



**NEAR EAST UNIVERSITY**

**INSTITUTE OF APPLIED  
AND SOCIAL SCIENCES**

**EFFECTS OF QUALITY CONTROL PLANNING  
ON TIME AND COST FOR REINFORCED  
CONCRETE BUILDINGS CONSTRUCTION  
PROJECTS**

**Mohammed Fawzi ASLAN**

**Master Thesis**

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PLANNING ON TIME AND COST FOR REINFORCED  
CONCRETE BUILDINGS CONSTRUCTION PROJECTS**

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DEDICATED TO

**MY PARENTS, & WIFE FATIMA**

WHOSE RESTLESS EFFORTS AND ENDLESS

PRAYERS ENABLED ME TO ACHIEVE

THIS AIM

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## **ABSTRACT**

Effects of quality control planning on time and cost for reinforced concrete  
buildings construction projects

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The quality of buildings reflects to the constructors as well as the clients as the service time of the building.

This thesis sets out to demonstrate that if principles of quality control are applied in building construction, it may affect the time and cost.

The proposed project is four storey residential building, supported with it's unique construction design based on American Codes.

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Also it gives two modern computer planning of this building construction. The first plan excludes the quality control charge, while the second plan includes the quality control charge to show the difference between them. It also covers the quality management factors and construction planning supported with two modern planning software.

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## **LIST OF ABBREVIATIONS**

<i>Symbol</i>	<i>Means</i>
QC	Quality Control
QA	Quality Assurance
QM	Quality Management
TQM	Total Quality Management
QS	Quality System
QMS	Quality Management System
ISO	International Standard Organization
ASTM	American Standard of Testing Materials
BS	British Standard
P3	Primavera (Computer Based Planning Program)
R/C	Reinforced Concrete

## **CHAPTER 1 INTRODUCTION**

1.1 Introduction to subject

1.2 Objectives

1.3 Reasons for objectives

1.4 Work undertaken

1.5 Achievements

1.6 Guides to the thesis

## 1.1 INTRODUCTION TO SUBJECT

"Quality Control" of the buildings construction sector has become linked in many construction managers' minds. This is partly because similar approaches to quality control is identified in the relevant British and international standards and partly because, in the minds of many senior managers, the issues of quality control is major threads in the strategic thinking which is expected to guide most organizations into the twenty-first century.

Managers have always been responsible for the quality application and systems of buildings construction produced by their teams. In this sense, there is nothing new about "Quality Control", but the emphasis given to delivering quality more systematically and in every aspect of the construction sector has certainly grown over the years. This is a reaction to at least two factors:

- Poor quality in construction components, production processes and service to clients.
- A reduction in clients' tolerance of poor quality. {1}

## 1.2 OBJECTIVES

The main objectives of this research are:

- Determining the principles and concepts of construction quality management and ways of assessment. This includes determination of the factors that affect the quality of a constructed facility.
- Determining the concepts and principles of the construction planning and its application to the construction.

- Determining the concepts and principles of the "Quality Control" for conventional reinforced concrete buildings construction supported by details of stages of quality control.
- Carrying out surveys with construction controllers (Four approved construction laboratories in Palestine) to determine the benefits needs of quality control application and its effects on the time and cost.
- Determining the degree of the effects of quality control application principles on the construction buildings plan.

### 1.3 REASONS FOR OBJECTIVES

The reasons for the aims can be written as:

1. To understand how to manage and plan the building construction with the international and modern techniques ways.
2. To understand how to construct a concrete building at the required quality.
3. To understand how to produce uniform construction materials throughout the job.
4. To investigate the ways of avoiding interruption in building construction and being able to finish the job at the planned time.
5. To understand the ways of testing the construction materials on the site and the construction laboratories at the minimum cost and time.
6. Being able to compare the time and cost of two different construction plans.

### 1.4 WORKS DONE

In order to achieve the objectives explained in section 1.2, the followings were done:

1. Four construction control institutes and laboratories were surveyed.

Which are:

- Association of Engineers – Materials Testing Laboratories
- Geotechnical and Materials Laboratories



- ♦ Osman & Farra Construction Materials Laboratories
- ♦ Islamic University - Materials and Soil Laboratories

## 1.5 ACHIEVEMENTS

According of the questionnaire that was done in Palestine, the quality control application as cost & time, man power costs and construction materials of the four storey apartment building was taken into consideration based on the Palestinian construction standards. Costs estimating of two methods which are included and excluded quality control are described. The time and cost of building construction are compared.

## 1.6 GUIDES TO THE THESIS

This thesis is divided into six sections. First section includes chapter I. This section defines the problem addressed by the researchers and discusses the background to the problem. It highlights the objectives and achievements of the research.

Second section includes chapter II and III. This section includes the theoretical and literature review of the principles of the construction management and construction planning supported with two computer programs.

Third section includes chapter IV, which gives the quality control application ways, discussions and international standards for the buildings construction process.

Fourth section includes chapter V and VI. Chapter V includes the surveys and the techniques used in the evaluation of the effects of the quality control principles on the duration and cost of the buildings construction projects, and in chapter VI, the conclusion, recommendations and implications for future research are mentioned.

## **CHAPTER 2 CONSTRUCTION QUALITY MANAGEMENT**

- 2.1 Introduction
- 2.2 Reducing construction cost
- 2.3 Quality
- 2.4 What is the “Quality Management”?
- 2.5 Construction “Quality Management”
- 2.6 The Role of the “Quality Manager”
- 2.7 The benefits of “Quality Management”

## 2.1 INTRODUCTION

The term construction management may be confusing since it has several meanings. As the construction engineers we can say it refers to the act of managing the construction process. The construction manager, who may be a contractor, project manager, superintendent, or one of their representatives, manages the basic resources of construction. These resources include workers and subcontractors, equipment and construction plant, material, money (income, expenditure, and cash flow), and time. Skillful construction management results in project completion on time and within budget. Poor construction management practices, on the other hand, often result in one or more of the following:

- Project delays which increase labor and equipment cost and the cost of borrowed funds.
- High material costs due to poor purchasing procedures, inefficient handling, and/or loss.
- Increased subcontractor cost and poor contractor-subcontractor relations.
- High insurance costs resulting from material and equipment loss or damage or a poor safety record.
- Low profit margin or a loss on construction volume.

Such poor management practices, if long continued, will inevitably lead to contractor failure.

While the principal objectives of every construction manager should be to complete the project on time and within budget. Responsibilities like safety, worker morale, public and professional relations should be taken into consideration. {1}

## 2.2 REDUCING CONSTRUCTION COSTS

Some of the best opportunities for construction cost savings occur in the design process even before construction begins. Some design factors that can reduce construction costs include the use of modular dimensions, grouping plumbing and other equipment to minimize piping and conduit runs, incorporating prefabricated components and assemblies, utilizing economical materials, and employing new technology. Injecting



constructability considerations into the design process is one of the advantages claimed for the use of the construction management contract arrangement.

Some ways in which productivity can be increased and costs minimized during construction include:

- Good work planning.
- Careful selection and training of workers and managers.
- Efficient scheduling of labor, materials, and equipment.
- Proper organization of work.
- Use of laborsaving techniques such as prefabrication and preassembly.
- Minimizing rework through timely quality control.
- Preventing accidents through good safety procedures. {2}

### 2.3 QUALITY

There are many different definitions of quality. Manufacturing-based definitions view quality as the ability to conform to requirements or specification. This measure of quality is objective, in that it is based purely on the ability of the product or service to meet a predefined specification or standard. We might, for example, measure if an electric fire produces the correct output of heat or whether a percentage of construction projects were completed on time. The problem with this type of quality definition is that there is no indication that what is measured is in fact what the customer wants. It is an inward-Looking measure of quality that could not be defined as a total quality approach. Product-based definitions of quality are also objective in that they are based on a measure of a specific characteristic of a product such as, for example, durability or maintenance. Also principal quality dimensions can be written as:

- Performance:

This is the primary reason for having the project along with the main characteristics it must have. In terms of a hospital this may therefore be the provision of wards, waiting rooms and operating theatres. {2}



- Reliability:

This asks if the building will operate for a reasonable period of time without failure.

- Conformance:

This is the degree to which specification is met.

- Durability:

This is the length of time a building lasts before it needs to be replaced.

- Serviceability:

This is the service given after the building is completed, particularly with regard to repair.

- Aesthetics:

This is how the building looks and feels.

- Perceived quality:

This is the subjective judgment of quality that results from image. {2}

Quality dimension	Building performance.
Performance	Do the majority of buildings achieve their main purpose?
Reliability	Are they reliable?

Conformance	Do they conform to the specification?
Durability	Do they last a longer or shorter period than is required?
Serviceability	Are they repaired quickly and with a quality service?
Aesthetics	Are they aesthetically pleasing internally and externally?
Perceived quality	Does the user and client feel it is a quality building?

**Table 2.1** Below examines these quality dimensions further. {2}

Also from dictionary it can defined as:

- Distinguishing characteristic: a distinctive characteristic of something.
- Essential property: an essential identifying nature or character of something.
- Standard: the general standard or grade of something.
- Excellence: the highest or finest standard quality products.
- People of upper social class: people of high social position. {3}

## 2.4 WHAT IS QUALITY MANAGEMENT?

Ironical as it may seem, an apparent problem with quality management is the word quality itself. For some it signifies excellence, and they may believe that ISO 9000 will automatically make their products or services better than a competitor's. Perhaps it can, but simply having 'quality', as if it were a bolt-on attachment, will not achieve the excellence they imagine. Improvement, which should be the objective, takes more than implementing a system. {5}

### 2.4.1 Getting to grips

When offering a service or product, the minimum objective of any organization or individual is to provide what is expected. There will be a provider and a customer.

Both are free to obtain what they can from the transaction and there is usually a market consisting of customers who can willingly purchase wherever they like. Providing they have choice, customers will normally seek to maximize their purchasing power. We all tend to buy on a daily basis, and normally we do so on the basis of the maxim: You pay your money and you take your choice. There is a tendency to think that quality has a price. Indeed it may, and to use the oft quoted cliché: You pay Rolls-Royce money and get a Rolls-Royce product.

However, a purchaser has an expectation about what they desire in seeking to maximize their purchasing power. The calculation that occurs is individual and perceptive. In effect, consumers make sophisticated judgments about value. Thus the amount they are prepared to spend provides a guide to the expectations. Normally we do it every day of our lives in order to achieve satisfaction.

Economists call this the theory of utility. It tries to provide an explanation of the decisions we make in terms of apportioning fixed income. We will try to ensure that what we receive will represent good investment.

Reputation plays its part. If you are recommended to use a particular supplier, it is usually because others who have used them think they are good. This does not mean that such suppliers are necessarily expensive. Far from it, they may be extremely cheap in comparison to others. The difference is that their product or service performs well in comparison to competitors. What is worth asking is how do good suppliers achieve their reputation?

Most potential buyers rarely bother to verify how suppliers actually manage their organization. As long as buyers continue to get what they expect, they will normally continue to purchase from them. But the important point is that being able to supply what customers want is not something which can be left to chance. It requires management, and quality management is the process that any sensible organization will use in order to consistently satisfy its customers' expectations. It need not be complicated. In fact, it can be summarized as being good or sensible management. {4}



### 2.4.2 The four stages

There are four stages of quality management (QM): inspection, quality control (QC), quality assurance (QA) and total quality management (TQM). Figure (2.1) shows the progression from one stage to the next.

Inspection and QC are retrospective; they operate in a detection mode, aiming to find problems that have occurred. QA and especially TQM aim to reduce and ultimately to avoid problems occurring. {4}

#### 2.4.2.1 Inspection

Inspection is the activity such as measuring, examining, testing or gauging one or more characteristics of an entity and comparing these results with specified requirements in order to establish whether conformity is achieved for each characteristic.

Using inspection to ensure conformance is still widely used in some industries, particularly construction. Much of what is built will be compared to the drawings and specifications. Unless the customer agrees otherwise, the contract requires that anything which does not conform will need to be done again until the client is satisfied that it meets the specification. {4}

#### 2.4.2.2 Quality control (QC)

This stage is often regarded as an extension of inspection ASTM; it involves the operational techniques and activities that are used to fulfill requirements for quality.

QC will require collection of data in order to use statistical techniques. From this information, trends will often emerge which show where certain problems are occurring. This technique is used as a matter of course in manufacturing. It is much rarer in construction. Statistical analysis of concrete cube test results is the one situation where statistics are routinely used. {4}

### 2.4.2.3 Quality assurance

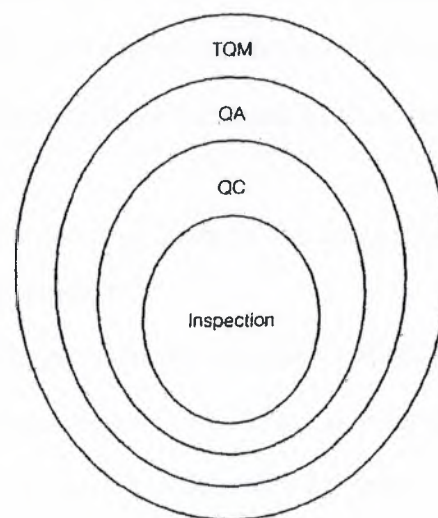
In a detection or environment, the emphasis is on the product, procedures and or service deliverables and the downstream producing and delivery processes.

Considerable effort normally goes into removing faults or problems before the product or service reaches the customer. However, this is not satisfactory because in this approach, there is a lack of creative and systematic work activities and planning and improvements are neglected. Problems in the process are not removed but contained. As they stress: An environment in which the emphasis is on making good the non-conformance rather than preventing it arising is not ideal for engendering team spirit, co-operation and a good working climate.

The focus tends to be on switching the blame to others, people making themselves "fireproof", not being prepared to accept responsibility and ownership, and taking disciplinary action against people who make mistakes.

It is essentially what is being advocated is that any organization should aim to logically 'prevent rather than cure' problems. In effect, using quality management should be proactive rather than reactive.

BS defines quality assurance as being all the planned activities implemented within the quality system, and demonstrated as needed, to provide adequate confidence that an entity will fulfill requirements for quality. {4}



**Figure 2.1** The four stages of quality management.



## 2.5 CONSTRUCTION QUALITY MANAGEMENT

It has long been recognized that in all construction projects steps must be taken to ensure that the constructed project meets the requirements established by the designer in the project plans and specifications. More recently, the terms quality management (QM) and quality assurance (QA) have been adopted to include all aspects of producing and accepting a construction project which meets all required quality standards. Quality management includes such activities & specification development, process control, product acceptance, laboratory and technician certification, training, and communication. Quality control (QC), which is a part of the quality management process, is primarily concerned with the process control function. Since the contractor has the greatest control over the construction process, it has been found that quality control is most effective when performed by the contractor.

Regardless of the procedures established, the construction contractor is primarily responsible for construction quality. Quality assurance inspections and tests performed by an owner's representative or government agency provide little more than spot checks to verify that some particular aspect of the project meets minimum standards. The combined effect of increased cost and poor reputation often leads to construction company failure.

In recent years, there has been an increasing use of statistics-based methods for quality assurance, particularly in asphalt and concrete pavement construction.

Since the results of virtually all construction processes are products which vary over some statistical distribution, statistical methods can be used for such purposes as:

- Ensuring that all elements of the work have an equal chance of being included in test samples.
- Verifying that test samples taken by the contractor and by other parties come from the same population.
- Analyzing the variations in the test results of material and processes sampled.
- Establishing acceptable levels of variation in sample results.
- Developing a payment schedule which rewards or penalizes the contractor depending on the level of quality attained in the constructed product. {5}

### 2.5.1 Total quality management (TQM)

Although it is not a prerequisite, TQM often follows the implementation of QA.

This is a normal transition and should not be interpreted as QA having failed.

The change from QA to TQM will need to be carefully managed. Although it normally requires the use of procedures and may be criticized for being too formal, QA does have the advantage of being tangible. It is possible to see how well the system is being accepted by auditing. If the procedures are being adhered to, the QA system can be judged successful. If procedures are not being adhered to, then they need to be rewritten or the users need more explanation of what is required.

TQM is less formal, having neither system nor procedures, but its very lack of formality makes it more difficult to describe. It is often described as a philosophy, which requires change in things like attitude, management style and culture. According to BS, TQM is a management approach of an organization, centered on quality, based on the participation of all members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society.

A list of five essentials for TQM:

- Intense focus on the customer
- Concern for continual improvement
- Improvement in the quality of everything
- Accurate measurement
- Empowerment of employees

It is significant to put the customer at the top. The word customer is not only the end customer as QA tends to imply. In every process there are various stages of production in order to provide the end result which gives the customer what they want. At every stage of the process, one group of people passes on the goods to another group of people. This is like the relationship between traders and buyers. In effect, the receiver of the goods is a customer. They have expectations which, if satisfied, will assist in providing the end customer with what they expect. This concept describes the internal customer, who is crucial to the philosophy of TQM. It is only by addressing all the constituent parts of every process that total improvement can be achieved. {4}



### 2.5.2 Benchmarking

Many firms have introduced benchmarking. It involves studying the best practices and achievements of competitors and others in the field, and adopting them as standards for improving the company's own performance. Benchmarking can be integrated with TQM or used as part of any quality system. It can include looking at the processes in, and product/service features of, other industries. Indeed, this is sometimes where the most creative improvements can be found. So important is this activity in a highly competitive environment that organizations may set up a research department to do their benchmarking activities. {4}

## 2.6 THE ROLE OF THE QUALITY MANAGER

Relatively little tends to be written about the work of a quality manager. This is perhaps surprising, given the importance of quality management.

Contrary to popular misconception, the role of a quality manager is not exclusively technical and need not be executed in a highly mechanistic fashion. In practice the system must be used by people who work in the organization, but as Jackson and Ashton admit, from the tasks indicated it may appear that the quality manager's role is relatively mechanistic, administration rather than management.

What stress is that the role has two interrelated parts:

- Administration (system skills)
- Management (people skills)

The administration skills consist of the following:

- Planning
- Record keeping
- Reporting
- Document production
- Liaison with assessors
- Understanding quality standards

These skills probably do require specialist technical know-how on what the organization will need to do in order to achieve ISO 9000.

The management skills are much more about the need to manage human relations:

- Leadership
- Championing
- Facilitating
- Motivating
- Re sourcing

It could be argued this is not a perfect list. For instance, it makes no explicit mention of communication. Never the less, it does contain the major elements of people management.

The quality manager must then be able to sympathies with any concerns, and support individuals' efforts.

Because quality managers require a variety of well-developed skills, they need to be carefully selected. Those who make the appointments should look beyond the short-term aim of getting the plaque on the wall. Although the immediate requirement is for someone to get the system up and running, the real objective is to find someone that will deliver long-term benefits. Such management skills are not exclusive to developing a quality management system. They apply to every level of management. However, they are the same characteristics that are particularly necessary when attempting other forms of quality management, such as TQM. Later chapters cover them in detail. Now it is time to look at some experiences of quality managers from construction companies. They more than amply demonstrate that, in conjunction with system skills, people skills are essential when implementing QA. {4}

satisfaction and incurs lower running costs. But, importantly, higher quality does not necessarily mean higher costs. There are costs associated with poor quality, examples of which are:

- The management cost of handling clients' complaints.
- Inspecting the work concerned.
- Making good faulty work.
- Replacing sub-standard materials and components. {4}



## **CHAPTER 3 CONSTRUCTION PLANNING**

### 3.1 Introduction

### 3.2 Planning techniques

### 3.3 Developing a network model

### 3.4 Computer – based construction planning

### 3.1 INTRODUCTION

Planning can be thought of as determining "what" is going to be done, "how," "where," by "whom," and "when." In construction projects the "plans" (blueprints) and specifications for the project generally define both the end product and, often, the general time frame in which to complete the project. However, they normally do not specifically identify the individual steps, their order, and the timing followed to achieve the end product. Thus, when we discuss planning in the construction process, we must address the "how" and, therefore, the "what," "when," "where," and "who."

When we discuss scheduling, we are usually interested in some aspect of the time element of the plan. In essence, a schedule is a timetable of activities, such as of what will be done or "who" will be working. Such a timetable can be looked at in two ways: The first is focusing on an activity, such as determining "when" a certain task will be performed relative to other activities. The second is concentrating on a specified time frame and then ascertaining "who" will be working (or needed) or what should be occurring at a particular time. All of us are involved in planning and scheduling on an ongoing basis. The degree to which we carry it out and the techniques we use vary depending upon the complexity of our situations and our needs and objectives.

We all do planning and scheduling on a regular, albeit informal basis. For whatever undertaking, we mentally determine a plan and schedule, such as what we will do in the next half-hour or how and when we will accomplish that task, such as a homework assignment. Often it is necessary for us to go a step beyond this level by creating a "to-do list." None of us can retain the organization of all the tasks we have to do on a daily basis, so we document what needs doing by writing down the information. This is also helpful if we are coordinating with other parties. By writing down the list of items, and perhaps copying and distributing it, we have documented a basis of agreement. We may also prioritize this list by writing the items in the order in which they will be done.

As the number of items increase and/or the time frame expands, we find we have to put our to-do list in the context of time. Normally, we do this using an appointment book or calendar. The driving forces typically are to avoid scheduling multiple things at the same time, to ensure that we allow sufficient time to prepare for an event, and/or to

provide a record of what activities we undertook and when and how long we spent on them. {6}

Or we can summarize the construction planning in some rows:

- Planning is defined by ASCE as the process of developing and formulating a course of action to be taken in the future.
- Planning is the systematic identification of program tasks, tasks schedules, and resources required for task accomplishment.
- Planning can be thought as determining "what is going to be done", "how", "where", by "whom", and "when".
- In a construction project plans (Blueprints) and specifications generally define the end product and the general time frame to complete the project.
- Thus, when we discuss planning in the construction process we must address the "how", and therefore, the "what", "when", "where", and "who". {7}

### 3.2 PLANNING TECHNIQUES:

Planning techniques covered in this article are as follows:

- Bar charts
- Networks
- Linear scheduling

### 3.2.1 Bar charts

Bar chart is a list of activities relating to a time scale in an effective manner

- It is especially used in un-complex constructions ( Figure 3.1)
- Major advantages of bar charts are:
  - Easy to prepare
  - Easy to understand
  - Easy to show the scheduled versus actual progress

#### 3.2.1.1 Progress reports

- Bar charts can show the scheduled versus actual progress of construction. (Figure- 3.1).
- In (Figure 3.1) the heavy dashed vertical line represents the current date, and the shaded portions of the activities indicate the amount of work completed by the current date. {7}

#### 3.2.1.2 Shortcomings of bar charts

- Figure (3.3) is the network form of figure (3.2).
- However, bar charts possess some features that make them difficult to use in complex projects.
  - In figure (3.1) there are several activities occurring simultaneously and bar charts do not show clear dependencies between activities.
  - Figure (3.2) shows the relative status of completion. But there is another shortcoming of bar charts.



