

**COST ESTIMATION & SCHEDULING OF A HIGH RISE  
BUILDING**

**A CASE STUDY OF  
NUST SCHOOL OF SOCIAL SCIENCES AND HUMANITIES**

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**Civil Engineering**



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This is to certify that the

Proposal entitled

**COST ESTIMATION & SCHEDULING OF A HIGH RISE  
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**A CASE STUDY OF  
NUST SCHOOL OF SOCIAL SCIENCES AND HUMANITIES**

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## **DEDICATION**

This whole project is dedicated to all the authors, teachers and project management professionals who worked day and night for this field in order to take Construction Engineering and Management to the peak and produce helpful material for others specially Dr. Saleh Mubarak, our teacher of Construction Engineering and Management and our mentor, A/P Zia-ud-Din, who not only taught the basics of this subject but his hard-work and his appreciation lead us to the completion of the course as well as our final year project.

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## **ABSTRACT**

Estimation, the process of approximate the cost of all the activities in a project which exhibit the total cost of the project, and Scheduling, which is the break-down of total time allocated to project into different activity's duration and sequencing it in such a way that it form a network which shows us how these activities are interlinked, are two very important components of project management which are used in different phases of project i.e. planning, execution and monitoring.

This paper helps to develop the basic understanding of these two topics along with project management and its other components. The project is the application of theoretical knowledge about project management and its implementation in construction industry of our country to complete different construction projects effectively. In spite of many developments in construction industry some negligence is made in this part due to which project stakeholders suffers different time and cost overrun. Starting from very basic we estimated the cost of each quantity and will estimate the time and then interlink them which will tell us the total cost and time of project and then we will interlink these activities in a way to give us the best suitable schedule of activities to complete the projects in a cost effective and time effective manner.

After estimating and scheduling a high rise building we will compare the cost and time we planned with the cost and time taken by real-time project and some measurements would be listed that should be taken at right time to avoid any loss.

## **LIST OF ACRONYMS**

AEC	Architecture, Engineering and Construction
BOQ	Bill of Quantities
WBS	Work Breakdown Structure
CAD	Computer aided design
C&W	Communication & Works
PMO	Project Management Office
HVAC	Heating, Ventilation and Air Conditioning
MEP	Mechanical, Electrical and Plumbing
PEC	Pakistan Engineering Council
QC	Quality Control
LF	Linear Feet
EA	Each
SF	Square Feet
CY	Cubic Yard
PMBOK	Project Management Book of Knowledge

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# CHAPTER 1

## INTRODUCTION

The Triple Constraint depicts in pictorial form, the key attributes that should be handled in an effective manner for successful completion of any project. For clear understanding, the key attributes of the Triple Constraint are listed as follows:

**Time** – This is the actual time needed to provide a definite result. In this case, it shows the end result of the project. Basically, the amount of time required to produce the deliverable will be in direct relation to the amount of requirements that are part of the final result (scope), along with the amount of resources acquired in the project (cost).

**Cost** – This is the predicted amount of money that will be needed to complete the project. Cost includes variety of things such as: resources, the risk estimates, bills of materials, labor rates for contractors etc. All aspects of the project that are somehow related to the monetary component are part of the overall cost structure.

**Scope** – These are the functional elements which, on completion, define the ultimate deliverable for the project. The field itself is usually identified in advance in order to give the project the best chance of success. Note that the common measure of success for the aspect scope of a project is its inherent quality delivery.



Figure 1.1 Triple Constraint

## **1.1 Understand the Triple Constraint**

For starting period, the project manager should kept in mind that the scope, time and cost are completely interrelated and that the triple constraint rules any settlement to any of these parts should affect the other. In most cases, a project manager can be aloof about addition of scope to a project without even realizing the consequences of that change. Ignoring the impact of the adjustments in the scope, time and cost of a project is only going to cause problems in the future and may also cause the project to fail miserably.

## **1.2 Convey the Triple Constraint**

Along with the knowledge of how the triple constraint works, it is important for the project manager to transmit that information to project stakeholders. Ensure that everyone involved in the project recognizes the importance of the restriction will make discussions on the scope, time and cost a lot easier. In most scenarios, stakeholders are mostly found to be involved in corruption in the scope or budget adjustments on a project. Taken into account from the beginning of what the results may be for any requested change or imposed make it easier to dialogue in follow-up meetings and also will scrutinize their change requests further rather than assuming that any changes will not have no problem in the release cycle project. Note that the transport of the triple constraint for stakeholders is best done in the beginning, probably during formation of the initial project plan.

## **1.3 Monitor the Triple Constraint**

As project manager, ensuring to stay on top of all the key attributes of the triple constraint will also ensure the success of a much larger project. So be aware of wavering in key attributes, whether unexpected or requested. Never assume that other attributes can be left un-changed if an attribute is known to be changing or fluctuating. As noted above, you cannot just provide a change in one without being completing knowing the fact that it will affect the other two.

An approximation of the probable cost of a product, program, or project, computed on the basis of available information.

A problem with a over-budgeted cost can be taken care of with a reliable and accurate cost estimate. An estimate is the combination of the quantities of all the items in the project and their costs respectively. Finally it contains the overall cost needed to complete the project.

“Project scheduling is the discipline of organizing and time-phasing the activities required to complete the objectives of an effort”.

Those items are often estimated in terms of resource allocation, budget and duration, linked by dependencies and scheduled events. A schedule is commonly used in project management and project portfolio management. Elements on a schedule are linked with the Work Breakdown Structure (WBS), the Statement of work, or a Contract Data. Before a project is started, it is properly planned. The owner hires a designer and he designs for his project. If the design is approved then working is started on it. An estimate is

prepared for the project and invitation to bid is sent. After the bidding process and awarding of tender, necessary documentation is done. Construction of a project is a vast procedure which also involves estimation of cost and scheduling of the project. The quantities used in the construction are estimated and their cost is calculated according to the market value. This step determines an idea of the total cost for the project. There is another process called the scheduling of the process. This step determines the step-wise advancement of the project with respect to time. Different activities of the project are related with their duration which makes it easy for the project team to account for the time allocated to the project. This step is used on a large scale in modern construction industry to save time.

#### **1.4 Objectives**

In order to implement the knowledge of construction cost estimation and project scheduling, this final year project has been undertaken. Following are the objectives of the project.

- To estimate the total quantity of material used.
- To estimate the total cost of material and labor required to construct the project.
- To prepare a schedule on computer program to find the total duration of the project
- 

#### **1.5 Reasons/Justifications for topic selection**

Due to the increasing demand of construction in the society, there is a need of well-planned, cost effective and time-effective structures. For this reason we have chosen this topic. If a proper planning of the cost and time is not done before the start of the project, there would be flaws in the project, delay would also occur and as, time is money, time would be wasted. The money wouldn't be used according to the plan and the project would take a lot, far more than its original price. So this technique shows how cost is measured, quantities are measured and time is managed before the start of the project so that the project would run efficiently.

#### **1.6 Advantages**

The cost estimation and scheduling at every stage in the project development process is necessary for responsible fiscal management. Unreliable cost estimates result in severe problems in planning phase and misuse of resources can be the effect.

With the help of scheduling, you can keep track of the project. When you have many employees in the project team working on one project, you would be able to see who is doing what and when. One of the major benefits of a project scheduling is that once all the project information, including deadlines and project phases, are entered into the software,

the software manages the notifications and organizes the tasks for you. Project management software is designed to help you organize and manage projects in an efficient manner. If project delay is unacceptable, it allows sufficient time for considering alternative ways such as changing of priorities. It enables project managers to determine the amount of flexibility they have over certain resources.

