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Abstract

Cost Estimation is the calculation of total cost for the construction of a particular project. It is done by quantity take-off of the materials from their planned drawings. The rate of the material is set according to the type and quality of work which is to be performed. The rates can either be through the currently applicable Schedule of Rates, such as Market Rate System (MRS) or Pakistan Institute of Cost and Contracts (PICC). Actual market rates can also be used. It is performed for billing, contract award and feasibility studies.

Scheduling is the planning and execution of the construction project according to the available resources and the working days. It is done in the planning and monitoring phase of a project. It helps in ascertaining the time required for the completion of the project. Scheduling is done by breaking down the work up to their activities and planning their execution.

In this project, we estimated the cost of the State Life Tower, Blue Area, Islamabad. The drawings were used for the quantity take-off and specifications which were made by National Engineering Services Pakistan (NESPAK) were used for the quality of work required. The quantities evaluated were used to calculate the duration of each activity. These were later entered into Primavera P6 after making the Work Breakdown Structure (WBS). We used floor wise approach for construction. Resources were arbitrarily allocated.

The total cost of the as planned construction of State Life Tower is **Seven Hundred and Thirty One Million Ninety One Thousand Two Hundred and Thirty Five** PKR (Rs. 731,091,235). The total duration of execution of the project is 5 years and 9 months from April 11, 2013 – January 11, 2019.

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Chapter 1

INTRODUCTION

Construction is a process that is always taking place in the world no matter what. Success is a huge point in everything, in construction, success is defined by three parameters; Cost, Quality and Time. In modern world, time is of the essence, time is money thus every project management team does its best to save time and finish the projects on the stipulated time. Time management is done using the scheduling of the project.

Business is not easy to manage. Sometimes, it takes too long to find a typical information and sometimes it takes a lot of hard work to keep record of everything. Estimation is an important part in planning and a determinant of effort put in the process of construction. The accuracy of the estimate will deliver on time and within the constraints of the budget. The more accurate an estimate, the lower is the cost of the construction.

The costs that are included for a completed construction facility are its initial cost i.e capital cost accompanied with the operation and maintenance costs. Usually, these are divided into a number of major cost components.

"The basic premise of cost modeling is that a historical database of software project cost data can be used to develop a quantitative model to predict the cost of future projects. One of the difficulties faced by workers in this area is that many of these historical databases contain substantial amounts of missing data. Thus far, the common practice has been to ignore observations with missing data" (Strike, El Emam, & Madhavji, 2001).

Design professionals and managers at the construction site need to realize that the initial cost is not the only substantial cost of a project, the maintenance and operation costs also signify the overall sum a lot. These are also not insignificant. For example, in high density urban areas, land acquisition is a major cost item as the land in those highly populated and dense areas is quite large.

In order to analyze the life cycle costs, the owner must estimate the corresponding operation and maintenance costs for each alternative for a proposed facility under construction.

Cost estimation is one of the most important parts of the construction of a facility to analyze the lifecycle costs.

According to the American Association of Cost Engineers, cost engineering is defined as that area of engineering practice where engineering judgment and experience are utilized in the application of scientific principles and techniques to the problem of cost estimation, cost control and profitability (Akintoye & Fitzgerald, 2000).

Scheduling is a method by which the Project Manager links the activities to be performed at the site according to a certain pattern to achieve the desired work at the stipulated time. Nowadays, scheduling is becoming more and more important as the projects have specific deadlines and they need to be finished at a fixed date otherwise the contractor is liable for claims. The owner also needs to know when his desired project is going to finish.

1.1 PROBLEM STATEMENT

The Estimation and Scheduling of State Life Tower, Blue Area, Islamabad.

1.2 OBJECTIVES

After discussing the introduction of our project, we will discuss the objectives what we kept in mind while pursuing our final year project. These are:

1) To study the estimation of cost and quantities and schedule of a construction project.
2) To prepare detailed estimate of quantities and cost of the State Life Building Tower, Blue Area, Islamabad.
3) To develop schedule of the State Life Building Tower, Blue Area, Islamabad.
4) To analyze Schedule after updating the Baseline Schedule.

1.3 JUSTIFICATION

The success and failure of a company largely depends upon the quick adoption of the new techniques and flexibility to meet the changed objectives rapidly. With the advent of the modern era which incorporates computer technology for the evaluation of almost everything, use of

software in the Construction Industry is an obvious step. These softwares are used for quick math of tedious calculations. In the Construction Industry Microsoft Excel has been in use for estimation since the start of the 21st Century. A lot of other softwares are also available in the Market, but MS Excel is the most widely and easily available software. The use of cells in the Spreadsheet helps in ease of formulae placement which calculates the values themselves.

Scheduling Softwares are also available in abundance in the Market but the one with the most functions are used. Primavera is the most sought after software which has a number of functions such as resource leveling, resource allocation, schedule update along with other functions which automatically update the project on entering the date from the field.

In this report we have used the softwares available for Estimation and Scheduling through which e have evaluated the total cost of construction for State Life Building Tower, Blue Area, Islamabad, and in this way be able to compare the theories available in textbooks and its application in field.

1.4 AREA OF APPLICATION

Cost Estimation is an important phase in a construction project. It is done during the feasibility analysis by Consultants and by Contractors during the bidding process. It is also a crucial deciding moment of project execution as the presence of fewer finances will lead to not starting of the project. The Cost estimate of any project is the budget of the project.

Scheduling is done to plan the execution of the project work. Work Scope is defined through Work Breakdown Structure (WBS) and planned according to which work is planned to be executed. The actual working vs planned working is always available for comparison.

Estimation and Scheduling are applicable wherever field construction work is being done.

Chapter 2

LITERATURE REVIEW

2.1 CONSTRUCTION

Construction is a process in which infrastructure is built or assembled. Construction ranges from a single activity to a number of activities done by humans to facilitate other humans. Usually, the job is done by a construction manager at the site. There are others to assist him at the site such as project engineer accompanied by design engineers and architects. Construction, usually is a job that has a lot of money and resources invested in it, so one needs to know as to how these are to be managed, otherwise, it gets too much expensive. After design, estimation is done to calculate the probable cost and after that the schedule is made.

Generally, there are 4 types of construction works:

- Residential
- Industrial
- Commercial building construction
- Heavy building construction

2.1.1 Types of Cost Estimates

- **Project definition**: Based on the completed architectural designs of the project
- **End usage of the estimate:** The conceptual estimate of the project comes in this type. Also involves/includes Investment feasibility, contractor's estimate for lump-sum bidding etc.
- **Estimate generating methodology:** Two sub-types. The stochastic approach in which estimates are made according to the amount of area on which project is to be constructed, or the number of people or things using the project after completion e.g. number of students in a school building or the number of cars in a parking lot. The deterministic approach which is the calculated estimate of a building project according to the quantity take-off or the unit price of each material used (Popescu, Ovararin, & Phaobunjong, 2003)

The estimates of a project are usually not accurate as construction is a haphazard process and cannot be controlled cent percent. If the estimates vary more than 10%, then the estimator is usually asked to recheck his\her estimate. To monitor\control a project, the design process must be kept in check. Architect\Engineers are asked for submittals the frequency of which can vary according to the scope and complexity of the project. Usually a submittal at 60% design completion is required.

2.1.1.1 Conceptual Estimate

The type of estimate which uses area of the project or the occupancy units as input to evaluate the estimate. The problem with Engineering\stochastic estimates is that they are not 100% accurate.

2.1.1.2 Preliminary or Rough cost or Approximate Estimate

This is an estimate to find out an approximate cost in a short time. Such an estimate is prepared to decide the financial aspect and policy matter, giving an idea of the cost or the proposal after taking into considerations the requirements of the department concerned. The rough cost estimate is prepared from the practical knowledge and cost of similar works (Upadhyay, 2009).

2.1.1.3 Unit Price Estimates and Unit Bid Price Estimates

Estimation is carried out according to price of single unit of each material or labor used. Unit Bid Price estimates incorporate the overhead costs, jobsite overhead and contractors profit for each unit price. This type of estimate is used when contractors and subcontractors have detailed list of the materials and accurate updated records of similar worked performed (Popescu et al., 2003).

2.1.1.4 Plinth Area Estimation

It consists of working out the plinth area of a building which multiplied by plinth area rate to get an estimate for that building (i.e. Plinth area rate sqm x Plinth area of the building). The plinth area should be calculated for the roofed area of a building by taking external dimensions, excluding the plinth offsets. However, the plinth area rates generally provided, can be deduced from the cost of the similar buildings constructed in the same locality having, more or less same finishing and same amenities (Upadhyay, 2009)

2.1.1.5 Lump-Sum Estimate

Once Design is compete and contractual documents are 90-100% complete, bidding process is started. These estimates are provided by contractors on their bid submission after viewing the contract documents, design specifications and drawings and future drawings. These include excavation, material, labor, equipment, contractor's profit, overhead costs etc (Popescu et al., 2003).

2.1.1.6 Cost plus a percentage fee

Such contracts are employed when the information regarding the project is not complete during contract signing. Tentative drawings and economic feasibility are used to finalize the contract and a percentage of the total contract fee is negotiated between owner and contractor (Popescu et al., 2003).

2.1.1.7 Cubic Content Estimate

This is also an approximate estimate. It is worked out on the basis of cubical contents of the proposed building to be constructed and then applying it to rate per cubic meter. (I.e. Plinth area of the building x Height x Cubic content rate). . However, the plinth area rates generally provided can be deduced from the cost of the similar buildings constructed in the same locality having, more or less same finishing and same amenities. For Storied buildings the height should be taken between the floor levels of one storey to top of the next higher floor. The foundation, plinth and parapet above roof are excluded in finding the cubical contents

2.1.1.8 Cost plus a fixed fee

It is very much like Cost plus a Fixed Fee, just the contractor's fee is stated as a fixed amount rather than a percentage of the cost incurred (Popescu et al., 2003).

2.1.1.9 Detailed Estimate

Detailed estimates consist of the detailed particulars for the quantities, rates and costs of all items involved for satisfactory completion of project. On the approval of rough estimate this estimate is prepared in detail prior to inviting of tenders and for getting "Technical Sanction" from the competent authority. The whole project is divided into sub works. The cost of each sub work is calculated and then added to together to give the cost of the project. Each sub-head of work are

calculated in detail from the dimensions taken from drawings and cost of each item is worked out. This estimate is best and accurate that can be prepared (Upadhyay, 2009).

2.1.1.10 Quantity Estimates

This is a complete estimate of quantities for all items of work required to complete a project. The quantity of each item of work is calculated from respective dimensions on the drawings. The cost of each individual item is obtained by multiplying the quantity with the rate per unit for the item (Upadhyay, 2009).

2.1.1.11 Revised Estimate

Revised estimate is also a detailed estimate and is prepared afresh, when the original sanctioned detailed estimates exceed by 5% or more, either due to the rates being found insufficient or due to some other reasons. The revised estimate should be accompanied by all the papers as in case of detailed estimate, showing the variation in each items of works, its quantity and costs-original and revised, excess or saving and giving the reasons of excess or saving in case of each item(Upadhyay, 2009).

2.1.1.12 Annual Repair or Annual Maintenance Estimate

In order to keep the structures/work and roads, etc; in proper condition, annual repairs are carried out annually for which an estimate is prepared. For buildings it includes whitewashing, painting, color washing etc. quantities are based on the previous measurements (Upadhyay, 2009).

2.1.1.13 Supplementary Estimate

When some changes are done in the original work, a fresh detailed estimate is prepared to supplement the original work. This estimate is called supplementary estimate. It is also accompanied by all the papers as required in the detailed estimate (Upadhyay, 2009)

2.1.1.13 Guaranteed Maximum Price

An owner biased contract in which the contractor assures the owner regarding the maximum amount which will be spent on that project. The contractor should make detailed estimates in such cases (Holm, Schaufelberger, & Griffin, 2005).