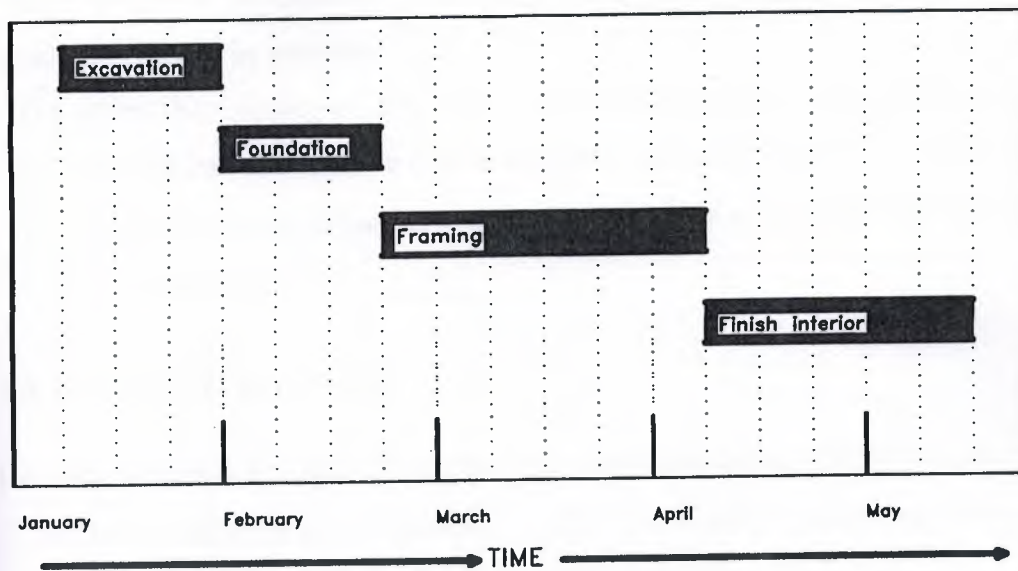


Figure 3.1 Bar chart showing general construction work tasks

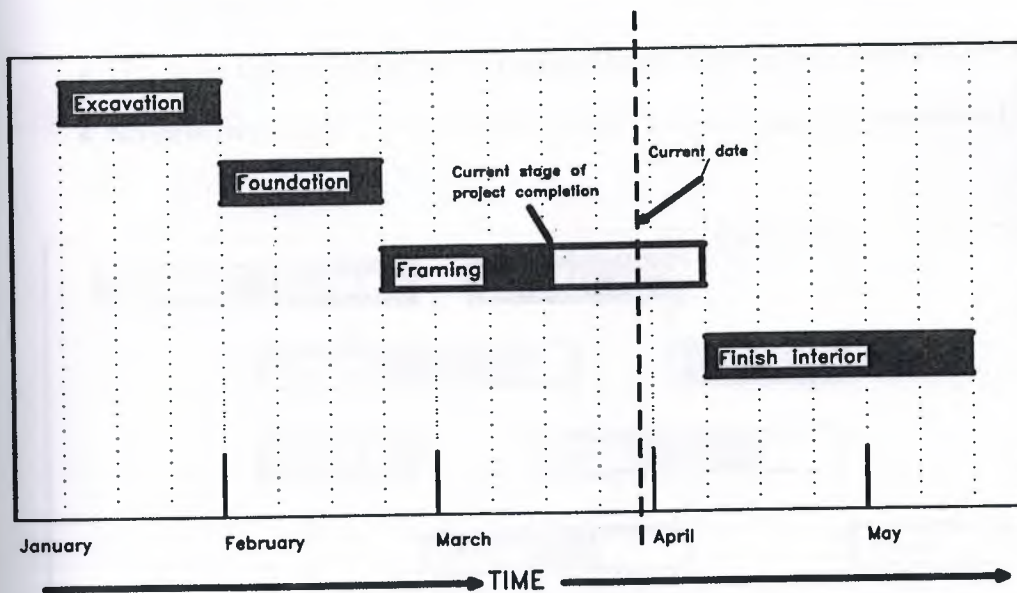


Figure 3.2 Bar chart showing scheduled versus actual performance



Figure 3.3 Simple arrow diagram of a project showing activity sequences

- Although the status of individual activities can be readily ascertained, the overall status of a project can not be determined when some activities are not on schedule.

- So, it is difficult to assess the need for making scheduling adjustments and to decide which activities to be accelerated.
- The other shortcoming of bar chart is "a change in the logical sequencing of the activities can not be made readily especially when many activities are involved.
  - The information in the bar chart in figure (3.4) is shown in the network diagram in figure (3.5). {7}

### 3.2.1.3 Value of Bar Charts

Despite their shortcomings, the value of bar charts can not be underestimated.

- Their major strength is the ability to clearly and quickly present the status of a project.
- Bar charts can be used to convey - often to upper management - the overall status of a project.
- The same type of information might also be conveyed to subcontractors.
- No extensive training is required to learn how to extract information from it.

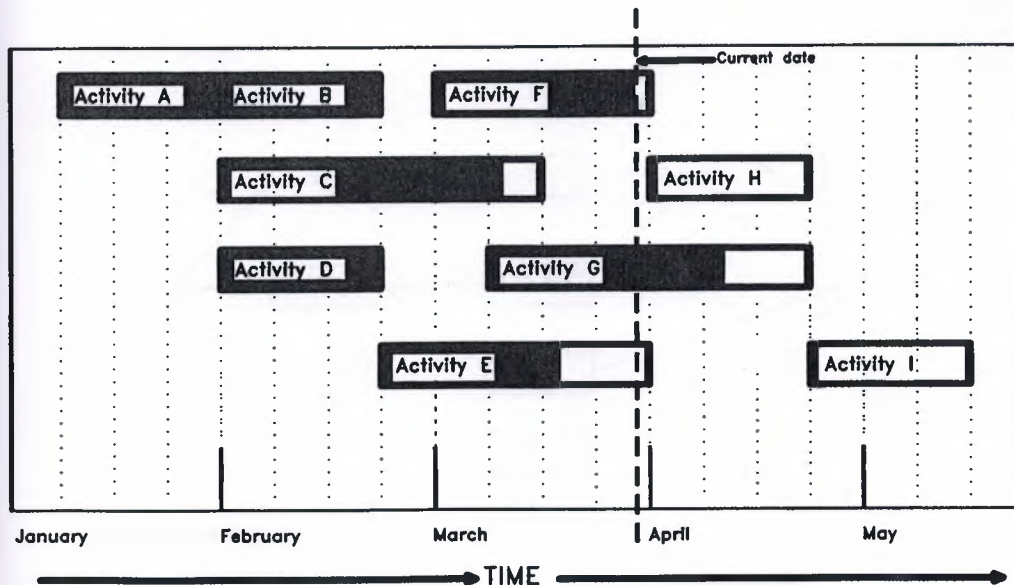


Figure 3.4 Bar chart showing construction work tasks

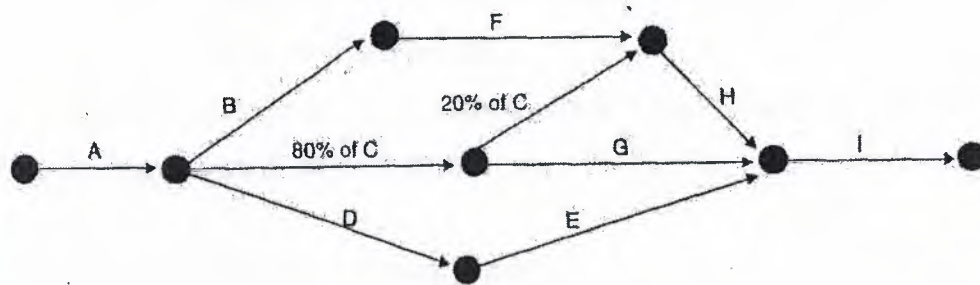
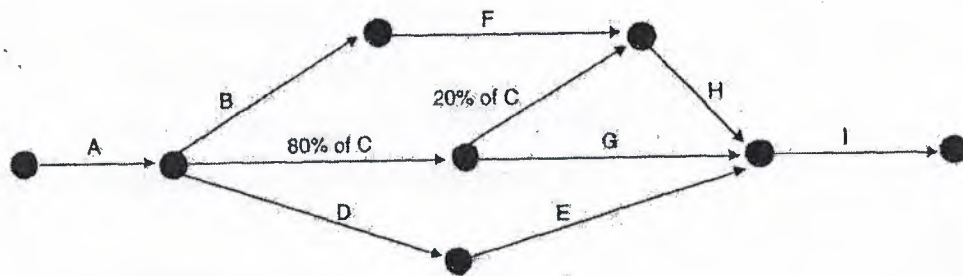
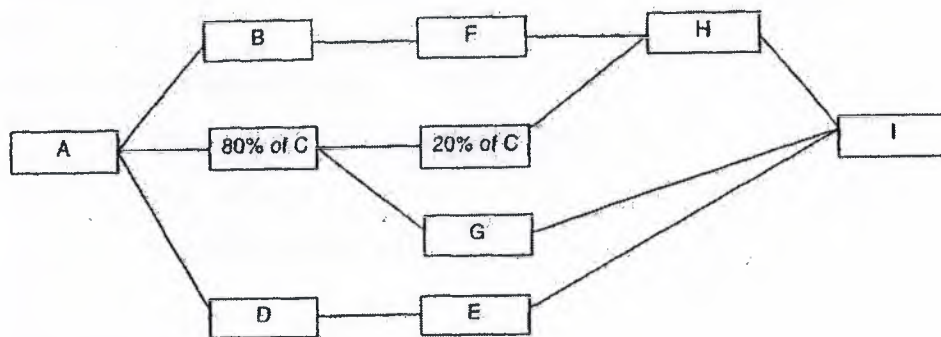


Figure 3.5 Arrow diagram of the project show erlier in bar chart form



(a) Arrow diagram



(b) Precedence diagram

Figure 3.6 An arrow diagram and a precedence diagram

### 3.3 DEVELOPING A NETWORK MODEL

- The model must bear a reasonably accurate portrayal of the actual steps to be followed in constructing a facility.
- The network represents not only a physical scale model of a project, but also represents a time-oriented model.

#### 3.3.1 Steps in Building A network Model

1. Define activities
2. Order activities
3. Draw a network diagram
4. Assign durations of activities
5. Assign resources and costs
6. Calculate early and late start/finish times
7. Schedule activity start/finish times. {7}

##### 3.3.1.1 Defining activities

Anything that must be accomplished (whether by the owner, contractor, subcontractor, supplier, inspector, or other parties) to complete the project may warrant inclusion in the network.

Types of activities are as follow:

- a. Production/construction activities
- b. Procurement activities
- c. Management activities

##### a. Production/Construction Activities

- They relate directly to the physical effort of creating the project.
- They are the most readily understood activities using labor effort to complete a facility.
- They include activities require not only labor but time also (e.g. curing concrete requires no labor but time).



**b. Procurement Activities**

- They are activities for the acquisition of materials, money, equipment, and manpower.
- Readily available procurement activities generally do not take place (Cement, aggregate, etc.)
- Special order, long or uncertain lead-time items activities should be incorporated into the network.

**c. Management Activities**

- They are activities for support of administrative tasks. Such as, activities preparing inspection reports, processing shop drawing approvals, tracking submittal approvals, developing as-built drawings, providing certifications on factory tests performed.

**3.3.1.2 Ordering activities**

- The order of activities is based on the timing of some activities relative to the occurrences of the other activities.
- For each activity the following must be determined:
  - Which activities must precede it?
  - Which activities must follow it?
  - Which activities can be concurrent with it?
  - Once immediately preceding activities (IPAs) list is completed, the network can be created.

**3.3.1.2.1 Constraints**

The reason why two activities must be done in a particular order is termed as constraints. Without any constraint, all activities can start on the first day.

### Types of Constraints

#### 1. Physical constraints

- They exist due to the physical process of construction. For example, the need to erect the formwork before concrete can be placed.
- These are logical constraints include "how" the construction methods of the project will be carried out.

#### 2. Resource constraints

These are constraints of limited availability of the resources that dictate that certain activities can't be performed simultaneously. For example, having only one crane on the site for both to lift the heavy formwork elements and lifting concrete bucket.

#### 3. Safety constraints

- Safety requirements may dictate that activities can't occur simultaneously. E.g. overhead and ground level work in the same area, or drilling and blasting.
- Safety requirements may dictate a specified sequence to occur (e.g. Erection of safety barriers before allowing doing work in an area.
- Safety requirements may also dictate non- working days for extremely hot or cold days.
- Project lightning requirements may also be dictated by safety concerns.

#### 4. Financial concerns

- Monetary constraints can include staggering of high cost effective activities to minimize cash requirements at a specific duration.
- Definition of 'tax year' can also require contractors to consider schedule for large cash flow items.

#### 5. Environmental constraints

- Constraints include mitigation procedures prior to other activities (e.g. dust, noise, etc.)
- They also may include restrictions such as not working in certain areas during such times as spawning season, fish runs, or eagle nesting).

#### 6. Management constraints

- Referred to as "arbitrary" and can be defined as additional constraints not otherwise categorized.
- They may be requirements of supervisory time, consequences of tax strategy decision, cash flow needs or the demand of other projects not reflected in the network (giving days between Christmas and New Year day as holiday).

#### 7. Contractual constraints

The owner may impose constraints on the construction process (e.g. making ready to occupy the first part of a project while second part is still under construction).

It is desirable to minimize constraints. Excessive constraints in network logic can have the following impacts on a project:

- Reduce scheduling flexibility
- Lengthen project duration
- Generally increase project cost
- Confuse basic scheduling logic.

Only the physical constraints should be entered during the early development stage of the project model.

Other constraints can be deferred until the actual scheduling of activities for two reasons:

- i. the other constraints can be met by scheduling calculations naturally
- ii. Shifting activities can be within their available "float" times.

Figure (3.8) is a sample activity list and associated list.

#### 3.3.1.3 Drawing the network diagram

There are two commonly used types of Network Diagrams:

- a) Arrow diagrams
- b) Precedence diagrams

Both types present the same basic information about the sequence of activities.



**a) Arrow diagrams**

- Figure (3.9) depicts the activities as arrows, beginning at the tail and ending at the head of the arrow.
- The relationships of activities in an arrow diagram are conveyed by activities (arrows) that precede or follow the nodes.
- The difference between the activities and event is that, activity consumes time, while event represents point in time.

**b) Precedence diagrams**

- Precedence diagram depicts activities as nodes and shows the relationships among activities by logic link lines that show dependencies between activities (Figure 3.9, the same project of Figure 3.8).
- The selection of an arrow diagram or a precedence diagram is not important. However, recently precedence diagram is becoming more popular.

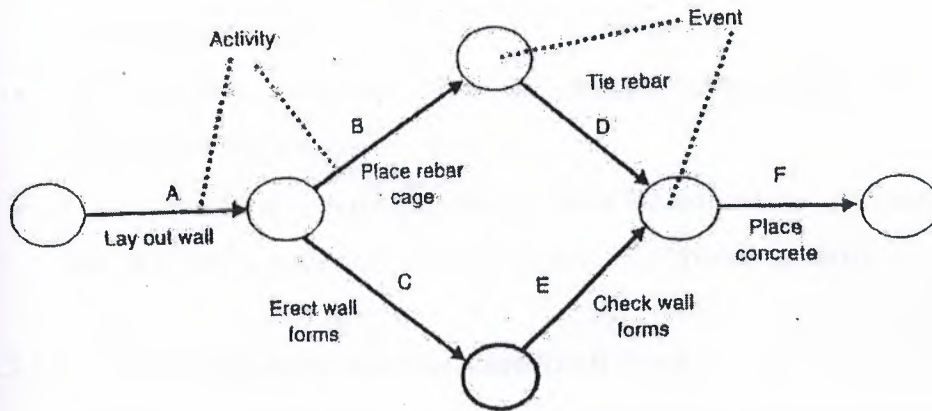
**3.3.1.4 Assigning durations to activities**

- The duration of an activity is an estimated time that will be required to complete it.
- The widely used unit of time in construction industry is 'day', however, 'month', 'week', or even 'hour' are also used.
- Defining duration is less of a science than it is an art.
- Activity durations frequently are tied directly to the resources, (e.g. crew size and equipment) and the productivity of the resources.

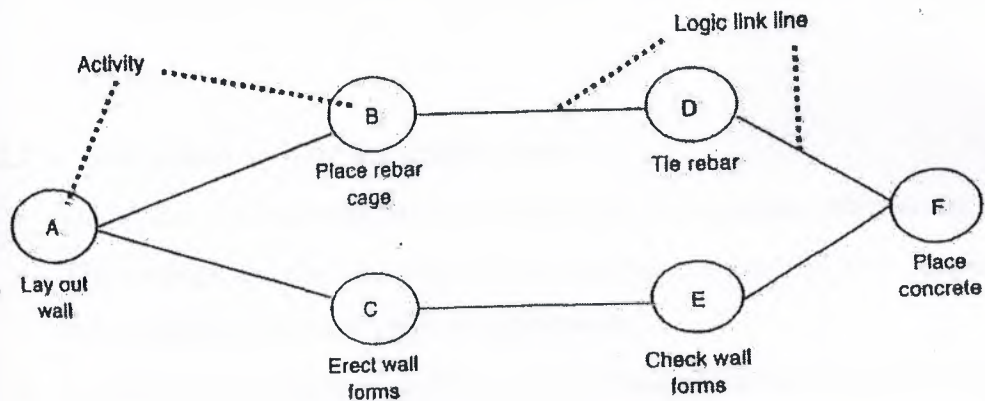
Activity label	Activity description	IPAs
A	Lay out foundation	--
B	Dig foundation	A
C	Place formwork	B
D	Place concrete	G, H
E	Obtain steel reinforcement	--
F	Cut and bend steel reinforcement	E
G	Place steel reinforcement	C, F
H	Obtain concrete	--

**Figure 3.7** Sample Activity List with IPAs





**Figure 3.8** Simple example of an arrow diagram for erecting a concrete wall



**Figure 3.9** Simple example of a precedence diagram for erecting a concrete wall

- Duration of an activity is

Crew-hours = Quantity of work / (quantity/crew-hours) or, Days - crew-hour / (hours / day)

- The primary issue is the reliability of the productivity factor (Quantity/crew-hour)

**3.3.1.5 Assigning resources and costs**

- CPM analysis includes evaluation of the temporal (time) distribution of resources and costs.
- Each activity associates with the amount of resources (labor, materials, and equipment) it requires and cost.
- Cost information is derivable directly from the estimating process, as costs for the labor, materials, and equipment for a specific activity.

**3.3.1.6 Calculating early and late start/finish times**

- Steps (3.3.1.1) to (3.3.1.4) must be completed for calculations to be made on the network.
- The initial calculations include the early/late start times and early/late finish times of activities.
- If the early and late start times differ, the activity is said to have flexibility or 'float'.

**3.3.1.7 Scheduling activity start/finish times**

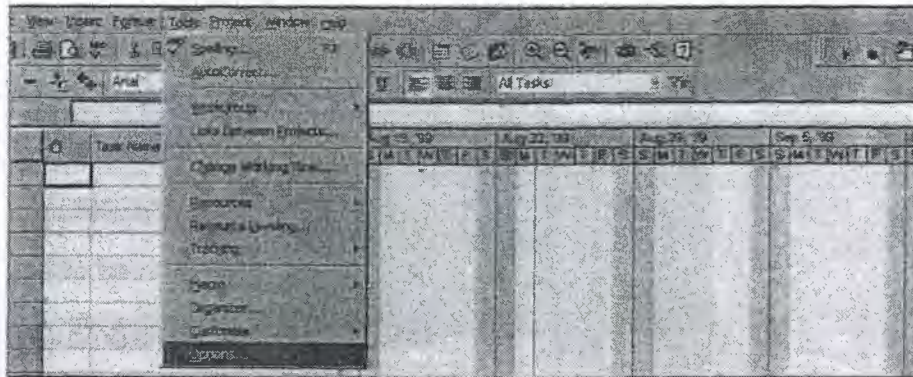
- Once the calculations have been made, the management process can begin.
- The network and the information generated for each activity will be used for management to execute project requirement.
- Management decision essentially revolves around the use of any flexibility or float that the activity possesses.
- The key is that the scheduling information must be used to make the network as a management tool. {7}

### 3.4 COMPUTER- BASED CONSTRUCTION PLANNING

#### 3.4.1 Scheduling with “Microsoft Project”

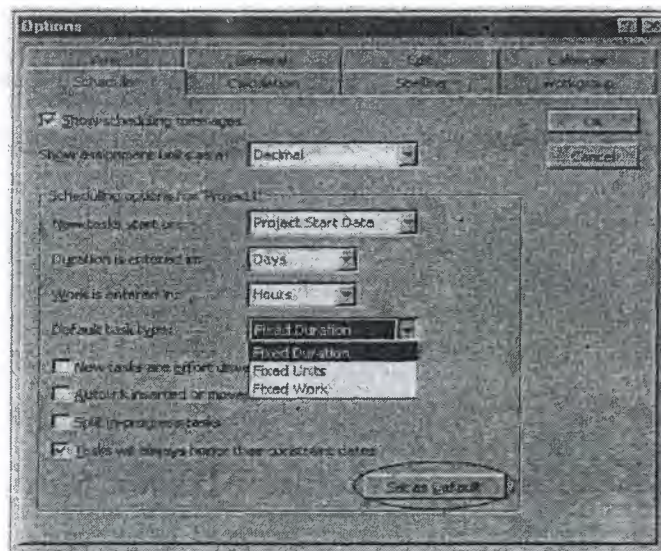
Use the commercial scheduling software (Microsoft Project).

First activate Microsoft Project to start a new project. In starting any project, follow the systematic steps shown in Figure (3.10) to (3.20).



**Figure 3.10** Initial setup of “Microsoft Project”

Once a new file is open, use the Tools-Options menu item to start setting up the Microsoft Project software.