### **1.7 Area of application**

Estimation and scheduling is widely used in construction industry all over the world. This technique can be used for large structures, roads, dams or any other civil engineering structure. It can be used by different companies ranging from small consultancy firms to multinational engineering companies. Now-a-days, scheduling and estimation has become a necessary component of any project in order to make it successful and run efficiently. Market is demanding this methodology as it saves time and money and decreases the errors in a project.

## CHAPTER 2

### LITERATURE REVIEW

Like the five blind men encountering different parts of an elephant, each of the numerous participants in the process of planning, designing, financing, constructing and operating physical facilities has a different perspective on project management for construction. Specialized knowledge can be very beneficial, particularly in large and complicated projects, since experts in various specialties can provide valuable services. However, it is advantageous to understand how the different parts of the process fit together. Waste, excessive cost and delays can result from poor coordination and communication among specialists. It is particularly in the interest of owners to insure that such problems do not occur. And it behooves all participants in the process to heed the interests of owners because, in the end, it is the owners who provide the resources and call the shots.

#### 2.1 Cost Estimation

Cost estimation is the approximate prediction of the total budget of the project and its quantities. A cost estimate can be an essential management technique to the planners during the design stages of a project providing important information about the facility and the budget of project.

All projects start with a definite idea and finished by filling a desired requirement. Most of the projects at conceptual design require changes to put forward an acceptable and workable solution. The conceptual cost estimate is now-a-days of high importance to owners, architects, and contractors. It is a method to predict the required financing and to assess the needs of a project. This method continues to be refined during the design phases of the project.

The cost estimate gives all items that would generally be included in the general contractor's bid. The cost estimate is prepared by splitting down the items of work using a standard format and calculating the cost of each item from experience and a database of current construction cost information.

A cost estimate should not be confused with a project budget. A project budget will include in it the total of the cost estimate and also what are known as "soft costs". These soft costs will particularly be excluded from the cost estimate and will normally include land acquisition, movable furniture and equipment, architectural and design fees, building permits and fees, fire and risk insurance. The project budget will also include in it the related non-construction costs such as finance raising and moving costs.(Isherwood 1999)

#### 2.2 Scheduling

Scheduling is the process of deciding how to commit resources between varieties of possible tasks. Time can be specified or floating as part of a sequence of events.



Schedule is a listing of a project's milestones, activities, and deliverables, with known (intended) finish and start dates. Such items are often quantified in terms of duration, budget and resource allocation that are effected by scheduling and other constraints. A schedule is commonly used in project planning and project portfolio management parts of project management. In schedule elements are linked to the Work Breakdown Structure (WBS) elements, the work statement, or a Contract Data Requirements List.

## **2.3 Importance of Cost Estimation and Scheduling**

### **2.3.1 Why Cost Estimation Is Required**

The reliability of project cost estimates at every stage in the project development process is necessary for responsible fiscal management. Unreliable cost estimates result in severe problems in project's programming and budgeting and planning, and it results in staffing and budgeting decisions which could impair effective use of resources.

Estimation is vitally important. When planning a project, such as building, costs can overrun seriously if correct estimates are not considered. Correct project planning details every summarized item and service required.

### **2.3.2 Why Scheduling Is Important**

Construction project scheduling has two aspects- "Developing a plan" and "Using that plan". The plan has different function- most important of which is to save the owner's money and letting him know what is the shortest duration required to complete the project. After developing the plan, the owner knows that when a specific aspect of the project is going to begin and when it would be completed. This is a planning function and is carried out before the job is started.

If you prepare a construction project schedule in advance, you, the owner builder, would be able to schedule the sub-contractors and materials to be on the job site when needed and this will eventually save your time, money trouble.

The construction project schedule is also a good tool to show potential lenders, demonstrating that you are well organized, and that you understand the construction process completely.

Though it may seem insignificant at first, construction scheduling is one of the most important aspects of a bid presentation and successful project. One of the most important things about it is the confidence it can bring to the client at the onset of a project. Having this road map helps clients envision their completed project (Hopkins 2011)

## **2.4 Cost Estimation Details**

### **2.4.1 The Professionals**

Licensed professional cost estimators calculate the cost estimates. An estimator can't be taught and trained completely in a class by giving lectures. The knowledge of estimating theory is important but one requires experience with construction industry, besides physically quantifying work to be a professional estimator. A person having the "skill of estimating" can produce better work, better construction practice and knowledge of the theory of estimating. Lesser the information available about a project, more the experience is required for cost estimation.

An estimator would normally have an engineering or architectural background and be skilled by experience. Information about building technology is essential to be able to narrow down a building into components in an organized structured way and then calculate the price of the different components with given unit rates to obtain the total cost.

For government or public financed projects (e.g. hospitals) there would be owner-required limits emphasized on the A/E firm to design within a limited budget. A professional construction cost calculating and management company would normally contract to perform a cost estimating job as a consultant throughout the different design stages of the particular project. Frequently, larger contracting, architectural and engineering firms would have their own in-house cost estimating sub-departments. Several planning firms choose to have two cost estimates as a cross-check against each other, but if a single cost estimate is to be used, then the use of a single cost estimator is highly recommended.

### **2.4.2 Types of Cost Estimate**

Cost estimates is divided into two groups: conceptual estimates and detailed estimates. They are comprehensively defined as following:

#### **i. Conceptual Estimate**

Conceptual estimating or parametric estimating is the technique of determining a project's cost, often before any graphical representation of a tool is established

#### **ii. Detailed Estimate**

The detailed construction estimate is the result of a process in which the cost of a required construction project is predicted. The estimate is developed by decomposing and dividing the work items in an order, obtaining thus, the cost of every item from experience and estimating the total amount.

### **2.4.3 Number and Timing**

The number of cost estimates required would depend upon project or owner and would normally be connected to the different design stages of the project. A cost estimating tool

for a typical project, which determines the number and timing of cost estimates, can be condensed as following:

#### **I. Pre-Design Phase**

Before the onset of programming and/or designing, the cost estimator produces a cost prototype and budget cost plan for the project. The cost prototype creates a construction budget and defines how the project budget is to be allocated among different building systems. The cost prototype also validates the project scope and determines any costs or work to be financed separately.

#### **II. Schematic/Design Development Phase**

The cost estimator works as an intrinsic member of the design team to analyze design decisions made throughout the design stages against the pre-established cost prototype. This process enables the cost management team to provide an integrated value engineering process throughout the design stage.

At the end of the schematic design and design development phases, the cost estimator gives a complete cost estimate. The estimate is equated against the cost prototype prepared during the pre-design stage of the project.

#### **III. Contract Document Phase**

Further cost estimates are produced upon completion of the 50% and 100% construction document phases.

#### **2.4.4 Inclusions and Exclusions**

A cost estimate includes all items that would specifically be in the general contractor's bid. A list of exclusions may include:

- Assessments, taxes, finance, legal or development fees
- Building permits
- Fire and other risk insurance
- Scope changes and post contract contingencies for change orders and/or claims
- Land and easement acquisition
- Professional design, tests, inspection and management fees
- Owner supplied and placed furniture, fixtures and tools
- Movable furniture and tools

Since the exclusions to a cost estimate are particularly for the project, it is significant that all parties involved must analyze the list of exclusions to become sure that they have a thorough knowledge of the scope of work illuminated in the cost estimate.