2.2 ACCURACY OF COST ESTIMATES

"The conceptual estimate should be near 5-10% of true cost on project completion. For determining accuracy of estimate two terms are employed. Construction Cost Accuracy and Bid Detail estimate accuracy. Construction Cost Accuracy is the amount in percentage which is the difference between engineering estimate and contract awarded amount." (Popescu et al., 2003).

2.2.1 Factors Affecting Accuracy of Detailed Estimate

- Construction Materials
- Erection Labors

2.2.2 Factors Affecting Accuracy of Engineering Estimate

- Type of the building being constructed
- Size of Contracts
- Geographical location
- Number of Bidders
- Ability of estimators
- Available levels of Information
- State of Construction Market

2.3 QUANTITY TAKE-OFF

A cost estimate comprises of two processes, the determination of quantities also called quantity take-off and the computation of the prices associated with those quantities. Calculating quantity take-off is the job of a quantity surveyor. He/she should has to not only take in consideration the structure shown in the drawings, but also the site modification works, which includes grading, bulk excavation, concrete formwork, shoring etc.

2.3.1 Procedures

- Linear Calculation, usually the perimeter of the slab or item and in single units e.g. meters, feet.
- Area calculation, the surface area of the slab in m^2 or ft^2
- Volumetric calculation

- Unit measures calculation, which enumerates number of a particular type of material e.g. Number of windows on a floor can be enumerated as 2(North Wall) + 6(East Wall)+ 5(West Wall) = 13 units

Quantity take-offs should be evaluated with keeping the field work in mind. In such a way, there is slight chance of forgetting any material in the estimate. Checklists can also be used for efficient planning.

2.3.2 Waste Factors

In order to procure a realistic amount of material, one should incorporate the wastage factor in the estimate. For example, if a quantity is required to be 100 cft, adding a wastage factor of 5%, 105 cft of work is to be done.

2.3.2.1 Waste factors for building construction

Usually, these are listed by some percentage of the actual quantity of the material that is left in place. E.g. if the actual quantity of concrete required is $100m^3$, then including 5% waste factor total quantity will be $105m^3$.

2.3.3 Industrial Standards

Material which comes in standard sizes needs to be cut into the required size to enable its fitting in the project. Some of the material which comes in standard size is tiles, plywood, lumber, bricks, pipes etc.

2.3.3.1 Material Handling and Installation

Influenced by the following factors:

- Pace of Work: There is more wastage in a rush work
- Worker's skills and attitudes
- Availability and sustainability of equipment
- Storage facilities
- Types and Packaging of Materials
- Sit Organization Factors: Orderliness and General Site Factors

2.3.4 Maintenance Stock

The material turned over to the owner by the contractor for maintenance. During the life of the building, a wall may have to be brought down or some tiles may have to be pulled out for some piping. In that case a maintenance stock is kept to keep the look of the building coherent as e.g. to red colored paint boxes may have slight change in their color.

2.4 PRICING

It is the act of pricing the cost of a work item based on the specifications and predetermined quantity required. Pricing gives materials costs. Prices are either ascertained through vendors or pre-listed items. Pricing should include:

- Materials to be procured
- Labor required
- The equipment that is required at site for moving and installing the materials
- Consumables such as fuels and tools

2.5 ESTIMATING LABOR COST

Labor cost in construction is determined by two factors

- Monetary
- Productivity

Monetary is related with wage rate, wage premiums, insurance, fringe benefits and taxes. Variety of work and many trades in construction complicate this. Productivity is more difficult as it is input and output ratio.

Productivity in construction is defined as the amount of work done in a stipulated time.

Productivity formulae is calculated as follow

Construction productivity=quantity of work produced/ Time duration (Popescu et al., 2003)

To estimate productivity the estimator need a sound historical record and some experience. Construction firm in the United States can decide whether they will operate an open or union shop. In open shop there is no agreement while in union shop an agreement is mandatory.

In union shop a contactor the contractor who hires the workers, has to sign a contract. While open shop contractors have less limitation placed upon them. Applying for greater logistic flexibility, the craft personnel must be hired directly. In open shop, a contractor has no legal precedence regarding worker compensation as with the union workers. The formulae for calculating the total labor cost is very simple. In this, we find out the total work hours of the labor and then multiply it with the rates of the labor.

Total cost of the labor=Total work hours *wage rate (Popescu et al., 2003)

Total work hours are calculated as follows,

Total work hours=Sum of quantity of work /productivity rate (Popescu et al., 2003)

Pricing the labor is one of the difficult tasks. Pricing labor involves many more variables. First step to pricing the labor is to determine the base wage rate. The base wage in the US is the dollar per hour given to the labor for the work he performs. Straight time hour or normal time hour refer to the 8 hours per day Monday to Friday. Union workers are classified as Own wage rate

- Journey man
- Apprentice
- Supervisor

Union agreements may also mandate special premiums on top of the base for dangerous work conditions for example working on high grounds, underground and close to the high voltage.

Along with the base wage rate, the contractor must also pay for various fringe benefits for worker. The benefits given include funds for health and welfare, vacations, training, pensions and many other items.

Work premiums is the extra money that is paid to the workers for shift work, overtime work, hazardous work conditions or some unusual non-stressful workday shift extends from 8:00am to 4:30pm. The swing shift extends 4:30pm to 12:30am.Graveyard shift extends from 12:30 to 8:00am with a half hour break each. Climatic conditions are wind, temperature and rainfall which may affect the productivity of labors.

Work conditions are related to site place, workplace and organization and lightning and the level of noise. The conditions that are involved with construction supports such as procurement, scheduling and information support are the Management Conditions.

It is very difficult to estimate the Labor Productivity due to the fact that it can be affected by numerous factors and their relationships are complex and have not been fully explored. Establishing a relationship between the labor productivity rates and the workplace can be a very tough task to perform. Contractor's own data of performing such similar tasks can be used as the base for historical data to be used to o such calculations. Productivity is also changed due to the change in working conditions.

Adjusted productivity rate standard= productivity rate*productivity factor (Popescu et al., 2003)

2.6 COST OF CONSTRUCTION EQUIPMMENT

Modern construction is shaping the trends in equipment usage on the sites as well. With new advancements being made and the increasing demands of precision require equipment to be an essential component of construction. Costs of the equipment are usually divided into two categories:

- Equipment of specific use
- Equipment of general use

2.6.1 Specific Use Equipment

It is the equipment used for a specific work and is mainly used for a shorter period of time on the site and then removed from work after the work has been done. This item is generally not shared by all sub-contractors.

Examples are tractors, hoes, front shovels, scrapers, compactors, hauling units etc.

2.6.2 General Use Equipment

It comprises of the equipment used generally in regular works being done on a site. These are kept on the site for a longer period of time. Other sub-contractors are also allowed to use the facility. Examples are cranes, air compressors, pumps, forklifts etc.

2.7 EQUIPMENT PLANNING:

Construction requires large quantities of material handling, horizontally and vertically. As the work gets complicated, so does the process of choosing the right equipment suitable for a particular job. It is thus the job of the management to select the suitable equipment for the required work.

Thus, equipment planning is essential for production achievement, controlling the cost, communication and co-ordination of the parties. Equipment planning involves the process of gathering the required information about the scope of work and a comprehensive analysis of the resources available with respect to the time available and the conditions at site.

The planning starts with a site investigation report. After complete understanding of the situation, the final result in equipment planning should lead to the following:

1) Lists of equipment and the schedules of procurement.

2) Productivity of equipment and a desired schedule of construction.

3) Equipment's realistic cost estimates.

2.7.1 Shared Utilization Consideration

Procurement of the shared equipment is the duty of the GC. Sub-contractors generally acquire additional or special equipment. The shared equipment improves the quality and safety of the work in progress as it gives a greater control to the general contractor.

Factors Influencing Equipment Selection:

These factors are mainly grouped in 3 categories: conditions at site, nature of work and characteristics of the equipment.

2.8 EQUIPMENT PROCUREMENT SOURCES AND ASSOSICATED COSTS

After the uncertainty in labor costs, uncertainty in equipment costs widely affects the total cost of the project. Therefore understand the requirements and procurement of the best suitable equipment is necessary for a perfect cost estimate.

Equipment can be obtained through 3 methods:

1) Purchasing
2) Renting
3) Leasing

2.9 DEPRECIATION

Distributing the tangible assets over the estimated life of the facility is called Depreciation.

2.9.1 Depreciation Methods

2.9.1.1 Straight line method

It can be stated as the simplest method of calculating depreciation in which depreciation is distributed over the overall useful life of the equipment.

2.9.1.2 Sum of the year's digits method

It is almost same as the Straight Line Method but it differs in the sense that depreciation is not distributed uniformly over a given time period considering the fact that the equipment may not be of the exact usage after a given time and that its productivity may decrease.

2.9.1.3 Internal Revenue Service's Modified Accelerated Cost Recovery System (MACRS)

MACRS provides two fixed rates on declining balance methods, at 200% (double declining balance method) and 150%.This gives more depreciation in the early years of a piece of equipment's recovery period. In this method, equipment is classified by a unit's life into appropriate classes of recovery periods. Each recovery period has a depreciation schedule from which the amount of depreciation for any given year in the recovery period can be calculated.

2.10 INVESTMENT COST

It is the cost of investment or putting up the company's resources in the equipment. If the capital used to purchase the equipment is borrowed, the investment cost is the cost of the interest paid on that borrowed amount. But, if the equipment is bought with company assets, an interest rate

that is equal to the company rate of return on the company investment should be charged as the investment cost.

2.11 INSURANCE, TAX AND STORAGE COST

Cost of insurance and the insurance premiums along with taxes and the storage costs add up in the cost estimated for a project.

2.12 EQUIPMENT OPERATING COSTS

The cost for operating equipment and the subsequently maintaining is also a huge one. An equipment if not maintained in a better way may lose its actual price and go towards depreciation at a faster rate as calculated.

Operator wages, mobilization, demobilization, freight cost, lube oil, filter, grease, ownership costs etc put a strain on the general contractor's resources and need to be catered in the cost estimate.

2.13 COST OF RENTING EQUIPMENT

Renting of construction equipment is a popular trend as it eliminates the problem of maintaining a piece of equipment. Owning a piece of equipment may compel the contractor to use inappropriate equipment for a typical job. These problems can be overcome by renting the equipment.

2.14 COST OF LEASING EQUIPMENT

The factor that differentiates in renting and leasing is the duration period. Leasing is usually done when equipment is used for more than six months at the site. Leasing works on the method that the person procuring the equipment on lease has full authority to use the equipment as if he/she were the owner in return of payments in installments to the original owner of the equipment. (Vazirani & Chandola, 2008).

2.15 COST OF EQUIPMENT MOBILIZATION

The cost of mobilizing and demobilizing the construction equipment is quite substantial especially when the equipment has to be taken away to a faraway destination.

2.16 EQUIPMENT OPERATOR AND OILER

These costs should not be included in the equipment costs; instead these should be included in the labor costs. The cost can be easily calculated by multiplying the associated wage rates of the required craft.

2.17 CONSTRUCTION TOOLS

Construction tools are an essential component of a construction project without which, nothing can be done. The life of an average construction tool is estimated to be one year as these are highly wear items. Examples are circular saw, power drill, hand saw, sledge hammer, chain saw etc.

2.18 CONCRETE

The overall direct cost of concrete work is the summation of all cost including labor, equipment, material and subcontractor required to complete the work. Cost of labor, equipment and materials in concrete constructions are relatively high.

2.18.1 Components of Concrete Work

Concrete work consists of 2 major components, structural and non-structural. Structural elements are major elements in construction. They include concrete filling, footings, foundation walls, beams, columns, slabs on grade, above-grade floor structure, abutment, wall structure, roof structure.