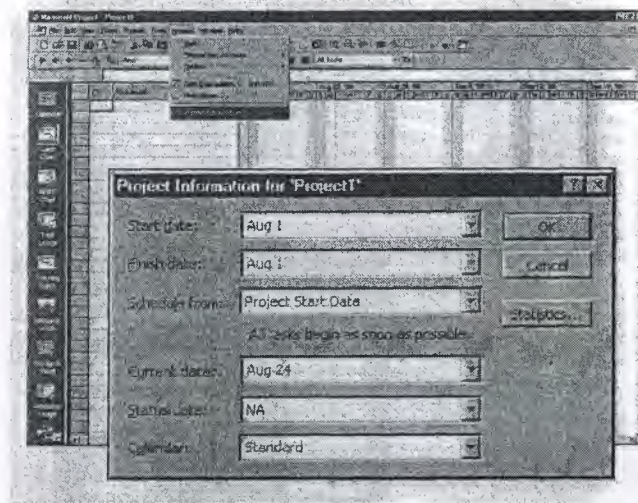
**Figure 3.11** Setup default options



With the Schedule tab, adjust default options as shown. Important ones are: scheduling from start date, duration entered in days, default task type is "Fixed Duration", and new tasks are not effort driven.

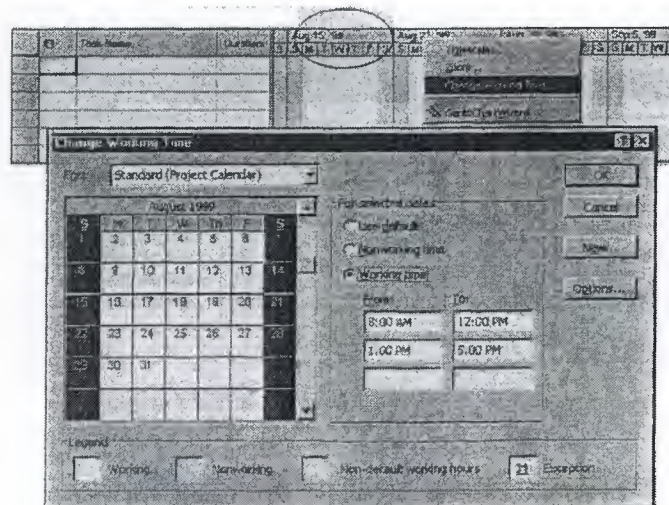
The last two options will not let the duration change automatically when resources are added or removed.

Click the Set as Default button, then the OK button.



**Figure 3.12** Setup project start date

Now, use the Project-Project Information menu option to specify the project start date as August 1. When finished, click the OK button.



**Figure 3.13** Setup working times



Use the right mouse button on the Gantt chart calendar and select Change Working Time. Then, as shown, select the Saturday and Sunday columns and specify them as Working Time. This gives us a 7-day working week. You may also specify any day as off or change the work hours on any day. Then, click OK.

Use the right mouse button on the Gantt chart calendar and select Time Scale. Set the major scale units as months labeled as shown. Also, set the Minor scale units as days labeled as shown. Use the Enlarge text box to adjust the view of the Gantt chart as desired. {8}

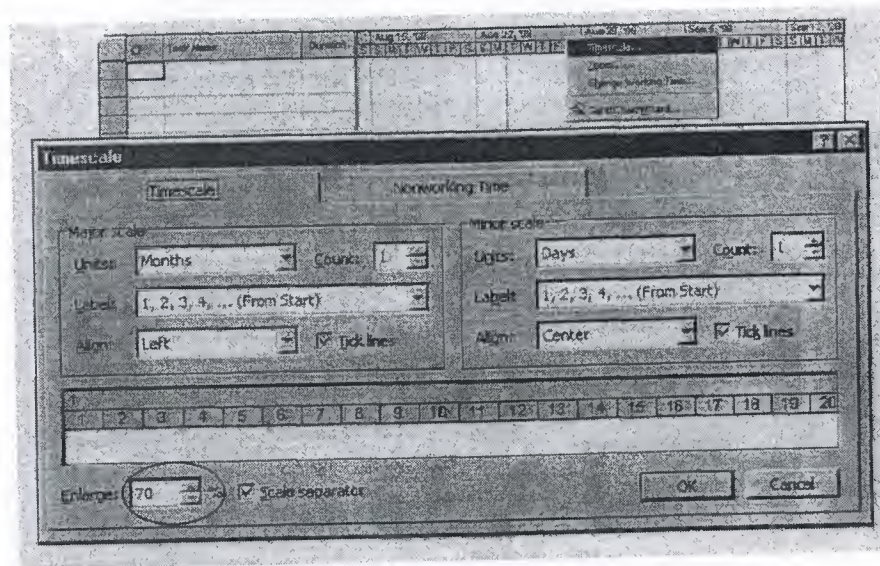


Figure 3.14 Setup time scale

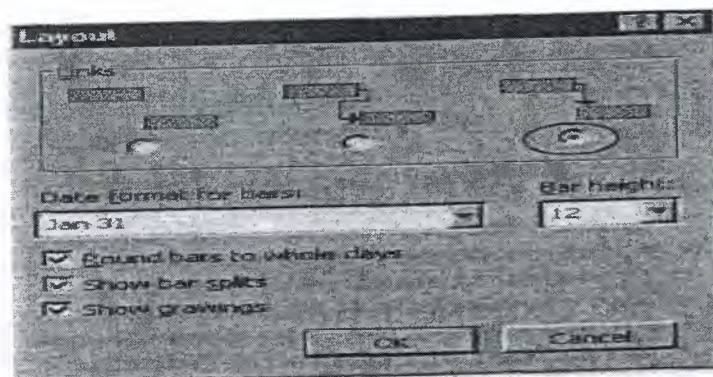
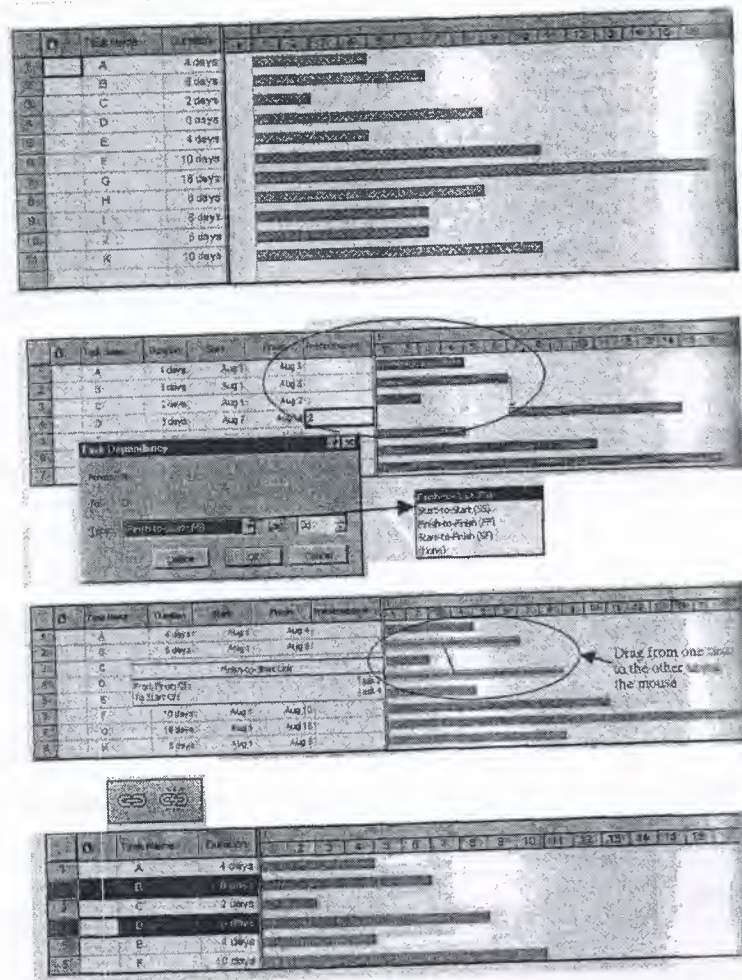


Figure 3.15 Set up the layout

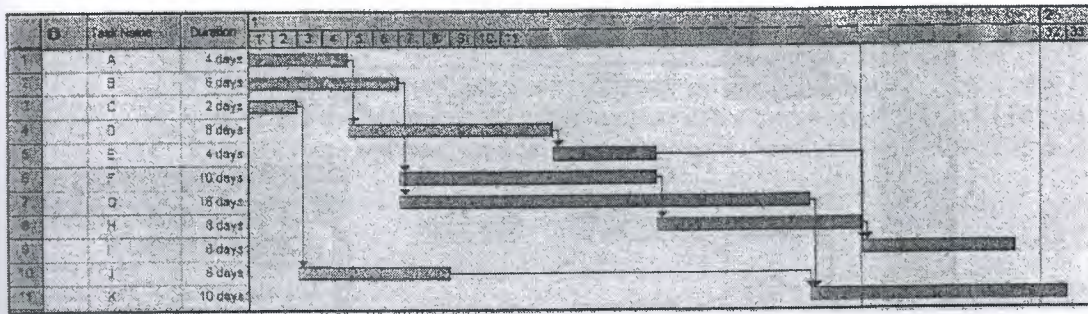


**Figure 3.16** Specifying relationships

There are several ways to specify the relationships among the tasks:

- Move the divider bar until you see the Predecessors column. Then type the row number of the predecessors separated by commas and hit the Enter key. A relationship will be inserted (arrow) and task 2 is made to follow task 1, as shown. If you double-click the mouse on the relationship arrow, a window for specifying the relationship type and lag time appears.
- Another simple way to insert a relationship is to drag from the middle of one task into another task. Automatically, a relationship will be inserted and predecessor ID is written into the Predecessors column.
- A third approach is to select two tasks using (use the Ctrl key) and then link them. {8}





**Figure 3.17** The schedule .

Once relationships are entered by any method, a 32-day schedule will result. You can adjust the project data to fit the screen as described before.

To view activity times such as Early-Start or the Total Float (called Total Slack), you have two options:

- Use the divider bars to view all the columns in the Gantt sheet. Select the top part of any column and then use Insert- Column menu option to add a column in the selected position. Now, select the type of information you would like to view. Here, we select the Total Slack and hit OK. Continue doing the same to view all desired data.
- View one of the software's preset tables. Use the View-Table-Schedule menu option to show all schedule data, as shown here. {9}

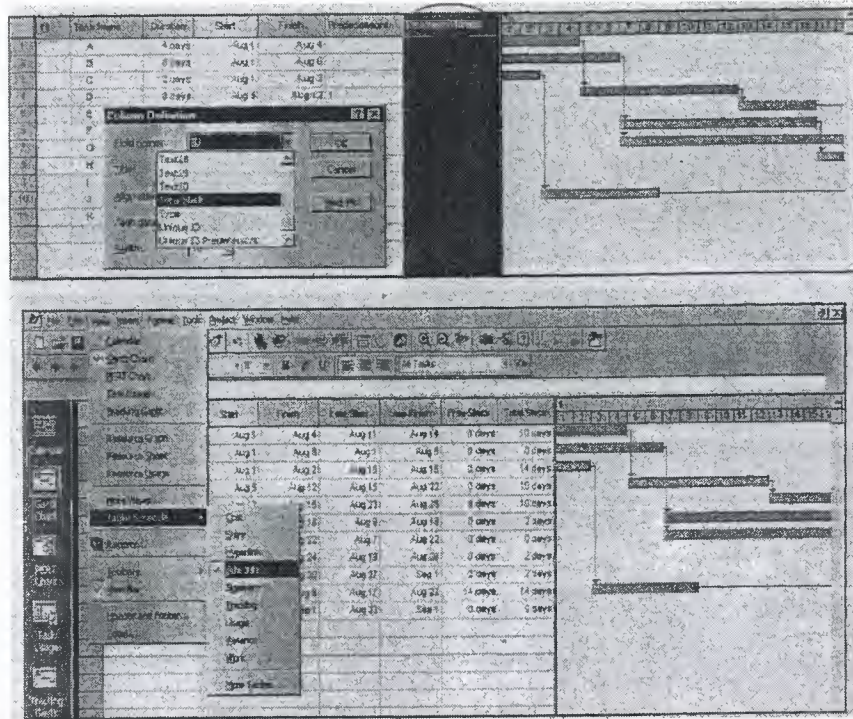


Figure 3.18 The schedule data

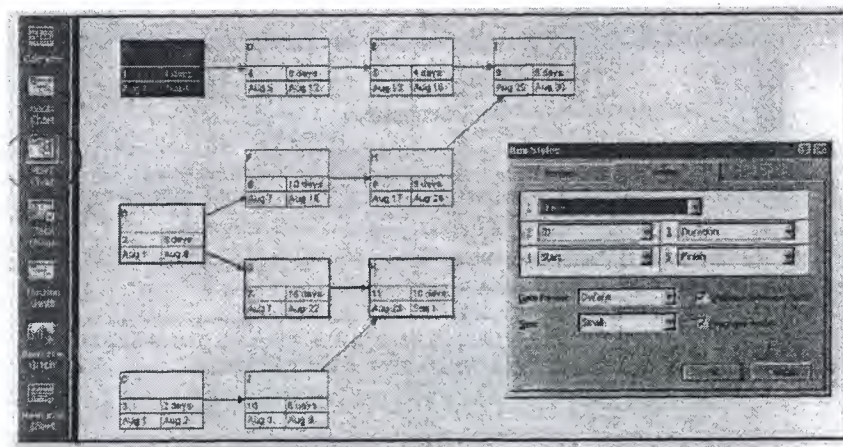
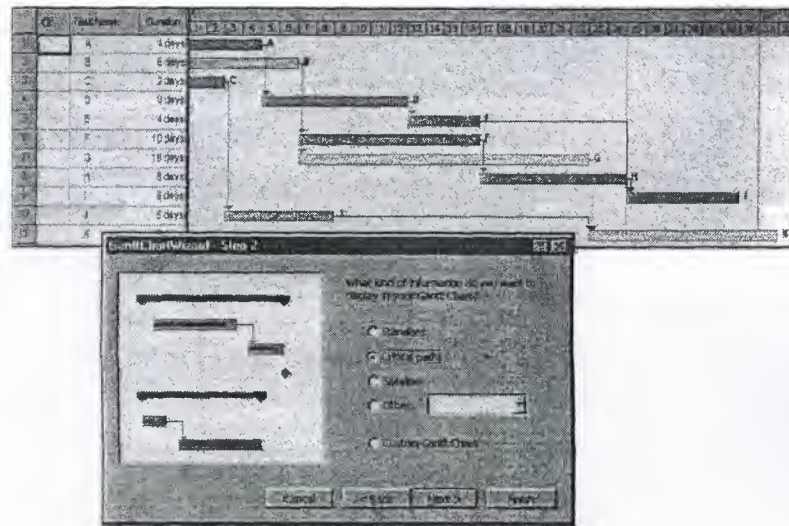


Figure 3.19 Viewing the project network

Use View-PERT Chart menu option to view the project network. Notice that critical activities have bold borders. To specify what data to view in the box of each task. Experiment with this option then view the project Gantt chart.



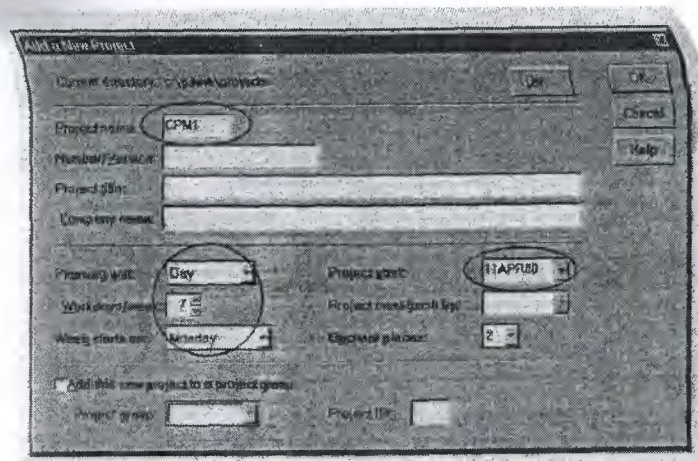


**Figure 3.20** Modifying the bar chart

Use the Format-Gantt Chart Wizard menu option to format the bar chart. Show the critical path, and put custom task information (task name) on the right side of the bars. You can also use Format-Bar Styles to change the pattern of tasks as shown. Now you can print your schedule and save the file. {8}

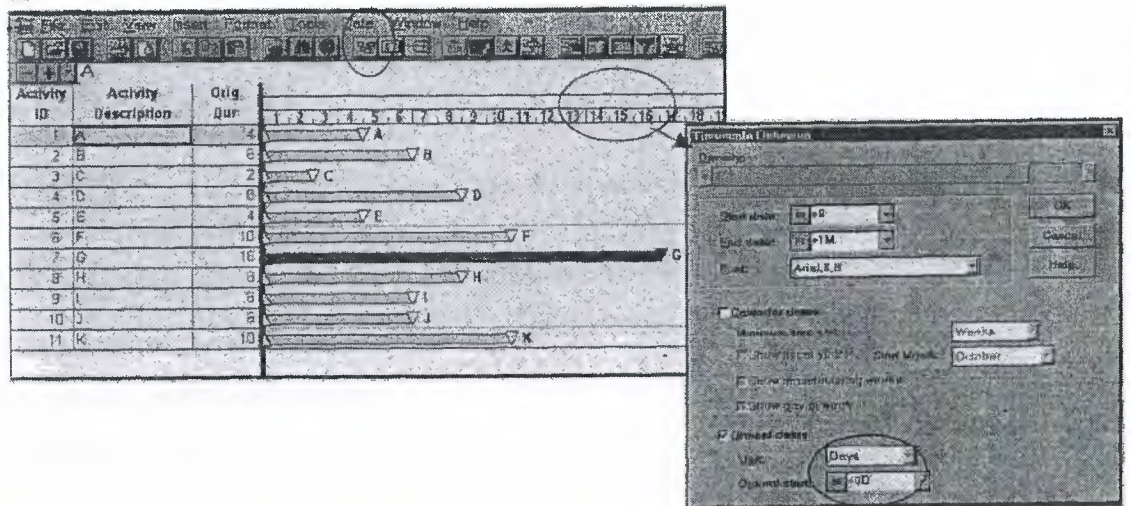
### 3.4.2 Scheduling with “P3 Software”

We can use P3 software on the case study project by either starting a new P3 file or converting the Microsoft file we generated in the previous step into P3 format. In performing these options, we will follow the steps shown in Figures (3.21) to (3.23). {8}



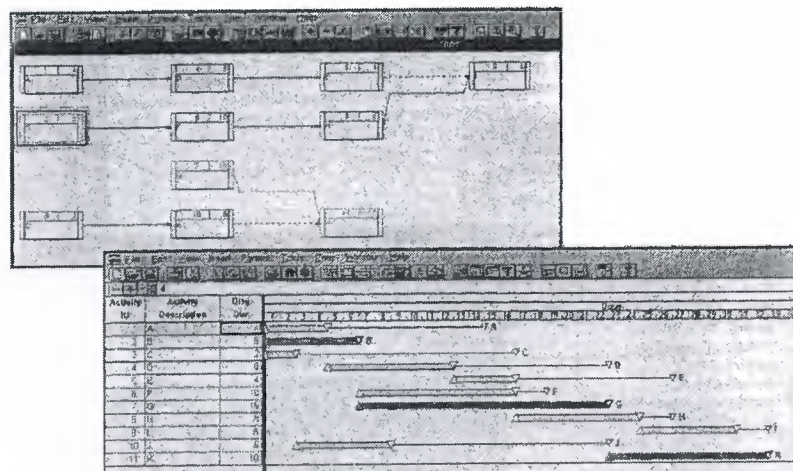
**Figure 3.21** Starting a new “P3 Project”

From the P3 main file menu, start a new project. Note that the process of creating a project is well described in the tutorial under the "Help" menu.



**Figure 3.22** Activity IDs, descriptions, and durations

Now, add activity IDs, descriptions, and durations as shown and the bars will all look parallel. To adjust the time scale, right-click the mouse on it and adjust the options as shown. Now, to add the logical relationships, we can simply access the PERT view (Network diagram) from the toolbar and add them by dragging from each predecessor task to its successor. {8}



**Figure 3.23** Adding relationships and calculating the schedule



## **CHAPTER 4 QUALITY CONTROL FOR CONVENTIONAL REINFORCED CONCRETE BUILDINGS CONSTRUCTION**

- 4.1 Introduction
- 4.2 Control the site's materials
- 4.3 Quality control for the concrete's materials
- 4.4 Quality control for the fresh concrete
- 4.5 Concrete cover to reinforcement
- 4.6 Concrete blocks
- 4.7 Finish works

## CHAPTER 4

# QUALITY CONTROL FOR CONVENTIONAL REINFORCED CONCRETE BUILDINGS CONSTRUCTION

### 4.1 INTRODUCTION

After these details of “Quality Management” and “Planning Construction” for the buildings, we can say that, it’s important to give complete details, strict design, and correct planning of building. But the more important thing, that to control the quality of such building, especially controlling the construction stages from materials to the finish work stage of the building.

### 4.2 CONTROL THE SITE’S MATERIALS

In order to produce uniform quality of building, soil under construction should be understood, and all concrete materials need to be controlled, handled and stored in an appropriate way on site. It is very difficult to produce uniform concrete when the aggregates are not of good quality and uniform in grading and moisture content. Cement should be kept in waterproof stores and the good quality of mixing water has to be uniform throughout the job. {9}

### 4.3 QUALITY CONTROL FOR THE CONCRETE’S MATERIALS

#### 4.3.1 Portland cement concrete

Portland cement concrete is a composite material obtained by mixing inert mineral, aggregates with Portland cement, water, and relatively small amounts of other materials. Concrete is composed of materials that are chemically and mechanically distinct. The resulting concrete has properties that are different from the properties of its constituents. In concrete, the particles of the mineral aggregate are embedded in a matrix of material formed by cement, water and air which fills the spaces between the particles and bonds them together. The binding matrix is called "cement paste" while the mineral aggregates



is called simply "aggregate" and is graded in sizes from fine sand to coarse particles in some cases up to several inches in size.

Concrete remains in a so called "fresh state" for a period of time after mixing, during which it is flow able and workable. Thereby it can be formed into any size and shape. When it hardens, concrete becomes strong and durable.

Aggregates take approximately  $\frac{3}{4}$  of the volume of concrete. The space between particles is filled with cement paste which consists of cement, water and air. The mixing of the components produces air which remains entrapped in the concrete. The percent of air varies from less than 1 percent to 3 percent in some cases. In some applications, air is entrained in the concrete on purpose, in which case the percentage of air can be up to 8 percent or more.

As a construction material, concrete has been used extensively in many applications; this popularity is due to its ability to be cast to any desired shape. It can be cast into typical structural elements such as columns, beams, slabs, etc., as well as into complex hyperbolic shells, massive monolithic sections used in dams or others. Concrete has the ability to be tailored to specific applications. On-site production can be obtained of reasonable quality with unskilled or semiskilled workers.