#### 2.4.5 Units of Measurement for Pricing

The unit of measurement is indicated by the particular item and also by the level of estimating detail. For example: the cost of a reinforced concrete can be calculated slab per square foot with a compound rate for all the components that constitutes the slab. Alternatively all items that constitute the slab can be priced separately in the unit of measurement that is relevant. A reinforced suspended concrete slab can typically also be quantified in the details as following:

Concrete	Cubic Yard
Reinforcing steel	Pounds
Formwork to soffit of slab	Square Foot
Curing top of concrete	Square Foot

The important factor indicating the unit of an item is that it can be quantified and priced in that specific unit. Pricing units include Linear Feet (LF), Each (EA), Square Feet (SF), Cubic Yard (CY), and Allowance or Lot (LS).

#### 2.4.6 Preparing a Cost Estimate

This section describes a generic process for preparing cost estimates. In certain cases, specific guidance is necessary to address special requirements such as those applicable to project work. And that can be worked out accordingly catering for the required condition/project.

The process for preparing an estimate includes:

- Plan the estimate preparation
- Develop an estimate purpose statement
- Prepare a technical scope summary
- Develop an estimate specific WBS and dictionary
- Identify estimate activities
- Develop a schedule
- Define resources and crews
- Apply quantities to estimate activities
- Document qualifications and assumptions
- Assign resources to estimate activities

- Apply indirect rates, if applicable
- Assign risk based allowances
- Apply escalation factors
- Prepare estimate summary and detail reports
- Review and check the estimate
- Assemble technical scope detail

#### **2.4.7 Techniques of Estimation**

There are four primary methods used to estimate construction costs. Those methods are known as Project Comparison Estimating or Parametric Cost Estimating, Area & Volume Estimating, Assembly & System Estimating, and Unit Price & Schedule Estimating. Each method of estimating offers a level of confidence that is directly related to the amount of time required to prepare the estimate.

##### **2.4.7.1 Order of Magnitude Estimate**

It could be described as educated guess. “Napkin Estimate“ is another word use for this type of estimate because this estimate often forms at the table during conversation of owner and contractor where nearest piece of paper is napkin usually. It could be completed in minutes and accuracy is about 20%.

##### **2.4.7.2 Square Foot and Cubic Foot Estimates**

When proposed size and planned building is known, amount of information required is very less, components for proposed use of structure can be adjusted by designer or estimator then square foot and cubic foot estimates are applied ,like wise other specifications and cost closer to final price is focused on .its accuracy is +,- 15%.

##### **2.4.7.3 Assemblies (or Systems) Estimate**

Every part of integrated sample is individually estimated and then combined to give total estimate of the assembly. Accuracy is 10%

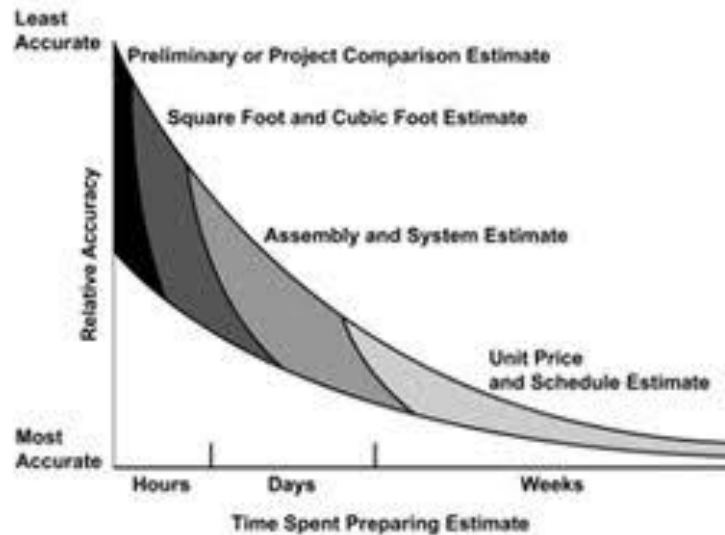
##### **2.4.7.4 Unit Price Estimate**

It is the most accurate type of estimate. It requires full specifications along with working drawings to complete. It is most time consuming of all. Accuracy is 5%.

Estimation of risk and its management is also important part of any project. By risk management we can get a brief concept of different risks leading to any accident. Safety manager should be aware of causes of accident they can be direct or indirect events or situations that effects safety of site. If safety engineer observe hazardous environment, than actions must be taken to eliminate that environment must be done or property or people related to that environment must be protected. The most efficient way to fight such situations is to predict such situations and reschedule that activity so that risk are not concentrated during certain period. History of accidents and other studies from different statistical sources must be done in order to predict highest level of risk, and it should be done during scheduling of activities. This will help us to analyze accident history and information about different risky situations. Risk management forms the basis of safety

planning by estimating risks of project and their distribution throughout the project and allows safety manager to reschedule those activities which are vulnerable to dangerous situations.

Estimation and scheduling form the basis of any project to its successful finish. If professionals are hired for this job , so that process of estimation and scheduling is properly performed it can provide any contractor with a lot of monetary response. (Steven Benjamin)



**Figure 2.1 Cost Estimation Techniques**

#### **2.4.8 Components of Project for Estimation**

Cost estimates are broken down into different sections, which can be referred to as components. Cost estimators will generally use a component format for their cost estimates. Components are basic parts of construction or groups of building systems performing a specific function or functions. Construction costs are separated by component for comparison and analysis. Following is a brief description of each component in a typical component format estimate that represents a good checklist to ensure that all relevant items have been included in the cost estimate.(Sonmez 2004)

##### **2.4.8.1 Foundations**

It includes basement excavation, from general site subgrade to subgrade for lowest floor, and disposal of excavated material or backfill and all supporting members driven into or resting on ground including any necessary excavation, backfill, removal of surplus,

temporary supports and reinforcing. Pile caps and tie beams, not part of the floor system.

#### **2.4.8.2 Vertical Structure**

It includes all columns, all load bearing retaining shear walls or bracing.

#### **2.4.8.3 Floor & Roof Structure**

Floor slabs including supporting rock base and sand cushion. All beams, girders, trusses, catenary supports, etc. supported by vertical structure

#### **2.4.8.4 Exterior Cladding**

- Any non-structural skin, finish color or curtain wall added to the structure to enclose the sides of the building. Any supported framing or connections required to reinforce or secure the cladding materials to the structure, any insulation of the enclosing walls or soffits. Waterproofing or damp-proofing membrane or coating added to above grade enclosing walls or soffits. Any furring, finish surface and minimum decoration (paint) to interior face of enclosing structural walls and non-structural balcony or parapet walls and railings including all finishes on both sides.
- Windows and doors in exterior walls including all glazing, screens, frames, hardware and finishes. Screens, shades applied to the exterior face of the building.

#### **2.4.8.5 Roofing & Waterproofing**

Waterproof membranes on floors or walls and sky-lighting, below grade or concrete admixtures and joint water-stops including sun slabs and protective coverings and exterior or interior roofing insulation. Exterior applied membranes and surfacing on structural decks or roofs including paving. All flashings and exterior rainwater gutters and downspouts, skylights and roof glazing. Roof hatches, scuttles and vents.

The total cost of the completely weatherproofed, and externally decorated enclosed building shell, including minimum finish (paint) to the inside face of enclosing walls, is included in Components 1 through 5.

#### **2.4.8.6 Interior Partitions, Doors & Glazing**

- Non load-bearing partitions including framing and minimum finish (paint) to both sides.
- Surface treatment including furring and minimum finish to both sides of interior structural walls.
- Sound insulation in partitions. Balustrades, rails, screens, etc. used to divide spaces, including all finishes; except prefabricated toilet or shower compartments. All interior doors and windows including frames, hardware and finish.