2.18.2 Concrete Construction Craft

Concrete works requires a significant number of grafts and the cost of crafts is normally high. Iron workers have the major responsibility for doing the iron work.

2.18.3 Take-off needs

It's purpose is to separate each item and to note it as a single category.

2.18.3.1 Take-off method for concrete cost estimating

One of the most common take-off needs of concrete work is concrete volume.

Volume (m^3) = length (m) * height (m) * width (m)

Take-off methods are differentiated by how the area of a structural component is determined, namely the unit, perimeter and centerline methods.

2.18.3.2 Checklist for concrete work

A checklist is a useful tool for cost estimation. It basically helps an estimator remember important points (Jorgensen & Shepperd, 2007).

2.19 BASIC CONCRETE MATERIALS AND METHODS

Concrete is widely used because of its durability, strength, water tightness and resistance to scratching, freezing, thawing and some chemicals.

2.19.1 Basic Concrete Materials

Concrete is basically a mixture of cement, water and aggregates. Portland cement is the most widely used cement all over the world. It is usually made from clay, limestone, iron ore, silica and other raw materials in a very high-temperature manufacturing process (1500C).

Water is an important mixture in concrete.

2.19.2 Cast-In-Place Concrete Work

There are five major operations for typical cast-in-place concrete work, namely from preparation, emended different methods to perform its respective work.

2.19.3 Precast Concrete Work

Precast construction is done at a plant under controlled conditions or at the job site.

2.19.4 Concrete Placement and Equipment

Concrete should be poured before it starts to set. At a certain height above the grade or at some distance from the truck, hosting or transporting equipment is needed. It is easy to place and transport concrete using a concrete pump, so it is getting quite in use. Miscellaneous equipment includes chute, a wheelbarrow, and a buggy.

2.19.5 Quantity Take-off and Pricing for Basic Concrete Materials

In building construction, concrete can be obtained from batching and mixing plants or a ready-mix concrete supplier. The more quantity a contractor needs the less waste factor is used by the estimator.

2.19.6 Formwork Systems

Cast in place construction requires formwork, which is the basic requirement of it. Different formwork systems have different functions according to the use and requirements. Formwork systems can be categorized into five work types:

- Wall
- Below-Grade
- On-Grade
- Beam
- High-Rise Concrete Construction.
- Column
- Slab
- Stair

2.19.7 Shoring System

False work also known as Shoring, is a supporting system of forms that carries the weights of building elements and the live loads on the elements during the phase of construction. Live load includes:

- Weight of crews
- Equipment
- Materials

The costs include installing the equipment and after usage, removing and cleaning it. The cost of each building components can vary because of differences in shapes and sizes.

2.20 MASONRY

A good estimator for masonry work has to be well organized and he should be a good information collector. Masonry contains a variety of products, unit sizes, unit types, specifications and properties. This is what causes difference in masonry costs.

2.20.1 Masonry Components

1) Masonry building elements such as masonry building walls normally contain many components, namely, masonry units, clay tiles, ceramic veneer, glass masonry units,

concrete masonry units, adobe masonry units, masonry stores and special non-conventional units. Mostly, clay and concrete masonry units are used.

2) Mortar is the second basic component of masonry.
3) Masonry Grout is the third basic component. It is used to fill some or all cells hollow units or between Wythes to increase wall strength.
4) Accessory Materials are termed as the last basic material. This category includes reinforcement, connectors, flashing, coating, sealants and vapor barriers.

2.20.2 Masonry Materials and Specifications

One of the important tasks of the estimator is to obtain correct cost data for materials and equipment. Usually, the material cost is 20-40% of the total masonry work. For this purpose, an estimator can request a quotation and special discounts from a manufacturer or a supplier. Usually, a supplier provides the total cost including the transportation cost, damage responsibility, applicable taxes, who will deliver, how to deliver, how to unload, delivery sequence and samples. A supplier can also provide estimated quantities which can be used as a standard by the estimator and he can compare his estimate with the estimate provided.

2.21 MASONRY TOOLS AND EQUIPMENT

Masonry equipment and tools prices vary from small project to larger ones. For small jobs, it is 10% of the masonry work and for larger ones, it is 5%.

In case the equipment is rented, the estimate will include the cost of renting and the cost of maintenance and the cost on its usage as fuel etc.

In case of purchased equipment, the estimate will be formed by doing its lifetime cost and the cost of its maintenance and supplies.

Small equipment maybe be not fit for use after the job is done, but larger equipment may be used for further use in future jobs. This is also taken in consideration while estimating.

2.22 MASONRY CONSTRUCTION CRAFTS

Masonry construction is labor intensive work and gets to 50-60% of the total masonry work. Labor cost varies according to the labor force and the labor productivity. Since the labor

productivity is based on many factors, the most adopted way of estimation is to access the performance of the same crew on previous jobs.

2.23 MASONRY PRODUCTIVITY

Factors affecting masonry productivity are the types of buildings being constructed, workmanship, materials, management, weather, construction techniques and others.

Building type includes high rise, commercial, industrial, residential, recreational etc.

Second major factor is the materials being used at site. Types, shapes, sizes and textures of materials have a strong impact.

The other two factors, workmanship and management may refer to experienced and responsible workers. Management can also motivate workers to work more efficiently and in time. A simple example can be given of a project on whose timely completion; the whole team working on it may get incentives and bonuses at its timely completion.

The next factor is weather. A very hot climate badly affects the working capabilities of the workers. A very cold weather also has the same effect. In addition to thins, very cold climates, such as of Russia, Canada, and Green Land, where water may freeze due to temperatures below freezing point causes hindrance in construction activities.

2.24 CLAY MASONRY UNIT

Brick is the most common type of masonry unit. Bricks are extensively used due to their durability, availability, minimum maintenance and aesthetically pleasing appearance. Bricks are classified as:

a) Glazed
b) Fire
c) Paving

Where durability and sanitary surface is required, glazed bricks are used.

On flat base in applications as canals, walkways, drive ways, patios etc, paving bricks are used.

Fire Bricks are used elsewhere in extremely hot places such as chimneys and incinerators.

2.24.1 Characteristics of Bricks

Different characteristics of bricks may result in different levels of productivity. Major brick characteristics include dimensions, shapes, colors and textures.

Masonry unit dimensions are usually described in terms of **thickness*height*length (T*H*L).** There are three masonry unit dimensions: **specified**, **nominal** and **actual dimensions.** The **specified** dimension of bricks is 90*57*190 mm. T bricks have a nominal dimension of 100*67*200 mm. Brick shapes generally include special corners, sills, lintel bricks and radial bricks. Special bricks result in low productivity and higher costs. Brick textures fall in three categories: **smooth, matte and rough finish.**

2.24.2 Masonry Unit Orientations, Surfaces and Mortar Joints

There are a variety of unit orientations which include stretcher, soldier, header, shiner, sailor and rowlock.

There are six mortar joint patterns: **concave, flush, raked, struck, and weathered and V joints.**

2.24.2.1 Brick bonds

The units in horizontal alignment are called course.

2.24.2.2 Brick Grades and Types

Commonly used bricks are building bricks and face bricks.

2.24.2.3 Wall Types

There are generally two types of walls: **single wythe** and **multiple wythe.** The figures or the drawings help the estimator decide the quantity of material to be used in the construction of a typical wall.

2.25 CONCRETE MASONRY UNITS

The Concrete masonry units, CMU are also extensively in use. They are used for both interior and exterior walls.

2.25.1 Characteristics of Concrete Masonry Units

These are mainly characterized by sizes, weights and textures.

2.26 OTHER MASONRY UNITS

Other types of masonry units include adobe masonry units, masonry stone and special nonconventional masonry units.

2.26.1 Glass Masonry Units

Glass masonry units are made up of silica sand, lime stone, soda ash and other inner components that are melted in a furnace over a temperature of 1260 *C. The most typical unit is the glass block.

2.26.2 Adobe Masonry Units

Adobe masonry units are unfired clay.

2.26.3 Stone Masonry

This includes both artificially shaped stone and naturally shaped rocks.

2.26.4 Special Non-Conventional Masonry Units

Some of these units are:

1) Interlocking units for mortar less construction.
2) Light weight units made from light weight manufactured aggregate; wood chips, saw dust or waste paper.
3) Masonry units incorporating waste products such as glass.

2.26.5 Masonry Mortar

Mortar is used to bed masonry and is used to individual units into combined components. It is also used to seal joints or empty spaces in order to prevent air and moisture from entering these spaces, give a pleasing appearance and also size variations in masonry units.

2.27 MORTAR MATERIALS

Mortar is made of three major materials including Portland cement, lime and masonry sand.

2.27.1 Types of Mortar

The major classifications are:

1) Portland cement lime (PCL) mortar

2) Masonry cement (MC) mortar
3) Mortar cement mortar

2.28 REINFORCEMENT

Reinforcements consist of steel deformed bars, deformed reinforcing wire and wire fabric. Rebars are of three categories, namely, billet, rail and axle steel. It is taken in linear meters and the multiplied by the unit weight and at the end multiplied with the number of rebars used.

2.29 MASONRY ACCESSORIES

This category includes connecters, sealants, flashing, coating, vapor barriers, lintels, sills, coping, bracing systems and scaffoldings.

2.30 MASONRY COST ESTIMATION

Following steps lead to the cost estimation of masonry work:

a) **Step 1:**

   Study the project specifications and the plans to understand the kind of work being done along with the types of units to be acquired.

b) **Step 2:**

   Calculating the takeoff quantities.

c) **Step 3:**

   Consider the quantities of masonry units needed, such as number of bricks or CMUs (1000 units or unit). This can be done by multiplying the wall areas with the number of units utilized in 1 m^2 of wall. The obtained quantities of units can be adjusted by multiplying by variable factors. A waste factor of 3-15% is applied.

d) **Step 4:**

   Masonry mortar can be determined by multiplying the wall area with the amount of mortar used in 1m^2 of wall. A waste factor of 10-30% is used in this case. All factors from the third and fourth steps can be obtained from Means (1999), Walker (1999) or a database gathered from an estimator's own experiences of similar jobs.

e) **Step 5:**

   Determine the quantities of grout and other necessary materials needed during construction.

f) **Step 6:**

For each material, determine the cost of labor, material and the equipment to be used.

g) **Step 7:**

Calculate total masonry cost. This can be done by multiplying the quantities of units by unit costs to get a sum of all costs. Unit costs can also be gathered from Means (1999), Walker (1999) or the estimator's database, materials suppliers, manufacturers or masonry sub-contractors. Cost of equipment, overhead and profit are also calculated.

2.30.1 Cost Estimation of Masonry Mortar

After masonry units, mortar costs need to be calculated.

2.30.2 Cost Estimate for Masonry Grout, Reinforcements and Accessories

This can be done while taking off the masonry units and mortar.

Masonry grout is taken off by volume (m^3).

The reinforcements are taken off by lengths or weight (m or kg).

Masonry accessories include anchor bolts (each), ties (100 ties), caulking, control joints (m), insulation (m^2), scaffolding (each), fasteners (each), waterproofing (m^2) and flashings (m^2). The total cost is found by multiplying the items needed with unit costs of each.

2.31 FINISHES

2.31.1 Lath and Plaster Work

Gypsum and Portland cement plasters can be applied as finishes provided the bonding capabilities are ample. If bond strength is not enough, a dash bond coat made of one part cement and two parts sand by volume can be used or by using a water proofing bonding agent. A water proofing coat is to be provided to masonry which absorbs water too quickly.

If plaster is to be applied on wood frame constructions, which are either sheathed or unsheathed, a metal re-enforcement should be provided. The most common type of metal re-enforcement is the metal lath in which the wire is cut to form hexagonal diagonal openings. Metal re-enforcements should have a backing paper in exterior locations, in wet interior places and when plaster is done by spraying.