Factory-controlled production, on the other hand, can be achieved with very good quality for applications such as pre cast concrete, pre stressed concrete, and ready mixed concrete. In general, concrete of small variability in its properties is obtained through factory or plant production.

Another feature of concrete is that it behaves more as a brittle material which creates a challenge for design engineers.

The properties of both freshly mixed and hardened concrete are intimately related to the properties and proportions of the ingredients. In fresh concrete, consistency, workability, resistance to segregation are controlled by the proportions of aggregate and paste, shape and gradation of aggregates and other factors. {10}

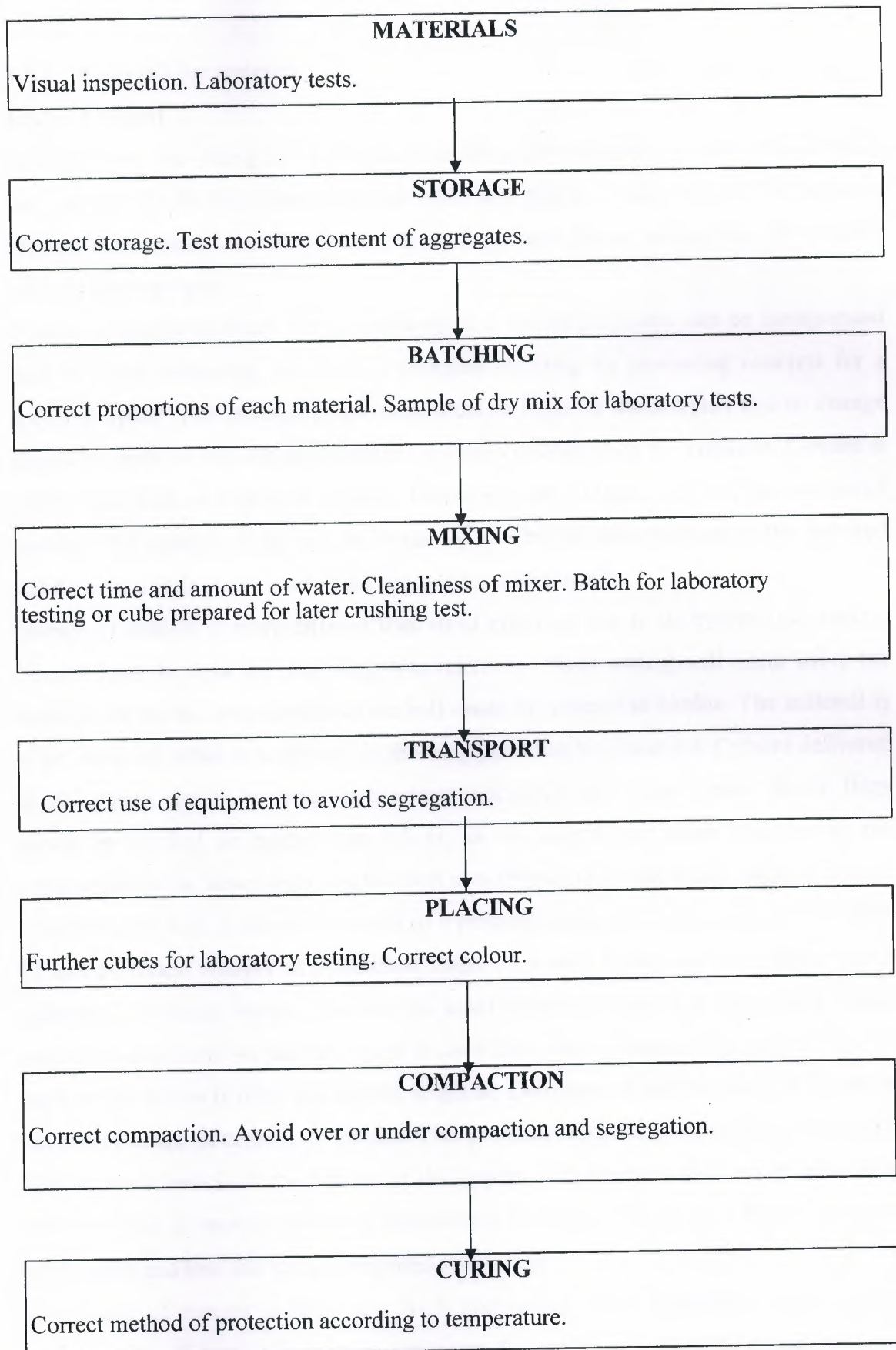
### 4.3.2 Concrete quality

Concrete is an important and regularly used material in almost every number of functions which include durability, protection against fire, thermal insulation as well as structural support. Consisting as it does of a mixture of cement, water and aggregates in different ratios, quality control is vital to ensure the designed mix is being used and properly placed. The mix will have been designed and materials specified at the time of designing the construction project for use in any particular part of that project. The concrete's actual strength and qualities are determined by the amount of adherence to correct procedures in preparing and placing the concrete.

Quality control is the control of the various stages of concrete production and placement aimed at achieving the expected performance of the originally designed mix with no variations in each batch. This falls into two distinct but related functions, one is the control of the production of the concrete including sampling and testing the raw materials; the other is testing the finished product for compliance with design requirements. Figure (4.1) shows concrete production steps covered by quality control.

Concrete is either mixed on site in suitable equipment or more often, on all but the larger sites, mixed and delivered in mixer trucks. In the latter case mixing plants must not be too far away from the site to allow the concrete to start setting or lose its workability.

No set time can be given for this as much depends on the weather conditions, the temperature and the designed mix. However, for any given site and purpose these need to be established. If ready-mixed concrete is used then as far as the contractor or engineer is concerned his quality control does not start until delivery at his site. When concrete is mixed on site then the control starts with the materials used to produce the concrete. {10}



**Figure 4.1** Concrete production steps covered by quality control.



### 4.3.3 Materials for concrete

#### 4.3.3.1 Cement

Cement forms the setting agent and binder holding the materials together, thus forming the concrete. To do this cement requires water and hydration takes place. Heat is given off and the cement sets. The cement in its fluid state before setting fills the smaller voids in the aggregate.

Cement is usually ordinary Portland cement, but special properties can be incorporated such as rapid hardening, low heat or soleplate resisting for producing concrete for a special purpose. The decision to use these must be made by the designer and no change should be made to this during construction unless instructed by the engineer. Cement is made from chalk or limestone and clay heated to form a clinker and then ground into a powder. The control of the cement is carried out by the manufacturer to the required standards and little more can be said about the material itself.

Storage of cement is more difficult than most materials due to its hygroscopic nature. Cement must be kept dry and damp-free otherwise 'flash setting' will occur using the moisture in the air, even condensation will cause the cement to harden. The material is of no use at all when it is affected in this way and must be discarded. Cement delivered in 50 kg bags should be stored in weatherproof sheds with raised timber floors. Bags should be stacked no higher than 1.5 m, as the weight can cause heat due to the compaction in the lower bags and the heat is sufficient to set the lower bags. If cement is delivered in bulk it should be stored in a properly made silo with a capacity between 12 and 50 tones. Usually of cylindrical shape on a steel frame, silos are fitted with a controlled discharge hopper to ensure an exact measured amount is discharged. Stock rotation is important so that the oldest is used first. This is particularly important with bags, as the oldest is often the hardest to get at. Deliveries should be planned based on the rate of usage of cement on the site. This problem is virtually removed by the use of silos as the oldest is at the bottom of the hopper. Unloading is also easier with bulk deliveries and is usually blown by compressed air direct into the silo. Bulk deliveries are cheaper and less site space is required for storage.

The testing of cement is laboratory work and only a visual inspection can really be made on site. If testing is deemed necessary then at least 7 kg will be required and should be placed in a clean dry airtight container which is then sealed. Sampling should



be representative and must be extracted within seven days of delivery. Twelve portions are taken from different parts of the bulk supply or from twelve separate bags to make up the sample for testing. {11}

Unless otherwise specified or ordered by the engineer, the cement shall be ordinary Portland cement complying with BS. The cement shall be delivered either in unbroken bags of the manufacturer and stored in a waterproof shed with a raised boarded floor, or delivered in bulk for bulk storage, provided that the engineer is satisfied that the methods of transport, handling and storage are satisfactory.

In both cases the cement shall be stored in such a way that each consignment shall be used in order of receipt. Each consignment of cement shall be delivered to the site at least two weeks before it is required for use and the contractor shall supply the engineer with a copy of the manufacturer's test certificate for each consignment.

The special conditions relating to the storage and use of rapid-hardening cement shall be strictly observed and different types of cement shall be kept separate at all times.

It is essential that all cement used complies with the appropriate British standard. It is customary to permit delivery in bags and storage in suitable sheds, or delivery in bulk in specially designed vehicles and storage in suitable bins or silos.

On delivery fresh cement may be at a high temperature and for this reason it is customary to require cement to be stored on the job for at least two weeks prior to use. Conversely, the contractor will not be permitted to use stale or lumpy cement. {12}

#### 4.3.3.2 Water control

Water for use in mixing concrete is considered to be drinking water or water of the same quality from another source. It should be free from impurities which could affect the performs two roles in the concrete mix. It is required to produce the chemical reaction of hydration with the cement, thus allowing the cement to harden, and the amount of water gives the mix its workability by forming a paste.

If water is stored in tankers it must not be contaminated in any way nor be left open so that contamination could take place. If water is not from a potable water supply then it must be tested. {10}

#### 4.3.3.3 Aggregates

All concrete mixes contain aggregates, usually in two ranges of sizes known as coarse and fine. Some non-structural concrete mixes use an 'all-in' aggregate which consists of a mixture of the two. Coarse aggregates are further divided into categories of heavy or light densities. The normal range of aggregates is covered by BS, and consists of naturally occurring sands, gravels or crushed rock or stone. Coarse aggregates are considered to be those particles retained on a 5 mm British Standard sieve and fine, those which pass through it. Lightweight aggregates are made of foamed slag, shale, fly ash or Vermiculite.

The purpose of incorporating aggregates in the concrete design mix is to enhance the basic properties of the solidification of cement and water. The cement/water mix would set on its own but would shrink excessively and would have little durability or strength. Adding aggregates of the right type provides the hard durable particles which will not shrink or change shape and these, bound by the cement/water paste create a strong mix. Aggregates must be clean, non-porous and resistant to chemical attack to achieve this. Care must be taken to avoid the modern problem of alkali reaction between the cement and substances such as silica's in the stone as this causes Expansion and damage to the concrete.

The aggregate grading is important to achieve the right balance so that the voids in the coarse aggregate are filled by the fines and the remaining voids are filled by the cement/water paste. This grading, together with the shape of the particles also affects the workability of the concrete, an important aspect in placing and compacting.

Storage is another important factor in the use of aggregates. As has been mentioned the stone must be clean and therefore needs to be stored away from possible contamination by mud or surface water. Ideally each type and size should be separately stored in proper bins made of dwarf walls on a concrete floor slab. Other alternatives can be used providing they achieve the same protection. Weather conditions can affect the stored aggregate and rain will change its moisture content for example and frost will affect the temperature and therefore the setting of the concrete. For large sites heated bays may be worthwhile. Consideration must also be given to ease of unloading deliveries and also subsequent removal to the mixing plant.



Testing the aggregate for suitability and compliance with the specification is also part of quality control. Little can be done on site other than a visual inspection but this would give an indication of the size, cleanliness and moisture content. {13}

Laboratory tests can be carried out to establish the following:

The clay/silt content.

Organic impurities content.

Particle size analysis.

Bulk density.

Moisture content.

Crushing strength.

Resistance to abrasion.

#### **4.3.3.3.1 Effect of aggregate properties on concrete**

Production of concrete of certain desired quality and properties is achieved through a careful control of constituents, including the aggregates, and the proportions used in the concrete mass. Since aggregates take approximately 75% of the volume of concrete, the properties of the mixed aggregates control the properties of the resulting concrete. {14}

The desirable characteristics of aggregate for concrete production include:

- strength
- gradation
- cleanness
- hardness
- durability

#### **4.3.3.3.2 Aggregate Properties and Testing**

The behavior of aggregates in use depends on the interrelationship of many properties. Many of these properties have been identified and defined. Standard tests have been devised to evaluate the properties. Performance can be predicted from test results based on past performances.

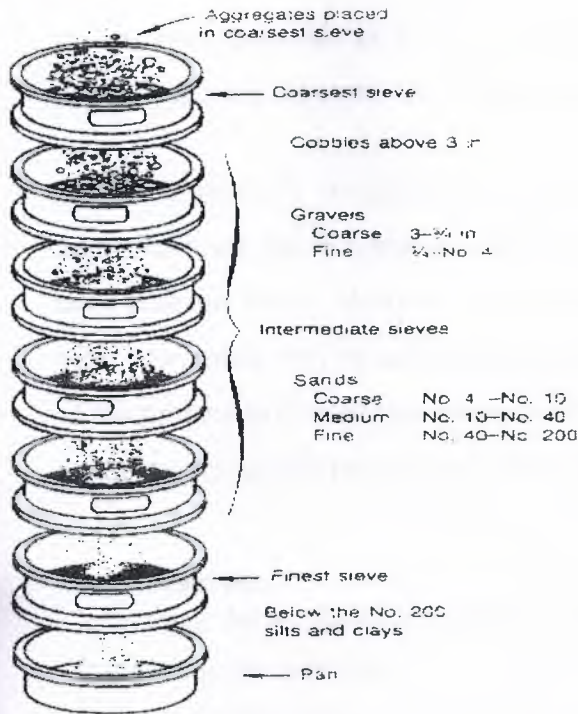
Cost is of great importance when large quantities of aggregates are being selected. Aggregate is always available at low cost, but the cost rises significantly if the aggregate must be handled one additional time or transported a great distance. It is often preferable to use the best aggregate available nearby rather than to improve it by



processing or to obtain better aggregate from a greater distance. It must sometimes be decided whether to accept aggregate of a satisfactory quality or to pay for more processing to obtain aggregate of a better quality. The value of a particular property is often a matter of engineering judgment. Aggregate routinely used in some areas might not be acceptable where better aggregate is readily available. Because of this there is no absolute value required for many of the properties and even ASTM standards do not specify exact requirements for acceptability. {16}

Half-sizes, 1000 mm = 1.0 mm	ASTM Sieve Designation	Nominal Size of Sieve Opening	
		mm	in.
Coarse	3 in	75	3
Aggregate	2 1/2 in	63	2.5
	2 in	50	2
	1 1/2 in	37.5	1.5
	1 in	25	1
	3/4 in	19	0.75
	1/2 in	12.5	0.50
	3/8 in	9.5	0.375
Fine	No. 4 (3/16 in)	4.75	0.187
Aggregate	No. 8	2.36	0.0937
	No. 16	1.18	0.469
	No. 30	0.60 (600 $\mu$ m)	0.0234
	No. 100	150 $\mu$ m	0.0059

**Table 4.1** ASTM Standard sieves for concrete aggregates



**Figure 4.2** A nest of sieves with ASTM material designations by size.

This set of sieves has the peculiarity that the ratio of the openings between two consecutive sieves is 2. Therefore, in a logarithmic scale, sieve openings are equally spaced.

In the sieve analysis, particles on each sieve are of different sizes are separated by the sieves and the amounts retained weighed. The weights are converted to percents of weight of the total sample and designated as partial percents retained on each sieve.

The grading of this aggregate is shown in the figure 4.2.

#### 4.3.3.3 Admixtures

Admixtures to change some of the properties of the more commonly used cements by incorporating a suitable additive or admixture. It should be noted that additive refers to substance is added at the cement manufacturing stage, while admixtures addition at the mixing stage.

An admixture is a proprietary mixture of chemicals, normally as a solution, which is added to a batch of concrete during mixing in order to modify the properties of the fresh

or hardened materials in some way. Obviously, the term excludes water, cement and aggregates since these are the essential ingredients of concrete.

If mix is properly designed, most concrete does not need admixture. Furthermore, admixtures are not a substitute for cc concreting practice and are unlikely to make a poor concrete better. However, there may be occasions when using an admixture is the most convenient way of achieving a particular result, and the following list shows some of the properties of concrete which can be modified. The main thing to remember is that an admixture should be used only when there is a valid reason.

**Fresh concrete**

- Increasing the workability without increasing the water/cement ratio
- Improving the cohesion
- Reducing segregation
- Reducing bleeding
- Retarding the setting (stiffening) process
- Accelerating the setting (stiffening) process

**Hardened concrete**

- Increasing the frost resistance
- Increasing the rate of early strength development
- Increasing the strength
- Decreasing the permeability

**4.3.3.3.1 Use of admixtures**

Because admixtures are added to concrete mixes in small quantities, they should be used only when a high degree of control can be exercised over the batching and mixing. Incorrect dosage, either too much or too little, of an admixture may adversely affect the strength and other properties of the concrete.

This article briefly describes some of the types of admixture which are most commonly available, the effect they have on the concrete and the circumstances when their use may be helpful or beneficial in modifying some property or properties of the concrete.

BS specifies the requirements for five types of admixture:

- (1) Accelerating
- (2) Retarding



- (3) Normal water-reducing
- (4) Accelerating water-reducing
- (5) Retarding water-reducing.

The above types of admixture should be purchased from suppliers whose material complies with this British standard. {16}

#### 4.3.3.3.2 Control the admixtures

No matter what admixture you are using, some general points are worth remembering.

- 1) Make sure that the job specification permits its use: some prohibit particular admixtures.
- 2) Make sure you are using the right admixture and never use one from an unmarked container. Read the container label to see whether special storage conditions are required and, if so, provide them. Store containers so that the labels are not obliterated and when not in use keep them closed to prevent accidental contamination.
- 3) Make sure that you know and use the correct dosage for each batch. Avoid the temptation of adding that 'little bit extra' because it is likely to do more harm than good.
- 4) Liquid admixtures are best added from a dispenser which accurately measures the required quantity; this can usually be hired from the admixture supplier who will also give advice on its use.
- 5) Every day, before starting to mix concrete, check that the dispenser is gauging the correct dosage and at the end of each day's concreting wash it out thoroughly.
- 6) Because it can be difficult to ensure that the admixture is evenly dispersed throughout the concrete, liquid admixtures should be added to the mixing water before it goes into the mixer. If this cannot be done - as for example, when dispensing by hand using a measure - mix the concrete for a slightly longer time.
- 7) Check aggregate deliveries even more closely for variations in grading and moisture content, since adjustments to the added a later may be required: changes in grading and water content can alter the effect of the admixture.
- 8) Accelerating admixtures containing calcium chloride must not be used in reinforced concrete. {16}

#### 4.4 QUALITY CONTROL FOR FRESH CONCRETE

Concrete construction involves concrete batching, mixing, transporting, placing, consolidating, finishing, and curing. We will discuss the concrete stages by small details such as production and methods involved in placing, consolidating, finishing, and curing concrete used for structural purposes. Special considerations for pouring concrete during extremely hot or cold weather are also described. {5}

##### 4.4.1 Batching

Before mixing can take place the correct proportions of each material have to be obtained in accordance with the set mix design. This process is known as batching or weighs batching and can be done in two ways -by volume or by weight. However, measurement by volume is little used these days but in any case is only used for small quantities of low-grade concrete up to  $15 \text{ N/mm}^2$  compressive strength. Generally materials batched by volume are mixed by hand. Measurement by weight is accepted as giving a more accurately proportioned mix which is essential for all structural members and is due to greater control over fractional quantities. To batch by volume requires the use of a gauge box and this consists of an open-topped wooden box which must not allow any material leakage. The mix proportions will have been given in terms of volume and for each material the box is filled and leveled off the required number of times. Batching by weight involves the use of various types of weighing equipment. In many cases this forms an integral part of the mixing equipment such as the swinging hopper. An alternative is to use weighing equipment fitted to a loading skip. Four basic types are in common use, the spring balance, the pendulum, the beam and jockey weight and hydraulic systems. The spring balance is not as accurate as the other methods. The hydraulic system consists of an oil-filled capsule in the hopper bottom or on which the hopper bottom rests and as the weight is increased the fluid is forced out of the capsule and flows along a flexible pipe to a gauge. All measuring equipment should be set up resting on solid level ground and checked for accuracy both initially and at regular intervals.

Weigh batching of each material is in accordance with the designed mix proportions given in weight terms. It is usual to base the overall quantity on a whole number of 50 kg cement bags which are an acceptable unit and need not be reweighed. If bulk storage of cement is used then the weighing mechanism on the discharge chute will give an



accurate measure. If any other equipment is used for measuring cement, although it should not be necessary, the cement and aggregates should not be weighed on the same equipment so that contamination or the introduction of moisture does not take place.

Aggregates measured by weight should be tested first to establish the free water content. If correct site storage has taken place then testing need only be on a once a day basis during periods of mixing and should not cause any problems. An alteration to the amount of water for the mix should be made if the water content is above the permitted level. {11}

#### 4.4.2 Mixing

The mixing of the materials to produce concrete can be carried out on site. Whilst it has been said that quality control does not start for off-site ready mixed concrete until delivery, it is necessary to understand the mixing methods. All mixing takes place in the truck mixer but the method depends on the type of mix and the travel time to make the delivery. The truck is loaded with the dry materials at the depot and either commences the mixing by adding the water or only mixes the dry materials adding the water at a point somewhere near the delivery address. Thus the truck mixer can mix and agitate for the traveling time or mix during the latter part of its journey to the site. Loads are normally between 4 and 6 m<sup>3</sup> of wet concrete and care is needed in discharging this from the rear chute of the lorry to avoid its overturning. Good access is also required to the discharge point and the concrete should be unloaded and placed within thirty minutes. This includes any additional handling if the truck cannot discharge direct to the working area.

The use of ready-mixed concrete is particularly common on the many smaller construction sites. The main advantage is the space saving by not requiring site storage of materials or mixing plant or where space just is not available. However, careful planning is required on site and in ordering ready mixed concrete as the mixing and delivery are not controlled by the site engineers and a time exists which makes changes in requirements difficult to adjust.

On-site mixing can be done in a variety of different sizes of mixer to suit the quantities and rates of use of any given construction site. All mixers are of two main types according to the principle of operation. Each type and style has a reference number which indicates the type and capacity, for example 200T-200 liter tilting drum.



Freefall mixers, otherwise known as drum mixers, rely on the revolving drum with fixed blades fitted inside. These carry the mixture up as the drum revolves and let it fall back to the bottom as it nears the top. This action is continuous and keeps turning the materials until mixed.

Freefall or drum mixers are made in three different styles and are generally portable. The tilting drum (T) has a single compartment, pear-shaped drum which only has one opening. It revolves near vertically but rotates. About a horizontal axis until it discharges downwards. It is suitable for small quantities up to 200 liter per batch.