#### **2.4.8.7 Floor, Wall & Ceiling Finishes**

- Floor covering of all types over structural decks including any necessary supports or membranes.
- Bases or skirtings including finish.
- Furring and finish to all structural columns. Finish to interior soffits of structure including suspension for ceilings and sound insulation above ceilings. Ceiling trim or decoration of any kind.
- Expansion joint covers.

#### **2.4.8.8 Stairs & Vertical Transportation**

Staircases and ramps complete including landings, finishes, balustrades and wall rails—enclosing walls are part of components 2, 4 or 6. Elevators and moving staircases or ramps. Dumbwaiters, book lifts and hoists rising from floor to floor. Trash and mail chutes.

#### **2.4.8.9 Site Preparation & Demolition**

- Demolition, shoring of existing structures and site clearing.
- Grading to ground level floor subgrade including any necessary fill to construct a building pad.
- General site grading to required subgrades.
- Removal or relocation of existing utilities or drains.
- Retaining walls necessary to protect adjoining property or to maintain existing grades.

#### **2.4.8.10 Site Paving, Structures & Landscaping**

- Retaining walls to support site terraces or landscaping.
- Paving and curbs. Landscaping and irrigation.
- Site furniture, pools, sculpture, equipment, etc.
- Covered walks, trellises, pergolas and small ancillary structures. Fencing and rails.
- Drainage (not main storm sewers).
- Lighting.

#### **2.4.8.11 Utilities on Site**

- Connection of mains in the immediate vicinity of the property line to all service lines in the building or on site. Sanitary and storm sewers.
- Domestic and fire water mains and hydrants.
- Gas, electric and fuel oil services.
- Telephone or communications systems conduit and pull boxes.
- Heating and cooling lines and enclosing structures.
- Onsite septic tanks and leaching fields, wells, fuel oil storage, electric substations, etc. are all included in utilities on site.



#### **2.4.8.12 Off-Site Utilities**

Any required extension of services from existing distribution points to immediate vicinity of designated project property line.

#### **2.4.8.13 General Conditions**

All costs of administering and performing a construction job which cannot be assigned to any component: Site establishment and storage facilities, supervision, temporary service, security, insurance, weather problems, general equipment, permits and bond, etc.

#### **2.4.8.14 Contractor's Overhead & Profit or Fee**

General management and overhead, return on fee or contractor's capital investment and profit.

#### **2.4.8.15 Contingency and Escalation**

The above components will include the total project cost at the time of the cost estimate. To arrive at the total recommended budget, additional line items will be included in the component summary for:

- Contingency for design development.
- Allowance for rising costs to the mid-point of construction.

The contingency for design development is determined by consultation with the owner and typically can range from 5% up to 15% of the total construction cost. Frequently, the contingency is decreased during the design process as the likelihood of changes to the plans decreases.

Allowance for rising costs, or escalation, is determined by national or regional conditions. A predetermined monthly percentage is used to increase the construction cost from the date of the cost estimate by the number of months to start plus one-half of the number of months of construction. For example, if it is June 2002 and construction is anticipated to begin in December 2002 and last for a period of 12 months, the construction cost will be increased or escalated by the percentage utilized times 6 (June 2002 to December 2002) plus 6 (January 2003 to June 2003), or times 12. At an annual inflation rate of 3%, or a monthly rate of .25%, the escalation would be  $.25\% \times 12$  months, or a total of 3% of the total construction cost.(Schmeida 2010)

## **2.5 Scheduling Details:**

### **2.5.1 Work Breakdown Structure (WBS):**

A Work Breakdown Structure in project management is decomposition of project into smaller parts which is deliverable oriented. Discrete work elements are defined and grouped in such a way that total scope of work is properly defined

Work breakdown structure element may be any combination. After completion of WBS estimation can be easily done as it forms the basic frame work for estimation. (

The Work Breakdown Structure (WBS) is used for defining work packages and developing and tracking the cost and schedule for the project. The work is broken down into tasks, each of which has a manager, a responsible institution, costs and schedule, technical scope.

All the information related to activities used in project scheduling is present in WBS dictionary. Each activity is completely defined in it which also forms scope statement in a nutshell. Resources will check wbs dictionary to check scope of activity they have been assigned so should be defined clearly.(Barnes 1988)