Gypsum plaster is applied in either two or three coats. In two coat plaster, base and finish coat are applied. In three coat plaster, a scratch coat, brown coat and finish coat is applied. The base coat (scratch and brown in case of three coats plaster) is applied by hand with trowel. Finish coat can either be applied by trowel, float or spray.

2.31.1.1 Estimating area and quantities

The total area to be plastered is calculated and the area of openings is subtracted. Some contractors do not subtract the area of openings. Opening area less than .5m^2 is not counted. As a general rule 50% of the opening area is subtracted. For columns, beams and girders to be plastered measure the actual area with no deductions. Circular surface work should be doubled as straight surface work.

20mm thick plaster is applied on metal lath, 10mm on gypsum lath and 15mm on unit masonry. If dash bond coat is used, the cost of plaster will increase. The surface on which might also have to be roughened, further increasing cost.

2.31.1.2 Pricing

The cost of the material is to be calculated from per kg or per ton weight of plaster from an authentic hawker. The pricing of labor is done according to the quality of workmanship. It ranges from 25 to 35% for ordinary to first-grade workmanship.

2.31.2 Gypsum Plasterboard Systems

Gypsum wallboard or drywall is used as finishing for walls and ceilings. It is manufactured in different types and sizes including the tongue & groove, square, tapered, beveled edges, foil-back gypsum panels, moisture resistant gypsum panels and fire resistant gypsum panels.

Gypsum wall boards are usually attached to the wall or ceiling through nails and screws. A small groove is made at the corners at usually 10mm spacing from the edges. Then a screw is drilled into it using a mechanical screw driver.

Gypsum wallboards are usually installed according to ASTM. Perpendicular installation is usually preferred as it provides better bonding and strength bearing.

2.31.2.1 Cost estimate of finished area

Perimeter of the finished area is calculated, usually the length and width of the rooms along with the maximum height is used. Openings less than $4m^2$ are not subtracted. Including the type and thickness of wallboard to be used we get the quantity required. 1-5% waste factor is applied.

2.31.2.2 Accessories

Fasteners such as nails, screws and staples are estimated at approximately 12 fasteners per m^2, joint tape at 1.4m at per m^2 and joint compound at 0.28L per m^2 of finished area. Studs, furring and other support systems are estimated as per specifications.

2.31.3 Ceramic Tile Work

2.31.3.1 Tile installation on floors

Tile installation is done either on concrete subfloors or wooden subfloors. For concrete subfloors, the most common method is by application of thin layer of Portland Cement Mortar not less than 30mm with can be troweled before placing of tiles to ensure filing of holes and voids. Tamping of tiles after installation is also done to ensure proper bonding of tiles.

For wooden subfloors, either Portland cement Mortar is used for tile installation or organic adhesives. In case or Cement Mortar, the process is same as that on concrete subfloors but thickness should be 25 to 35mm minimum. For organic adhesives the subfloor should be 25mm nominal boards or 16mm plywood with 10mm or thicker plywood. While for epoxy mortars and adhesives the underlayment should be 13mm or more. Grouting should be delayed for at least 16 hours.

2.31.3.2 Tile installation on walls

On interior surfaces it is either done by application of 10 to 19 mm of Cement mortar for “one coat method” and no more than 25mm for “two coat method”. For Dry-Set and Latex-Portland Cement Mortars the thickness should be between 2 and 6 mm whereas for organic adhesives should be between 2.5 and 3 mm.

For exterior walls metal lath should be used when Portland Cement Mortar bed is being laid and corners be cut at expansion joints for proper setting of tiles. For Thinset Installation use of

monolithic course, concrete and brick masonry, structural clay tile and cured Portland cement mortar bed should be ensured.

2.31.3.3 Estimating procedures

The area of the wall/floor on which tiles are to be installed is calculated and openings are subtracted. The total price will constitute cost of ceramic tile delivered to the jobsite, costs of materials and accessories, cost of mixing and placing floor fill and direct labor cost for tile installation. Wastage of 5-10% incorporated. Also cost of special tiles such as bull-nose, trim, surface bull-nose or base-tile is also to be considered.

2.31.4 Marble and Stone Flooring

Marbles and stones are of various types and colors and their prices vary according to their properties and colors. Hence the Marble institute of America has classified all stones and marbles into four groups

- Group A: Most favorable qualities of stones and marbles. Require no sticking, waxing or filling because they have no natural faults. They are characteristically uniform.
- Group B: Require no sticking, waxing or filling because they have no natural faults. They are characteristically uniform.
- Group C: Requires sticking, waxing or filling because they have natural faults. They have an uncertain variation in working qualities.
- Group D: Poor quality of Marbles and stones having largest proportion of natural faults and the maximum variation in working qualities.

Marbles/stones when arrive at the construction site have to be stored with great care, preferable in wooden enclosed cases. Placing of marbles is either on Portland cement bed in which case it should be 60 to 75 mm thick. Epoxy grouts are also used in which case an Epoxy Grout bed of 10 to 20 mm should be laid down.

2.31.4.1 Cost estimating procedures

The time and hence the price of installing small tile pieces is more than of installing large tiles. Similarly thick tiles are more expensive to install than thin-set stones/tiles. The cost for installing of tiles will depend on the workmanship employed and the type and quantity of bricks which is

to be used. Usually areas measurements are used for tile quantity take-off, but in particular cases for example circular base or stair thread, linear meter is used.

2.31.5 Acoustical Treatment

Baffles are mounted either mounted or suspended and are standard acoustic treatment measures. Wall panels are also used. Mostly consist of a fiber facing over mineral such as glass wood or fiber board.

In case of hung-suspension system, they such are attached to concrete, wood or steel structure. Direct connection to steel decks, pipes, conduits, and ducts, electrical or mechanical devices should be avoided. Bolts screws are required for fastening purposes.

2.31.5.1 Cost estimating procedure

The manpower required for installation of acoustic treatments is dependent upon height of ceiling and type of treatment installed. Usually one carpenter installs wall-mounted baffles, but if a suspended baffle is to be placed a helper or larger crew sizes may be required.

Usual places for acoustical treatments are hallways, corridors, offices and conference rooms. Opening sizes are not deducted and neither are HVAC openings. To estimate the total quantity required, specifications are considered. For suspension systems, 1 hanger per 1.44m^2 is estimated per usual practice.

2.31.6 Finished Wood Flooring

Wood Flooring is either done with soft wood with width of 100 to 150 mm and hardwood with varying width. Flooring wood is either plain sawed or quarter-sawed; each providing a different grain quality which should be checked before using it in flooring. The types of flooring techniques are

- Strip Flooring: strips usually of 56 mm width are used.
- Plank Flooring: planks of 75 mm width are screwed or nailed to the subfloor.
- Parquet Flooring: comes in blocks of 15x15 cm blocks.
- Unfinished Wood Flooring: sawed, sized and dressed wood pieces are used which are sanded/finished before application.
- Prefinished Wood Flooring: use of sanded and finished wood.

- Engineering Wood Flooring: different layer of wood laminated together used, which is more stable.

2.31.6.1 Cost estimating procedures

Estimate of quantity of wood required is done by area of flooring and thickness of wood required. Subfloors are either of softwood or plywood and moisture barriers such as asphalt felt and building paper are placed to prevent moisture from reaching flooring. Required amount of nails required is measured according to weight of nails. Waste percentage is 5 to 6% but 10% if area has a lot of angles or to be laid on a diagonal. Labor cost varies from the amount of work done in 8-hour span. A skilled labor will install more in the same time span as a non-skilled labor would, hence reduce the flooring cost.

2.31.7 Carpets, Underlay and Trim

Carpeting estimates are carried out by total area to be carpeted and multiplying it by the per m^2 cost of carpet given by vendor. Waste factor ranges from 4-9.25% for residential carpet laying while 4.5-9.25% for commercial building carpet laying.

2.31.8 Painting and Decorating

Estimating the price of paints the area to be painted is calculated multiplied by the coverage ratio and the cost of paint per liter. The shape of surface, height, type of paint, labor productivity, labor cost, equipment cost, and location are the factors which measure the cost required for paint.

2.32 `ESTIMATES OF R.C.C WORKS

RCC work mainly classified into

1. Bending of reinforcement.
2. Centering and shuttering work.
3. Placing reinforcement in position and binding of steel.
4. Concrete work (Vazirani & Chandola, 2008)

In some departments the schedule of rates specified includes complete RCC item inclusive of steel centering, shuttering, bending and binding. It is normal practice to issue cement and steel from the departmental store and issue rates of these materials and the place of the material are

mentioned in the contract document. Sometimes bending, binding, centering and shuttering of steel are considered as single unit excluding the rates of steel.

In case of complicated centering, and shuttering work the area of centering and shuttering is estimated separately.

As for as the payment of contractor is concerned, it depends on the nature of the contract. In case of item rate contract RCC work (usually 1:2:4) concrete is taken as 1 item and is measured in cubical contents and no extra payment is made for shuttering, centering or bending or binding of steel, reinforcement steel is calculated separately and pared as a separate item at the specified rate.

In a very specialized jobs such as silos, water tanks etc. the payment for complete unit is made as lump sum item.RCC work including steel is considered as one item and steel is taken as an additional item. The area of steel is ignored while calculating RCC work (Vazirani & Chandola, 2008).

Bending of the bars is required to have most economical use of steel, proper quantity and position with respect to upper and lower face of concrete as well as bending is required.

2.33 FOUNDATIONS

Foundation that supports steel structure includes footing, piles, and drilled shaft foundation. Footing is shallow foundations that are generated by excavating the soil from the ground and then installing the reinforced concrete.

2.33.1 Footing

Construction of footing includes excavating the soil to the required depth, erecting framework, setting reinforcing steel, placing concrete, removing formwork and backfilling soil above the footing to the surface of the ground.

For some shallow continuous footing, sides of the excavated soil are unstable. Thus, the trench is excavated wider than the footing, formwork is installed, and reinforced concrete is placed in the formwork.

2.33.2 Sheeting Trenches

The earth is so unstable that it must be restrained therefore trench box is installed. The sheeting of trench box is typically constructed with 2-, 3- or 4-in thick lumber placed side by side or overlapping over entire length of the trench.

2.33.3 Pile Driving Equipment

Equipment used to drive piles usually consists of a truck-mounted or crawler-mounted crane, leads, a hammer, and a source of compressed air or steam to drive hammer.

When a pile I driven into water, the driving rig is usually mounted on barge. The size of a drop hammer is indicated by the weight of the hammer, whereas the size of an air stream or diesel hammer is indicated by theoretical foot pound.

A single acting air hammer has a free-falling weight called Ram that is lifted by steam or compressed air that flows to the underside of a piston. A cap is mated to the case of the hammer. This cap is commonly called an anvil or a helmet.

2.33.4 Sheet Pilling

Sheet piles are used to form a continuous wall by installing sheets of steel that interlock. The cost of sheet pilling in place will include the cost of the piling material, driving equipment, and labor.

2.33.5 Wood Piles

The cost of wood load bearing piles in place will include the cost of the piles delivered to the job, the cost of moving the pile-driving equipment to the job, setting it up, taking it down and moving it out, the cost of the equipment and labor driving the piles.

2.33.6 Prestressed Concrete Piles

Prestressed concrete piles are manufactured by companies that specialize in precast concrete. The piles may be round, square, or octagonal. The amount of steel, strength of concrete, and amount of prestressing depends on the specifications prepared by the designer

2.33.7 Cast-In-Place Concrete Piles

Cast in Place piles are especially suitable for use on projects where the soil conditions are such that the depth of penetration is not known in advance and the depth varies among the piles driven.

The mono tube pile is installed by driving fluted, tapered steel shell to the desired penetration depth. After driving is completed in a given area, the condition of the tubes is inspected for damage. If a tube is damaged, it can be replaced and removed.