The non-tilting mixer (NT) is a larger, single-compartment machine of a cylindrical shape. The ends are partly closed to leave two circular smaller diameter openings. The cylinder rotates about a fixed horizontal axis and loads at one end and discharges at the other. Maximum capacity is 750 liter.

The common pan mixer (P) consists of a shallow open-top circular pan into which paddles project and rotate. Materials are fed through the top but discharge is through the bottom of the pan at its centre. Water for the mix is fed in through the sides. A disadvantage can be loading at high level but the final mix is of a more even quality. Intended for semi-fixed installation and larger outputs the capacity goes up to 2 m<sup>3</sup> (2000 liter).

The turbo mixer (P) is a forced action mixer which uses a closed pan and thus is able to have two rows of paddles, one above the other on a central cylinder. The pan is stationary and the paddles revolve with the cylinder. The base is fitted with a semi-circular door and the mixed concrete is discharged through this. This type is more compact than the open pan and also has the advantage of being unaffected by wind blowing away fine material or by rain. Capacities range up to 2 m<sup>3</sup>.

The third style of forced-action mixer is the trough mixer (P) and is capable of dealing with dryer mixes than other types. It consists of a cylindrical-shaped trough with paddles on horizontal spindles projecting through the ends of the trough. Loaded from the top, the mixed concrete is discharged from the bottom through a door.

General considerations to be remembered when mixing concrete on site include ensuring that the materials are thoroughly mixed. This is evident when the concrete has a uniform color and consistency. The materials are normally added for mixing in the following order; coarse aggregate, cement, fine aggregate and lastly the water. Each mixer has its own mixing time for any given mix design and this is counted from the

moment the water is added. Times vary from 30 s for certain forced action types to 3 min for free-fall models. It is essential that the mixer is cleaned completely at the end of each intermittent mixing cycle or each day for continuous mixing. The first mix in a clean mixer will differ slightly from following mixes due to the coating of the blades and compartment with fine concrete particles. This first mix is often used for blinding or other non-structural concrete. {11}

#### 4.4.3 Transporting of concrete

A number of different items of equipment are available for moving concrete from the mixer to its final position. Equipment commonly used includes wheelbarrows, buggies, Should be limited to about 5 ft (1.5 m) unless down pipes or ladders are used to prevent segregation. Down pipes having a length of at least 2 ft (0.6 m) should be used at the end of concrete conveyors.

Wheelbarrows have a very limited capacity (about 1 1/2 cu ft or 0.04 m<sup>3</sup>) but are often used for transporting and placing small, amounts of concrete. Push buggies that carry 6 to 11 cu ft (0.17 to 0.31 m<sup>3</sup>) and powered buggies carrying up to 1/2 cu yd (0.38 m<sup>3</sup>) are often employed on building construction projects. However, these items of equipment are gradually being replaced by concrete pumps capable of moving concrete from a truck directly into final position up to heights of 500 ft (152 m) or more. Truck-mounted concrete pumps equipped with placement booms such as that shown in (photo 4.1) are widely used in building construction.

Concrete conveyors are available to move concrete either horizontally or vertically. Chutes are widely used for moving concrete from the mixer to haul units and for placing concrete into forms. Truck mixers are equipped with integral retracting: chutes that may be used for discharging concrete directly into forms within the radius of the chute. When chuting concrete, the slope of the chute must be high enough to keep the chute clean but not high enough to produce segregation of the concrete. Concrete buckets attached to cranes are capable of lifting concrete to the top of high-rise buildings and of moving concrete over a wide area. Concrete buckets are equipped with a bottom gate and a release mechanism for unloading concrete at the desired location. {5}

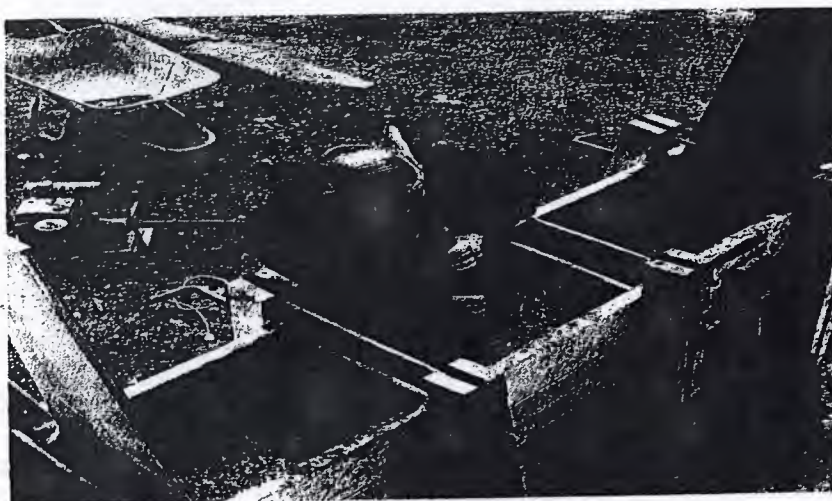




**Photo 4.1** Transporting concrete in the construction site

#### **4.4.4 Placing and Compaction of Concrete**

The term placing causes some confusion as it suggests placing in the formwork, but that is covered by transportation. Placing is positioning the heaps of discharged concrete evenly across the formwork over the length or area being cast and ensuring that the concrete is to the exact shape of the formwork. Compaction refers to the need to ensure that not only is the concrete to the correct shape but is to the correct density and material distribution. Air is trapped in the concrete during the mixing process and must be released once the concrete is its final position in order to prevent voids.

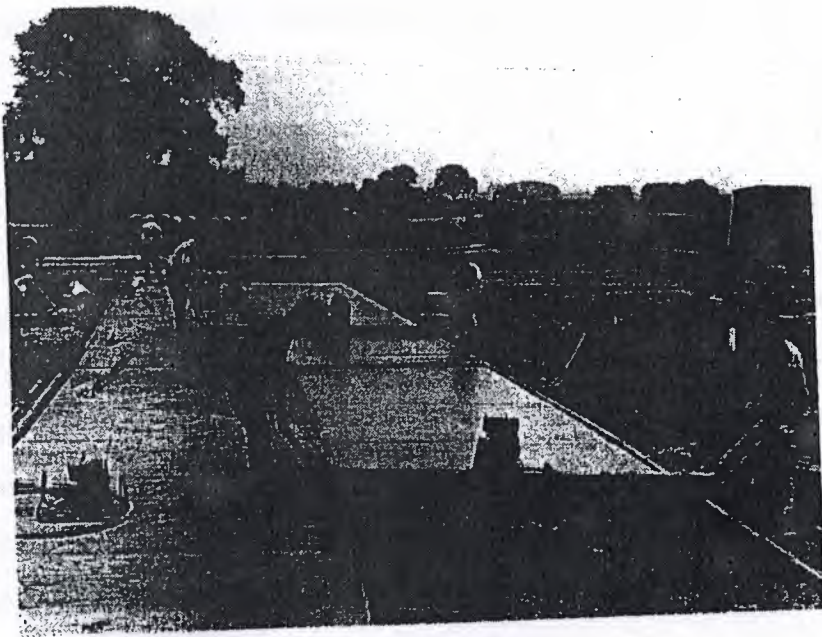


**Photo 4.2** Vibrating poker concrete compactor



Any voids will create weaknesses and reduce the finished strength. Compaction is therefore considered complete when the trapped air ceases to rise in the form of bubbles.

Compaction by hand is still carried out for small quantities mainly of un-reinforced concrete. The simplest method is to use a small diameter metal rod raised and lowered in the concrete. However, this does not give an even distribution or compaction. A tamping board consisting of a length of timber fitted with handles at each end can be used to hand tamp depths of up to 250 mm of un reinforced concrete or 150 mm of reinforced concrete. The board is raised and lowered across the top of the surface of the concrete compacting and leveling to the finished level. {11}



**Photo 4.3** Vibrating beam concrete compactor

Is better but in any event one should be used at 0.5 m centers, inserting the poker after a thickness of concrete is in position tends to compact the top layer and restrict the rise of air from the lower layers.

A less common method is the external clamp-on vibrator but it has to be used for small or heavily reinforced beams where the internal poker cannot be inserted. A similar type of vibrator is used but can be integral with its power pack and is placed on the outside

of the formwork of the length to be compacted. The vibrator is started as the first concrete is being poured and left on until the rising air ceases. Often a number of clamp-on vibrators are used in a row along the formwork but even so are less effective in ensuring the concrete forms the exact shape of the formwork. Also there is a tendency to over compact the outer edges of the concrete. A big disadvantage is the strength requirement of the formwork which has to withstand the vibration without losing its shape.

For flat slabs of concrete a vibrating beam is used which consists of a timber or metal beam to which is attached a self-contained power pack and vibrator. Side formwork for the concrete is used as support for the beam which is drawn by hand slowly across the top of the slab. As the beam vibrates it compacts the concrete at the same time as leveling the top surface to the finished level. The maximum thickness that can be satisfactorily compacted by this method is 200 mm. {11}

#### 4.4.5 Curing of concrete

Concrete when placed is initially fluid or plastic in nature and sets in position. Curing is the process of allowing the concrete to set in its final position under controlled conditions until the cement-water reaction is complete. Extremes of temperature during curing cause deterioration in the concrete as it sets with subsequent loss of strength. Excessive heat causes evaporation of moisture leaving insufficient water in the mix for the hydration reaction to be completed. Also the temperature through the concrete may vary according to its thickness causing variations in the setting process. Thus uneven shrinkage will occur which sets up tensile stresses in the concrete such that cracking occurs. If the surface dries faster than the middle then the cracking will be at the surface.

Very cold temperatures cause the worst problems, with rain, sleet or snow in freezing conditions slowing the rate of hydration to the point where it stops altogether. The rate of evaporation is increased and thus the rate of heat loss. The expansion of the water as it freezes causes damage to the concrete and makes it useless. Even in concrete which has begun to set the free water freezing will reduce the bond between the aggregates and the cement paste. Ideally the minimum temperature for concrete work is 5°C but British



standard allows work to continue down to 2°C if the concrete temperature is maintained at or above 5°C by artificial means.

The functions of controlled curing therefore are to avoid these extremes of hot and cold temperatures to allow the concrete to mature and harden to its design strength. Some precautions can be taken at an earlier stage for example, heating the aggregate or using additives to accelerate hardening but even so curing precautions need to be taken.

During hot weather it is therefore necessary to keep the concrete to a lower temperature. There are a number of ways of doing this, all of which use the same principle, that of providing a cooling layer to the surface of the concrete. The materials used vary from dampened sawdust, dampened straw or sand to sheet coverings such as polythene sheet, canvas or damp. Care must be exercised in the choice initially as the wet concrete can adhere to the material particles. The concrete can also be stained by any seeping coloration from the covering. Another method is to spray the concrete surface with a curing membrane, usually a resin which dries on the concrete and reduces evaporation. However this is not suitable for areas requiring further treatment such as a floor screed.

In cold weather the concrete needs to be protected from the cold but not be hot. Excessive heating of the concrete will naturally produce the problems of concreting in hot weather. Careful regulation is therefore needed when using such methods as heated enclosures. This is where a space heater or coke brazier or equivalent is placed in an area beneath the concrete to be protected. The correct use of formwork can also help and the use of timber in place of steel provides better insulation preferably at least 35 mm thick. If steel formwork is to be used, it can be preheated or insulated by covering. The stripping times of formwork must be lengthened in order to ensure the appropriate maturity. Insulation blankets should be placed on top of the concrete in the form of tarpaulins, dry straw, expanded polystyrene or wood wool slabs. A waterproof membrane and an air gap will provide protection from the weather and windbreaks will reduce the cooling effects of strong winds.

#### **4.4.6 Testing and sampling**

As mentioned at the beginning of the chapter, quality control applies during the preparation of the concrete and also at the end of the production to establish if the final concrete is of the required standard. To carry out the latter, fresh concrete has to be sampled at the discharge point. The testing and sampling of fresh concrete is covered by



BS and states that the sample must be representative, of the whole batch being tested. Approximately 20 kg of concrete are required for all testing purposes and the best way is to take samples from a moving flow, such as a discharge chute. A stationary heap does not give even samples and therefore does not give quite as good results.

The sample should be made up of four separate small quantities from a moving flow or six from a heap. A dry, clean metal scoop should be used and thrust into the discharge at regular intervals to obtain the individual samples. Samples should be remixed on a hard non-absorbent surface before being tested. {11}

#### **Desired Properties of Fresh Concrete**

- It must be easily mixed and transported.
- It must be uniform throughout a given batch and between batches.
- It must have flow properties such that it is capable of filling completed the forms for which it was designed.
- It must have the ability to be compacted fully without an excessive amount of energy being applied.
- It must not segregate during placing and consolidation.
- It must be capable of being finished properly, either against the forms or by means of trowelling or other surface treatment. {15}

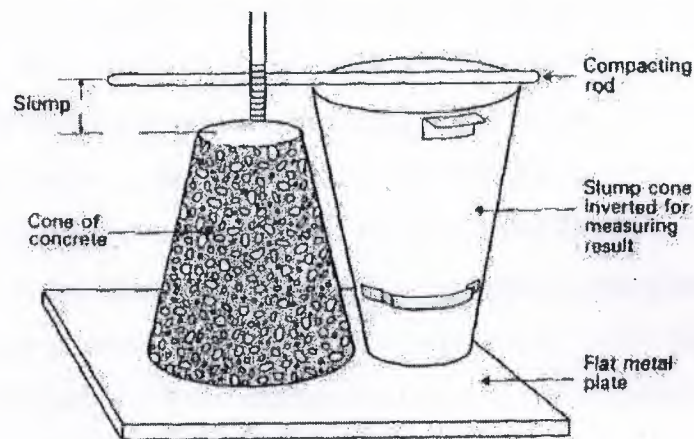
##### **4.4.6.1 The slump cone test**

This test is very useful as a general guide to the mix performance and any change between separate batches. The test measures the degree of workability of the concrete and can be carried out quite easily on site. Any change in slump would indicate a variation in material content, water content or mix properties.

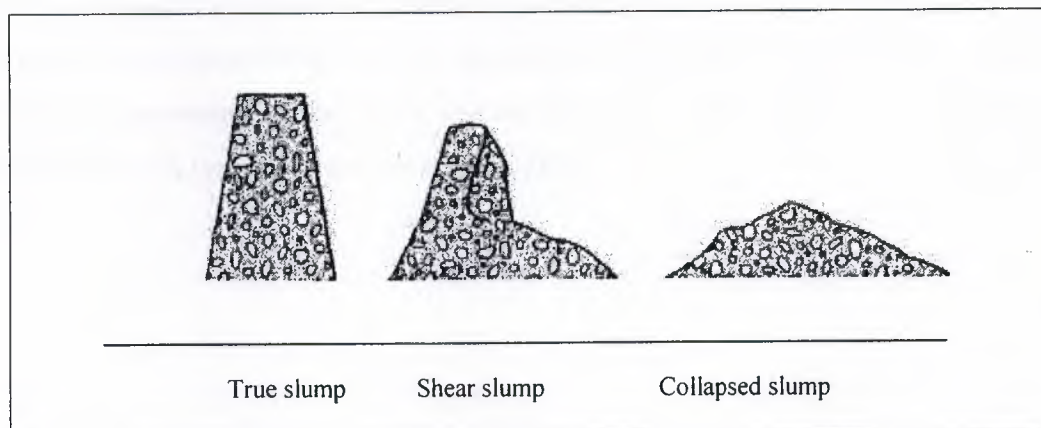
The apparatus consists of a conical shaped open mould varying from 100 mm diameter at the top to 200 mm at the bottom. Two lugs are fitted for holding down the mould with the feet and two lifting handles are on the sides to allow a vertical lift. A standard rod of 16 mm diameter is also provided and has one rounded end. The mould is placed on a flat metal plate which rests on hard level ground and filled with fresh concrete in four roughly equal layers. Each layer is compacted with 25 strokes of the standard rod using the rounded end. When the mould is full, the concrete is struck off level with the top of the mould and the area around the base cleaned of any moisture seepage. The

mould is then carefully lifted off and placed upside down on the metal plate adjacent to the concrete. The rod is placed across the top of the mould and over the concrete. The slump is the distance between the underside of the rod and the top of the concrete recorded to the nearest 5 mm.

Three types of slump known as true shear or collapse. The results are recorded indicating the type of slump but two further tests should be carried out if the slump is not a true slump. The true slump expected from concrete to be used in normally reinforced members and compacted would be between 25 mm and 50 mm. Figures (4.3) and (4.4) illustrates the slump test and the three types of slump. {11}



**Figure 4.3** The slump cone test.



**Figure 4.4** Types of slump.



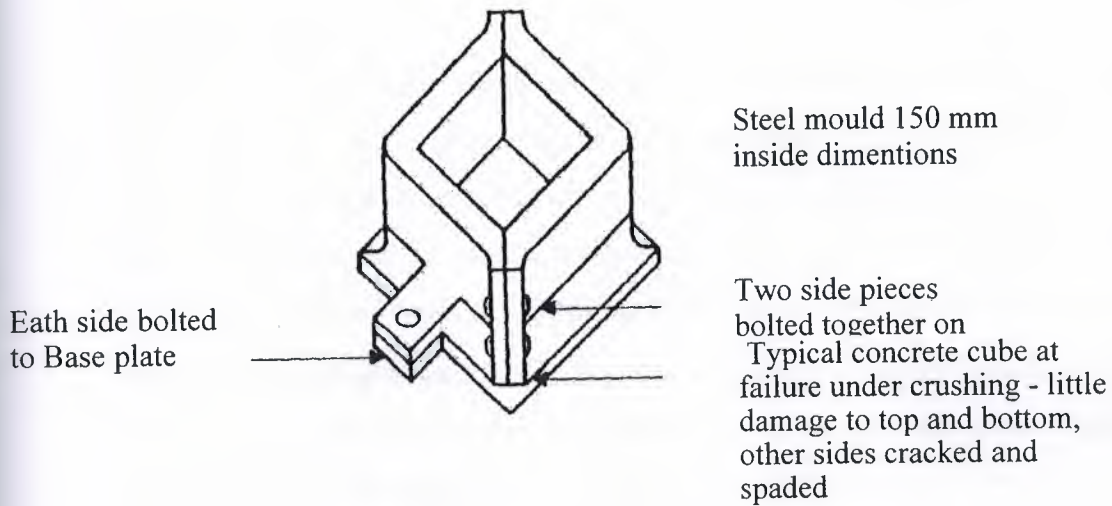
#### 4.4.6.2 The compressive strength cube test

This is generally accepted as being the best test for quality control purposes but has two disadvantages. The test has to be carried out in a special laboratory with crushing test equipment and after 28 days. This means that the concrete will have been placed and cured and if totally unsatisfactory would have to be removed. The results of this test also depend on very careful attention to the preparation of the sample cube.

The site requirements are a metal mould which consists of a base plate and two halves. When bolted together a 150 mm hollow cube shape is formed. Using approximately 10 kg from the remixed sample of concrete and having painted the interior of the mould with mould oil, the concrete is placed inside in 50 mm layers. Each layer is properly tamped 35 times with the standard compacting rod of at least 25 x 25 mm dimensions. The top of the concrete is left roughly leveled off higher than the mould top for one hour and then trowel led level. This allows for any normal settlement to take place.