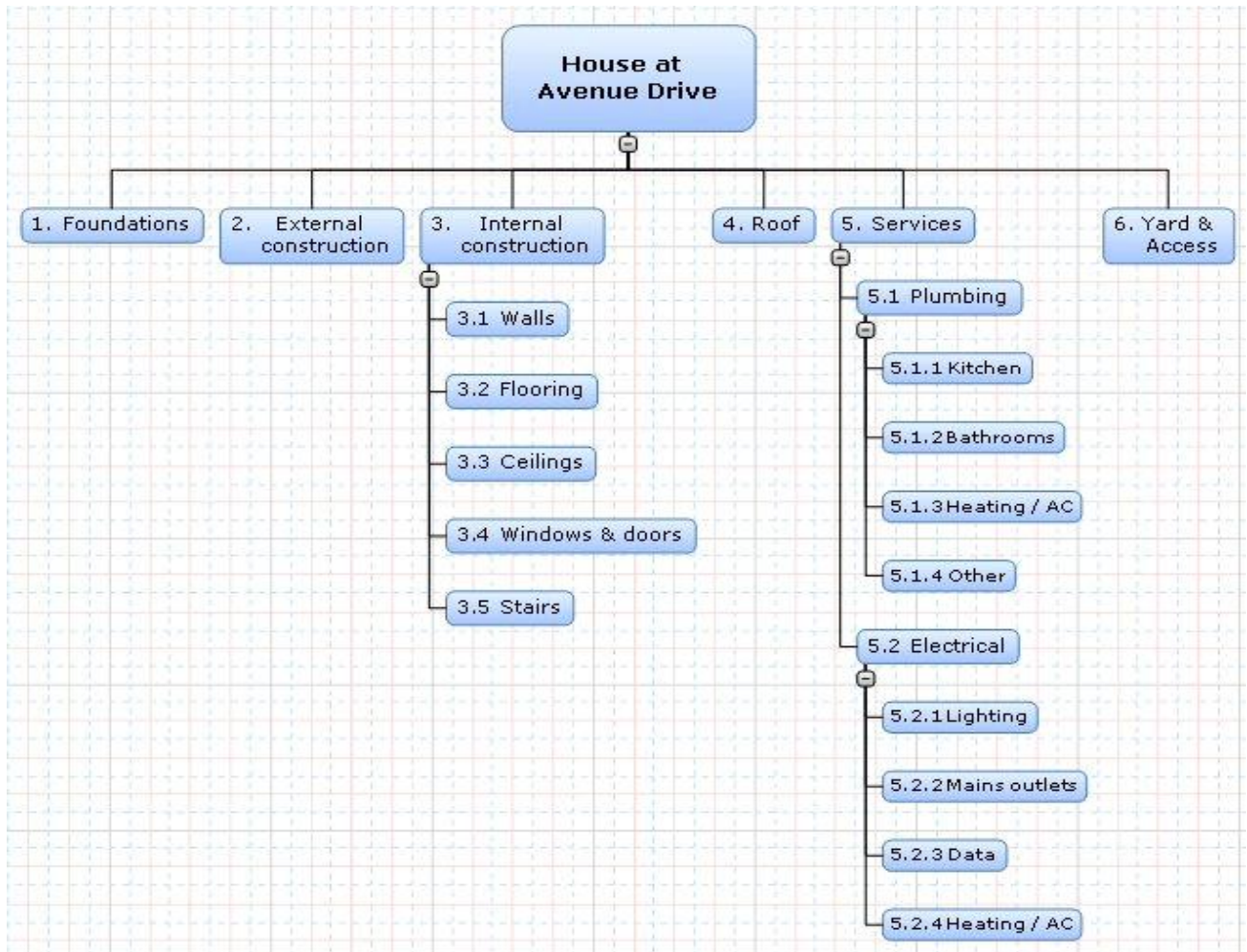


Figure 2.2 Work Breakdown Structure (WBS) Sample

Level	WBS Code	Element Name
4	4	Construction Project
5	4.1	Initiation
6	4.1.1	Evaluation
7	4.1.2	Initial survey
8	4.1.3	Submit report
9	4.1.4	Project Sponsor Reviews report
10	4.1.5	Survey report signed
11	4.2	Excavation
12	4.2.1	Rent machinery
13	4.2.2	Start digging
14	4.2.3	Dumping debris

Figure 2.3 WBS Tabular Form

### 2.5.2 Project Management Body of Knowledge:

Project Management Body of Knowledge (PMBOK) defines five key processes of developing project schedule. PMBOK's Time Management knowledge area explains each of the inputs, tools and techniques and output in detail. So for development of schedule of any project five basic keys are:

1. Define Activities
2. Sequence Activities
3. Estimate Activity Resources
4. Estimate Activity Durations
5. Develop Schedule

#### 2.5.2.1 Define Activities

Identifying overall task required to attain desire results is basically done in this step. As a result of this all the work packages and deliverables are identified by which scope of project can be clearly defined. Work breakdown structure (WBS) comprises of these deliverables. In project schedule deliverables are further decomposed in actual activities required to complete the project. At the very beginning all the information is not available so to gather information activities can be built in project schedule .Even before the delivery phase it is

perfectly normal to build a plan for analysis .When all the activities are defined at the initial level it provide us with the basic skeleton of our project and how it should be carried forward.

#### **2.5.2.2 Sequence Activities**

After the entire task names have been entered and deliverables of WBS are further decomposed in other activities. The next step is to sequence the activities. During this step, dependencies of related tasks are identified and documented in the project schedule. Every task has to be checked independently to understand its dependency on other additional tasks. Finish to start and Start to Start relationships are normally used. These relationships do impact finish and start dates of project.

#### **2.5.2.3 Estimate Activity Resources**

Identification of resources and their availability to project is done during this process. It should be kept in mind not all team members will be available at every time on project as some team members might be on multiple tasks. In this step, you'll also assign resources to each of the tasks. Gantt chart can be used to assign resource to tasks in Microsoft Project. For each task, available team member is selected from resource name column. It is recommended that tasks should be broken down so one task should assigned to one resource to avoid complications on a single task .Although by doing this we create a larger project schedule, but it allows better control in tracking and allocating resources during its execution.

#### **2.5.2.3 Estimate Activity Durations**

Estimation of every activity's duration is done during this process after resources are assigned. The number of working periods required to complete the task is any activity's duration. It can be defined in different working units in Microsoft Project. Different duration types are also important to understand like (Fixed Work, Fixed Duration and Fixed Units). Selection of the correct relation does impact availability of resources and the expected task end date.

#### **2.5.2.4 Develop Schedule**

The last process is to analyze schedule of the project and examine the duration, resources, sequences and constraints (inevitable). During this process we to validate that project schedule correctly portray the planned work. Either Duration estimates or resource allocation are correct or not, is validated in this step .Resource levelling important step to ensure project dates are realistic and the resources are assigned appropriately. Microsoft Project is used for automatic resource levelling feature, but some people suggest not using it. In spite of this, allocation of resources should be manually done. Although it will consume more time but better results will be obtained with realistic end dates.

#### **2.5.2.5 Updating Schedule**

A good project schedule can serve as an important and key rule for the successful completion of project. After you have developed the schedule you can update it by applying

actual data to activities directly in the project. So when you update the schedule, you can evaluate where you are lying, you can do the Earned Value Analysis by updating schedule and forecast whether the budget will finish within budget and in time.

#### **2.5.2.6 Resource Loading**

Resource loading or resource allocation is the the assigning of resources to each activity. Resources of each activity is determined by using its quantities, productivity and the duration to complete the project.

#### **2.5.2.7 Resource Leveling**

Resource leveling is done to ensure the maximum resource demand should not exceed the resource availability. It is done by shifting the activities or by pausing the interruptible activities so that a continuous constant amount of resources remain on the project site and the fluctuation on the resource demand on the project site decrease.(Kastor and Sirakoulis 2009)

### **2.5.3 Techniques for scheduling:**

#### **2.5.3.1 Gantt chart:**

Gantt chart is a special type of bar chart which is used to illustrate the project schedule. Gantt chart is the graphical representation of the project and its activities. It represents WBS and activities, their start and finish date, their duration and relationship between them. Its horizontal axis shows time (days, weeks, months or any unit) while vertical axis shows activities. It is easier to understand and have gained wide acceptance due to its simplicity. As the project progresses, the chart is updated by filling in the bars is proportional to the fraction of the work that has been achieved in the task length. This way, you can get a quick reading of project progress by drawing a vertical line across the table to the current date. Completed tasks are to the left of the line and are completely filled in. Current tasks cross the line and are overdue if your section is filled to the left of the line and ahead of schedule if the filled-in section stops to the right of the line. Future work is completely to the right of the line. This way you can check the status of the project, monitor the tasks of the project, displays sequence and duration of activities demonstrate the tasks which depend on the completion of the previous tasks. (Hofmann 1993)