2.33.7.1 Cost of cast-in-place concrete piles

In estimated the cost of cast-in-place concrete piles, it is necessary to determine the cost of the shells delivered to the project, the cost of equipment and labor required to drive the shells, and the cost of the concrete placed in the shells. All these costs, except the cost of driving the shells, are easy to obtain.

If a project requires the driving of a substantial number of piles, it may be desirable to make subsoil tests, to obtain reliable information related to the difficulty to driving piles and the lengths of piles required.

2.33.8 Drilled Shaft Foundations

Drilled-shaft foundations are installed by reinforced concrete in holes that have been drilled in to soil. Truck mounted rotary drilling rigs can drill holes with diameters from 12 to 96 in. depths up to approximately 100 ft are possible.

The cost of drilled-shaft foundations will include mobilization of equipment, drilling of the shaft, if casing, fabrication and placement of the reinforcing steel and concrete and placement (Peurifoy & Oberlender, 1975).

2.44 CONSTRUCTION SCHEDULING

Scheduling can be simply defined as “determination of time requirements and the order in which they will be completed” to get a feel of total duration of project. However, it is important to note here that scheduling of construction project and planning of project are different things.

Planning of project deals altogether with finances, stakeholders, responsibilities of all the team members, quality standards etc while scheduling is concerned just with arranging activities that will be required to complete the project in some order to achieve maximum productivity.

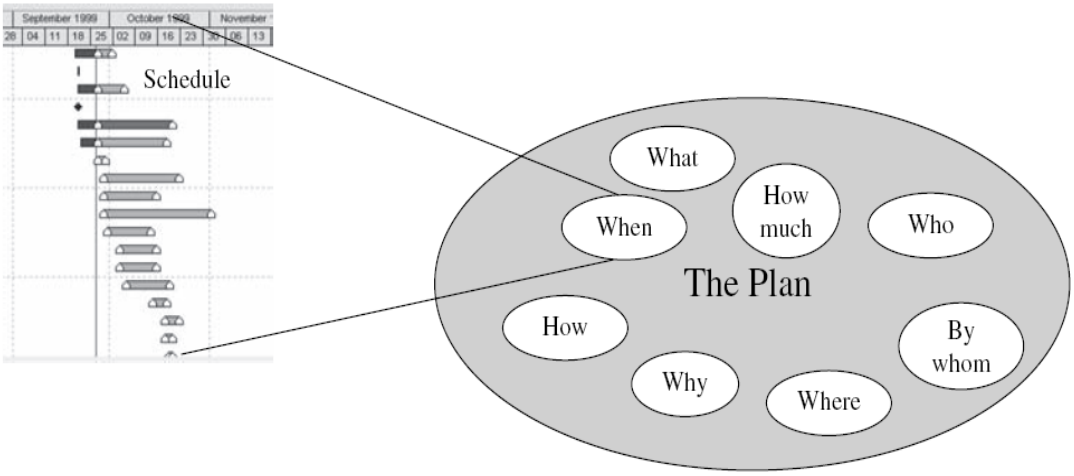

Figure 1: Relation between Schedule and Planning

(Mubarak 2010)

2.45 PROJECT PLANNING

In Project Planning, Project Management techniques such as scheduling is used in terms of Gantt charts to keep up pace with the construction work. Firstly, the project scope is defined and then, it is determined as to how the tasks will be performed, at the end of which a Work Breakdown Structure is made WBS. Activity network diagrams are used to make logical paths and to identify the critical path. Float is calculated using different softwares. After which the total cost can be determined. Now, the term of resource leveling comes into play to adjust the resources in a well managed way. Once established and agreed, the plan becomes what is known as the baseline. During its lifecycle, the progress of the project is measured against the baseline that is made. Analyzing progress compared to the baseline is known as earned value management. The inputs of the project planning phase include the project charter and the concept proposal. The outputs of the project planning phase include the project requirements, the project schedule, and the project management plan. (Hendrickson and Au 1989)

2.46 SCHEDULE

A schedule consists of the terminal elements with their identified start and finish dates. Terminal elements are the lowest element in a schedule, which can not be further subdivided.

A simple pan to explain how it works is as following:

- Who wants to go on a trip?
- Which place do you wish to see?
- The time frame for vacations?
- Total budget in hand?
- What will be the tasks during the trip that needed to be done?
- What is the means of conveyance?
- Other problems that needed to be taken into account such as food, accommodation, health issues etc?

The project schedule is simply answering this:

- Leave home from Islamabad, on April 19, 2011.
- Arrive in Murree, on April 20, 2011.
- Leave Murree on April 22, 2011.
- Arrive in Natiagali, on April 22, 2011.
- Leave Natiagali on April 30, 2011.
- Arrive in Abbottabad, on April 30, 2011.
- Return home to Islamabad on May 5, 2011.

2.46 WHY SCHEDULE A PROJECT?

Usually a project is not owned by a single entity, there are always many stakeholders, who want to take benefits in their own ways. Here are stated some of the reasons for project scheduling:

2.46.1 Why Contractors and Owners Need Project Scheduling

1. Calculate the project completion date: Usually, it is compulsory for the General Contractor to finish the project in the stipulated time limit. For this, he is required to contact the sub-contractors. This requires him to submit a plan to the owner as to how the project will be approached and finished. Usually, the GC is penalized for not completing the project on time. So, to make a good reputation and to prevent the heavy fines, he requires a schedule.
2. Calculate the start or end of a specific activity: There are some activities in huge projects which require special attention. Such as providing certain equipment at the site, purchasing certain materials. For the timely finish of the project, it is necessary for the Project Manager

to have a clear information about how and when a certain item will be made available at site or the project will go in jeapordy.

3. Coordinate among trades and subcontractors, and expose and adjust conflicts: Nowadays, the projects are f huge scopes. There is mainly a GC which hires sub-contractors. His main role is to co-ordinate among the sub-contractors. Make the funds available ad to provide proper workspace and equipment at site in order to keep the work going. Thos co-ordination needs to be done precisely in accordance with the progressing work. For example, if there is a wall to be constructed, the sub-contractor for the task needs to have proper space for his crew and equipment to operate in a proper manner.

4. Predict and calculate the cash flow: Predicting cash flow is a major job to be done as all the work is based on these calculations. Projects are run on money, so having money before a certain task is performed is necessary. The GC (or the owner) need to access the situation and keep an eye on the availability and the flow of money in a certain time frame that it does not exceed a certain cap in a month.
5. Improve work efficiency: By distributing the money and the materials along with the equipment is necessary for the GC to save his money and time in the project's over all life cycle.
6. Serve as an effective project control tool: There should be a solid and sound baseline in the Project Control with which the progress of the project can be checked. The flow of money, the schedule and the budget should be kept according to the Project Control or the there is a likelihood of the project to go in the lagging phase.
7. Evaluate the effect of changes: Change orders in a project are always a possibility. The owner can always change his mind and ask the contractor for addition, deletion or substitution of certain items. However, these changes can be avoided if the project is well planned and there is a good relation in between the owner and the GC. Change orders may have an impact on the overall budget or the time schedule of the project. Estimators also keep in mind the need for change orders but the schedulers keep in mind the delays in the project that can be made for procuring certain changed items on site.
8. Prove delay claims: Construction delay claims are quite common in construction industry. A contractor needs to prove that there has been a delay that has caused him substantial loss.

This is usually proved using the critical path method or the schedule developed for the project.

2.46.2 Why Project Owners and Developers Need Project Scheduling

1. Ensure contractor's proper planning for timely finish: The owner can demand a schedule from the contractor so as to how the contractor is going to complete the project? The owner has a huge liability because he will approve the schedule and anything wrong in terms of the time frame will become the headache of the owner. The schedule should be checked if it's realistic or not?

2. Predict and calculate the cash flow: The owner should make arrangements to pay the contractor on time. Delaying the payments will take the project in a lagging phase which is not desirable as delay paves way for claims from the contractor. Cash flow affects the project in a way that can be useful and harmful at the same time if funding is not sufficient.
3. Evaluate the effect of changes: Usually, owners require changes during the ongoing phase of construction of the project. These changes may become intense as the owner sometimes neglect the impact these will be having on the cash flow and the schedule of the project.
4. Verify delay claims: CPM is used to address the delay claims. Usually the claims are made by the contractors but this can also be done in reverse. The owner may also ask the contractor for claims when the project is delayed without any mistake done by the owner.
5. Get an idea on project's expected finish date: Before the GC is asked to finish the project by a certain deadline, the owner must analyze the project and know a feasible date that can be achieved by the contractor. An unrealistic finish date is not acceptable by the contractor, even if it is accepted, the bid gets too expensive as the risk is getting huge.

2.46.3 Project Planning and Scheduling

A schedule is not sufficient to keep an eye on huge projects. There is a need to develop a strategy for the work progress and it should be implemented for better results. CPM (Critical Path method) is the best possible tool for such cases. It provides mechanism to keep an eye on schedule, activities and the problems which may arise during the construction life of the project. For this purpose, mainly, a Master schedule is developed. For having a good work baseline and a track record, all the people working at the site such as sub-contractors need to report the daily

progress to keep in touch with the Master Schedule. Sub-contractors, who develop their own schedules usually are not aware of the plans in the master Schedule and thus create ambiguities and misconceptions in the project most probably, creating a lag.

2.47 PROJECT CONTROL

The term "Control" in Project Management means an effort to take control and keep a record of all the activities in the project and make sure they go in accordance with the planned schedule.

Things always go out of control once construction starts. It may be in the form of overspending, activities running behind the schedule, labor/material unavailability etc therefore It is of utmost importance to know—at all times—where you stand in relation to where you planned to be (the baseline).

If you find that you are behind the schedule or can't make up with the available budget, you need to take corrective measures to ensure there is not a bigger loss. Taking things in such methods is known as Project Control. As it brings the things under the control of the manager, or atleast minimizes the losses he might be facing. This is an example of Project Control and it's advantages.

A single project that fails may cost the profit earned in the whole year, so it is very necessary to keep an eye on the activities going on and have a good Control.

Project Scheduling helps in project control in following ways:

- A good scheduled project provides us with more project control
- It provides us with the baseline against which the progress of the project is to be measured.

Figure 2: Project Control as iterative process

(project_control[wikimedia.org])

2.48 WORK BREAKDOWN STRUCTURE (WBS)

The WBS is defined as a detailed breakdown of activities that organizes, defines, and graphically displays the total work to be accomplished to achieve the final objectives of a project. WBS breaks the project into sublevels that are easily interpreted and it gets easy to implement smaller tasks as compared to a larger task at a single time.

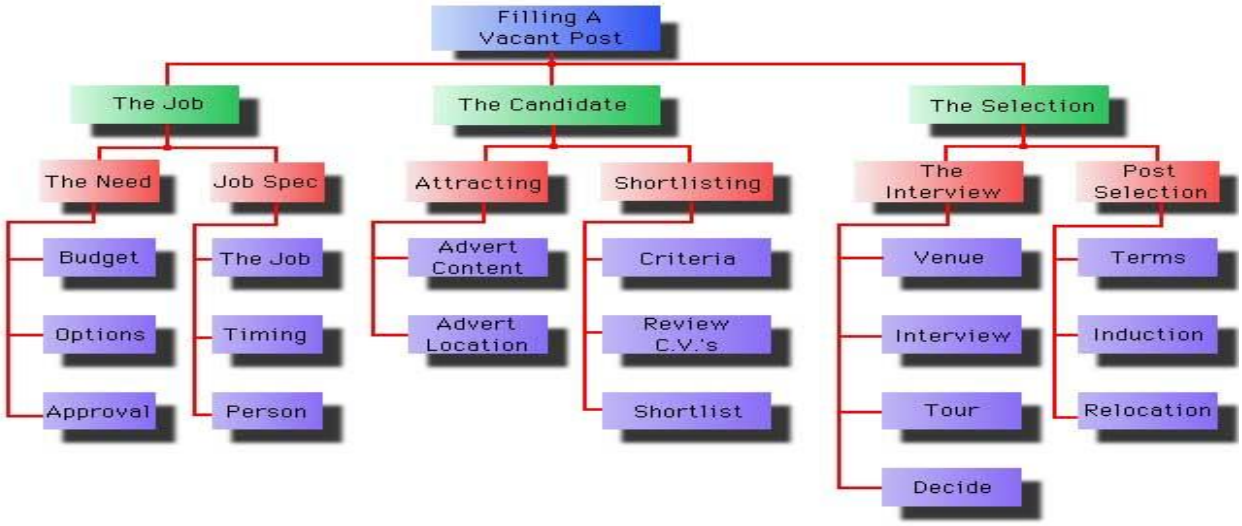

Figure 3: Sample WBS

(WBSChart[http://ygraph.com])

2.48.1 Why Use a WBS?

In planning a project, one may get confused when he tries to get into the minor details of a medium sized project. There are several people that do work in a project over a period of time and understand the work of a lot of people is not an easy task to do. The only way to avoid this confusion is to have a WBS that will identify each work separately in a presentable manner so everyone can understand it.