The concrete is left in the mould for two days in a damp atmosphere or under damp. The cube must be protected from extremes of temperature. After this time the cube is removed from the mould without damage and extreme care is required in loosening the section of the mould. The cube should then be placed in a curing tank of clean water at 20 °C until taken to the laboratory for testing. These conditions should be maintained during transit as well and delivery should be 24 hours before any tests, which are usually carried out at either seven days or 28 days from casting. The laboratory report will give the compressive strength of the concrete in N/mm<sup>2</sup> which should be compared with the requirements of the grade of concrete being used. Figure 4.5 illustrates the model used and a typical cube after testing. {11}

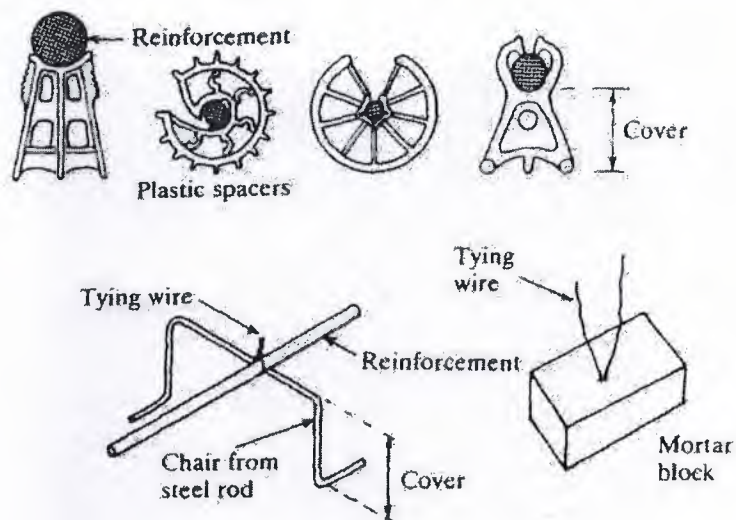




**Figure 4.5** Concrete Test Model cube and test apparatus

#### 4.5 CONCRETE COVER TO REINFORCEMENT

In all steel reinforcement to concrete sub-structural work it is essential to obtain the specified minimum cover. This will be at least 40 mm preferably, 50 mm. This is achieved with spacers of concrete or plastic of the type shown in Figure (4.6). {18}



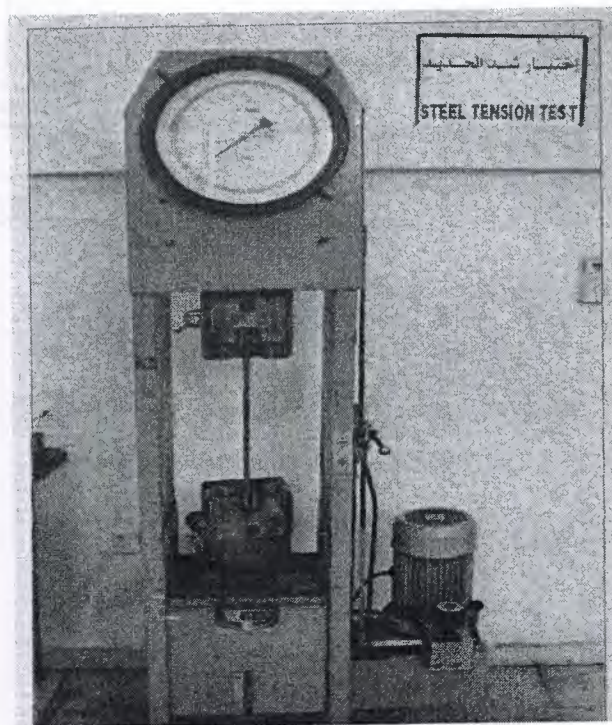
**Figure 4.6** Reinforcement spacers

#### 4.5.1 Steel tensile test

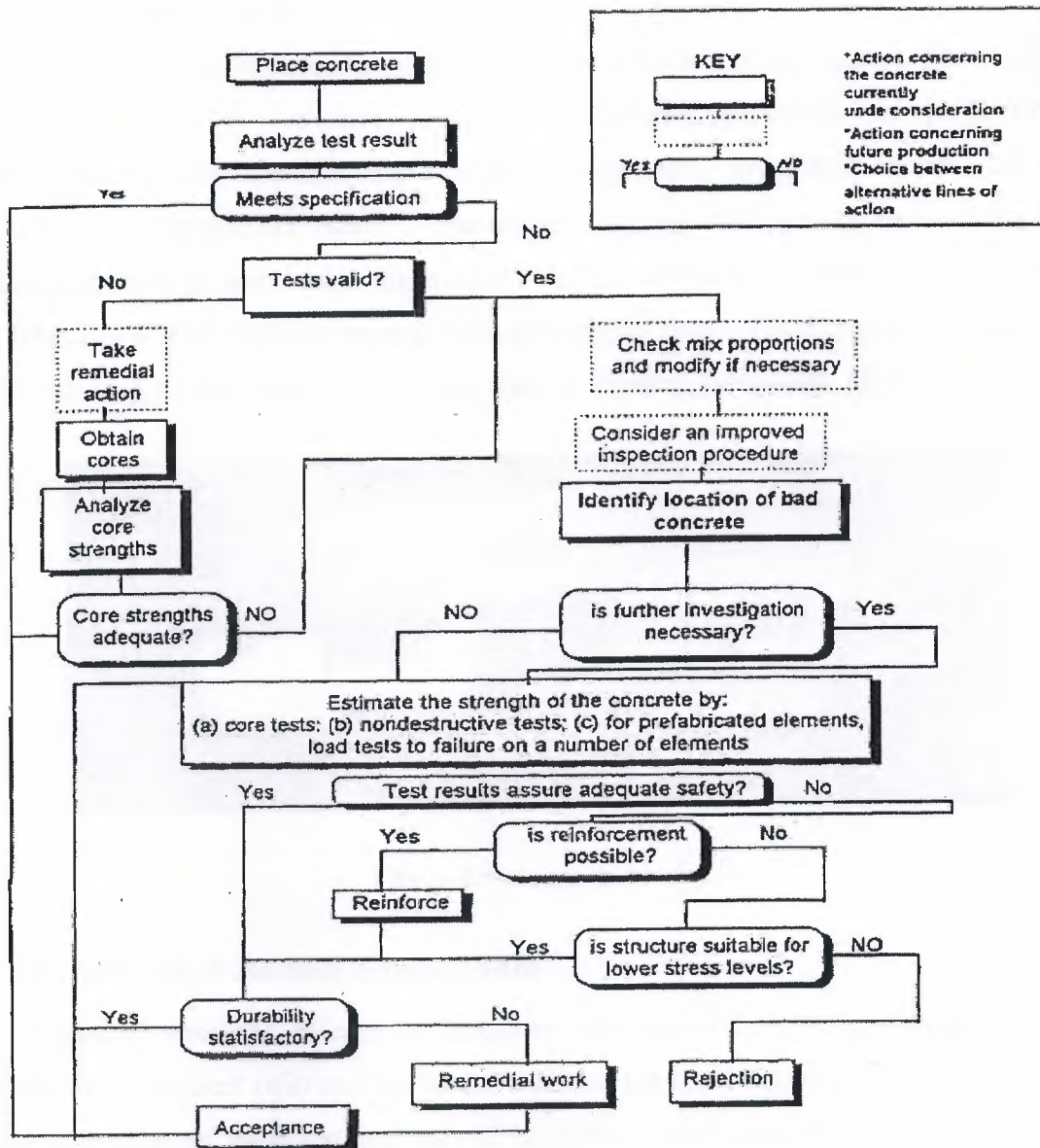
Mechanical tests for steel include tension, bending, hardness, and impact. For structural steel the tension, or tensile, test is the most important. (Photo 4.4) The purchaser may specify that the test be performed on steel from the furnace, after rolling, or after fabrication. Specimens for testing are poured separately as an ingot is being made or are cut from the waste material of a rolled member. Specimens may be of various sizes.

The typical tensile test specimen is a 0.500-in.-diameter cylinder machined to a smooth, accurate circular cross section. The specimen is clamped at each end or threaded into a testing machine that applies an axial pull at a uniformly increasing rate until the specimen breaks. As the pulling proceeds, the force is constantly indicated in digits or by a dial on the machine. Tensile stress is calculated by dividing the force by the original cross-sectional area.

Before the force is applied, two marks are made on the specimen two inches apart in the direction of the applied force. The two marks are drawn farther apart as the specimen deforms under the tension. Strain is calculated by dividing the increase in distance between the marks by the original 2-in. distance. {18}



**Photo 4.4** Steel tension test



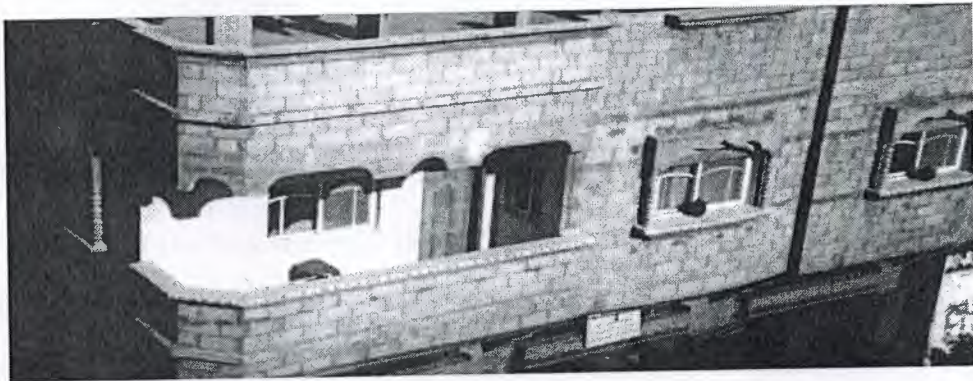
Flowchart for action following of compliance with specifications. (adapted from materials and structure- Paris)

**Flowchart 4.1** The concrete quality procedure.



## 4.6 CONCRETE BLOCKS

Concrete blocks are manufactured from Portland cement and aggregates. The range of aggregates used is extensive in order to achieve a variety of performance characteristics. Classification of blocks is by compressive strength categories, 2.8, 3.5, 5, 7, 10, 15, 20 and 35 N/mm<sup>2</sup>. The denser, stronger blocks may be used for sub structural work or party wall construction in place of bricks and the lighter, weaker, hollow blocks for non-load bearing internal partition walls. The majority of blocks are 440 mm long x 215 mm high x 100 mm thick to relate to brickwork. {17}



**Photo 4.5** Concrete blocks

### 4.6.1 Strength of concrete masonry units

Compressive strengths of concrete masonry units are difficult to predict because the useful water-cement ratio concept is not valid for harsh block mixes. The production of concrete masonry units requires careful control of water quantities in the block mix. Wetter mixes are easier to mold and generally yield higher compressive strengths; however, breakage of green units increases during handling operations. The use of very dry mixes produces consolidation problems during molding operations and ultimately lowers compressive strengths. Therefore, each block-manufacturing facility, through experimentation, will develop mix designs that will produce concrete masonry units of adequate strength without sacrificing other required properties.

The factors which affect compressive strength values for concrete block include: the type and gradation of aggregate, the type and amount of cementations material, the degree of consolidation attained during molding, the curing method, the size and shape of the concrete masonry unit, and the conditions of the block with regard to moisture and temperature at the time of test.

Tensile strength, flexural strength, and modulus of elasticity values vary with the compressive strength values of a concrete masonry unit. Tensile strength will normally range from 7 to 10 percent of the compressive strength, flexural strength from 15 to 20 percent of compressive strength, and the modulus of elasticity from 300 to 1200 times the compressive strength. {17}

#### 4.6.2 Absorption of concrete masonry units

Absorption tests provide a measure of the density of the concrete in concrete masonry units. The absorption value is calculated in pounds of water per cubic foot of concrete and varies over a wide range, depending upon the aggregates used in the unit. Values for water absorption may vary from 4 lb per cu ft for dense sands and stones to as much as 20 lb per cu ft for lightweight aggregates.

The porosity of the concrete will also influence other properties, such as permeability, thermal conductivity, weight reduction, and acoustical properties. When these properties are required, the absorption values will rise. However, since these properties are usually required of interior or protected masonry, the higher absorption values are not detrimental to the concrete masonry units' durability. A high initial rate of absorption or suction indicates concrete masonry units of high permeability and low durability, because the concrete contains a large number of interconnected pores and voids. However, unconnected air-filled voids present in lightweight aggregates and air-entrained cement paste impart some of the desired porosity properties' to the concrete masonry unit while limiting the permeability of the unit to water.

Even though concrete masonry units may have reasonably high suction rates, unlike clay masonry, concrete masonry units are never presoaked and in some cases may require a covering system to prevent moisture content changes in the units because of weather conditions. {17}

#### 4.6.3 Dimensional Changes in Concrete Masonry Units

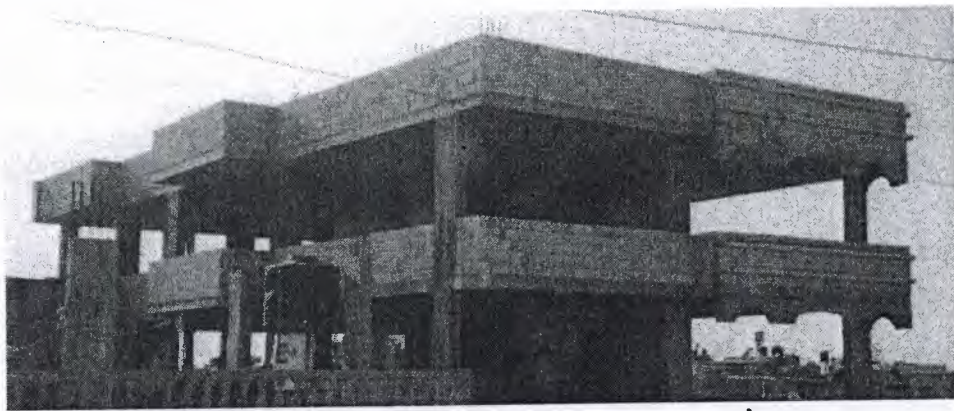
Concrete masonry units normally undergo dimensional changes due to changes in temperature, moisture content, and a chemical reaction called carbonation.

Temperature changes cause units to expand and contract when heated and cooled. These volume changes are reversible through the same temperature ranges. The thermal expansion and contraction of concrete masonry units is governed primarily by the type



of aggregate in the unit, since aggregates normally comprise 80 percent of the concrete volume. These volume changes, while relatively small in a single unit, can cause serious problems in the construction of long walls. Therefore, the designers of masonry structures will place control joints in long walls as relief areas for the compounded volume changes occurring in individual masonry units.

Moisture content changes cause concrete masonry units to expand when wet and shrink when dried. During the first few cycles of wetting and drying, the concrete masonry units may not return to their original sizes, because the concrete has a tendency toward a permanent contraction state. However, during subsequent wetting and drying cycles, the volume changes are reversible.



**Photo 4.6** Concrete blocks

Original drying shrinkage is an important factor in crack development in concrete masonry walls. If concrete masonry units are placed in a wall before they have been allowed to shrink to a dimensionally stable volume, wherever the wall is restrained tensile stresses will develop and cracks will occur. Drying shrinkage is greatly reduced by properly curing and drying units so that when they are placed in the structure the moisture content of the unit is in equilibrium with the surrounding air.

Carbonation causes irreversible shrinkage in concrete masonry units when carbon dioxide is absorbed into the hardened concrete paste of masonry units. The changes in volume are approximately the same as those caused by moisture condition fluctuations. One method of reducing carbonation on the jobsite during cold weather masonry construction is to require all heat sources to be properly vented to the exterior of the work area. {17}



## 4.7 FINISH WORKS

### 4.7.1 Doors and windows

#### Doors

The fundamental purpose of a door is to provide access into or out of a building, and between the various compartments within a building. Additionally, the following functions are fulfilled, the extent depending on the building type and purpose: {18}

1. Security.
2. Weather resistance.
3. Fire resistance.
4. Thermal insulation.
5. Sound insulation.

### 4.7.2 Windows

The functions of a window are to admit daylight, provide natural ventilation and to exclude rainwater. In some circumstances the view from a window provides an important function as relief and pleasant relaxation from the daily internal routine. {18}

### 4.7.3 Glass and glazing

Glass is made by fusing sand (70%), soda (13%), lime (13%) and other minor ingredients such as metal oxides and clay at a temperature of 1500 to 1550 °C. The molten glass is drawn vertically for about 10 m and then along horizontal rollers where it is cut into sheets. Patterned glass is made in the same manner, but reduced in size by a series of opposing steel rollers. The final rollers are surface profiled to produce a patterned effect on one side of the glass. Both drawing and rolling are used for making clear glass, but the result is never perfect as the strain of drawing and the mark from rollers produce slight surface flaws and deformities. Perfectly finished glass for mirrors, cabinets and other high glass joinery is produced by floating the molten glass over a bath of molten tin until all the imperfections even out. For general glazing purposes glass is produced in 3, 3.5 and 4 mm thicknesses. {18}

#### 4.7.4 Plaster

Building plasters are produced from gypsum rock. This is crushed, heated and ground to a fine powder before bagging and delivery to site. On site, water is reintroduced to the powder to create a plaster solution for application to walls and ceilings before a chemical reaction and evaporation occur, which return the solution to the original gypsum rock. Plaster composition, quality and finish vary to suit different applications.

{18}

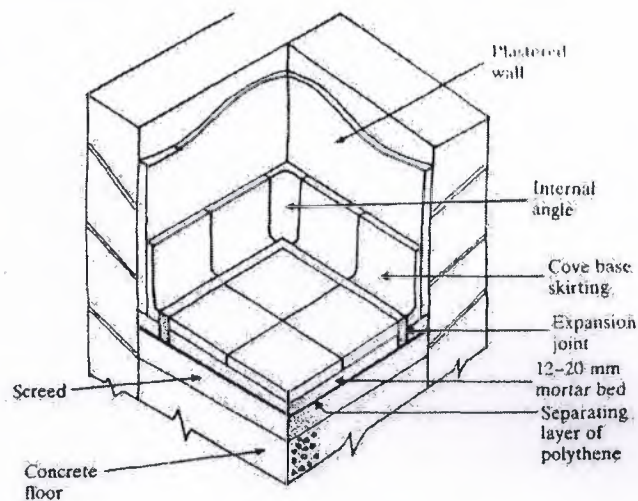


Figure 4.7 Clay/quarry tile flooring

## **CHAPTER 5 SURVEY ANALYSIS**

### 5.1 Introduction

### 5.2 Discussions and analyzing



## 5.1 INTRODUCTION

The first part of the research focuses on the concept and techniques of “Quality Control” as site, laboratory (See Form 5.1, part I, page 77), and supervision “Quality Control”, as well as the value of these control for the building construction.

After collecting the questionnaire results to make the general average result of needed time and cost to apply the “Quality Control System” on the building construction.

## 5.2 DISCUSSIONS AND ANALYSING

### 5.2.1 Questionnaire procedure

As shown in the form 5.1, four pages questionnaire model had been done. The first two pages aimed to check the opinions of the technical and controllers about the quality control value in the construction projects, the effects of quality control on the construction project as duration and cost and which of the construction establishments are more concerned to apply quality control tests on the projects.

Then a form table had been prepared, (Form 5.1, part II, page 79), to be ready and easy to fill, while this part of the questionnaire tried to cover the most famous quality control test for the conventional reinforced concrete building as detailed from A to H in section (5.2.1.1).

#### 5.2.1.1 The considered construction tests

A. Bearing capacity test of the soil

B. Aggregates tests (Fine & coarse)

1- Gradation test

2- Specific gravity test

3- Absorption test

4- Abrasion test

5- Crushing value test

6- Impact test

C. Cement tests

1- Compressive strength test

2- Setting time test

3- Fineness test

4- Soundness test

**D. Fresh concrete tests**

1- Slump test

2- Compressive strength test (Cubes or cylindrical)

**E. Hardened concrete tests**

1- Core test

2- Estimated strength (Schmidt Hammers test)

**F. Reinforcing steel bars tests**

1- Tensile strength test

2- Bending test

**G. Concrete hollow blocks**

1- Compressive strength test

2- Dimensions, shape, color test

**H. Tiles**

1- Flexural strength test

2- Abrasion test

### **5.2.1.2 The result of the questionnaire**

The results of the questions that regarded with value of applying quality control system on the buildings construction, was heuristic while almost of the construction controller believed that, the constructors should use the quality control system during and after the buildings construction process.

Smoothly different digital results of the needed time and cost was found in the four questionnaires form, but in general, all of the result was closing to each other in time as well as cost of the quality control tests.

As detailed in the table 5.1 in page 81, a general average cost and duration had been done to combine all of the smooth differences and get one digital result for cost and time.

### **5.2.2 Comparison procedure**

In the first, four floors residential building construction had been prepared as a proposal project as shown in the appendices part.

According of Palestinian construction standard, the unit price of the building project and the man power costs had been calculated and detailed for the first plan of the project which is exclude the quality control charge, (88,510.45 \$) and (23,440.80 \$) were found, as a total unit price and man power cost for the building project exclude the quality control charge.

As a time plan that did by using computer based program (Microsoft Project), (136 days), was found as total duration time for the building project exclude the quality control charge.

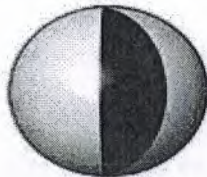


The other hand of the comparison which is the soul of the thesis that is considering the quality control charge in the same construction project. (90,910.28 \$) and (25,156.80 \$) were found, as a total unit price and man power cost for the building project include the quality control charge.

Also as a time plan, (144 days), was found as total duration time for the building project includes the quality control charge.

### **5.2.3 The effects of "Quality Control" on time and cost**

From the analysis results that explained in sections 5.2.1 and 5.2.2, quality control techniques affect smoothly the cost and duration of execution a buildings constructions project. According of the digital result that written in sections 5.2.1 and 5.2.2, not more than 3.5% of the total execution time for such this building project can be affected by applying quality control system. Not more than 5.9 % of the total cost of the building construction project can be affected.

**Form 5.1** Questionnaire for the constructions controllers.***Near East University******(Nicosia-Northern Cyprus)***Web: [www.neu.edu.tr](http://www.neu.edu.tr)***Civil Engineering Department***  
***Master of Construction Engineering Branch******QUALITY CONTROL FOR R/C BUILDINGS***  
***CONSTRUCTUION (2006)***

Supervisor Name: Prof. Dr. Ata ATUN

Student Name: Mohammed Fawzi ASLAN

**QUESTIONNAIRE FOR THE CONSTRUCTIONS CONTROLLERS****Part I****T01:** Laboratory / Institute Name:**T02:** Laboratory / Institute Address:**T03:** Officer Name:**T04:** Profession:**QS 01:** Do you think, the Quality Control in the construction stage will help to improve the quality of buildings?Yes ☐No ☐No idea ☐

Other

Strongly agree ☐ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☐

**QS 02: Do you think that Quality Control can affect the duration (Execution time) of the building construction?**

Yes ☐ No ☐ No idea ☐ Other

Strongly agree ☐ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☐

**QS 03: Do you think that Quality Control can affect the cost of the building construction?**

Yes ☐ No ☐ No idea ☐ Other

Strongly agree ☐ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☐

**QS 04: What numbers of construction contractors bring you for Quality Control works in a year?**

Less than 30/year ☐ Around 70/year ☐ More than 100/year ☐ Note

**QS 05: Which of these Construction Establishments are more concerned to do Quality Control tests?**

Government ☐ Companies ☐ Privet ☐ Other

**QS 06: Do you think that, the price of the tests can be high comparatively with the value and benefit to the buildings Quality?**

Yes ☐ No ☐ No idea ☐ Other

Strongly agree ☐ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☐



**The tests that are concerned in survey (Questionnaire)**

**Part II**

- ♦ *Average Cost and Duration taken from four Construction Controllers Institutes*

Construction Test Name	Exact Needed Time(day)	Exact Needed Price (U.S \$)
<ul style="list-style-type: none"> <li>• <b>Soil Capacity test for foundations (In general)</b></li> <li>1- Soil bearing test</li> </ul>		
<ul style="list-style-type: none"> <li>• <b>Aggregates tests(Fine &amp; coarse)</b></li> <li>1- Gradation test</li> <li>2- Specific gravity test</li> <li>3- Absorption test</li> <li>4- Abrasion test</li> <li>5- Crushing value test</li> <li>6- Impact test</li> </ul>		
<ul style="list-style-type: none"> <li>• <b>Cement tests</b></li> <li>1- Compressive strength test</li> <li>2- Setting time test</li> <li>3- Fineness test</li> <li>4- Soundness test</li> </ul>		
<ul style="list-style-type: none"> <li>• <b>Fresh concrete tests</b></li> <li>1- Slump test</li> <li>2- Compressive strength test (Cubes or</li> </ul>		

Cylindrical)  <ul style="list-style-type: none"> <li>• <b>Hardened concrete tests</b></li> </ul> 1- Core test  2- Estimated strength (Schmidt Hammers test)  <ul style="list-style-type: none"> <li>• <b>Reinforcing steel bars tests</b></li> </ul> 1- Tensile strength test  2- Bending test		
<ul style="list-style-type: none"> <li>• <b>Concrete hollow blocks</b></li> </ul> 1- Compressive strength test  2- Dimensions, shape, color test (If it's available)		
<ul style="list-style-type: none"> <li>• <b>Tiles</b></li> </ul> 1- Flexural strength test  2- Abrasion test		
<ul style="list-style-type: none"> <li>• <b>Others (If Available)</b></li> </ul> 1- Painting test 2-		
<u><b>Please leave these areas (free)</b></u>		

*Thank you,*

*Near East University  
(Nicosia -Northern Cyprus)  
Web: [www.neu.edu.tr](http://www.neu.edu.tr)*

Table 5.1 Average cost and duration taken from four construction controllers institutes