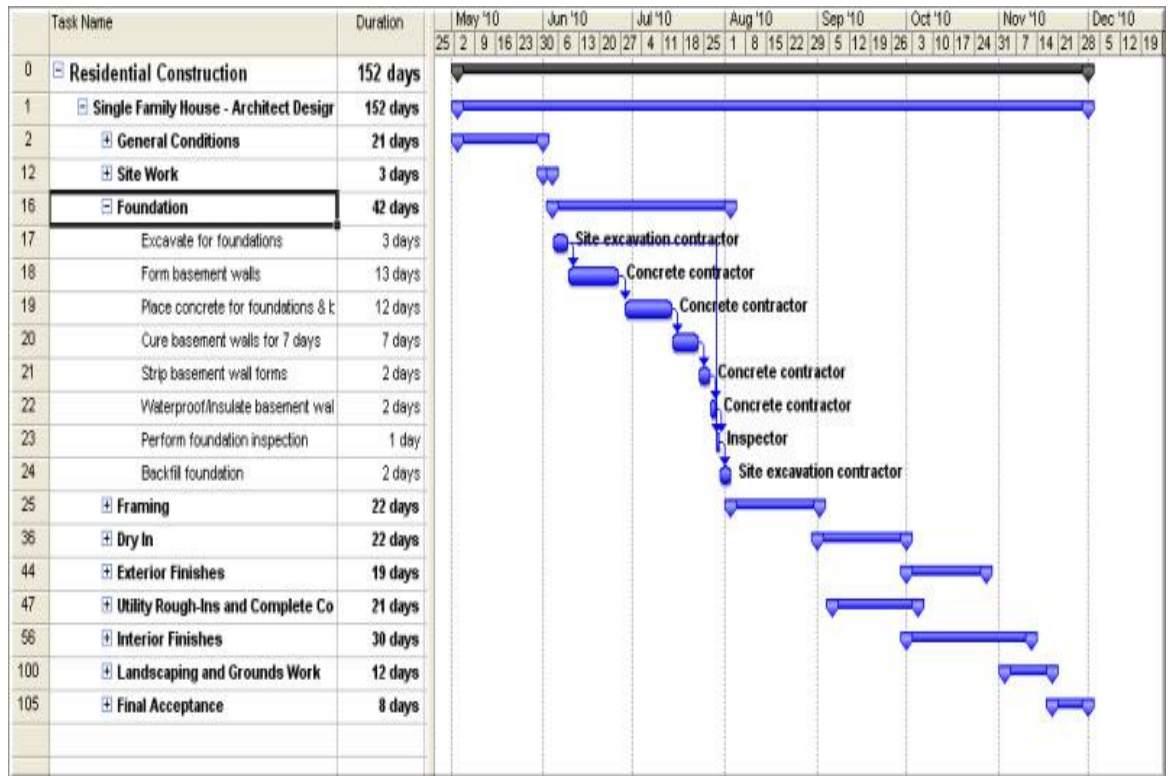


Figure 2.4 Gantt Chart Sample

### 2.5.3.2 Program Evaluation and Review Technique

Program Evaluation and Review Technique is an event oriented network analysis technique used to estimate project duration when individual activity duration estimates are highly uncertain. It is a probabilistic approach used to calculate the activities of such activities and project whose duration estimation are highly uncertain and have no previous data. Formula use to estimate the duration of activities is:

$$T_E = (T_o + 4T_m + T_p) \div 6$$

**T<sub>E</sub>**- Expected Time

**T<sub>o</sub>**- Optimistic Time

**T<sub>m</sub>**- Most Likely Time

**T<sub>p</sub>**- Pessimistic Time

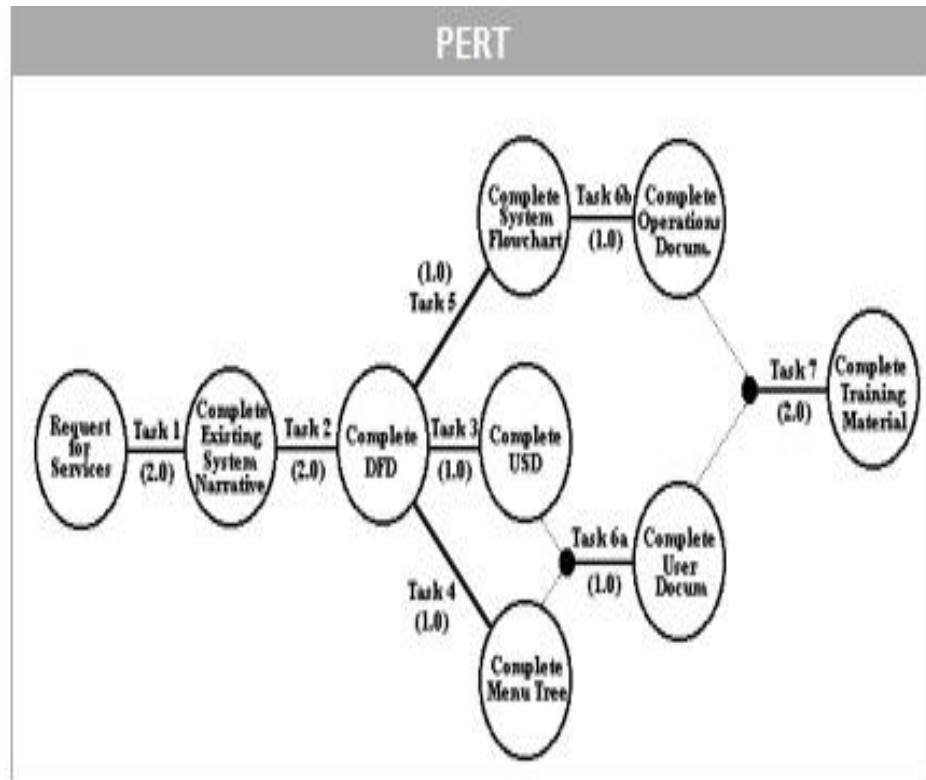


Figure 2.5 PERT Sample

### 2.5.3.3 Critical Path Method

Critical path method is an important tool for effective project management. It uses mathematically based algorithm for scheduling a set of project activities. It provides an easy to understand, graphical view of project and its activities. It take input as activities, their duration and dependencies and give you the duration of project, critical path and critical activities. So with such information you can reduce the duration of your project by adding more resources to the critical activities hence shortening its time will eventually reduce the duration of the project. A CPM diagram represents a project as a network, with its various activities denoted as circular nodes and lines or arcs connecting the nodes representing events.





Figure 2.6 Critical Path Method Sample

## 2.6 SOFTWARES

### 2.6.1 Software for Estimation

- **Autodesk Quantity Takeoff 2013**

Autodesk® Quantity Takeoff building cost estimate software helps make material costing faster, easier, and more accurate. Cost estimators can create synchronized, comprehensive project views that combine important information from building information modeling (BIM) tools such as Revit® Architecture, Revit® Structure, and Revit® MEP software together with geometry, images, and data from other tools.

- **Sage Estimating (formerly Sage Timberline Estimating)**

Sage Estimating is the most widely used construction estimating software. Automate your job estimating and give yourself the ability to create job estimates with maximum accuracy and precision. With Sage Estimating construction software you'll create more estimates in less time and increase your bid-to-win ratio.

- **Maxwell Systems ProContractorMX Estimating**

ProContractor is the industry's only all-in-one construction software solution that brings together estimating, project management, and accounting. It's scalable and flexible, so you can start with what you need now and grow into more as your business requires.

- **PlanSwift**

PlanSwift construction estimating takeoff software calculates everything you need to get an estimate together, labor, square footages, perimeters, volumes of simple or complex areas, beams, rebar, studs, gallons of paint, concrete, insulation, gravel and length of copper wire (or anything in between).

- **ConEst IntelliBid**

ConEst Software System is the leading software innovator takeoff, estimating, project and service management solutions for the electrical, low-voltage and Data/Telecom industries.

- **FastPIPE & FastDUCT**

FastPIPE is used for estimating plumbing, HVAC piping, industrial process piping, or insulation.

