

After softening the Bitumen it is heated at constant temperature until a flash appears and the temperature is noted down. The heating is continued until the bitumen literally catches fire. The temperature is noted down and this is the fire point. This experiment is performed frequently on the site.

3) Ductility of Bitumen:

This experiment is done to measure the ductility of bitumen. The bitumen's ductility or its ability to stretch is the distance in cm the bitumen sample stretches before it breaks. Ductility of bitumen is required to know how longer it can spread while we pouring the bitumen higher the ductility more area can be covered.

4) Viscosity of Bitumen:

The viscosity of bitumen is determined by timing the flow of bitumen through a glass capillary viscometer at a given temperature. The product of flow time and calibration matter gives the viscosity of in centistokes. This test is conducted to check the flow of bitumen.

5.1.5 Soil and Aggregation Test:

1) Sand Equivalent:

This test is used to determine the proportion of clay like particles in fine soils. In the sand equivalent test, appropriate aggregate and a solution are mixed together and violently shaken which separates the clay like particles from fine soils. After this, the height of the clay particles and the sand particles are determined and the sand equivalent is expressed as a ratio of the height of sand over the height of clay. Higher sand equivalent values indicate "cleaner" (less fine dust or clay-like materials) aggregate.

AASHTO T-176

2) Specific Gravity of Coarse and Fine Aggregates:

The coarse aggregate specific gravity test is used to for determining the specific gravity f coarse aggregates. Specific gravity can be calculated by measuring the weight of aggregates and equally weighted water and then taking their ratio. It is similar in nature to the fine aggregate specific gravity test. AASHTO T 85.

For Fine Aggregate Specific gravity test it is AASHTO T 84, the test is similar to coarse aggregate test. Absorption, which is also determined by the same test procedure, is a measure of the amount of water that an aggregate can absorb into its pore structure. Pores that absorb water are also referred to as “water permeable voids”.

It is a very important test for determining the specific gravity because these aggregates are used further in construction.

3) California Bearing Ratio:

To evaluate and measure the strength of subgrades and base courses, this test is used by penetrating the soil sample. It requires a plunger of a specified area and it is allowed to fall on the soil sample until it penetrates it. To know the penetration on crushed material we determine the ratio of the pressure measured by the experiment and the pressure required for penetration. ASTM-D-1883

4) Plasticity Index:

This term gives us the measure of the flowing capacity or the plasticity of soils. The water content range of any soil which shows these flowing characteristics gives us the size of plasticity index. Accordingly high plasticity index means that the soil is clay and as the water range goes down so does the flowing capacity. ASTM D-4318

5) Field Density Test:

The in situ density of natural soil is needed for the determination of bearing capacity of soils, for the purpose of stability analysis of slopes, for the determination of pressures on underlying strata for the calculation of settlement and the design of underground structures. It is very quality control test, where compaction is required, in the cases like embankment and pavement construction.

The sand is placed in a calibrated cylinder and then the bulk density of soil and finally the dry density of soil are determined.

6) Maximum Dry Density Test:

This test determines the point at which the soil will exhibit the maximum density which will be at a corresponding water level. To determine this soil sample is compacted into cylindrical moulds of specified dimensions at a given water level. After this is done the same procedure is repeated for various other moisture contents and their dry densities are determined. A graph is plotted between the moisture content and the dry density to get a curve and the peak of the curve gives us the maximum dry density from the corresponding moisture content. AASHTO T-193

5.1.6 Quality Control:

A Quality control inspector from the consultant side is present to conduct these tests and it is only after his approval that the contractor can use the material under consideration.

5.2 CONCLUSION

The new Benazir Bhutto international airport provides us with a ravishing prospect of a first world class international airport in Pakistan. To ensure that the construction is done according to standards and proper quality control and quality assurance is maintained, the contractors together with the consultants are doing a great job by proper monitoring by their respective employees. The material testing is done according to the international standards to ensure the quality and in terms of quality in managerial aspect, every package of construction has it's devolution of authority starting from the quality control manager right down to the employees working on the quality principles.

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APPENDIX

Table A-1

Main Laboratories	
Test	**AASHTO Designation**
Asphalt Test	
i. Specific Gravity	T-166
ii. Penetration	T-49
iii. Extraction	T-164
iv. Gradation	T-30
v. Viscosity	T-20, T-202
vi. Stability	T-245
vii. Bulk Sp. gravity	T-230, T-166
viii. Marshall Test & Loss stability	T-245
ix. Flow	T-245
x. Flash & Fire Point	T-48
xi. Solubility of bitumen in organic solvent	T-44
xii. Coating & stripping of bitumen aggregate mixture	T-182
xiii. Sampling bituminous material	T-40
CBR	T-193
Sieve Analysis of soils, aggregate & mineral filler	T-88,T-27 &T-37
Unit Wt. of aggregate	T-19
Abrasion Test (aggregate)	T-96
Atterberg Limit	T-89 & T-90
Sand Equivalent	T-176
Sodium Sulphate Soundness	T-104
Specific Gravity & water absorption of coarse aggregate	T-85
Specific Gravity & water absorption of fine aggregate	T-84
Slump Test	T-119
Moisture density relationship of soil (modified method)	T-180
Moisture density relationship of soil (Standard method)	T-99
Specific Gravity of soil	T-100
Amount of material passing 200 sieve	T-11
Clay lumps and friable particles in aggregates	T-112
Curing concrete compressive test specimen	T-23
Making and curing concrete Test Specimen	T-141, T-126
Compression Test (concrete)	T-22
District Laboratories	

CBR	T-193
Sieve Analysis of soils, aggregate & mineral filler	T-88,T-27 &T-37
Moisture density relationship of soil	T-180
Atterberg Limit	T-89 & T-90
Sand Equivalent	T-176
Sodium Sulphate Soundness	T-104
Specific Gravity	T-85
Absorption	T-85
Slump Test	T-119
Field Laboratories	
Sieve Analysis of soils, aggregate & mineral filler	T-88,T-27 &T-37
Atterberg Limit	T-89 & T-90
Field Density	T-191 or T-238 & T-239
Moisture density relationship of soil	T-180

Table A-2

Sl. no.	Description	Record Availability			
		TL	REs	AREs	Site office
1	Contract Documents	√	√	√	√
2	Drawings, Specifications	√	√	√	√
3	Inspection Instructions, RFI and work Instructions			√	√
4	Quality Assurance Manuals and System Procedures	√	√	√	√
5	Field Inspection and Checklists and inspection reports			√	√
6	Interim Payment Certificate Records	√	√		
7	Subcontractors Records	√	√	√	
8	Inspection Measuring and Test Equipment Calibration records				√ (Lab.)
9	Nonconformance and Corrective action Records	√	√	√	
10	Approved submittals	√	√		
11	Maintenance Manuals	√	√	√	√
12	Field Inspection and Checklists and inspection reports- In ARE office			√	√
13	Inspection log book			√	√
14	Laboratory test reports- Laboratory record				√ (Lab.)

15	Joint Cross-sections, original in Head office PMC			√ (copy)	