Construction Test Name		Exact Needed Time(day)	Exact Needed Price ( \$ )
Soil Capacity test for foundations      (In general)			
1-Soil bearing test		6,50	500.00 (for three holes)
Aggregates tests(Fine & Coarse)			
1- Gradation test		1,50	17,50
2- Specific Gravity test		1,25	15,00
3- Absorption test		1,50	20,00
4- Abrasion test		1,75	35,00
5- Crushing value test		1,25	23,75
6- Impact test		1,25	23,75
		1,75	135,00
Cement tests			
1 - Compressive Strength test		7,00	52,50
2- Setting time test		1,00	22,50



3- Fineness Test	0,78	26,25
4- Soundness test	3,00	38,75
	7,00	140,00
<b><i>Fresh concrete tests</i></b>		
1- Slump test	0,02	6.25 (for cone)
2- Compressive strength test (Cubes or Cylindrical)	7,00	2.13 (for cube)
<b><i>• Hardened concrete tests</i></b>		
1- Core test	3,25	32.50 (for core)
2- Estimated strength (Schmidt Hammers test)	1,25	22.50 (for test)
<b><i>• Reinforcing steel bars tests</i></b>		
1- Tensile strength test	0,75	10.00 (for a bar)
2- Bending test	0,75	10.00 (for a bar)
	0,75	20
<b><i>Concrete hollow blocks</i></b>		
1- Compressive Strength test	0,78	10.00 (for one)
2- Dimensions, Shape, Color test (If it's available)	0,78	8.75 (for one)

	0,78	18,75
<b><i>Tiles</i></b>		
1- Flexural Strength test	1,53	24.00 (for one)
2- Abrasion test	1,75	55.00 (for one)
	1,75	79
<b><i>Others (If Available)</i></b>		
1- Painting test	7,50	100.00 (for a sample)
2-		

Exclude (QC)

Description of Work	Unit	NO.	Length	Width	Height	Quantity	Unit Price (\$)	Total Price(\$)
<b>EARTH WORKS</b>								
Sand for back filling	m3	1	12	11	0.8	105.60	2,90	306.24
Water compaction	m3	1	1	1	1	1	15,00	15.00
								<b>321.24</b>
<b>CONCRETE WORKS</b>								
Lean concrete under foundation	m3	3	1,5	1,5	0.1	0.675		
		5	1,7	1,7	0.1	1,45		
		3	1,8	1,8	0.1	0,97		
		1	1,9	1,9	0.1	0,36		
						<b>3,46</b>	54,00	186,84
Foundation	m3	3	1,5	1,5	0.40	2,70		
		5	1,7	1,7	0.45	6,50		
		3	1,8	1,8	0.55	5,30		
		1	1,9	1,9	0.60	2,17		
						<b>16,67</b>	58,00	966,86
Columns necks	m3	3	0,45	0,2	1	0,27		
		5	0,5	0,2	1	0,5		
		4	0,6	0,2	1	0,48		
						<b>1,25</b>	61	76,25



# BILL OF QUANTITY Exclude (QC)

Tie beams	m3	1	83.0	0,2	0,4	6,64	58	385,12
Ground floors	m3	1	11	10,2	0.1	11,22	58	650,76
Columns for Ground Floor	m3	3	0,45	0,2	3	0,81		
		5	0,5	0,2	3	1,5		
		4	0,6	0,2	3	1,44		
						<b>3,75</b>	61	228,75
Staircases for 4 storey	m3	1				14,5	61	884,5
Slab for Ground Floor	m3	1	11	11,4	0.17	21,32	58	1236,56
Casting over wall beams(for 4 Storey)	m3	4	180	0.20	0.15	21,6	58	1252,8
Columns for First Floor	m3	3	0,45	0,2	3	0,81		
		5	0,5	0,2	3	1,5		
		4	0,6	0,2	3	1,44		
						<b>3,75</b>	61	228,75
Slab for First Floor	m3	1	11	11,4	0.17	21,32	58	1236,56
Columns for Second Floor	m3	3	0,45	0,2	3	0,81		
		5	0,5	0,2	3	1,5		
		4	0,6	0,2	3	1,44		
						<b>3,75</b>	61	228,75
Slab for Second Floor	m3	1	11	11,4	0.17	21,32	58	1236,56
Columns for Third Floor	m3	3	0,4	0,2	3	0,72		
		5	0,45	0,2	3	1,35		
		4	0,55	0,2	3	1,32		





Exterior walls over windows (Ground Floor)	m2		42,59		1,8	76,66	7	536,62
Partition walls under windows (Ground Floor)	m2		35,27		1,1	38,8	5	194
Partition walls over windows (Ground Floor)	m2		35,27		1,8	63,49	5	317,45
Exterior walls under windows (Typical floor)	m2	3	52,52		1,1	173,32	7	1213,24
Exterior walls over windows (Typical floor)	m2	3	52,52		1,8	283,62	7	1985,34
Partition walls under windows (Typical floor)	m2	3	43,5		1,1	143,55	5	717,75
Partition walls over windows (Typical floor)	m2	3	43,5		1,8	234,9	5	1174,5
Fence blocks	m2		42,59		1,2	51,11	7	357,77
Slab blocks	Unit					2900	0,4	1160
								<b>7984,62</b>
<b>PLASTERING WORKS</b>								
External plastering (Ground Floor)	m2					221	2,9	640,9
Internal plastering (Ground Floor)	m2					512	3,15	1612,8
External plastering (Typical floor)	m2	3				817,68	2,9	2371,27
Internal plastering (Typical floor)	m2	3				1894,35	3,15	5967,2
								<b>10592,17</b>
<b>PAINTING WORKS</b>								
Ceiling painting (Ground Floor)	m2					112	1,75	196
Interior walls painting (Ground Floor)	m2					430	2	860
Exterior painting (Ground Floor)	m2					221	1,75	386,75





**BILL OF QUANTITY**  
**Exclude (QC)**

CE 500(Thermal) Project

Accessories	I.s									1200	1200
											<b>5615</b>
<b>WINDOWS WORKS</b>											
Windows & fence	Unit	33								140	4620
Small windows	Unit	17								55	935
Stair windows	Unit	8								60	480
											<b>6035</b>
<b>SANITARY WORKS</b>											
Pipes	m,l					350				2,2	770
W. c. Ch.	Unit	8								130	1040
Shower Basin	Unit	4								280	1120
Washing basin	Unit	8								55	440
Washing basin for kitchen	Unit	4								160	640
Accessories	I.s	4								300	1200
Sewage pipes	m,l	150								3,8	570
Manholes	Unit	6								70	420
Heating unit & water tanks	Unit	4								720	2880
											<b>9080</b>
<b>ELEC. &amp; ST. WORKS</b>											

Electrical panel	Unit	4						260	1040
Electricity tubes	m,l		240					2	480
T v and tel. connections	l,s							800	800
Switches and sockets	l,s							700	700
Lights	l,s							550	550
Main connection	l,s							200	200
									3770
<b>INTERNAL METAL WORKS</b>	Ton	5						620	3100
<b>ROOFING WORKS</b>									
Roof red bricks& Woods	m2	139						16	2224
<b>ISOLATION WORKS</b>	m2	128						7	896
<b>TOTAL</b>								<b>88,510.45 (\$)</b>	



Description of work	No. of workers	price (\$ ) hourly	Working hr.	Total(\$)
<b>Excavation works</b>				
Clam shell machine	1	30	2*8	480
<b>Form works</b>				
Foreman	2	2,6	79*8	3286,4
Helpers	3	1,8	79*8	3412,8
<b>Bricks work</b>				
Foreman	2	2,6	42*8	1747,2
Helpers	2	1,8	42*8	1209,6
<b>Electrical works</b>				
Foreman	2	2,45	15*8	588
Helpers	2	1,65	15*8	396
<b>Sanitary works</b>				
Foreman	2	2,45	22*8	862,4
Helpers	2	1,65	22*8	580,8
<b>Plastering</b>				
Foreman	3	2,35	30*8	1692
Helpers	3	1,7	30*8	1224

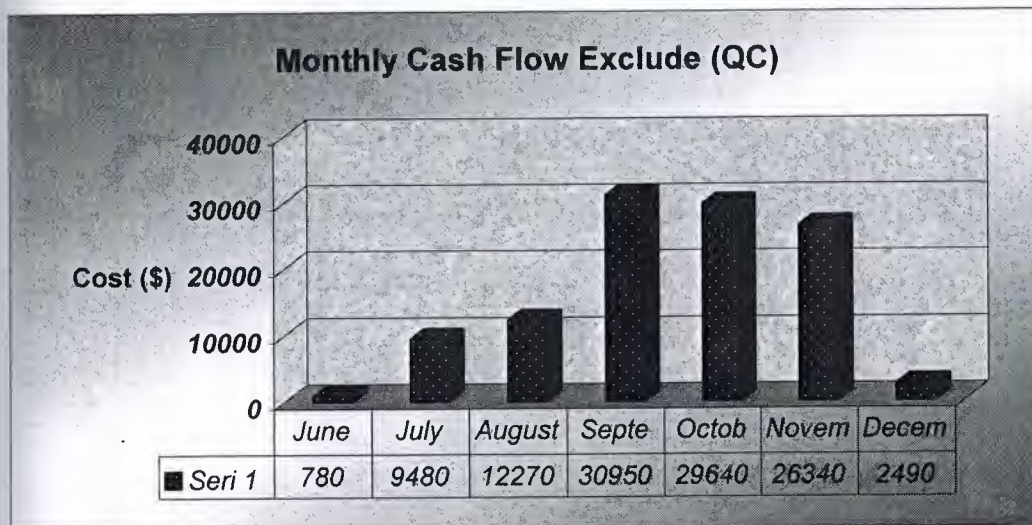
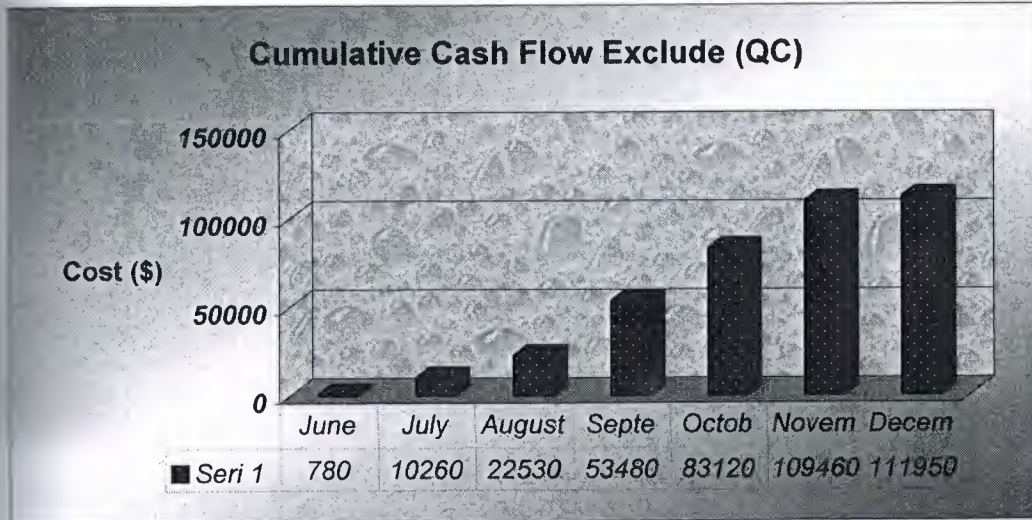
<b>Painting</b>					
Foreman	3	2,45	32*8	1881,6	
Helpers	2	1,8	32*8	921,6	
<b>Windows works</b>					
Foreman	2	2,45	10*8	392	
Helpers	2	1,8	10*8	288	
<b>Ceramic &amp; tiling works</b>					
Foreman	3	2,45	33*8	1940,4	
Helpers	2	1,8	33*8	950,4	
<b>Doors works</b>					
Foreman	2	2,45	15*8	588	
Helpers	2	1,6	15*8	384	
<b>Isolation works</b>					
Foreman	1	2,45	7*8	137,2	
Helpers	2	1,7	7*8	190,4	
<b>Fixing works</b>					
Foreman	1	2,1	4*8	67,2	
Helpers	1	1,6	4*8	51,2	
<b>Cleaning works</b>					

Exclude (QC)

Foreman	1	2,1	4*8	67,2
Helpers	2	1,6	4*8	102,4
Total mp. cost				23,440.80 \$



June	780	780
July	9480	10260
August	12270	22530
September	30950	53480
October	29640	83120
November	26340	109460
December	2490	111950
	111950	



Description of Work		Unit	NO.	Length	Width	Height	Quantity	Unit Price (\$)	Total Price(\$)
<b>EARTH WORKS</b>									
Sand for back filling		m3	1	12	11	0.8	105.60	2,90	306.24
Water compaction		m3	1	1	1	1	1	15,00	15.00
Soil bearing test		No.	1					500,00	500
<b>CONCRETE WORKS</b>									
Aggregates tests (Fine & Coarse)		No.	1					135	135
Cement tests		No.	1					140	140
Reinforcing steel bars tests		No.	15					20	300
Lean concrete under foundation		m3	3	1,5	1,5	0.1	0.675		
			5	1,7	1,7	0.1	1,45		
			3	1,8	1,8	0.1	0,97		
			1	1,9	1,9	0.1	0,36		
							<b>3,46</b>	54,00	186,84
Foundation									
Slump test 1		No.	2					6,25	12,5
Compressive strength test 1		No.	6					2,13	12,78
		m3	3	1,5	1,5	0.40	2,70		
			5	1,7	1,7	0.45	6,50		
			3	1,8	1,8	0.55	5,30		
			1	1,9	1,9	0.60	2,17		







	m3	1	11	11,4	0,17	21,32	58	1236,30
Casting over wall beams(for 4 Storey)	m3	4	180	0,20	0,15	21,6	58	1252,8
Columns for First Floor								
<b>Slump test 6</b>	No.	1					6,25	6,25
<b>Compressive strength test 6</b>	No.	6					2,13	12,78
	m3	3	0,45	0,2	3	0,81		
		5	0,5	0,2	3	1,5		
		4	0,6	0,2	3	1,44		
						3,75	61	228,75
Slab for First Floor								
<b>Slump test 7</b>	No.	2					6,25	12,5
<b>Compressive strength test 7</b>	No.	6					2,13	12,78
	m3	1	11	11,4	0,17	21,32	58	1236,56
Columns for Second Floor								
<b>Slump test 8</b>	No.	1					6,25	6,25
<b>Compressive strength test 8</b>	No.	6					2,13	12,78
	m3	3	0,45	0,2	3	0,81		
		5	0,5	0,2	3	1,5		
		4	0,6	0,2	3	1,44		
						3,75	61	228,75
Slab for Second Floor								
<b>Slump test 9</b>	No.	2					6,25	12,5









Include (QC)

Slab blocks	Unit							2900	0,4	1160
										<b>7984,62</b>
<b>PLASTERING WORKS</b>										
External plastering (Ground Floor)	m2							221	2,9	640,9
Internal plastering (Ground Floor)	m2							512	3,15	1612,8
External plastering (Typical floor)	m2	3						817,68	2,9	2371,27
Internal plastering (Typical floor)	m2	3						1894,35	3,15	5967,2
										<b>10592,17</b>
<b>PAINTING WORKS</b>										
<b>Painting Sample Tests</b>	No.	3							100,00	300
Ceiling painting (Ground Floor)	m2							112	1,75	196
Interior walls painting (Ground Floor)	m2							430	2	860
Exterior painting (Ground Floor)	m2							221	1,75	386,75
Ceiling painting (Typical floor))	m2	3						414,39	1,75	725,18
Interior walls painting (Typical floor)	m2	3						1590,96	2	3181,92
Exterior painting (Typical floor)	m2	3						817,68	1,75	1430,94
										<b>6780,79</b>
<b>TILING WORKS</b>										
<b>Tiles Tests</b>	No.	7							79,00	553
Floor tiling (Ground Floor)	m2							105	9	945

[illegible]



<b>SANITARY WORKS</b>										
Pipes	m,l								2,2	770
W. c. Ch.	Unit	8							130	1040
Shower Basin	Unit	4							280	1120
Washing basin	Unit	8							55	440
Washing basin for kitchen	Unit	4							160	640
Accessories	l,s	4							300	1200
Sewage pipes	m,l	150							3,8	570
Manholes	Unit	6							70	420
Heating unit & water tanks	Unit	4							720	2880
										<b>9080</b>
<b>ELEC. &amp; ST. WORKS</b>										
Electrical panel	Unit	4							260	1040
Electricity tubes	m,l								2	480
T v and tel. connections	l,s								800	800
Switches and sockets	l,s								700	700
Lights	l,s								550	550
Main connection	l,s								200	200
										<b>3770</b>



INTERNAL METAL WORKS	Ton	5							620	3100
ROOFING WORKS										
	Roof red bricks& Woods	m2	139						16	2224
ISOLATION WORKS										
		m2	128						7	896
TOTAL										90,910.28 (\$)

Description of work	No. of workers	price (\$) hourly	Working hr.	Total(\$)
<i>Quality Control Engineer (2 Hr / day)</i>	1 Eng.	6	143*2	1716
<b>Excavation works</b>				
Clam shell machine	1	30	2*8	480
<b>Form works</b>				
Foreman	2	2,6	79*8	3286,4
Helpers	3	1,8	79*8	3412,8
<b>Bricks work</b>				
Foreman	2	2,6	42*8	1747,2
Helpers	2	1,8	42*8	1209,6
<b>Electrical works</b>				
Foreman	2	2,45	15*8	588
Helpers	2	1,65	15*8	396
<b>Sanitary works</b>				
Foreman	2	2,45	22*8	862,4
Helpers	2	1,65	22*8	580,8
<b>Plastering</b>				
Foreman	3	2,35	30*8	1692

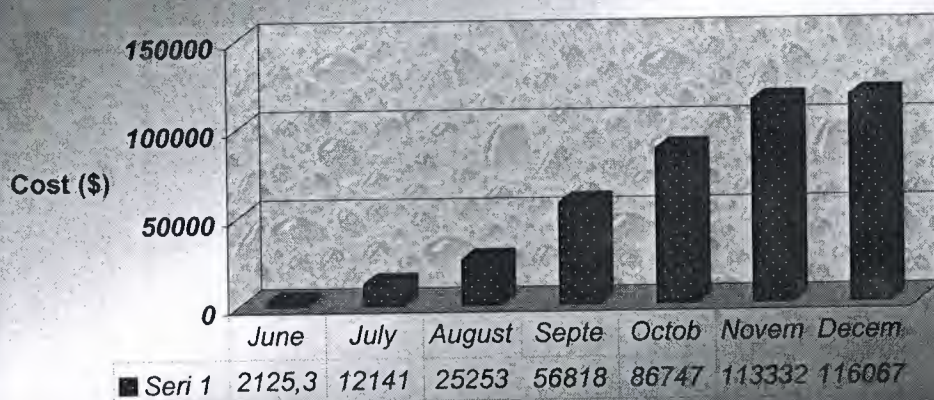
	Helpers	3	1,7	30*8	1224
<b>Painting</b>					
	Foreman	3	2,45	32*8	1881,6
	Helpers	2	1,8	32*8	921,6
<b>Windows works</b>					
	Foreman	2	2,45	10*8	392
	Helpers	2	1,8	10*8	288
<b>Ceramic &amp; tiling works</b>					
	Foreman	3	2,45	33*8	1940,4
	Helpers	2	1,8	33*8	950,4
<b>Doors works</b>					
	Foreman	2	2,45	15*8	588
	Helpers	2	1,6	15*8	384
<b>Isolation works</b>					
	Foreman	1	2,45	7*8	137,2
	Helpers	2	1,7	7*8	190,4
<b>Fixing works</b>					
	Foreman	1	2,1	4*8	67,2
	Helpers	1	1,6	4*8	51,2



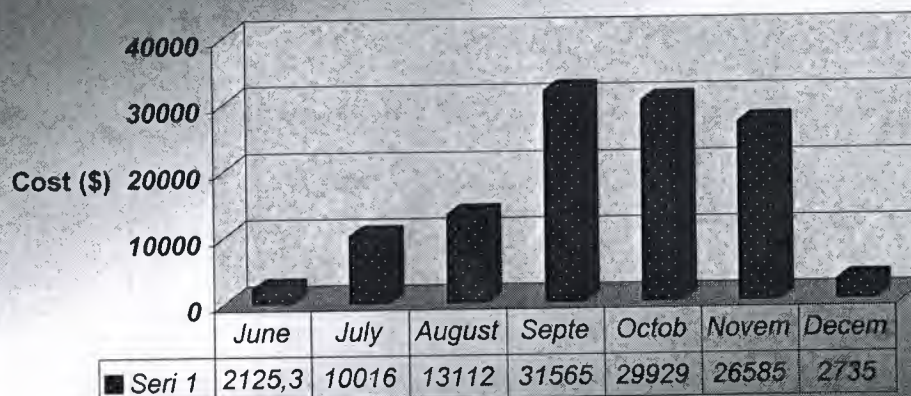
<b><i>Cleaning works</i></b>					
Foreman	1	2,1	4*8	67,2	
Helpers	2	1,6	4*8	102,4	
<b><i>Total mp. cost</i></b>				<b>25,156.80 \$</b>	

June	2125,3	2125,3	
July	10015,6	12140,9	245 \$ monthly for the control engineer
August	13112,3	25253,2	
September	31564,6	56817,8	
October	29929,3	86747,1	
November	26585	113332,1	
December	2735	116067,1	

**Cumulative Cash Flow include (Q C)**



**Monthly Cash Flow include (Q C)**





Description		Result
Total Duration for the Construction (Only the Execution time /days) <u>Exclude Quality Control (QC)</u>		136 days
Total Duration for the Construction(Execution time + Quality Control time / days) <u>Include Quality Control (QC)</u>		144 days
Total Cost (Bills of Quantities + Workmen Ship + 5 % Taxes ) <u>Exclude Quality Control (QC)</u> 88510,45 (\$) + 23440,80 (\$) + 5597,56 (\$) taxes		117548.81 (\$)
Total Cost (Bills of Quantities + Workmen Ship + 5 % Taxes + Quality Control Cost) <u>Include Quality Control (QC)</u> 90910,28 (\$) + 23440,80 (\$) + 5597,56 (\$) taxes + 4115.83 (Tests & Control Engineer)		121664.64 (\$)
The Effecting of Quality Control on the Construction Duration 144 days - 136 days = 8 days , 8days /136 days * 100% = 5.88 %		5.9 % (of original duration)
The Effecting of Quality Control on the Construction Cost 121664.64 (\$) - 117548.81 (\$) = 4115.83 (\$) , 4115.83 (\$) /117548.81 (\$) * 100 % = 3.5 %		3.5 % (of original cost)



## **CHAPTER 6 CONCLUSION AND RECOMMENDATIONS**

### 6.1 Conclusion

### 6.2 Recommendations

### 6.3 Implications for future research

## 6.1 CONCLUSION

### 6.1.1 Presentation

This chapter summarizes the study and its major findings first. Then it gives implications for quality control planning and the results of an experiment done by the researcher to assess the effectiveness of strategy construction. Finally this chapter provides recommendations for further research.