- **QuickMeasure OnScreen by Tally Systems**

The Tally system is a cost effective simple system to learn and use, it integrates flawlessly with Excel spreadsheets. It use both on screen and with digitizer, it definitely improves the accuracy and speed of our take-offs

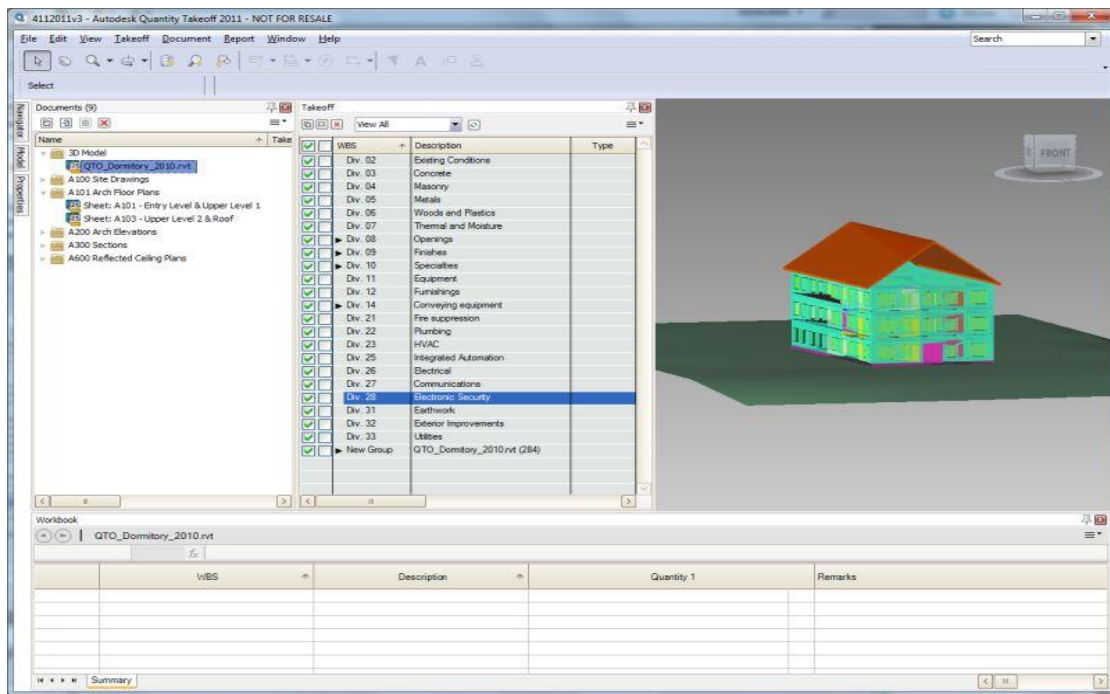


Figure 2.7 QTO Tabular Form

## 2.6.2 Software for Scheduling

- **Microsoft Project**

Microsoft Project is a project management software program, developed and sold by Microsoft, which is designed to assist a project manager in developing a plan, assigning resources to tasks, tracking progress, managing the budget, and analyzing workloads.

- **ZOHO Projects**

Zoho Projects supports creating tasks, assigning ownership, setting deadlines and tracking milestones; working with calendars, Gantt charts, reports, share supporting files—standard features in a project management package.

- **FastTrack Schedule 9**

FastTrack Schedule is project management software program that is used for planning, tracking, and reporting project goals. It enables users to organize tasks into project plans, assign resources to tasks, use effort driven scheduling, and view project details in Gantt charts, monthly calendars, and resource histograms

- **Primavera P6**

The Primavera name is well-known for their project management solutions. P6 is their answer to the project schedule software question. This software package is flexible and has the ability to handle everything from time sheets to resource management. However, P6 does have more extensive hardware requirements than some other project management applications. It is intended for use by larger organizations, and may not be ideal for managers working with smaller projects.

- **@task**

This web-based project management option focuses on an easy-to-use interface. Just looking at @task's Gantt charts shows some impressive utilities. You can drag and drop information to avoid unnecessary typing, easily schedule individuals for specific tasks, and view real-time reports showing your project's status. @task offers a variety of pricing plans depending on the number of users and the number of projects you need to manage.

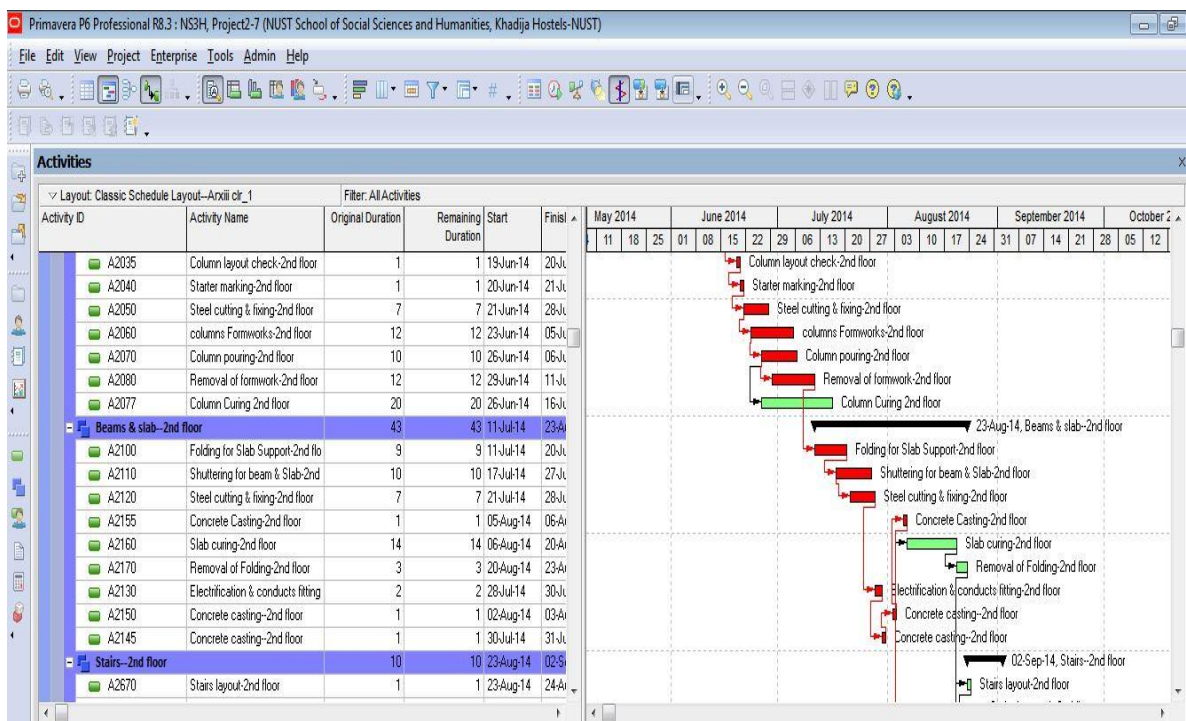


Figure 2.8 Primavera P6 Gantt Chart

### METHODOLOGY

Cost estimation is the critical component of project management. All the three actors (owner, designer and contractor) of construction industry need to know the cost of project. The owner's primary concern is to know if he can pay for the project, Designer needs to know the cost of design alternatives, and Contractor wants to know how much will he paid for the project.

Similarly scheduling is a very important component of project management as it provides with the schedule baseline to compare the actual performance of your project. As these two are very important components of project management so an effective and appropriate methodology should be adopted to carry-out these two quantities.

The methodology we adopted to carry-out these processes consists of following steps:

#### 3.1 Selection of the Topic

We were given with different topics, to select one, for FYP but we chose "SCHEDULING AND ESTIMATION OF A HIGH RISE BUILDING". There are several reasons for selecting this topic which are:

- After proper scheduling and estimation of construction project it is easy to control the execution process.
- We can evaluate the performance of project team by comparing it with schedule or cost baseline.
- To complete the project within time and budget.
- Due to its importance in planning and in execution process, construction industry has a high demand for engineers have good understanding with such topic.

#### 3.2 Literature Study

**Scheduling** is the determination of the timing and sequence of operations in the project and their assembly to give the overall completion time. Different techniques and soft-wares are used to calculate the time of each activity and help to sequence them. Different methods are used to produce certain type of schedule like we can use CPM (Critical Path Method) or Gantt chart technique for large, complex project with a multitude of inter-related tasks; in the same way for small projects we can use PERT method. As we will use PRIMAVERA P6 software for scheduling which will use CPM(Critical Path Method) or Gantt Chart for scheduling.