According to psychologists, human brain can only manipulate 7-9 tasks at a time, where a project is composed of thousands of tasks. So it may get out of our hands. The solution is to divide and conquer. The WBS helps break a huge project into small understandable segments

that are easy to be implemented. Preparing and understanding a WBS is a big step towards managing and mastering its inherent complexity.

2.49 SCHEDULING TECHNIQUES:

2.49.1 Bar Charts (Gantt Charts)

A bar chart is a graphic representation of the activities that is not linked between and it is drawn against a time scale.

Before making a bar chart, the project must be broken down into smaller segments known as activities.

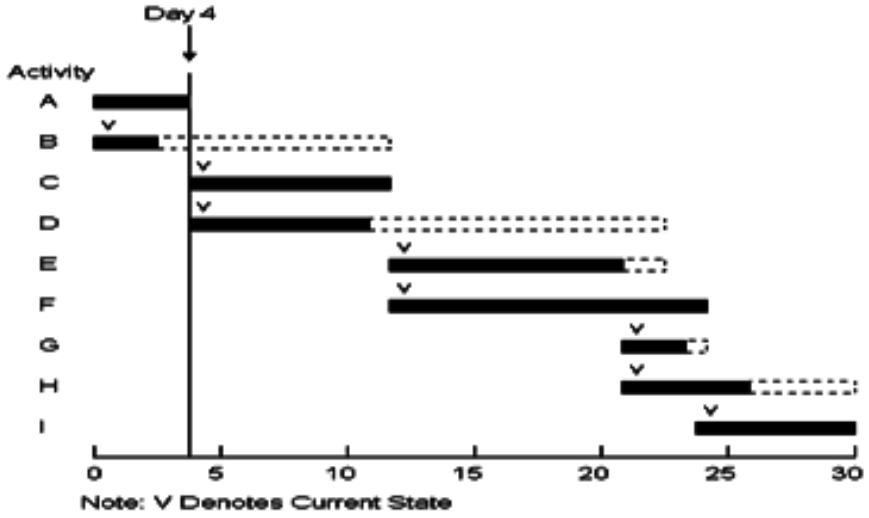

Figure 4: Bar Chart 1

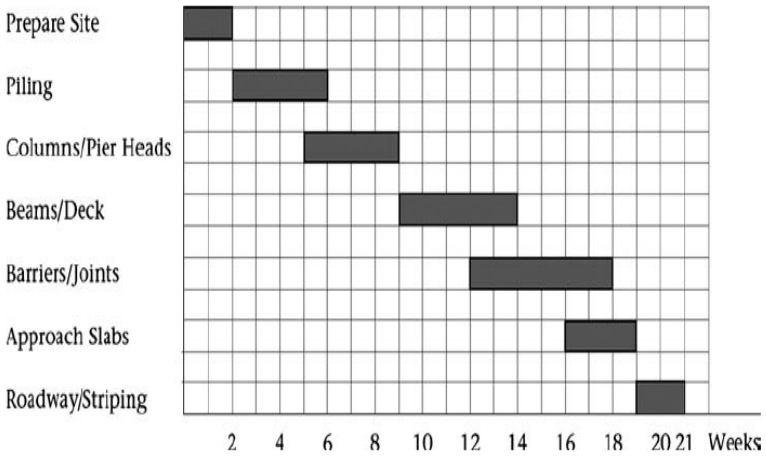

Figure 5: Bar Chart 2

(Mubarak 2010)

2.49.2 Network Diagrams:

A logical and chronological graphic representation of the activities composing a project is known as a network. Network diagrams are basically of two types: Arrow and Node networks.

2.49.2.1 Arrow Diagram Method:

Arrow networks are also called the arrow diagramming method (ADM), activity on arrow (AOA) networks. Activities are represented on arrows.

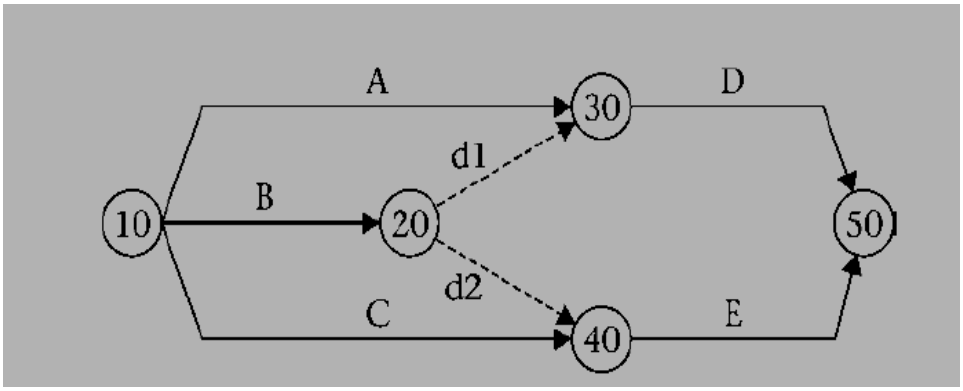

Figure 6: Arrow Network

2.49.2.2 Node Networks:

Node networks also known as activity on node (AON) networks. In node networks, a node represents an activity. Nodes (activities) are connected with arrows (or lines) that represent the logical relationships.

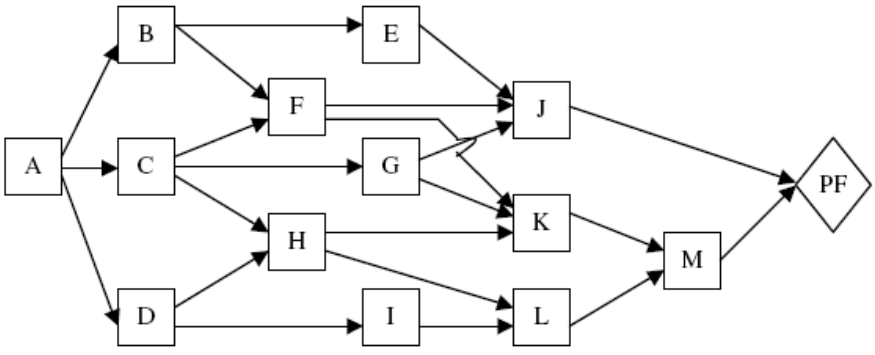

Figure 7: Node Network

2.49.3 Critical Path Method

To use CPM, the following technique must be used:

- A list of activities that will be required to finish the project.
- The time in which each activity will be completed.
- The dependencies between the activities.

Using this data, the CPM analyzes and helps us identify the longest path that can be taken and also shows the shortest and the longest activities that can be adjusted without making the project longer that the stipulated time limit. This process determines which activities are "critical" (i.e., on the longest path) and which have "total float" (i.e., can be delayed without making the project longer). This determines the shortest time possible to complete the project. If a single activity on the critical path is delayed, the whole project is delayed as a result because the critical path is devoid of floats. An additional parallel path through the network with the total durations shorter than the critical path is called a sub-critical or non-critical path. ((CPM))

2.49.4 Project Evaluation and Review Technique (PERT)

PERT uses a probabilistic approach, which requires a duration frequency distribution for each activity. In most cases, such distributions are unknown or unavailable. Because of this, PERT requires the user to set three durations that constitute the practical range of the duration for each activity.

PERT then uses simple statistics to calculate the mean and variance (or standard deviation) of the time required to complete the chain of events leading to Substantial Completion. It gives the probability as when the Substantial Completion will be achieved or it gives the confidence level in percentage as to when the Substantial Completion will be met by a certain date.

2.50 SCHEDULING ISSUES

While determining schedule of activities it is important to consider various other factors

A decision must be made early about the “float” and about the use of early start schedule or “late start schedule” according to the cash flow requirements. Both types have their advantages and shortcomings. Early start is good as the activities are not critical however resources are not used in a constant manner but again this problem can be overcome by the use of “resource leveling”.

Also after the schedule is determined the timings to execute the important activities should be examined as to anticipate any possible hindrance due to the weather or any other i.e precautionary measures against high temperature, rain, snow, high winds etc.

Other factors to be considered are delay/shortage/ non-availability of material, expiration of labor agreements and discontinuity of cash flows.

A deficient cash flow can be handled by scheduling the possible expensive material late 7 relatively cheap ones earlier.

In short a scheduler who can anticipate as much as possible actual project condition as possible will be contributing a large part to the project management efforts (Peurifoy and Peurifoy 2008).

2.51 FACTORS AFFECTING CHOICE OF ACTIVITY SCHEDULE

Scheduling must satisfy the constraints that are imposed by contract. Primary focus is placed on physical constraints other constraints in developing network logic i.e. resource, safety, management etc are introduced at some later stage.

Activity start times are so designed in a way that they do not overlap, because you can not start two simultaneous activities at the same time. So it is preferable to have different start dates for each activity.

Weather during the project and other contingencies that occur may be incorporated into a schedule during the project planning in a manner just described.

2.52 RESOURCE LEVELLING

Resource leveling is a technique in construction management that overlooks resource allocation and it resolves all the problems regarding resources during the project. When project managers undertake a project they had to allocate resources for the best of interest of the project.

This is a benefit for the organization and will save from conflict and is not be able to do the project on time. Resource leveling is crucial for resource management in an organization.

The main aim of resource leveling is to allocate the resources efficiently and to complete the project at required time and meet the required standards. Hence, resource leveling can be divided into two main areas; projects that can be finished by using all available means and the projects that can be finished using limited resources.

The projects in which limited resources are used are extended up to a time when the resources are fully available. If then again, organization overtook larger project then the resources are not available to carry out the project then it is best to postpone the project and complete the first.

Resource leveling helps an organization to make use of the maximum available resources. It is used to minimize the wastage of resources and stop the over allocation of the resources.

There disadvantages due to resource conflicts, such as:

- Delay in the tasks being completed
- Difficulty in assigning a different resource to the task
- Unable to change task dependencies
- To remove certain tasks
- To add more tasks
- Overall delays and budget overruns of projects

Critical Path Method CPM is also quite effective in resource leveling as it stipulates the longest and the shortest paths to be followed.

Resource leveling allows the organization to utilize its resources effectively and gain maximum out of them. Proper resource leveling prevents heavy expenditures.

2.53 SCHEDULING SOFTWARE

Nowadays a wide range of computer softwares are available to facilitate the scheduling process. Now the softwares are used for the scheduling of projects making it easy and more manageable, as u can change or update the schedule as you want to anytime. Following are few important types of software that are mostly used:

2.53.1 Microsoft Project

It is one of the most widely used softwares due to the following features:

- **Simplicity**: It is quite simple and can be learnt with minimum training.

- **Maturity**: It was launched in 1984 and since then it has been developing. They get the feedback from various project managers and incorporate the new items into their software thus upgrading it from time to time.
- **Quickly Estimating project timelines:** It can provide estimated timelines quite easily and fastly.
- **GANTT chart**: It is quite versatile and has a number of tools, such as GANTT charts, resource leveling, etc...