### 6.1.2 Summary of the Study

As it is mentioned in the first chapter, the study aims at examining what effects can be happened to the buildings construction projects as a cost and time by applying quality control system.

The questions of the study are:

1. What is the construction management in construction engineering?
2. What is the construction planning in construction engineering and how it can be developed by the modern technology?
3. What is the quality control procedure in construction engineering?
4. How to apply quality control system in the construction process?
5. Does the meaning of construction quality vary according to the country standard?
6. Is there a relationship between the quality control and the serviceability of the building construction?
7. How the quality control can affect the working time plan of the building construction as well as the price?

### 6.1.3 Summary of the Results

The results of the study are:

1. The construction management deemed as the mother source for the construction engineering stages from the first step of the project until to the finishing , and at the same time it is the reference for them.
2. Construction managements cover the most important articles in construction that called (five M) which are men, machine, materials, money and minutes.
3. Any construction plans must consider the pervious five elements which are men power, technological tools, materials, cost and time, because they are the basic factors

in order to execute a complete construction project according of the construction planning system.

4. Planning can be thought of as determining "what" is going to be done, "how," "where," by "whom," and "when." In construction projects the "plans" (blueprints) and specifications for the project generally define both the end product and, often, the general time frame in which to complete the project.
5. The Quality Control for the construction stages helps to improve the quality and serviceability of buildings.
6. The charge of the quality control has been found low comparatively with the value and the benefit of the buildings quality.
7. The meaning of construction quality can vary smoothly according to the country standard but the logic and the aims of all construction standards are same which produces qualified constructions.

## 6.2 RECOMMENDATIONS

Since the quality control strategies have been proved to be an active player in the construction success, these strategies must be integrated with the construction management logic. Construction managers are expected to explicitly planning, and to raise their projects awareness of the ideal works. Construction planners should talk to their work staff about their construction problems and encourage them to find different ways to solve these problems. In order to be professionals, construction planners must be continuous researchers finding more and more variables that influence their projects' success in construction process.

Quality is not a recent phenomenon.

Quality is a difficult concept to define in the absence of other measures, but value is something all customers are expected to maximize.

Quality on construction projects as well as project success can be regarded as the fulfillment of expectations of the participants involved.

A successful selection of components of construction facility needs knowledge of design alternatives and how much of these match with the quality criteria of client.

Tools and techniques are tangible aspects of quality management. Without them, any improvement initiative will be based on hope rather than sound data. It is the



combination of the so-called hard tools, in conjunction with the soft methods of developing teamwork which will determine success.

Any improvement tool or technique should be used within a teamwork situation; this will encourage collective effort and consensus.

An appropriate tool should be used to collect, analyze and develop solutions to problems which obstruct quality.

The techniques should be simple but effective, and all employees should be trained in their application, especially workers at the operational level.

### **6.3 IMPLICATIONS FOR FUTURE RESEARCH**

Since this study finds significant relationship between the quality control strategy and affection of work planning for the conventional reinforced concrete buildings projects as a time and cost, it can be recommended that, other factors should be considered in future research. Factors like, the relationship between the quality control system and the benefits that the reinforced concrete buildings will gain may had to an ideal serviceability.



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## APPENDICES

## **Definitions and details of the polled institutes and people**

### Islamic University - Materials and Soil Laboratories

Details of the polled person:

**Name:** Ahmad KOURD

**Profession:** Civil Engineer

**Education:** Master of Science in Civil Engineering (EMU - Northern Cyprus)

**Address:** P. O. Box 108 - Gaza, Gaza Strip – Palestine

Telephone No.: +97 28 282 33 11 / +97 28 286 35 52

Fax No.: +97 28 288 65 52 / +97 28 282 33 10

E-mail: riffi@iugaza.edu or mriffi@papp.undp.org

### Association of Engineers – Materials Testing Laboratories

Details of the polled person:

**Name:** Iyad ABO- HAMMAM

**Profession:** Civil Engineer (Technical Manager)

**Education:** Master of Science in Civil Engineering (Cairo University - Egypt)

**Address:** P. O. Box 111 - Gaza, Gaza Strip – Palestine

Telephone No.: +97 28 282 50 65



Osman & Farra Construction Materials Laboratories

Details of the polled person:

**Name:** Bassam S. DABBOUR

**Profession:** Civil Engineer

**Education:** B.S.c of Science in Civil Engineering (Bear- Zait University - Palestine)

**Address:** P. O. Box 111 – Nile Tower -Gaza, Gaza Strip – Palestine

Telephone No.: +97 28 286 07 00

Web site: [www.enggaza.org/](http://www.enggaza.org/)

Geotechnical and Materials Laboratories

Details of the polled person:

**Name:** Mohammed OUDA

**Profession:** Civil Engineer

**Education:** B.S.c of Science in Civil Engineering (Islamic University - Palestine)

**Address:** P. O. Box 208 – Al Jalaa -Gaza, Gaza Strip – Palestine

**Near East University**

(Nicosia-Northern Cyprus)

Web: www.neu.edu.tr



**Civil Engineering Department**  
**Master of Construction Engineering Branch**

**QUALITY CONTROL FOR R/C BUILDINGS**  
**CONSTRUCTUION (2006)**

Supervisor Name: Prof. Dr. Tahir ÇELİK  
Student Name: Mohammed Fawzi ASLAN

**QUESTIONNAIRE FOR THE CONSTRUCTIONS CONTROLLERS**

T01: Laboratory / Institute Name:

Association of Engineers - Materials Testing

T02: Laboratory / Institute Address:

Palestine - Gaza strip - Gaza

T03: Officer Name:

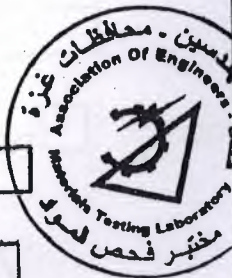
Iyad Abu Hammam

T04: Profession:

Technical Manager

QS 01: Do you think, the Quality Control in the construction stage will help to improve the quality of buildings?

Yes ☒ No ☐ No idea ☐ Other   
Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree ☐



**Q2:** Do you think that Quality Control can affect the duration (Execution time) of the building construction?

Yes ☒ No ☐ No idea ☐ Other   
 Strongly agree ☐ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☐

**Q3:** Do you think that Quality Control can affect the cost of the building construction?

Yes ☐ No ☒ No idea ☐ Other   
 Strongly agree ☐ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☐

**Q4:** What numbers of construction contractors bring you for Quality Control works in a year?

Less than 30/year ☐ Around 70/year ☐ More than 100/year ☒ Note

**Q5:** Which of these Construction Establishments are more concerned to do Quality Control tests?

Government ☐ Companies ☐ Privat ☐ Other

**Q6:** Do you think that, the price of the tests can be high comparatively with the value and benefit to the buildings Quality?

Yes ☐ No ☒ No idea ☐ Other   
 Strongly agree ☐ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☐

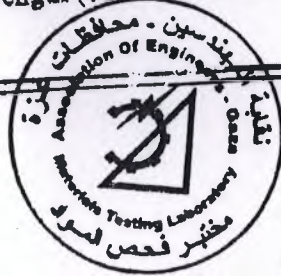




**The tests that are concerned in survey (Questionnaire)**

*Please fill in this table Time and Price only*

Construction Test Name	Exact Needed Time	Exact Needed Price (U.S \$)
<ul style="list-style-type: none"> <li>• Soil Capacity test for foundations (In general)</li> </ul>		
1- Soil bearing test	1 week	500
<ul style="list-style-type: none"> <li>• Aggregates tests(Fine &amp; Coarse)</li> </ul>		
1- Gradation test	1 day	25
2- Specific Gravity test	1 day	20
3- Absorption test	2 days	20
4- Abrasion test	2 days	30
5- Crushing value test	2 days	30
6- Impact test	2 days	30
<ul style="list-style-type: none"> <li>• Cement tests</li> </ul>		
1- Compressive Strength test	28 days	100
2- Setting time test	1 day	20
3- Fineness Test	1 day	30
4- Soundness test	5 days	30
<ul style="list-style-type: none"> <li>• Fresh concrete tests</li> </ul>		
1- Slump test	on time	5 per cm
2- Compressive strength test (Cubes or Cylindrical)	28 days	2 per Cube
<ul style="list-style-type: none"> <li>• Hardened concrete tests</li> </ul>		
1- Core test	3 days	30 per core
2- Estimated strength (Schmidt's Hammer test)	1 day	30 per test



<ul style="list-style-type: none"> <li>• Reinforcing steel bars tests</li> <li>1- Tensile strength test</li> <li>2- Bending test</li> </ul>	2 hours. 2 hours.	10 Per bar 10 Per bar
<ul style="list-style-type: none"> <li>• Concrete hollow blocks</li> <li>1- Compressive Strength test</li> <li>2- Dimensions, Shape, Color test (If it's available)</li> </ul>	1 day 1 day	10 Per one 5 Per one
<ul style="list-style-type: none"> <li>• Tiles</li> <li>1- Flexural Strength test</li> <li>2- Abrasion test</li> </ul>	2 day 2 days	15 Per one 30 Per one
<ul style="list-style-type: none"> <li>• Others (If Available)</li> <li>1- Painting test</li> <li>2-</li> </ul>	From 1 to 14 days	Average 100 \$ for the sample
Please leave this areas (free)		



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**Civil Engineering Department**  
**Master of Construction Engineering Branch**

**QUALITY CONTROL FOR R/C BUILDINGS**  
**CONSTRUCTUION (2006)**



Supervisor Name: Prof. Dr. Tahir ÇELİK  
Student Name: Mohammed Fawzi ASLAN

**QUESTIONNAIRE FOR THE CONSTRUCTIONS CONTROLLERS**

T01: Laboratory / Institute Name:

S.A.A.  
Material & Soil Lab Test

T02: Laboratory / Institute Address:

Gaza - Al Salaa St.

T03: Officer Name:

Eng. M. Ouda

T04: Profession:

Tech. Manager



QS 01: Do you think, the Quality Control in the construction stage will help to improve the quality of buildings?

Yes ☒ No ☐ No idea ☐ Other

Strongly agree ☒ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree ☐



**QS 02:** Do you think that Quality Control can affect the duration (Execution time) of the building construction?

Yes ☐ No ☒ No idea ☐ Other

Strongly agree ☐ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☒

**QS 03:** Do you think that Quality Control can affect the cost of the building construction?

Yes ☒ No ☐ No idea ☐ Other

Strongly agree ☐ Agree ☒ Normal ☐ Disagree ☐ Strongly Disagree ☐

**QS 04:** What numbers of construction contractors bring you for Quality Control works in a year?

Less than 30/year ☒ Around 70/year ☐ More than 100/year ☐ Note

**QS 05:** Which of these Construction Establishments are more concerned to do Quality Control tests?

Government ☒ Companies ☐ Privat ☐ Other

**QS 06:** Do you think that, the price of the tests can be high comparatively with the value and benefit to the buildings Quality?

Yes ☐ No ☒ No idea ☐ Other

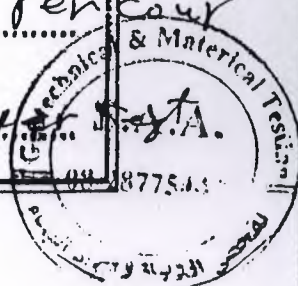
Strongly agree ☒ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☐



**The tests that are concerned in survey (Questionnaire)**

*Please fill in this table Time and Price only*

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<ul style="list-style-type: none"> <li>• Soil Capacity test for foundations (In general)</li> <li>1- Soil bearing test</li> </ul>	1 week	500 \$
<ul style="list-style-type: none"> <li>• Aggregates tests(Fine &amp; Coarse)</li> <li>1- Gradation test</li> <li>2- Specific Gravity test</li> <li>3- Absorption test</li> <li>4- Abrasion test</li> <li>5- Crushing value test</li> <li>6- Impact test</li> </ul>	2 day 1 day 1 day 2 day 1 day 1 day	20 15 20 20 20 20
<ul style="list-style-type: none"> <li>• Cement tests</li> <li>1- Compressive Strength test</li> <li>2- Setting time test</li> <li>3- Fineness Test</li> <li>4- Soundness test</li> </ul>	7 1/2 day 1 1/2 day 1 day 1 day	30 15 20 25
<ul style="list-style-type: none"> <li>• Fresh concrete tests</li> <li>1- Slump test</li> <li>2- Compressive strength test (Cubes or Cylindrical)</li> </ul>	10 min 7 1/2 day	5 2 per cube
<ul style="list-style-type: none"> <li>• Hardened concrete tests</li> <li>1- Core test</li> <li>2- Estimated strength (Schmidt's Hammer test)</li> </ul>	2 day 1 day	20 per core 20 per test





<ul style="list-style-type: none"> <li>• Reinforcing steel bars tests</li> <li>1- Tensile strength test</li> <li>2- Bending test</li> </ul>	...1 day... ...1 day...	...10 Per bar ...10...
<ul style="list-style-type: none"> <li>• Concrete hollow blocks</li> <li>1- Compressive Strength test</li> <li>2- Dimensions, Shape, Color test (If it's available)</li> </ul>	...1 day... ...1 day...	...10 per one ...10...
<ul style="list-style-type: none"> <li>• Tiles</li> <li>1- Flexural Strength test</li> <li>2- Abrasion test</li> </ul>	...2 day... ...2 day...	...15 per one ...30 per one
<ul style="list-style-type: none"> <li>• Others (If Available)</li> <li>1- Marshall for</li> <li>2- Asphalt &amp; other</li> </ul>	...2 day... ...7 day...	...70... ...100 for all
<u>Please leave this areas (free)</u>	63 days	...



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## Civil Engineering Department Master of Construction Engineering Branch

### QUALITY CONTROL FOR R/C BUILDINGS CONSTRUCTUION (2006)

Supervisor Name: Prof. Dr. Tahir ÇELİK  
Student Name: Mohammed Fawzi ASLAN

#### QUESTIONNAIRE FOR THE CONSTRUCTIONS CONTROLLERS

T01: Laboratory / Institute Name:

Material & Soil Labs

T02: Laboratory / Institute Address:

Islamic University of Gaza

T03: Officer Name:

A. Kourdi

T04: Profession:

M.Sc.



QS 01: Do you think, the Quality Control in the construction stage will help to improve the quality of buildings?

Yes ☒ No ☐ No idea ☐ Other

Strongly agree ☒ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree ☐

**QS 02: Do you think that Quality Control can affect the duration (Execution time) of the building construction?**

Yes ☐ No ☒ No idea ☐ Other

Strongly agree ☐ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☒

**QS 03: Do you think that Quality Control can affect the cost of the building construction?**

Yes ☐ No ☐ No idea ☐ Other

Strongly agree ☐ Agree ☒ Normal ☐ Disagree ☐ Strongly Disagree ☐

**QS 04: What numbers of construction contractors bring you for Quality Control works in a year?**

Less than 30/year ☒ Around 70/year ☐ More than 100/year ☐ Note

**QS 05: Which of these Construction Establishments are more concerned to do Quality Control tests?**

Government ☒ Companies ☐ Privat ☐ Other

**QS 06: Do you think that, the price of the tests can be high comparatively with the value and benefit to the buildings Quality?**

Yes ☐ No ☒ No idea ☐ Other

Strongly agree ☒ Agree ☐ Normal ☐ Disagree ☐ Strongly Disagree ☐





**The tests that are concerned in survey (Questionnaire)**

*Please fill in this table Time and Price only*

Construction Test Name	Exact Needed Time	Exact Needed Price (U.S \$)
<ul style="list-style-type: none"> <li>• Soil Capacity test for foundations (In general)</li> </ul>		
1- Soil bearing test	...week...	\$ 500.....
<ul style="list-style-type: none"> <li>• Aggregates tests(Fine &amp; Coarse)</li> </ul>		
1- Gradation test	...2 day...	.....10.....
2- Specific Gravity test	...1 day...	.....15.....
3- Absorption test	...1 day...	.....30.....
4- Abrasion test	...1 day...	.....30.....
5- Crushing value test	...1 day...	.....20.....
6- Impact test	...1 day...	.....20.....
<ul style="list-style-type: none"> <li>• Cement tests</li> </ul>		
1- Compressive Strength test	...7 days...	.....30.....
2- Setting time test	...1 day...	.....30.....
3- Fineness Test	...1 day...	.....20.....
4- Soundness test	...1 day...	.....20.....
<ul style="list-style-type: none"> <li>• Fresh concrete tests</li> </ul>		
1- Slump test	...15 min...	.....5.....
2- Compressive strength test (Cubes or Cylindrical)	7, 28 days...	...2 / cube
<ul style="list-style-type: none"> <li>• Hardened concrete tests</li> </ul>		
1- Core test	...5 day...	.....30.....
2- Estimated strength (Schmidt hammer test)	...1 day...	.....30.....



<ul style="list-style-type: none"> <li>• Reinforcing steel bars tests</li> <li>1- Tensile strength test</li> <li>2- Bending test</li> </ul>	.....1 day..... .....1 day.....	.....10..... .....10.....
<ul style="list-style-type: none"> <li>• Concrete hollow blocks</li> <li>1- Compressive Strength test</li> <li>2- Dimensions, Shape, Color test (If it's available)</li> </ul>	.....1 day..... .....1 day.....	.....10..... .....10.....
<ul style="list-style-type: none"> <li>• Tiles</li> <li>1- Flexural Strength test</li> <li>2- Abrasion test</li> </ul>	.....2 day..... .....2 days.....	.....30..... .....60.....
<ul style="list-style-type: none"> <li>• Others (If Available)</li> <li>1- Marshall for Asphalt</li> <li>2-</li> </ul>	.....2..... .....	.....60..... .....
<u>Please leave this areas (free)</u>		

**Thank you,**

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**Civil Engineering Department**  
**Master of Construction Engineering Branch**

**QUALITY CONTROL FOR R/C BUILDINGS**  
**CONSTRUCTION (2006)**

Supervisor Name: Prof. Dr. Tahir ÇELİK  
Student Name: Mohammed Fawzi ASLAN

**QUESTIONNAIRE FOR THE CONSTRUCTIONS CONTROLLERS**

**T01: Laboratory / Institute Name:**

OSMAN & FARRA LAB.

**T02: Laboratory / Institute Address:**

Nile Tower - Behind Islamic University G

**T03: Officer Name:**

Eng. Bassam S. Dabbour

**T04: Profession:**

Engineer

**QS 01: Do you think, the Quality Control in the construction stage will help to improve the quality of buildings?**

Yes ☒

No ☐

No idea ☐

Other

Strongly agree ☒

Agree ☐

Neutral ☐

Disagree ☐

Strongly Disagree ☐



**QS 02:** Do you think that Quality Control can affect the duration (Execution time) of the building construction?

Yes ☒ No ☐ No idea ☐ Other

Strongly agree ☐ Agree ☒ Normal ☐ Disagree ☐ Strongly Disagree ☐

**QS 03:** Do you think that Quality Control can affect the cost of the building construction?

Yes ☒ No ☐ No idea ☐ Other

Strongly agree ☐ Agree ☒ Normal ☐ Disagree ☐ Strongly Disagree ☐

**QS 04:** What numbers of construction contractors bring you for Quality Control works in a year?

Less than 30/year ☒ Around 70/year ☐ More than 100/year ☐ Note

**QS 05:** Which of these Construction Establishments are more concerned to do Quality Control tests?

Government ☒ Companies ☐ Privat ☐ Other

**QS 06:** Do you think that, the price of the tests can be high comparatively with the value and benefit to the buildings Quality?

Yes ☐ No ☒ No idea ☐ Other

Strongly agree ☐ Agree ☐ Normal ☒ Disagree ☐ Strongly Disagree ☐





OSMAN & FARRA LAB.

The tests that are concerned in survey (Questionnaire)

Please fill in this table Time and Price only

Construction Test Name	Exact Needed Time	Exact Needed Price (U.S \$)
<ul style="list-style-type: none"> <li>• Soil Capacity test for foundations (In general)</li> <li>1- Soil bearing test</li> </ul>	3-5 day	500 every three hole
<ul style="list-style-type: none"> <li>• Aggregates tests(Fine &amp; Coarse)</li> <li>1- Gradation test</li> <li>2- Specific Gravity test</li> <li>3- Absorption test</li> <li>4- Abrasion test</li> <li>5- Crushing value test</li> <li>6- Impact test</li> </ul>	1 day 2 days 2 days 2 days 1 day 1 day	15 10 10 50 25 25
<ul style="list-style-type: none"> <li>• Cement tests</li> <li>1- Compressive Strength test</li> <li>2- Setting time test</li> <li>3- Fineness Test</li> <li>4- Soundness test</li> </ul>	28 day 2 hour 1 hour 5 hour	50 25 25 80
<ul style="list-style-type: none"> <li>• Fresh concrete tests</li> <li>1- Slump test</li> <li>2- Compressive strength test (Cubes or Cylindrical)</li> </ul>	5 minute 28 day	10 2.5 / for one
<ul style="list-style-type: none"> <li>• Hardened concrete tests</li> <li>1- Core test</li> <li>2- Estimated strength (Schmidt hammer test)</li> </ul>	2 day 2 hour	40 every core 10 every eleven



<ul style="list-style-type: none"> <li>• Reinforcing steel bars tests</li> <li>1- Tensile strength test</li> <li>2- Bending test</li> </ul>	<p>.....</p> <p>.....</p>	<p>.....</p> <p>.....</p>
<ul style="list-style-type: none"> <li>• Concrete hollow blocks</li> <li>1- Compressive Strength test</li> <li>2- Dimensions, Shape, Color test (If it's available)</li> </ul>	<p>1... hour...</p> <p>1... hour...</p>	<p>10... every... sample</p> <p>10... every... sample</p>
<ul style="list-style-type: none"> <li>• Tiles</li> <li>1- Flexural Strength test</li> <li>2- Abrasion test</li> </ul>	<p>1... hour...</p> <p>1... day...</p>	<p>36... every... three sample</p> <p>100... every... three sample</p>
<ul style="list-style-type: none"> <li>• Others (If Available)</li> <li>1-</li> <li>2-</li> </ul>	<p>.....</p> <p>.....</p>	<p>.....</p> <p>.....</p>
<p><u>Please leave this areas (free)</u></p>		

**Thank you,**

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