**Cost estimating** is a well-formulated prediction of the probable construction cost of a specific building project. A cost estimate is an important management tool to library

planners during the design phases of a project providing information about the facility and the project budget. Different types of estimates are required at different stages of project life cycle and for a successful project.

### **3.3 Site Selection**

As we are students of undergraduate level so considering the resources we have and the time we can manage for scheduling and estimating a building we choose a building which is easily accessible and the related authorities would provide us with necessary documents and drawings etc. Moreover we had to find a real-time project to compare our schedule with the schedule developed by the Management team of this project. So we have chosen the building which is in NUST premises that is NUST SCHOOL OF SOCIAL SCIENCES AND HUMANITIES, a 3-storey building under construction.

### **3.4 Data Collection**

After selecting the site we collected some useful data from site e.g.

- Architectural Drawings
- Structural Drawings
- MEP Specifications
- Civil Works Specifications

Moreover proper consultation with the site engineer was ensured and proper information was taken from time to time.

### **3.5 Analysis of Data**

After getting relevant data from site the main task was to study the drawing properly and thoroughly and to extract all the relevant information about the items of the project for estimation purposes i.e. to calculate the quantities of materials used in the project. Detailed and separate calculations for each item has been done using “UNIT PRICE ESTIMATION” technique for estimation.

After estimating the quantities we establish work breakdown structure (WBS) using the bill of quantities we generated. To estimate the duration of each activity we added in WBS level a productivity table was used. From this table we calculated the duration and resources of each activity then relationships were given to calculate the total duration of the project.

### **3.6 Conclusion**

Extracting the information from the available documents, a proper estimate has been developed containing the BOQ and Summary Sheet. Moreover, a proper baseline for schedule and WBS has been formed using this information.

### **3.7 Summary**

“Estimation and Scheduling” is such a topic which is very useful in construction industry. These components of project planning are useful in all phases of project i.e. planning, execution and monitoring. Engineers good in this area have very demand in construction industry and within available resources we are going to schedule and estimate a high rise building using PRIMAVERA P6 software. Managing different hurdles and difficulties we would be able to complete the project within a year.

### RESULTS

“Estimation and Scheduling” is such a topic which is very useful in construction industry. These components of project planning are useful in all phases of project i.e. planning, execution and monitoring.

Completion of the scheduling ,done using the provided specifications and drawings, deduced documents as the result:

#### **4.1 Bill Of Quantities**

##### **4.1.1 Civil Works**

- Structural Works
- Architectural Works
- External Works
- Elevations

##### **4.1.2 M.E.P.**

- HVAC
- Plumbing
- Electric Works
- Vertical Transportation



Themes		Page Setup		Scale to Fit		Sheet Options	
J38		fx					
	A	B	C	D	E	F	G
1	Number	Description	Unit	Qty	Rates	Amount	
2	<b>Earth work</b>						
3	1	Excavation in all kind of soil (including gravelly, clay or mud conglomeration of gravel or boulders, soft, sandy or disintegrated sandy & hard rock etc)upto required depth for	Cft	34347.06	1		
4	2	Fill and back fill with suitable selected material obtained from borrow pits within h-12.	Cft	22298.2969	1		
5	<b>Termite proofing</b>						
6	3	Termite proofing of new building including wood work therein with	Cft		1		
7	<b>Reinforced Concrete Work</b>						
8	4	Providing and laying RCC with minimum compressive cylinder strenght of 3000 psi at 28 days using crush or broken stones in foundations	Cft	8777	1		
9	5	Providing and laying RCC with minimum compressive cylinder strenght of 3000 psi at 28 days using crushed stones in plinth beam as specified required shuttering	Cft	1764	1		

Figure 4.1 BOQ-1

	A	B	C	D	E	F
24	<b>Flooring</b>					
25	18	Providing and laying of sand cushion under floor as per drawing and specifications	Cft	3375	1	
26	19	Providing and laying mosaic (terrazo 3/4" thick) of white cement laid on floor set in CM	Sft	11550	1	
27	20	Laying of granite tiles in building	Sft	1394.4	1	
28	<b>Plaster work</b>					
29	21	1" thick cement plaster ceiling , external walls and internal walls	Sft	117436		
30	<b>Painting work</b>					
31	22	3 coats of plastic emulsion paint including surface preparation of a film with alkali resisting primer on plaster wall and ceiling to form smooth base	Sft	117436	1	
32	23	3 coats of synthetic enamel paint including primer coat on new work such as doors of any type and description as specified	Sft	3760	1	
33	<b>Marbel works</b>					
34	24	Providing and laying 0.5" thick white coloured marbel tiles (botticena tibby flower) in floor	Sft	24468	1	
35	25	Laying of granite tiles in building	Sft	1394.4	1	

(BOQ-2)

### DISCUSSION

#### 5.1 Project Details

<b>CASE STUDY:</b>	3-Storey Building of NS <sub>3</sub> H (NUST School of Social Sciences and Humanities)
<b>CONTRACTOR:</b>	IZHAR CONSTRUCTION
<b>CLIENT:</b>	NUST
<b>SUPERVISION:</b>	NUST
<b>DESIGN:</b>	SHAMI ASSOCIATES
<b>DATA:</b>	PMO (Collection of drawings)

#### 5.2 Hurdles

- Specifications were not provided.
- Structural drawings were not given in time.
- Drawing details were not easily visible.
- Hectic manual work.
- No proper assistance for studying drawing details.
- 

#### 5.3 Things we did not include

All the direct costs we have included in the estimation of the project, but indirect costs like job overheads, office overheads, contractor's profit etc. were not included in the estimation of cost.

#### 5.4 Per Square feet Cost

Per square feet cost of the project is 2258 PKR.

#### 5.5 Total Duration of the Project

Total duration of the project calculated is 510 days.

### CONCLUSION

“Scheduling and Estimation”, if managed in an effective way, can lead the quality of the project to a higher level benefitting all the Project Stakeholders. For a successful completion of a project, it must be ensured that the triple constraints (scope, time and cost) must be managed in the best possible way. Estimators are highly regarded all over the world but in Pakistan estimating (both cost and time) does not get much attention and is taken for granted as a result of which the quality of the project is affected. Much attention is needed in this field of study with the introduction of software like QTO 2013 for Cost Estimation and Primavera for Scheduling. Although some professionals are taking interest in scheduling through Primavera or MS Project but still a lot of work is needed to be done in construction field to make it a common practice, as these two things (estimation and scheduling) if done properly in time can save a lot of effort and ambiguities stakeholders face at construction site during execution phase of the project.

For the successful completion of a project it is necessary that a project is planned well, executed well in short it is managed well. So for the effective management of a project it is necessary that manager knows when to do a specific task and how much cost is going to take that task or activity. If the project is already planned and scheduled it is easier for the manager to know whether he is doing good or not by comparing his/her progress to the as planned schedule using Earned Value Analysis.

### RECOMMENDATIONS

- This subject should be part of the curriculum in the universities because of its importance in the field.
- Latest software knowledge should be provided to the interested students thoroughly.
- Developing a cost database in Rupees for materials available in Pakistan, which can be updated.
- Moreover 3-D Modeling should be introduced for better accomplishment of the project scope.
- Professionals of construction industry should be taught by academia about the importance of that topic.
- For this purpose, students as well as faculty should held seminar for professionals.
- Workshops on such topics should be conducted.
- Students should be encouraged to work on such softwares.
- Students should be encouraged to do research work on that topic and new softwares and apps should be made using other databases as well.





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