However Microsoft Project, is not construction-specific. It's used to schedule and track "stuff" across all industries.

2.53.2 Primavera P6:

Primavera P6 is a very powerful project scheduling tool developed by Oracle Inc.

- It has flexible web-based interfaces which give easy access to the project details at any time. In addition, team members can easily and quickly update status by using any of the P6 Team Member interfaces which include the P6 Team Member Web (which is optimized to run on a tablet), P6 Team Member for iPhone application, and an email stat using option.
- P6 covers the full project management lifecycle – from project initiation to project closeout.
- Interactive activity Gantt charts allow schedulers, planners and project managers to communicate a more accurate and complete graphical representation of a project's schedule, while calendar and activity network views provide team members with an intuitive view for displaying their assignments.
- Primavera P6 EPPM is ideal for organizations that need to simultaneously manage multiple projects and support multi-user access.
- Supporting both top-down and bottom-up resource request and staffing processes, P6 makes it easy for project and resource managers to communicate their requirements and decisions throughout a project's lifecycle.
- It has powerful security features to help the organizations secure their data.

However the software is relatively difficult and expensive. It requires adequate computer and internet skills to master and is ideally suited for large construction projects.

(OracleandPrimavera[oracle.com]).

Other softwares ideal for small projects are:

BuilerTrend , CoBuilder etc

Chapter 3

METHODOLOGY

3.1 LITERATURE REVIEW

Cost estimation is the science of calculating the quantities of different material needed for construction and calculating the cost by multiplying the quantity with its unit rate.

3.2 SITE SELECTION

The construction site which we selected for which the estimate is to be developed is the State Life Building Tower located in Blue Area Islamabad.

Figure 8: The State Life Building Tower, under-construction

3.3 SITE VISIT

After contacting the site engineers at work on the state life tower, our group went to the site for setting an approach methodology for the project work.

3.4 ACQUIRING DRAWINGS AND SPECIFICATIONS

We collected all the relevant data. All drawings which included architectural, structural, electrical and plumbing drawings were copied. Also the specifications of the building were collected which supplement the drawings i.e. data not clearly understandable in drawings is clearly explained in the specifications. Each and every detail is available. Also the bar bending schedule and the Schedule of opening are used for making Bill of Quantities.

3.5 DETAILED STUDY

The drawings were understood by the estimators and list was made of the materials used in the building. The specifications had also to be read for the complete understanding of the quantities.

3.6 QUANTITY TAKE-OFF

For estimation, we started by listing the quantities of different works. Doors, windows, and materials we required for the work. Studying the drawings, and reading the specifications for details of the work to be installed, work was executed for our project.

3.7 PREPARING ESTIMATE IN EXCEL

Work was done on Excel by unit rate method, taking composite rates of materials. Composite rates are usually calculated by adding material, labor and profit of the contractor. We took rates form website such as picc.org.pk (Pakistan Institute Cost and Contracts) and Rawalpindi MRS-2012 (Market Rate System). Material quantity was multiplied by composite rates and cost for quantities was evaluated.

3.8 CALCULATION OF DURATIONS

The estimate prepared is of just for the cost, but for evaluating the time required for that particular task. The quantity evaluated is used to calculate the duration of the particular activity using the formula Duration = Quantity / Productivity. The Productivity is available by using historical data available behind the MRS rate we used for that particular item.

3.9 PREPARATION OF SCHEDULE

Scheduling was done after evaluating the duration and defining the activities of each floor, which is done through cost estimation. After making a Work Breakdown Structure (WBS), the activities are entered in their respective floors in the WBS. From their relationships

(Predecessor/Successor) and resources are assigned. The schedule is optimized to finish within minimum time possible.

3.10 UPDATING THE SCHEDULE

The Schedule was updated up to 8 weeks from its starting date on Primavera. It was done to check the percentage of work completed during the first two months of the project. Updating is also done to compare the actual/working schedule from the proposed/baseline schedule.

3.11 PREPARATION OF FINAL REPORT

All the Estimation and Scheduling was compiled in a report along with the Literature Review, Methodology and Results.

3.12 PRESENTATION OF REPORT

After preparing the report, it was presented to a panel of judges who questioned us regarding the project and estimation and scheduling theories, methodologies and our work on the project.

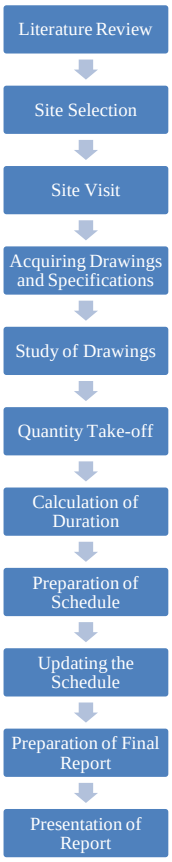

Figure 9: Flow Chart of Methodology

Chapter 4

ESTIMATION AND SCHEDULING OF STATE LIFE TOWER

4.1 PROJECT PROFILE:

The State Life building Tower is situated on Jinnah Avenue, Blue Area, Islamabad. It covers an area of 274,554 Sft (176,400 SQM). The tower has three basements, Ground Floor and 18 Floors.

The Three Basements will be used for Parking and Cafeteria while Ground Floor and above for commercial purposes. The project started in 2004. Expected Completion of the project is in 2019. Expected Cost on the state life tower is PKR 1.5 Billion.

Contract was awarded to Moeen Sons Pvt. Limited in 2004. Construction work will take place in three phases. Phase I is up to the 4^{th} Floor, Phase II is up to the 12^{th} Floor and Phase III is up to the 18^{th} Floor.

The Consultants are Sohail and Pasha whilst Supervisionis done by National Engineering Services Pakistan (NESPAK). A team of three acts as the Project Manager of the State Life Building Tower, Blue Area, Divisional Head (Hassan Abbas), General Manager (Col. Mohsin), Assistant General Manger (Hussain Ahmed). The construction work was halted after the 2005 Earthquake to make it Earthquake resistant. It is currently Earthquake resistant up to level 3 although NESPAK wanted it to be level 2 resistant.

4.2 ESTIMATION OF STATE LIFE TOWER

For evaluating the area or volume of particular item, drawings have to be consulted. After the quantity take-off there is a path through which the required material can be evaluated. Shown below are some of the materials which are required for every 100Cft of preparation.

SR. NO.	ITEM OF WORK	QTY. OF MATERIAL IN (F.P.S) SYSTEM	QTY. OF MATERIAL IN (M.K.S) SYSTEM
1	For Brick Work (9”x 4-½”x3”) (20x10x10 cm)	1350 Nos. for 100 Cft.	50000 Nos. for 100 m^3 or 500 Nos. for 1m^3
2	Dry Mortar for Brick Work	30 Cft. For 100 Cft.	30m^3 for 100 m^3
3	Stone for Rubble Stone Masonry	125 Cft. For 100 Cft.	125m^3 for 100 m^3
4	Dry Mortar for Rubble Stone Masonry	42 Cft. For 100 Cft.	42m^3 for 100 m^3

5	Brick for brick ballast for cement concrete.	1050 Nos. For 100 Cft.	3700 Nos. for 100 m^3
6	Brick Bats. Or brick ballast for time cement	105 Cft. For 100 Cft.	105m^3 for 100 m^3
7	Brick ballast for lime concrete	100 Cft. For 100 Cft.	100m^3 for 100 m^3
8	Dry mortar for lime concrete	35 Cft. For 100 Cft.	35m^3 for 100 m^3
9	Dry material for P.C.C	154 Cft. For 100 Cft.	154m^3 for 100 m^3
10	Bricks for R.B stab	1200 Nos. For 100 Cft.	4200 Nos. for 100 m^3
11	Dry mortar for R.B work	45 Cft. For 100 Cft.	45m^3 for 100 m^3
12	Dry mortar for 12mm (½") plaster	6 Cft. For 100 Sft.	2m^3 for 100 m^2
13	Dry mortar for cement pointing	2 Cft. For 100 Sft.	6m^3 for 100 m^2
14	Lime for white washing single coat	1 kg For 100 Sft.	10 Kg. for 100 m^2
15	Dry distemper for 1st coat	0.65 kg. For 100 Sft.	6.5 Kg. for 100 m^2
16	Dry distemper for 2nd coat	0.5 kg. For 100 Sft.	5 Kg. for 100 m^2
17	Snow-cement for 1st coat	3 kg. For 100 Sft.	30 Kg. for 100 m^2
18	Snow-cement for 2nd coat	2 kg. For 100 Sft.	20 Kg. for 100 m^2
19	Paint ready mixed for painting one coat	½ gl. For 100 Sft.	10 Lit. for 100 m^2
20	Paint (stiff) for painting one coat	1kg. For 100 Sft.	10 Kg. for 100 m^2
21	Bricks on edge	500 Nos. For 100 Sft.	5000 Nos. for 100 m^2
22	Dry mortar for ½" Brick Wall	12 Cft. For 100 Sft.	3.2 m^3 for 100 m^2
23	Brick on Flat	350 Nos. For 100 Sft.	3500 Nos. for 100 m^2
24	Dry mortar for flat brick floor	8 Cft. For 100 Sft.	2.5 m^3 for 100 m^2
25	Hony comb for brick wall	325 Nos. For 100 Sft.	3250 Nos. for 100 m^2
26	Dry mortar for Brick wall (Hony comb)	8 Cft. For 100 Sft.	2.5 m^3 for 100 m^2
27	Bitumen or asphalt for D.P.C or on roof 1st coat	15 kg. For 100 Sft.	150 Kg. for 100 m^2
28	Bitumen or asphalt for D.P.C or on roof 2nd coat	10 kg. For 100 Sft.	100 Kg. for 100 m^2
29	G.C.I. Sheet for roof	128 Sft. For 100 Sft.	128 sqm^2 for 100 m^2
30	A.C sheet for roof	115 Sft. For 100 Sft.	115 sqm^2 for 100 m^2

Using these tables we have been able to evaluate the required materials for a number of items. For example, the ½" thick 1:4 CS-mortar required for plastering on the 14th floor is 12900 sft which came from (215000/100)*6 = 12900 sft.

4.2.1 Excavation

Excavation is done in order to construct the foundations or in cases where we have to go deep down into the earth for construction, it is also used in tunneling, in dam construction etc.

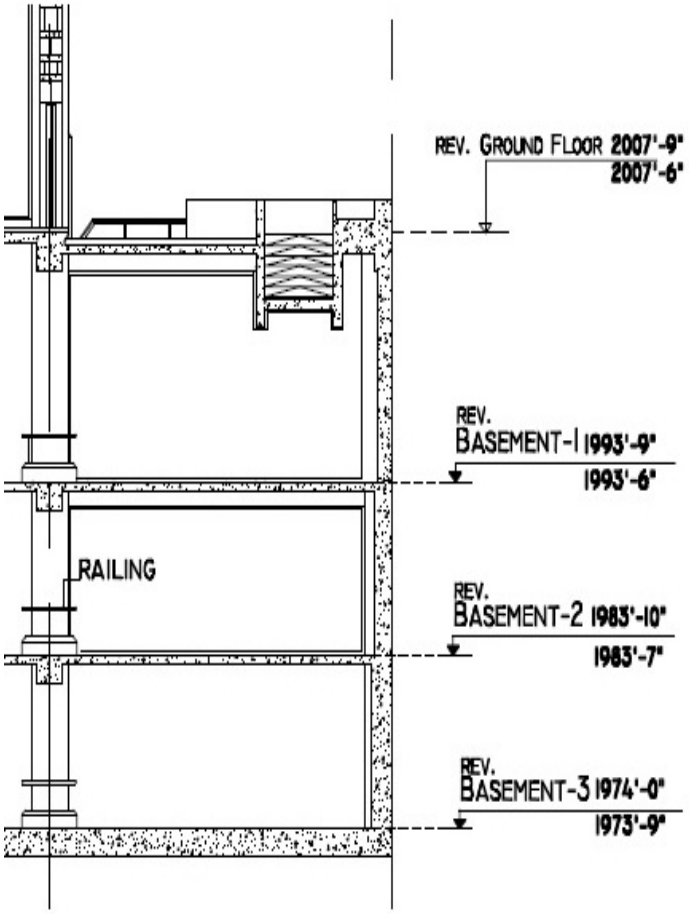

Figure 10: Basement Excavation

For excavation, the difference of basement 3 datum and NSL which is 2000' gives depth, while area of basement from plan gives the other two dimensions which come out to be (2000-1974)*160*290 = 1,206,400 Cft. Cost of excavation depends on the equipment which will be used for this task.

4.2.2 Columns

Columns are vertical members that transfer the loads to the foundations.

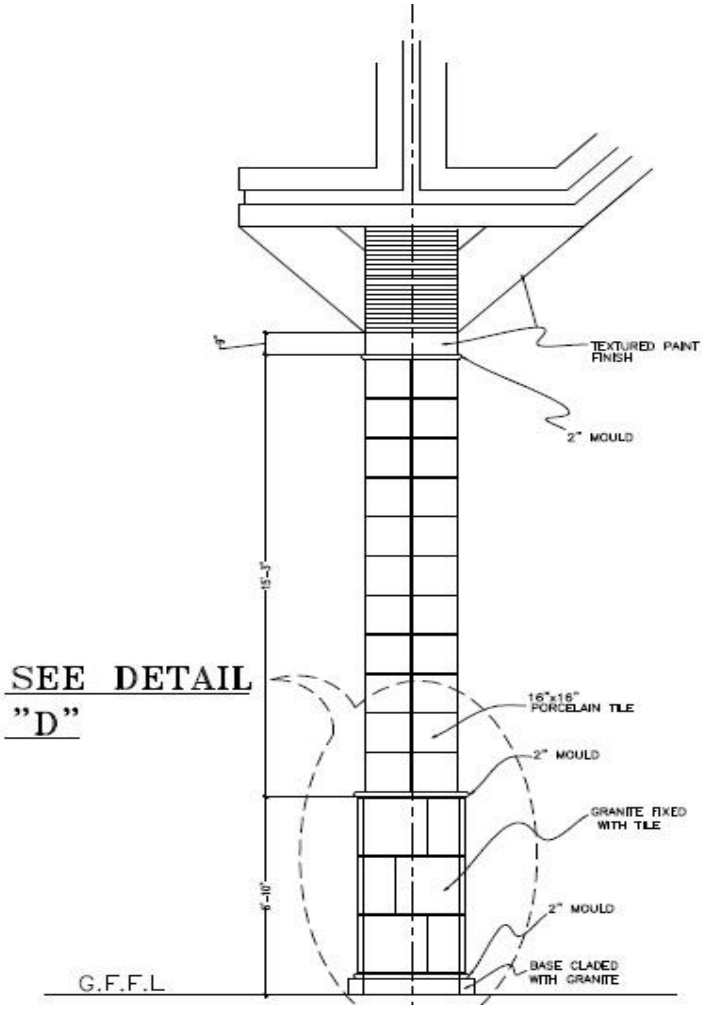

Figure 11: Typical Column details

External Columns used are 2'-6" x 2'-6".They run throughout i.e. from 3rd basement (el. 1974'-0") to mumty (el. 2232'-0"). For 4000 psi strength composite rate from MRS is 187.43 per cft. Cost for one external column = (2232-1974)*2.5*2.5*187.43 = Rs. 303,309

4.2.3 R.C.C Purdi

R.C.C Purdi is non- load bearing wall adjacent to bracing beams.

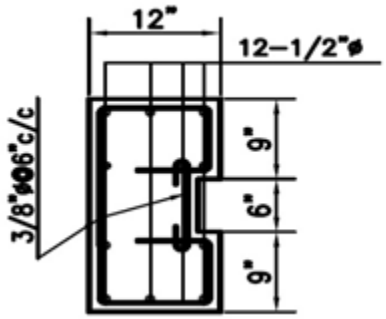

Figure 12: Typical Section of R.C.C. Purdi

The quantity of this item is evaluated by the length on which it runs and the cross sectional details. This gives the quantity of concrete. The reinforcement is evaluated using typical section of Purdi, which gives the length. This length multiplied by the weight per unit length gives the total steel required for the purdi.

4.2.4 Beams and Bracing Beams

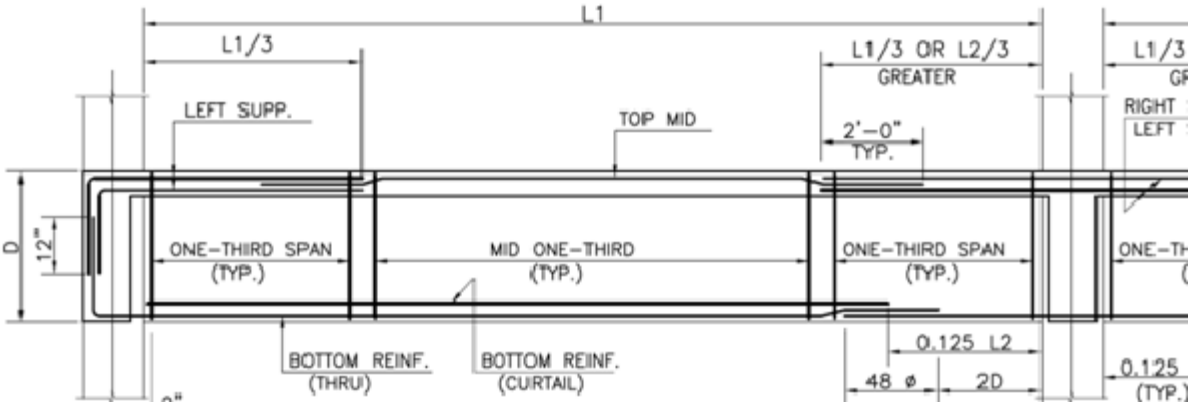

Figure 13: Typical Beam Elevation

Reinforcement in beams was evaluated by according to the length and cross sectional detail of the beams. Beam schedules provide information necessary for the reinforcement detail required for every beam. Bottom bars run for two-thirds of beam length and an additional 48 x (diameter of bar), 12" and column width minus cover.

An extra one-third is provided on top left and right support of every beam unless mentioned otherwise. Bar diameter and number of bars are mentioned for each and every beam. If extra supports are not provided in top left and right, the top bar runs throughout the beam plus 2 x 48 x (diameter of bar). If supports are provided, it is one-third plus 2 x 48 x (diameter of bar). Similar manner is used for bracing beams calculations.

4.2.5 Columns

Column dimensions are same throughout the building. The reinforcement details are also same, except the numbers of columns are increased where excessive load is to be bared. Same methodology is used as in beams. Length of reinforcement is calculated multiplying it with Weight in kg per unit length.

4.2.6 Plumbing and Electrical Works

Plumbing and Electrical Works are evaluated by the length of piping, the quantity of which is evaluated by the Electrical and Plumbing Drawings. Quantity take-off is done in Running Feet (Rft) and the diameter of the pipes/conduits is specified in the specification of the work.

4.2.7 Preparation of Estimate in Excel

The quantities evaluated are placed in excel in which the detailed estimate was prepared. The length, breadth, width and Nos are used to evaluate the quantity. This quantity is later priced according to the specification stated in Market Rate system (MRS). No other method of pricing was available and we used the closest price correlating it with the specifications. With this estimate, we prepared the Bill of Quantities which is the summary of the estimate. The specifications and quantities of items of each floor are only enlisted with the unit price. The total cost of items is then evaluated.

4.3 SCHEDULING OF STATE LIFE TOWER

4.3.1 Calculation of Duration

Duration of an activity is calculated by Time = Quantity/Productivity. Activities are delineated by the quantity of items which is done by studying the drawings. Productivity of items are evaluated by using a file which shows the working behind the rate used for pricing of that particular activity. In this case, a particular example of Third Floor R.C.C Work for wall around stairs is 4908.384 Cft. Per 100 Cft of quantity requires 1 unskilled Labor and 6.6 unskilled Labour Man-Days. Per Labour Hour, Skilled Labor Hours requied is (4908.386/100) = 49.08 man days. The skilled resources for this activity are 2 skilled labor. Duration (Time) comes out to be 24.54 days.

For Unskilled Labor (4908.38/100)*6.6. This quantity is divided by the resources which are 12 in this case. Duration for this activity is 26.99 days.

The larger of these two quantities is the duration of the activity.

4.3.2 Scheduling using Primavera

The Work Breakdown Structure (WBS) is made which is used in planning of the building. WBS was floor wise and work was planned to be executed accordingly. The activities of respective floors were added into Primavera after which their resources and relationships were assigned. This was the planned schedule of the State Life Tower. Baseline was created of the project with respect to the start date of the project.

4.3.3 Updating the Schedule

Update of the Schedule was done on hypothetical field values. The schedule was updated to 2 months after start date of project. Activity codes were also assigned which the rearrangement of the schedule was without disturbing the Work Breakdown Structure (WBS). Enterprise Project Structure (EPS) was made which is the division of works within any organization. Organizational Breakdown Structure (OBS) which is the chain of command in a construction firm was also made. Later the EPS and OBS were linked together i.e. showing the responsible manager for a particular EPS division.

For details, see appendix.

Chapter 5

RESULTS AND CONCLUSIONS

The State life Building Tower is currently Under Construction. Work is progressing as we speak. Whenever we went to the site for construction work, the Engineer we were assigned to have to do work. We waited until he was free for addressing our doubts. For estimating, a lot of site work is not required. Rather studying of the project is required.

The total cost of the State Life Tower evaluated by us has come out to be **Seven Hundred and Thirty One Million Ninety One Thousand Two Hundred and Thirty Five** PKR (Rs. 731,091,235). This cost has been evaluated after preparation of detailed estimate and pricing of items to their closest specifications according to unit rate method. Prices were taken from Market Rate System (MRS) Bi-annual Period, 1st August, 2012 to 31st January, 2013, The Government of Punjab, Finance Department and from Pakistan Institute of Cost and Contracts (PICC) website. The total cost of the project evaluated by State Life officials is not known as the data of the estimate was not provided to us but the expected cost on completion including the cost of delays is One Point Five Billion PKR (Rs. 1.5 Billion).

Estimation is a methodology with which one can predict the expected cost of a construction project. Drawings are to be scrutinized as the smallest mistake will multiply manifold to increase the cost of the project, especially in a large scale project such as ours. Albeit the most used item in a construction project is Concrete but the most crucial item in terms of pricing is steel which is used as reinforcement. This quantity take-off of reinforcing steel has to be evaluated carefully as the slightest error will multiply and result in tons error. A single ton of reinforcing steel cost 115,469.5 PKR according to MRS Bi-annual Period, 1st August, 2012 to 31st January, 2013.

The Schedule was prepared on Primavera p6 and the duration of the proposed project is April 11, 2013 – January 11, 2019. This is makes a duration of 5 years and 9 months if the project goes according to plan. The schedule is an important aspect of a construction project which is important for monitoring the progress of the project. A schedule gives a clear picture regarding the kind of work which is to be done i.e. rather the current pace is to be kept or work is to be expedited. Using Primavera, a lot of tedious calculations are easily done through software.

The difference between the duration of the project evaluated by us and the one evaluated by the State Life officials is different as the actual work on a project may result in delays of work execution, delay in procurement or low productivity. In either case, it is a serious issue for the Contractor which should be addressed and make work complete by expediting the work or addressing the issues which cause the delays.

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Appendix